BRONCHIAL ARTERY EMBOLIZATION IN LIFE THREATENING HAEMOPTYSIS

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Abstract: *Massive haemoptysis is an alarming event and represents one of the most challenging conditions encountered in medical emergency. Over last few years, bronchial artery embolization (BAE) has emerged as a primary modality for managing severe and life threatening haemoptysis. In 90% of cases, the source of massive haemoptysis is the bronchial circulation whereas in approximately 5% each non bronchial circulation and pulmonary circulation may be responsible for haemoptysis.In the non-Western world, pulmonary tuberculosis and post tubercular bronchiectasis are the most common underlying causes of massive hemoptysis.BAE comprises of an initial thoracic aortogram that shows abnormal bronchial arteries and non bronchial systemic arteries that supply parenchymal lesions in majority of cases. Selective catheterization of bronchial arteries and super-selective catheterization using microcatheter may be performed for safe positioning in the bronchial circulation beyond the origin of spinal cord branches to prevent severe complications. Abnormal angiographic findings in massive hemoptysis include hypertrophic & tortuous bronchial arteries, hypervascularity, shunting into the pulmonary artery or vein or extravasations of contrast medium. A variety of embolic materials are used for BAE. Absorbable gelatin sponge is widely used because it is inexpensive and easy to handle. BAE is effective in controlling acute massive hemoptysis. An initial success rates for BAE have been reported to be 73%–98%. However, long-term recurrence rates have been reported to be 10%–52%. Recurrence rate may also be influenced by the cause of the hemoptysis. Recurrent bleeding is more common in patients with chronic tuberculosis, aspergilloma, or neoplasm. Indeed, massive haemoptysis should be considered as a life-threatening medical emergency. A well co-ordinated strategy involving different medical and surgical specialists is required for successful management.*

Key Words : Massive Haemoptysis : Bronchial artery embolization (BAE) : Recurrent bleeding

INTRODUCTION

Massive haemoptysis is an alarming event and represents one of the most challenging conditions encountered in medical emergency. Definitive treatment depends on the cause and anatomical localization of massive haemoptysis ranging from immediate surgery to conservative approach. Contraindications to surgery may exist due to bilateral advanced lung disease, poor respiratory effort, large transpleural blood vessels, and continued haemoptysis after previous surgery. Conservative management of massive haemoptysis carries a mortality rate of 50%–100% [1]. Death from haemoptysis is mostly caused by asphyxia resulting from flooding of the airways and alveoli with blood rather than by exsanguination. Hence, early management of haemoptysis is essential for successful outcome. Emergency thoracotomy has been replaced by various bronchoscopic interventions and over last few years, bronchial artery embolization (BAE) has emerged as a primary modality for managing severe and life threatening haemoptysis since its use was first reported in 1973 by Remy et al[3]. The efficacy, safety, and utility of BAE in controlling massive haemoptysis have been well documented. Even in surgical candidates, BAE is effective in preparing the patient for elective rather than high-risk emergency surgery[3].

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SOURCE AND CAUSES OF HAEMOPTYSIS

The definition of massive haemoptysis varies from 100 to 600 ml of blood loss per 24 hours[1-3]. Obviously, haemoptysis that jeopardizes respiratory function should be treated as a medical emergency. In 90% of cases, the source of massive haemoptysis is the bronchial circulation whereas in approximately 5% each non bronchial circulation and pulmonary circulation may be responsible for haemoptysis.

Massive haemoptysis may result from various causes, In the non-Western world, pulmonary tuberculosis and post tubercular bronchiectasis are the most common underlying causes of massive hemoptysis whereas bronchogenic carcinoma and chronic inflammatory lung diseases such as bronchiectasis, cystic fibrosis, or aspergillosis are the more prevalent causes of hemoptysis in Western countries[2,3,4]. Other causes include lung abscess, pneumonia, chronic bronchitis, pulmonary interstitial fibrosis, pneumoconiosis, pulmonary artery aneurysm (Rasmussen aneurysm), congenital cardiac or pulmonary vascular anomalies, aorto-bronchial fistula, ruptured aortic aneurysm, and ruptured bronchial artery aneurysm[5].

