



Bronchial Artery Embolization in Management of Hemoptysis in a Developing Country: An Initial Experience

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Abstract

Objectives This article evaluates the immediate success, recurrence rate, complications, and the culprit vessel of bronchial artery embolization (BAE) in patients presenting with hemoptysis.

Materials and Methods All patients who underwent BAE from July 1, 2018 to August 31, 2021 were included. BAE was done for moderate to severe hemoptysis or for mild hemoptysis which was recurrent and not controlled by medical management. Patients referred for surgical intervention and hemoptysis controlled on medical management were excluded.

Results One hundred and thirty patients underwent BAE in the study period. Mean age was 41.5 years and majority (73.1%) was male. Forty-three (33.1%) patients had mild, 46 (35.4%) had moderate, and 41 (31.5%) with the duration of symptoms ranging from 3 days to 25 years. Most common culprit vessel was posterior intercostal artery closely followed by the intercostobronchial artery. Hypervascularity was the most common angiographic abnormality encountered. On an average, 2.75 vessels were embolized per BAE with a wide range of 1 to 8 vessels. Hemoptysis control was seen in 96.1% patients immediately, 90.7% at 1 month, 82.3% at 3 months, and 66.9% at 6 months. Overall recurrence was seen in 43 patients (33.1%). Chest pain was the most common minor side effect occurring in 77.1% cases.

Conclusion BAE is a safe and effective procedure that can be performed routinely in patients presenting with moderate to massive hemoptysis or with mild hemoptysis refractory to medical management.

Keywords

- ▶ bronchial artery embolization
- ▶ hemoptysis
- ▶ recurrence
- ▶ PVA

Introduction

Hemoptysis is defined as expectoration of blood in sputum. Massive hemoptysis has been defined by various researchers as expectorant volume varying from 100 mL to more than 1,000 ml in 24 hours; however, nowadays the focus is being

shifted to other clinical risks like hemodynamic instability, shock, and hypoxic respiratory failure rather than absolute volume quantifications.¹ Nonetheless, massive hemoptysis is life threatening if left untreated.² In the majority of cases, the culprit arteries are the bronchial arteries and nonbronchial systemic collaterals (NBSCs).³

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Some of the common causes of hemoptysis in our country include tuberculosis, aspergilloma, bronchiectasis, chronic bronchitis, and malignancy among the noncardiac causes.⁴

The bronchial arteries usually originate from the proximal descending thoracic aorta and are termed orthotopic if the origin is between the superior endplate of the T5 vertebral body and the inferior endplate of the T6 vertebral body. Angiographic landmark for the same is 1 cm below or above the level of left main bronchus, where it is seen to cross the descending thoracic aorta.⁵ These arteries are called ectopic if the origin is from any other vertebral level or other artery. Multiple variations of bronchial arteries are seen with the most common being origin of right bronchial artery as intercostobronchial trunk and two left bronchial arteries.⁶

NBSCs include vessels from the inferior aortic arch, distal descending thoracic aorta, subclavian artery, brachiocephalic trunk, thyrocervical trunk, and internal mammary artery and even a coronary artery and they can also contribute to hemoptysis. These can also be the sources of ectopic bronchial arteries if they are seen to follow the course of bronchus.⁷

Bronchial artery embolization (BAE) involves selective catheterization and angiography of bronchial arteries followed by embolization of abnormal vessels. BAE has been used for control of hemoptysis in variety of clinical conditions ranging from active pulmonary tuberculosis, aspergilloma, bronchiectasis, fibrocavitary lung disease, and even malignancy. It has undergone widespread use in Indian subcontinent especially in view of high burden of persistent hemoptysis due to tuberculosis or post-tubercular sequelae. Even in surgical candidates like unilateral localized disease, aspergilloma, benign lesions, etc., BAE can serve to control life-threatening hemoptysis and decrease the size of the lesion preoperatively.

BAE has undergone a lot of advancements including superselective catheterization to minimize complications and use of polyvinyl alcohol (PVA) particles instead of gelatin or coils to achieve a greater success. These advancements have made BAE a safe, minimally invasive, and highly effective procedure with low complication rate and decreased recurrence rate.

This study was carried out to evaluate the culprit vessels responsible for hemoptysis and study their angiographic signs, and to evaluate the immediate success rate and eventually recurrence rate of hemoptysis following BAE.

Methods

All patients undergoing BAE from July 1, 2018 to August 31, 2021 for hemoptysis were included. The inclusion criteria were moderate to severe hemoptysis or mild hemoptysis which was recurrent and not controlled by medical management. Patients referred for surgical intervention or controlled on medical management were excluded.

