Bronchial Artery Embolisation for Acute Massive Haemoptysis: Retrospective Study

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ABSTRACT

Objective: To assess the efficacy and safety of bronchial artery embolisation in the treatment of acute massive haemoptysis.

Patients and Methods: Records of 34 consecutive patients (28 males and 6 females) who presented to the United Christian Hospital from June 2000 to July 2003 with acute massive haemoptysis and who underwent a total of 47 bronchial artery embolisation procedures were retrospectively studied. The following data were analysed: age, sex, aetiology, computed tomograms of the thorax, bronchial angiographic findings, embolisation results, complications related to bronchial artery embolisation, and clinical outcome during follow-up.

Results: The aetiology included previous pulmonary tuberculosis in 18 (53%) cases, previous tuberculosis with bronchiectasis in 7 (21%) cases, bronchiectasis in 6 (18%) cases, and active pulmonary tuberculosis in 1 (3%) case. No identifiable cause could be detected in 2 (6%) patients. Computed tomography of the thorax was not helpful in locating the site of bleeding in 9 (26%) patients. Massive haemoptysis was successfully controlled immediately after the embolisation procedure in 33 (97%) of 34 patients. Procedures were repeated in 7 (21%) patients because of recurrent symptoms. Three (9%) patients developed recurrent haemoptysis during the month after the procedure and were treated by re-embolisation. In addition, 3 (9%) cases developed repeated haemoptysis within 6 months of the procedure and required further embolisation. The 1-month and 6-month non-recurrent rates were 91% (31/34) and 82% (28/34), respectively. No major procedure-related complication such as bronchial infarction was identified. No patient experienced any neurological complications.

Conclusion: Bronchial artery embolisation is a safe and effective means of controlling massive haemoptysis and should be regarded as the first-line treatment for this condition.

Key Words: Bronchial arteries; Embolization, therapeutic; Hemoptysis/therapy; Treatment outcome

INTRODUCTION

Massive haemoptysis is a life-threatening respiratory emergency. The condition has been widely defined as blood loss of 300 to 600 mL during a period of 24 hours.1-5 However, the volume of blood that is lost is usually underestimated because a considerable amount of blood may not be expectorated and therefore remains inside the lungs. The cause of death among patients with massive haemoptysis is usually asphyxiation rather than exsanguination.

Conservative management of massive haemoptysis carries a mortality of 50% to 100%.6 The reported mortality for surgical treatment ranges from 7.1% to 18.2%.3 Mortality increases significantly, up to about 40%, when the surgery is undertaken as an emergency procedure.4 Because of poor pulmonary reserve, most patients with massive haemoptysis are not fit for surgical treatment.

Bronchial artery embolisation was first described by Remy et al in 1973.5 It has now been generally accepted as a first-line treatment for acute massive haemoptysis.7 Bronchial artery embolisation is also effective in preparing patients for elective rather than highly risky emergency surgery.4 This retrospective study aimed at assessing the efficacy and safety of bronchial artery embolisation in the management of acute massive haemoptysis.
PATIENTS AND METHODS
From June 2000 to July 2003, a total of 47 bronchial artery embolisation procedures were performed for 34 patients who presented with acute massive haemoptysis to the Department of Radiology and Organ Imaging at the United Christian Hospital. All procedures were done on an emergency basis. The clinical records of all patients were reviewed. Age, sex, aetiology, the findings from computed tomography (CT) of the thorax and bronchial angiography, complications related to bronchial artery embolisation, and outcomes of bronchial artery embolisation during follow-up were studied and analysed.

In all 47 procedures, vascular access was achieved by the femoral approach. Flush-descending thoracic aortography was performed during 42 procedures using 5-French catheters with multiple side holes. Abnormally dilated, hypertrophic, and tortuous bronchial arteries (Figures 1 and 2) were identified and selectively cannulated with the use of 0.035-inch (0.09-cm) angled-tip hydrophilic guide-wires and 5-F catheters, such as Simmons 1 glide-catheters (Radifocus; Terumo Corporation, Tokyo, Japan). Digital subtraction selective bronchial angiography was subsequently performed.

In 32 procedures, 3-F coaxial microcatheters, such as SP microcatheters (Radifocus; Terumo Corporation) and Tracker microcatheters (Target Therapeutics, Fremont, CA, United States [US]) were used to achieve more distal and stable cannulation of the affected vessels. Embolic agents were subsequently injected until the blood flow inside the affected vessels became sluggish (Figure 3).

The contrast medium used was the non-ionic agent iopamidol, which was mixed with normal saline in a ratio of 1:1. We used the following particles as embolic materials: trisacryl gelatin (Embosphere; BioSphere Medical, Rockland, MA, US), and polyvinyl alcohol (Trufill from Cordis, Miami Lakes, FL, US, or Contour from Boston Scientific, Natick, MA, US); the particle size ranged from 300 to 700 µm. Polyvinyl alcohol was used in 29 procedures, whereas trisacryl gelatin was chosen in 13 procedures. The embolisation particles could not be traced in 5 procedures. Absorbable gelatin sponge (n = 1) or coils (n = 4) were occasionally added to achieve satisfactory haemostasis.