PATHOGENESIS

Bronchial arteries proliferate and enlarge to compensate for the reduced pulmonary circulation following occlusion of pulmonary arterioles consequent to hypoxic vaso-constriction, vasculitis and intravascular thrombosis[6].These enlarged bronchial arteries in inflamed area may rupture either due to elevated blood pressure or erosion by a bacterial agent. The arterial blood under systemic arterial pressure subsequently extravasates into the respiratory tree, resulting in massive hemoptysis[6,7].

DIAGNOSTIC WORKUP

It is essential to detect the cause and localize source of bleeding prior to bronchial artery embolization in order to perform procedure efficiently and obtain optimum results.

Conventional radiography is helpful in diagnosing and localizing possible causes of haemoptysis such as pneumonia, pulmonary tuberculosis, bronchogenic cancer, or lung abscess[8]. However, radiographic findings are normal or non localizing in 17%–81% of patients with hemoptysis[9-14]. Hirshberg et al[12] reported diagnostic value of radiography in only 50% of cases. Fiber-optic bronchoscopy (FOB) is effective in evaluation of central bronchial lesions and the overall diagnostic accuracy of FOB in haemoptysis is reported to be 10%–43%[8]. However, its usefulness is limited due to presence of blood in the bronchi in acute haemoptysis. However, the risks of FOB include possible airway compromise from sedation, delay in definitive treatment, hypoxemia, and high cost. Moreover, endo-bronchial therapies are not effective in most cases of massive haemoptysis[8].

CT has proved to be of considerable value in diagnosing bronchiectasis, bronchogenic carcinoma, and aspergilloma in patients with massive hemoptysis[8]. CT may demonstrate lesions that may not be visible on conventional radiographs, and contrast enhanced CT may help demonstrate bronchial and non bronchial systemic feeder vessels and vascular lesions that cause massive hemoptysis. CT findings can suggest a specific diagnosis in 50% of patients in whom FOB findings are non diagnostic and in 39%–88% of patients in whom chest radiographs are non diagnostic[10,11,13]. CT can also help localize the site of bleeding in 63%–100% of patients with hemoptysis[9,14]. Moreover, Multislice CT allows rapid scanning,making timely examination feasible in critically ill patients. It has been stated the combined use of FOB and CT yield the best results in evaluating hemoptysis [14]. However, CT should be performed prior to bronchoscopy in all patients with hemoptysis[10,11,13].

ANATOMICAL CONSIDERATIONS

The bronchial arteries supply the trachea, extra- and intrapulmonary airways, bronchovascular bundles, nerves, supporting structures, regional lymph nodes, visceral pleura, and esophagus as well as the vasa vasorum of the aorta, pulmonary artery, and pulmonary vein[10].The bronchial arteries originate directly from the descending thoracic aorta, most commonly between the levels of the T5 and T6 vertebrae[15]. But the bronchial arteries may have variable anatomy as regards their origin, branching pattern, and course.

Cauldwell et al[16] described four classic bronchial artery branching patterns: two on the left and one on the right that presents as an intercostobronchial trunk (ICBT) (40% of cases); one on the left and one ICBT on the right (21%); two on the left and two on the right (one ICBT and one bronchial artery) (20%); and one on the left and two on the right (one ICBT and one bronchial artery) (9.7%). The right ICBT usually arises from the right posterolateral aspect of the thoracic aorta and is seen in 80% of individual. The normal right and left bronchial arteries usually arise separately from the anterolateral aspect of the aorta but right and left bronchial arteries may arise from the aorta as a common trunk.

The reported prevalence of bronchial arteries with an anomalous origin ranges from 8.3% to 35%[7,18]. Aberrant bronchial arteries may originate from the aortic arch, internal mammary artery, thyrocervical trunk, subclavian artery, costocervical trunk, brachiocephalic artery, inferior phrenic artery, or abdominal aorta.

The aberrant origin of bronchial artery should be suspected especially when a significant bronchial arterial supply to areas of abnormal pulmonary parenchyma is not demonstrated during a catheter search, at descending thoracic aortography or in patients with recurrent hemoptysis despite successful embolization and in those in whom the source of bleeding has not been detected[17,19]. In addition, bronchial arteries of anomalous origin should be suspected and investigated angiographically in patients who present with.