A collaborative effort between department of radiodiagnosis and pulmonary medicine was sought. All eligible patients were admitted in the pulmonary medicine depart-

ment, procedure done in the radiology department and interventional radiology after taking informed written consent, and the patients were observed for 24 hours postprocedure and subsequently discharged; the patients were serially followed up in the pulmonary medicine department at 1, 3, and 6 months. All such patients who had undergone BAE were analyzed retrospectively.

Hemoptysis was defined as mild if < 100 mL/day, moderate if 100 to 300 mL/day, and severe/massive if > 300 mL/day. Patients having a hemoglobin fall by 1 g%, hypoxemic respiratory failure after hemoptysis ($pO_2 < 60$ mm Hg), or developing hypotension (systolic blood pressure < 90 mm Hg) were also classified under severe/massive hemoptysis.⁸

The vessels embolized included both bronchial and NBSCs depending on a pre-BAE computed tomography bronchial angiography with an aortic run to identify hypertrophy (> 2 mm), tortuosity, blush, pseudoaneurysm, and venous and pulmonary artery shunting.

We used 60 to 80 mL of contrast at flow rate of 4 mL/sec followed by saline chase and obtained arterial phase and venous phase images. Axial sections were scrutinized for hypertrophied bronchial and nonbronchial systemic feeders to the area of lung pathology. Number, ostial location, vertebral level, and parent artery origin were noted for each suspicious culprit vessel. Maximum intensity projection and multiplanar reconstruction images were scrutinized.

This was followed by the procedure of BAE in Digital subtraction angiography (DSA) lab. Prior to the procedure, informed consent was obtained and basic investigations checked including complete blood count, kidney function test, and coagulation profile. Under local anesthesia, arterial access was obtained thorough transfemoral route and secured using vascular sheath. This was followed by selective catheterization and angiography of bronchial vessels and NBSCs done using nonionic iodinated contrast material. Abnormal angiographic signs like hypertrophy, tortuosity, parenchymal blush, shunting, or aneurysms were looked for and then superselective catheterization done using microcatheter (2.7Fr) followed by embolization using PVA particles of size varying from 200 to 500 μ m. Post-embolization runs were obtained to look for any residual abnormal signs.

Immediate success was defined as cessation of hemoptysis in the same admission or within 24 hours. Recurrence was defined as hemoptysis of any degree occurring after complete cessation of hemoptysis post-BAE and occurring after discharge requiring either hospital admission, medical management, or repeat intervention either as bronchoscopy, repeat embolization, or surgery.⁸

Major complications were defined as sequelae, which were permanent or a cause of death, requiring treatment or prolonged hospitalization. Minor complications were complication that did not require treatment and were self-limited.⁹

Results

One hundred and thirty patients underwent BAE in the study period. Mean age was 41.5 years (16–70 years) and 95 (73.1%) of them were males while 35 (26.9%) were females.

Forty-three patients had mild, 46 had moderate, and 41 had severe hemoptysis with the duration of symptoms ranging from 3 days to 25 years. The major symptoms were hemoptysis in all cases (100%) followed by cough in 15.3%, chest pain (3.8%), and dyspnea (2.3%). Underlying condition was found to be active tuberculosis in 11 patients (8.46%), post-tuberculosis sequelae in 65 patients (50%), tuberculosis with aspergilloma in 9 patients (6.9%), aspergilloma in 1 patient (0.76%), and bronchiectasis in 36 patients (27.69%) while 8 patients had no coexisting condition.

Most common culprit bronchial vessel was intercostobronchial artery (50.8% cases) followed by left bronchial artery (39.2%), while posterior intercostal artery was the most common NBSC involved (51.5%) followed by internal mammary artery (50%) (→ **Table 1**). A total of 381 vessels were found to be abnormal, out of which 358 were embolized.

The most common angiographic finding was hypertrophy seen in 259 vessels followed by tortuosity in 243 vessels (→ **Table 2**).

All abnormal vessels were embolized using PVA particles of sizes varying from 300 to 700 μm. On an average, 2.75 vessels were embolized per BAE with a wide range of 1 to 8 vessels with a total of 358 vessels embolized. In 23 (17.7%) patients, there was technical difficulty in the form of inability to catheterize the abnormal artery. More than one session was required in 16 cases (12.4%). → **Figs. 1** and **2** show the digital subtraction angiographic findings seen in our study.