RESULTS
The 34 consecutive patients undergoing bronchial artery embolisation for acute massive haemoptysis comprised 28 males and 6 females whose mean age was 65 years (range, 17-84 years). The aetiology included...
previous pulmonary tuberculosis in 18 (53%) cases, previous tuberculosis with bronchiectasis in 7 (21%) cases, bronchiectasis in 6 (18%) cases, and active pulmonary tuberculosis in 1 (3%) case. No identifiable cause could be detected in 2 (6%) patients.

Thirty (88%) patients underwent CT of the thorax. For 16 (47%) patients, the affected pulmonary lobe as visualised by CT corresponded well to the location of abnormally dilated bronchial arteries in bronchial angiograms. Furthermore, CT was able to show the side of bleeding in 10 (29%) patients. However, CT was not helpful in locating the site of bleeding in 9 (26%) patients.

A total of 47 bronchial artery embolisations were performed (Table 1). Flush-descending thoracic aortograms were obtained before selective bronchial angiography during 43 (91%) of the 47 procedures. Abnormal bronchial arteries could be visualised in 37 (86%) of these 43 aortograms (Figure 4).

Massive haemoptysis was successfully controlled immediately after the procedure in 33 (97%) of 34 patients. In 1 case, cardiac arrest occurred during the procedure, and the procedure was aborted. Abnormal non-bronchial systemic collateral supply was noted in 14 (41%) cases (Table 2). The abnormal systemic collateral arteries included an internal mammary artery (n = 7), an intercostal artery (n = 4), and a costocervical trunk (n=3). Four patients had multiple systemic collateral vessels. Bronchiopulmonary shunting was demonstrated in 9 (26%) patients, either during flush-descending thoracic aortography (Figure 4) or during selective bronchial artery angiography (Figure 1).

Procedures were repeated in 7 (21%) patients because of recurrent symptoms. The aetiology was tuberculosis in 5 cases and bronchiectasis in 2 cases. Three (9%) patients developed recurrent haemoptysis during the month after the procedure and were treated by re-embolisation. In addition, 3 (9%) patients developed repeated haemoptysis within 6 months of the procedure and required further embolisation. The 1-month and 6-month non-recurrent rates were 91% (31/34) and 82% (28/34), respectively.

![Figure 3. Postembolisation angiogram for the same case as in Figure 2, showing a marked decrease in hypervascularity after the abnormal left bronchial artery had been selectively embolised with polyvinyl alcohol particles.](image)

![Figure 4. Descending thoracic aortogram showing shunting between the left bronchial and left pulmonary arteries.](image)

### Table 1. Number of arteries embolised during bronchial artery embolisation.

<table>
<thead>
<tr>
<th>Artery embolised</th>
<th>No.</th>
</tr>
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<tbody>
<tr>
<td>Right bronchial artery</td>
<td>23</td>
</tr>
<tr>
<td>Left bronchial artery</td>
<td>17</td>
</tr>
<tr>
<td>Combined right and left bronchial trunk</td>
<td>3</td>
</tr>
<tr>
<td>System collateral</td>
<td>16</td>
</tr>
</tbody>
</table>
One patient complained of recurrent massive haemoptysis more than 1 year after the initial bronchial artery embolisation; he was subsequently treated by multiple embolisations. No major operation was performed in any of the 34 patients. Neither the anterior medullary spinal artery nor artery of Adamkiewicz was visualised in any patient. In addition, no major procedure-related complication, such as bronchial infarction, stroke, or transverse myelitis, was identified, and no patient experienced any neurological complications. No procedure-related mortality was encountered.

**DISCUSSION**

Massive or life-threatening haemoptysis can have many causes, and the aetiology varies in different parts of the world. In eastern countries, pulmonary tuberculosis and bronchiectasis are the most frequent causes. In our series of patients, 72% of cases of massive haemoptysis were associated with previous pulmonary tuberculosis (52% with previous pulmonary tuberculosis and 20% with previous tuberculosis and bronchiectasis). In 1 patient, the massive haemoptysis was related to active pulmonary tuberculosis. In the West, however, bronchogenic carcinoma, cystic fibrosis, and aspergillosis are the more prevalent causes. Other causes include lung abscess, pneumonia, chronic bronchiectasis, pulmonary interstitial fibrosis, pneumoconiosis, pulmonary artery aneurysm (Rasmussen’s aneurysm), congenital cardiac or pulmonary vascular anomalies, aortobronchial fistula, ruptured aortic aneurysm, and ruptured bronchial artery aneurysm.  

Hypertrophied and tortuous bronchial arteries or collateral vessels, an unfolded aorta in elderly patients with diffuse atherosclerotic disease, and abnormal take-off of the vessels usually make stable cannulation difficult and embolisation unsafe. We used microcatheters in most cases to achieve a more stable and distal cannulation of abnormal vessels, to bypass spinal artery, and to prevent reflux of embolic agents into the aorta and therefore to non-target sites. None of the patients in our series experienced complications of stroke or organ infarction due to non-target embolisation.