Hypertrophic bronchial arteries are easily visualized as enhancing nodular or tubular structures within the mediastinum and around the central airway on contrast-enhanced CT scan[20] The primary locations of enlarged bronchial arteries at CT are the retroesophageal area, retrotracheal area, retrobronchial area, posterior wall of the main bronchus, and aortopulmonary window[21].

TECHNIQUE OF EMBOLIZATION

A preliminary descending thoracic aortogram should be performed prior to bronchial artery embolization (BAE) to evaluate the number and origin sites of bronchial arteries from the aorta. An initial thoracic aortogram is useful in visualizing abnormal bronchial arteries and non bronchial systemic arteries that supply parenchymal lesions in majority of cases[22]. The choice of catheter depends on the operator and either 4Fr or 5 Fr cobra catheter, Shepherd Hook or Simmons-1 can be used for selective catheterization of bronchial arteries. The super-selective catheterization using microcatheter may be performed for safe positioning in the bronchial circulation beyond the origin of spinal cord branches to prevent severe complications.After catheterization of the abnormal bronchial artery, bronchial angiography is performed with manual injection of contrast medium.

After a preliminary bronchial angiogram study is performed, the catheter is securely inserted into the bronchial artery to be embolized. A coaxial catheter may be used for more selective and more distal placement.

ABNORMAL ANGIOGRAPHIC FINDINGS

Abnormal angiographic findings in massive hemoptysis include hypertrophic & tortuous bronchial arteries, hypervascularity, shunting into the pulmonary artery or vein or extravasations of contrast medium (Figure1a,b&c). Although extravasations of contrast medium is considered a specific sign

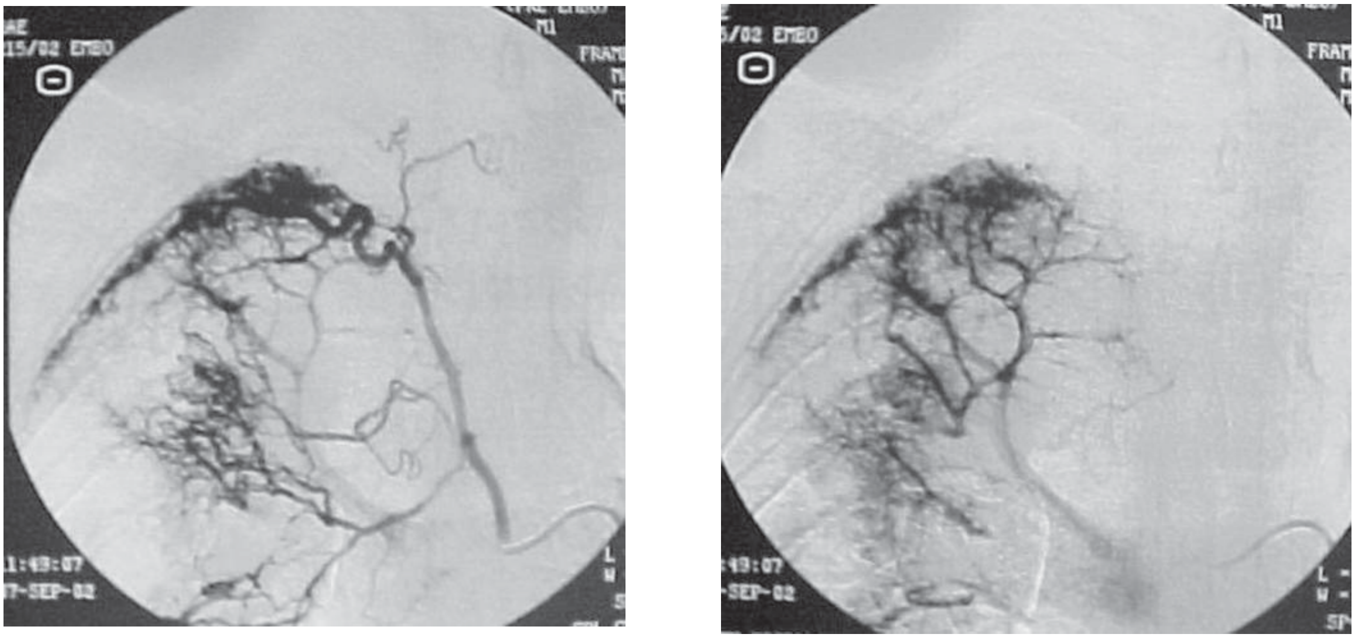

Fig. 1A,B*- Right intercostobronchial trunk supplying marked hypervascularity to upper zone with shunting to pulmonary vein in a case of Pulmonary tuberculosis with pleural thickening*