Table 1 Frequency of involvement of individual arteries in 130 patients

Vessel	Frequency of involvement (n = 130)
Intercostobronchial trunk	66 (50.8%)
Right bronchial	20 (15.3%)
Left bronchial	51 (39.2%)
Common bronchial	41 (31.5%)
Posterior intercostal artery	67 (51.5%)
Internal mammary artery	65 (50%)
Others	71
• Thyrocervical trunk	5 (3.8%)
• Costocervical trunk	15 (11.5%)
• Inferior phrenic	9 (6.9%)
• Lateral thoracic	23 (17.7%)
• Superior thoracic	16 (12.3%)
• Supreme Intercostal	3 (2.3%)

Table 2 Distribution of angiographic finding of abnormal vessels in bronchial artery embolization

Angiographic findings	Frequency
Hypertrophy/hypervascularity	259
Tortuosity	243
Parenchymal blush	208
Shunting	61

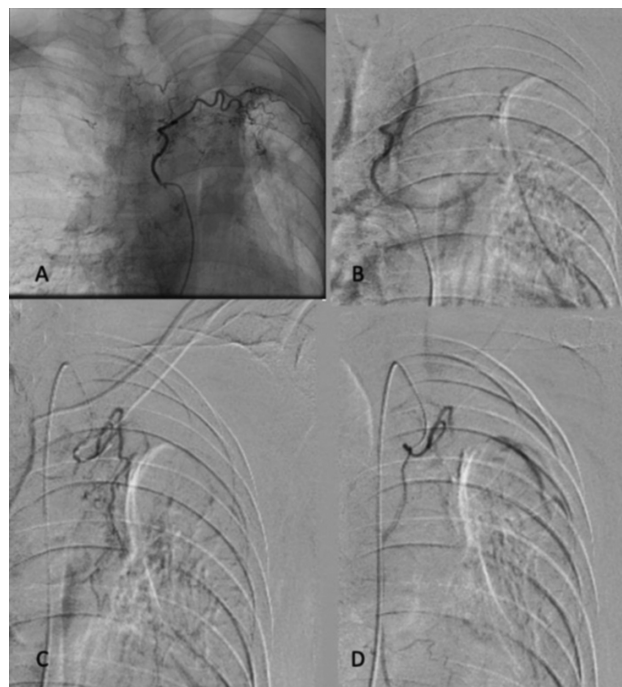


Fig. 1 (A–D) Angiographic images showing abnormal tortuous, hypertrophic left bronchial artery before (A) and after embolization using polyvinyl alcohol (PVA) particles (B). Another image showing abnormal tortuous and hypertrophic nonbronchial systemic collateral from left internal mammary artery before (C) and after PVA embolization (D).

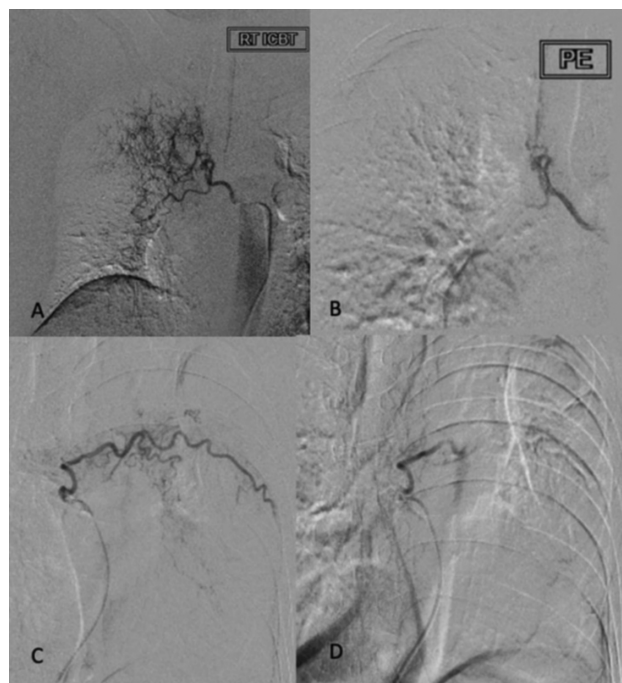


Fig. 2 (A–D) Angiographic images show hypertrophic, tortuous right intercostobronchial trunk with parenchymal blush before (A) and after embolization (B). Another image showing abnormal hypertrophic and tortuous posterior intercostal artery before (C) and after polyvinyl alcohol (PVA) embolization (D).

Immediate success was seen in 125 patients (96.1%). At 1-month follow-up, 7 patients had hemoptysis with only 4 having moderate amount for which a repeat BAE was done. At 3 months' follow-up, 11 patients had hemoptysis while at

6 months, 20 patients had recurrence. Overall, recurrence was seen in 43 patients (33.1%) while 87 patients (66.9%) remained symptom-free in our period of follow-up of 6 months.

Immediate complications in the form of chest pain (27 patients), fever (16 patients), and dyspnea (1 patient) were seen which resolved gradually and spontaneously. No chronic complications were seen during the course of our study. Two patients expired during the course of study due to hemoptysis.