Two different groups of spinal arteries may be encountered during bronchial angiography. The dorsal and ventral arteries are commonly identified as small and curvilinear vessels that extend towards the midline and supply the dorsal and ventral nerve roots. The anterior medullary arteries, which are rarely observed, run superomedially to join with the anterior spinal arteries, thereby forming characteristic hairpin loops. It has been stated that the presence of the radicular arteries should not be considered as a contraindication of bronchial artery embolisation.

On the other hand, some authors believe that embolisation or repeated angiography should be avoided in the presence of anterior medullary arteries because of risk of spinal cord ischaemia. The use of embolic particles larger than 200 to 250 µm has been postulated to be safe, because the particles are supposed to be too large to enter the spinal arteries. We believe that bronchial artery embolisation can be performed safely by using large particles (>300 µm) and with the catheter tip well beyond the origin of anterior medullary arteries.

Bronchiopulmonary shunts are occasionally encountered during bronchial angiography. Pulmonary infarction or systemic arterial embolisation may occur if embolic agents pass through the bronchial artery–pulmonary artery shunt or the bronchial artery–pulmonary vein shunt, respectively. Therefore, it is important not to use particles that can easily pass through the shunts. An experimental study has demonstrated that bronchiopulmonary anastomosis measures about 325 µm in human lungs. Some authors have suggested that bronchial artery embolisation can be safely performed in the presence of bronchiopulmonary shunt, provided that the size of the embolic agents exceeds 350 µm.  

Embolisation by metallic coils will block the proximal parent arteries. Any rebleeding caused by distal collateralisation will mean that further access to these collaterals may be lost, because proximal arteries are occluded. We therefore used particles ranging from 300 to 700 µm for bronchial artery embolisation, so that we could embolise only at the arteriole and capillary levels, while keeping the proximal parent arteries patent. Furthermore, these particles were unlikely to pass through the anterior medullary artery or bronchiopulmonary shunt.

### Table 2. Number of non-bronchial system collateral arteries embolised during bronchial artery embolisation.

<table>
<thead>
<tr>
<th>Non-bronchial system collateral artery</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal mammary artery</td>
<td>7</td>
</tr>
<tr>
<td>Intercostal artery</td>
<td>4</td>
</tr>
<tr>
<td>Costocervical trunk</td>
<td>3</td>
</tr>
<tr>
<td>Lateral thoracic artery</td>
<td>2</td>
</tr>
<tr>
<td>Inferior phrenic artery</td>
<td>2</td>
</tr>
<tr>
<td>Subclavian artery</td>
<td>2</td>
</tr>
<tr>
<td>Superior thoracic artery</td>
<td>2</td>
</tr>
</tbody>
</table>
We performed flush-descending thoracic aortography for most patients to locate the abnormally hypertrophied bronchial arteries. A normal thoracic angiogram, however, should not preclude the search for an abnormal bronchial artery. Selective search for abnormal nonbronchial systemic collateral arteries should be performed. Of particular importance are the subclavian artery and its branches (most commonly, the internal mammary artery) for upper lobe lesions, and the inferior phrenic artery for lower lobe lesions.

Radiological investigation for massive haemoptysis usually includes chest radiography, CT, and bronchoscopy; these tests aim at determining the cause as well as the source of bleeding. Conventional chest radiography is simple, fast, cheap, non-invasive, and readily available. However, in a retrospective study of 208 patients with haemoptysis, Hirshberg et al14 found that radiography was considered to be diagnostic in only 50% of cases.

Fibre-optic bronchoscopy has also been used to investigate haemoptysis. But with this method, it is usually difficult to locate the bleeding site in cases of massive haemoptysis in which most of the bronchi are flooded with blood. The potential risks of bronchoscopy include sedation, hypoxaemia, aspiration, and delay in definitive treatment. Although vasoactive drugs can be infused locally during bronchoscopy to stop bleeding, endoscopic therapy is usually not effective in most cases of massive haemoptysis.

Finally, CT of the thorax can demonstrate and locate most lung lesions, including pulmonary tuberculosis changes, bronchiectasis, bronchogenic tumours, and aspergillosis. The technique is fast, non-invasive, and readily available. Moreover, CT can help locate the site of bleeding in 63% to 100% of patients with haemoptysis—a rate that is higher than that for fibre-optic bronchoscopy.

CONCLUSION
In the cases of massive haemoptysis studied, CT of the thorax was useful in locating the site of bleeding in 74% of cases. Our overall success rate in the control of bleeding immediately after the procedure was 97%. The 1-month and 6-month non-recurrent rates were 91% and 82%, respectively. Bronchial artery embolisation is thus a safe and effective means of controlling bleeding and should be considered to be the first-line treatment for massive haemoptysis.

REFERENCES