of bronchial bleeding, this finding is seen in 3.6% to 10.7% of cases only[23]. Thus, the determination of arteries are to be embolized should be based on a combination of CT, bronchoscopic, and angiographic findings with clinical correlation. All angiograms, including intercostal arteriograms, must be carefully scrutinized for opacification of spinal arteries to avoid inadvertent embolization.

EMBOLIC MATERIALS

A variety of embolic materials are used for BAE. Absorbable gelatin sponge is widely used because it is inexpensive and easy to handle. However, disadvantages of absorbable gelatin sponge are its early resolvability and recanalization leading to recurrent haemoptysis[24].

Polyvinyl alcohol particles are non absorbable embolic materials, and particles 350–500 µm in diameter are the most frequently used worldwide[25]. Their use may prevent the early recurrence of hemoptysis due to recanalization of the embolized artery. Polyvinyl alcohol particles of less than 350–500 µm should not be used for BAE to prevent crossing of broncho-pulmonary anastamosis and pulmonary infarction. These particles , however, can be safely used even in the presence of Bronchopulmonary fistula for control of massive hemoptysis. Liquid embolic agents (eg, isobutyl-2 cyanoacrylate, absolute ethanol) are not currently used because of the high risk complications like tissue necrosis.

Stainless steel/ platinum coils are generally not used for BAE because they tend to occlude more proximal vessels and may preclude repeat embolization in case of recurrence of haemoptysis. However, they may occasionally be used in the internal mammary artery to prevent embolization of a normal vascular territory and development of collateral vessels (Figure 2 a&b).

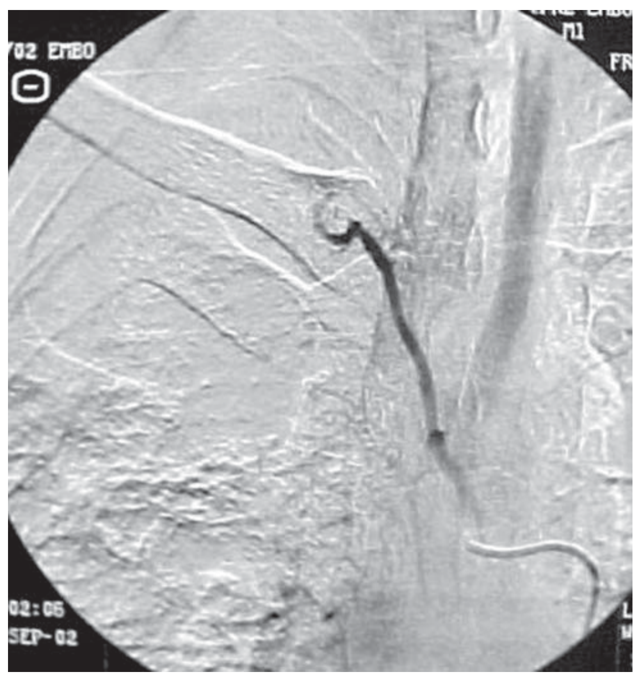

Fig 1C-Post embolization angiogram with total obliteration of hypervascularity

TECHNICAL SUCCESS

BAE is effective in controlling acute massive hemoptysis. The initial success rates for BAE have been reported to be 73%–