Discussion

The airways and supporting structures of the lung are supplied by bronchial arteries, while the lung, parenchyma, and respiratory bronchioles are supplied by pulmonary arteries. Bronchial circulation is the source of massive hemoptysis in 90% of cases.³ Remy et al first described BAE for the treatment of hemoptysis in 1973.¹⁰

Since its initial descriptions in 1973, BAE has evolved in terms of indications, technique, and efficacy of hemoptysis control. BAE has been used for treatment for all grades of hemoptysis arising from both benign and malignant causes.

Our results showed that moderate to massive hemoptysis was seen to be more associated with underlying chronic lung disease such as pulmonary tuberculosis and aspergilloma and accounted for 93.8% of our patients. This is in accordance with the study conducted by Chan et al in Hong Kong.¹¹

Hypervascularity was the most reported angiographic abnormality in our study seen in 250 abnormal vessels. It refers to the increased caliber and branching of the vessel supplying the abnormal area of lung parenchyma. In our study, the most common culprit vessel was the posterior intercostal artery (51.5% cases) followed by intercostobronchial trunk (50.8% cases) with pulmonary arteries having no significant role. Similar findings were also reported by Mal et al.¹²

The process of embolization was well tolerated by the patients in our study. In literature, the immediate clinical

success of BAE varied from 70 to 99%.^{2,3,12-16} In our study, hemoptysis control was seen in 96.1% cases immediately, 90.7% cases at 1 month, 82.3% at 3 months, and 66.9% at 6 months. The recurrence rate of hemoptysis ranged between 9.8 and 57.5%. The high recurrence rate is not surprising as BAE is essentially a palliative procedure to manage hemoptysis in patients with diffuse or bilateral lung disease or poor pulmonary reserve who are otherwise unfit to undergo surgery.^{13,14} The overall recurrence rate in our study was 33.1%.

The plausible explanation for early recurrences were technically inadequate or incomplete embolization, lack of complete search for all offending vessels, or inability to embolize all arteries including nonbronchial systemic vessels in the first session due to presence of collateralization. However, the late recurrences were attributed to recanalization of previously embolized arteries or recruitment of new arteries, especially nonbronchial systemic arteries, due to underlying disease progression.¹⁷⁻²⁰ In the present study technical difficulty to catheterize the abnormal vessel was seen in 23 arteries.

The most common complications after BAE included transient chest/back pain and dysphagia which were reported in 1.4 to 34.5% and 0.7 to 30%, respectively.⁸ The present study reported chest pain as the most common complication. However, no patient had contrast media hypersensitivity, groin puncture hematomas, and femoral artery pseudoaneurysms at the puncture site as previously documented in literature.⁸ The literature also has documented neurologic complications due to spinal cord ischemia leading to transient or permanent paraparesis or paraplegia occurring in 0.6 to 4.4%.⁸ This was attributed to inadvertent embolization of spinal arteries arising from bronchial or intercostobronchial arteries. This has not been observed in the present study, probably due to fewer number of cases. The potential limitations of the study include smaller sample size and evaluation of efficacy of BAE only under elective conditions. A review of the various studies done in relation to the management of hemoptysis by BAE is shown in ► **Table 3**.

Table 3 BAE in the management of hemoptysis: literature review

Author	Year	Number of patients	Amount of hemoptysis	Immediate success rate	Recurrence rate
Singhal and Banode ²¹	2011	11	Massive	91%	9.1%
Agmy et al ²²	2013	348	Moderate to massive	95%	9.6%
Bhalla et al ¹⁸	2015	334	Mild, moderate, and massive	78.1%	7.5% (long term)
Mishra et al ²³	2018	52	Intractable hemoptysis or massive hemoptysis	92%	4.2% at 1 month
Hwang et al ²⁴	2021	233	Mild, moderate	Technical 96.1% Clinical 94%	27.5% after 197 days
Dorji et al ²⁵	2021	145	Life-threatening hemoptysis	Technical 92.4% Clinical 70.1%	48.9%
Present study		130	Mild, moderate, and massive	96.1%	33.1%

Abbreviation: BAE, bronchial artery embolization.

Conclusion

Our results revealed that hypervascularity of abnormal bronchial and nonbronchial systemic arteries were the most common vascular abnormality. BAE is a safe procedure for control of moderate/massive hemoptysis or those with mild hemoptysis but refractory to medical management, with high success and low recurrence rate.

Ethical Approval Statement

Ethical approval was taken from the institute's ethics committee.

Consent for Publication

Written informed consent was taken from the patients.

Data Availability Statement

Written informed consent was taken from all study participants to share their clinical data.

Authors' Contribution

P.G., A.K., P.I. involved in conceptualization, literature search, writing the original draft of manuscript, literature search, planning, conduct, and editing. P.G., A.K., K.B., A.M., P.I., R.K. involved in review and editing. All the authors have agreed with the submitted manuscript.

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Conflict of Interest

None declared.

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