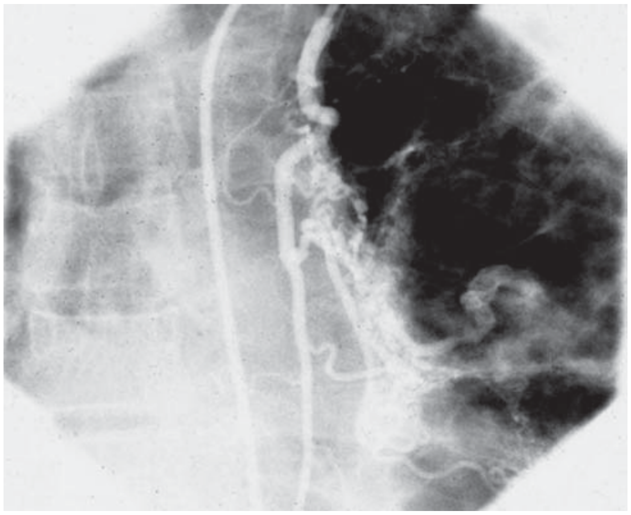

***Figure 2A(Pre)**: Hypertioplived left internal maxillary artery with marked hypervascularity*

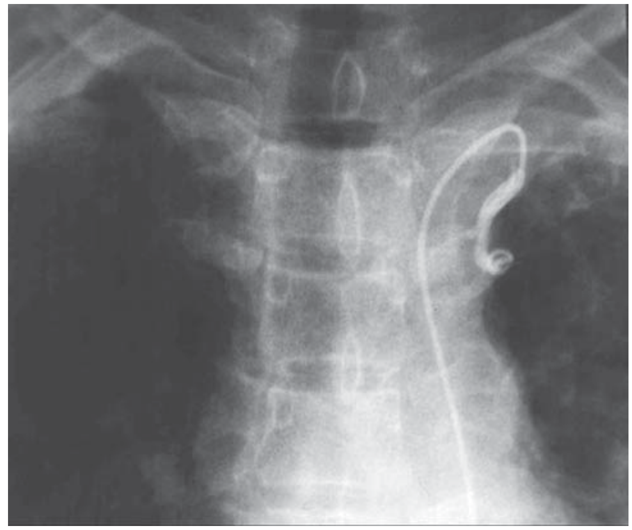

***Figure 2B (Post)**: Successful occlusion with coil & obliteration of hypervascularity*

98%.However, long-term recurrence rates have been reported to be 10%–52%, with a mean follow-up period ranging from 1 to 46 months [(1,3)]. However, the long-term success rate can be improved with repeat BAE. It is important to remember that BAE does not treat the underlying disease and hemoptysis may recur after successful BAE if the disease process is not controlled with drug therapy or surgery. BAE may also be used as a palliative procedure that prepares the patient for elective curative surgery for localized disease[13].

ROLE OF NON BRONCHIAL SYSTEMIC SUPPLY

Non bronchial systemic arteries can be a significant source of massive hemoptysis, especially in patients with significant pleural thickening caused by an underlying disease. In the presence of pleural thickening, non bronchial systemic feeder vessels that originate from intercostal arteries (Figure3 Pre & Post), branches of the subclavian and axillary arteries , internal mammary artery , inferior phrenic artery [20,26,27] and become enlarged as a result of the inflammatory process. Missing the non bronchial systemic arteries at initial angiography may result in early recurrent bleeding after successful embolization of the bronchial artery.

RECURRENCE OF HAEMOPTYSIS

Recurrent bleeding may be caused by recanalization of embolized vessels, incomplete embolization, revascularization by the collateral circulation, inadequate treatment of the underlying disease, progression of pre –existing lung disease, or unembolized non bronchial systemic arterial supply[1,3,27]. Recurrence rate may also be influenced by the cause of the hemoptysis. Recurrent bleeding is more common in patients with chronic tuberculosis, aspergilloma, or neoplasm. In a series by Katoh et al, 75% of patients with aspergilloma experienced recurrence of hemoptysis after undergoing initial embolization[27].

In our institution, BAE is performed as a pre operative measure to facilitate complete resection of extremely vascular aspergiloma. Thus we have been able to reduce the recurrence of haemoptysis considerably. Hayakawa et al[28] reported that BAE failed within 1 month in 42% of patients with neoplasm.

COMPLICATIONS

Several complications of BAE have been reported in the literature. Chest pain is the most common complication, with a reported prevalence of 24%–91%[23]. Chest pain is usually transient phenomenon after embolization. In addition, dysphagia due to embolization of esophageal branches may be encountered, with a reported prevalence of 0.7%–18.2% [28]. Dysphagia also regresses spontaneously. Sub-intimal dissection of the aorta or the bronchial artery during BAE is the other minor complication, with a reported prevalence of 1%–6.3%. There are usually no symptoms or problems related to the sub-intimal dissection. The most disastrous complication of BAE is spinal cord ischemia due to the inadvertent occlusion of spinal arteries. The prevalence of spinal cord ischemia after BAE is reported to be 1.4%–6.5% [28]. This can be prevented by using microcatheter to catheterized bronchial artery well beyond the origin of anterior medullary artery (artery of Adamkiewicz) when this is visualized at angiography or else embolization should not be performed.

Other rare complications that have been reported in the literature include aortic & bronchial necrosis, broncho-esophageal fistula, non–target organ embolization (eg, ischemic colitis), pulmonary infarction, referred pain to the ipsilateral forehead & orbit, and transient cortical blindness [29]. It is hypothesized that cortical blindness develops because of embolism to the occipital cortex, either via a bronchial artery–pulmonary vein shunt or via collateral vessels between the bronchial and vertebral arteries.

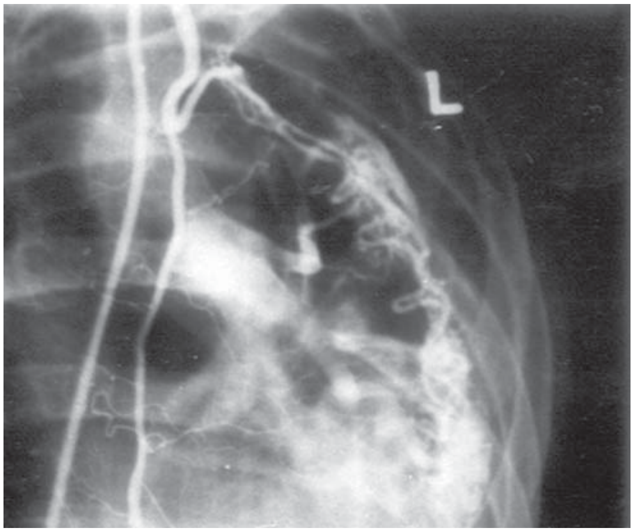

***Figure 3A** : Pre and post left intercostal arteriogram showing abnormal hypervascualrity to diseased peri-hilar region before and after embolization*

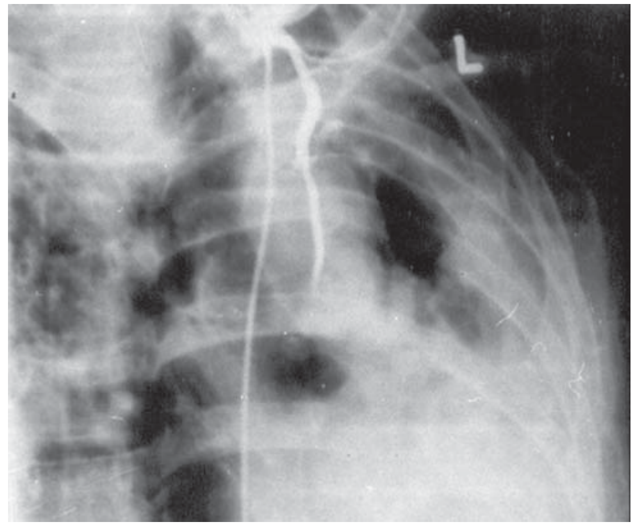

Figure 3B: Post Embolization angiogram showing near complete occlusion of hypervascularity

CONCLUSION

In conclusion, massive haemoptysis should be considered as a life-threatening medical emergency. A well co-ordinated strategy involving different medical and surgical specialists is required for successful management. Control of the respiratory tract is the first priority and should be followed by aggressive measures to identify the source of bleeding, and prompt treatment. Because of the high incidence of recurrent haemoptysis, these patients should not be discharged from hospital before the definitive diagnosis and, if possible, definitive treatment.

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