Endovascular treatment of haemoptysis: Medium and long-term assessment

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KEYWORDS
Haemoptysis; Angiography; Bronchial artery embolisation; Aspergilloma; Bronchial arteries

Abstract
Purpose: To assess the short, medium and long-term results of bronchial artery embolisation (BAE) and identify the factors favouring the recurrence of haemoptysis.

Patients and methods: This is a retrospective study, between January 2001 and June 2010, comprising 53 consecutive patients with BAE. The mean age was 53.8 years. There were 15 women (28.30%) and 38 men (71.69%).

Results: The aetiologies of haemoptysis were dominated by the residual signs of pulmonary tuberculosis: 18 cases (33.96%), bronchial dilations: 12 cases (22.64%) and aspergilloma: five cases (9.43%). The bronchial arteriography showed signs of bronchial hypervascularisation in 92.45% of the cases. Forty-six patients had a first embolisation (86.79%) with immediate efficacy in 84.90% of the cases (n = 45). This efficacy was noted after more than 3 years in 60.08% of the cases. Short (<30 days) and medium-term (>30 days and <3 years) recurrence of haemoptysis were noted in 17.39% and 8.69% of the cases respectively. A statistically significant correlation between aspergilloma and the immediate recurrence was found (P = 0.013). The risk of medium and long-term recurrence (>3 years) was correlated with age. The survival without recurrence was statistically higher when the age was less than 60 years (P = 0.0041).

Conclusion: BAE is an effective treatment. Aspergilloma is a major risk factor in the recurrence of haemoptysis. Repeated embolisation may be proposed for these patients.

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Haemoptysis accounts for 10 to 15% of all admissions in pneumology [1]. It requires emergency care in a specialised environment. In fact, in spite of this care, death due to major haemoptysis ranges from 50 to 100% even after surgical haemostasis [2,3]. Bronchial artery embolisation (BAE), first described by J. Rémy in 1973, achieves emergency haemostasis by reducing systemic hypervascularisation [4]. Interventional radiology is currently an alternative treatment to control haemoptysis. In fact, BAE is the only treatment for inoperable patients. In most cases, BAE can immediately control the haemoptysis although medium and long-term recurrences may occur. The purpose of this paper is to assess the short, medium and long-term results of BAE and identify the factors favouring the recurrence of haemoptysis, especially in our country, still a country with endemic tuberculosis.

Patients and methods

This retrospective study, carried out from January 2001 to June 2010, included 53 patients referred by different pneumology departments in Greater Tunis. All of the BAE were carried out by the same radiologist, in the interventional radiology unit at Hôpital Charles-Nicolle in Tunisia, equipped with a digital angiograph (Philips Integris V 3000) comprising of a rotary arc. The haemoptysis was considered to be mild if under 100 mL/24h, moderate if between 100 and 400 mL/24h and major if over 400 mL/24h. All of the patients benefited from bronchial fibroscopy and a chest CT with injection of contrast product in order to determine the source of the bleeding as well as the underlying disease. Thirty-six patients had a single-slice spiral CT (67.92%) and 17 patients (32.07%) had a multi-slice thoracic angio-CT (ATMC) (16 slices). The ATMC protocol included the acquisition at aortic time with an output of 4 mL/s. The acquisition was 16 × 1.25 mm with an interval of 0.625 min followed by vascular MIP, MPR and curvilinear reconstructions.

The embolisation was carried out under local anaesthetic. The arterial approach involved a puncture of the right common femoral artery, followed by the placement of a 5-French introducer according to the Seldinger technique. The arteriography prior to the embolisation was carried out using a 5-French Pigtail catheter. The selective catheterisation of the bronchial arteries was carried out with a 5-French Cobra catheter and a Terumo® hydrophilic guidewire. In certain cases, hyper-selective catheterisation was necessary with a 3F micro-catheter assembled through a catheter guide. At the end of the diagnostic stage, a decision for embolisation was made on the basis of the signs indicating systemic bronchial or non-bronchial hypervascularisation (Boxed text 1), or oriented by thoracic angio-CT specifying the topography and/or the cause of the bleeding. The angiograph is used to detect the anterior spinal artery that requires special care. This was identified in only one of our patients, since hyper-selective catheterisation beyond the origin of the spinal artery was technically difficult in this case. The embolic agent was chosen according to the vascular lesion and the availability of the vascular occlusion agent. We used three types:

- gelatine (Curaspon® or Spongell®) that are solid absorbable particles;
- embospheres that are 500 to 1200 μm solid non-absorbable particles;
- metal spires (or coils).

The results were immediately estimated after the arteriography, on a short-term basis until 30 days after the embolisation, on a medium-term basis (> 1 month and < 3 years) and on a long-term basis (≥ 3 years). For the statistical study, the means were compared using Student’s t-test and the percentages with Pearson’s Chi² test or Fisher’s exact test. A single and multivariate study was used to calculate the factors of risk.

Results

The mean age of the patients was 53.8 years (20 to 79 years). There were 15 women (28.30%) and 38 men (71.69%). Only one patient suffered from mild haemoptysis although it was recurrent. The haemoptysis was moderate in 41 patients (77.35% of the cases) and major in 11 patients (20.75% of the cases). The aetiologies of the haemoptysis are presented in Table 1. They are dominated by the residual signs of pulmonary tuberculosis: 18 cases (33.96%), bronchial dilation: 12 cases (22.64%) and aspergilloma: five cases (9.43%). The thoracic tomodensitometry detected unpolished glass images in 10 cases (18.86%) and parenchymatous condensation in 12 cases (22.64%), attesting to local bleeding in the pulmonary parenchyma and signs related to the underlying disease in 17 cases (32.07%).

Study of the systemic and non-systemic arterial vasculatisation was inadequate by the single-slice CT. In the 17 patients with ATMC, we detected hypertrophic and dilated bronchial and non-bronchial systemic arteries in 14 cases (82.35%) (Fig. 1). The thoracic CT helped determine the cause of the haemoptysis in 92% of the cases. It was not helpful in five patients (9%). In these patients, the arteriography revealed the existence of a parenchymatous blush and hypertrophy of an arterial segment in four patients. The bronchial arteriography revealed signs of bronchial hypervascularisation in 49 patients (92.45% of the cases). The association of arterial hypertrophy and parenchymatous blush was noted in 41 patients (77.35%). Isolated parenchymatous blush was found in eight cases (15.09%). Systemo-pulmonary shunting was observed in four cases (7.54%), in all cases consisting of countercurrent shunting. Associated extravasation of the contrast

Boxed text 1 Signs of bronchial hypervascularisation in the bronchial arteriography.

- Hypertrophy of the arterial branch: this may occur by an increase in the diameter of the artery, a twisted appearance or excessively good distal visualisation.
- An excessive parenchymograph or parenchymatous blush attesting to hypervascularisation.
- A systemo-pulmonary or systemo-systemic shunt.
- Aneurisms, or extravasation of contrast product in the bronchial lumen.
Table 1 Aetiology of haemoptysis.

<table>
<thead>
<tr>
<th>Aetiology</th>
<th>Number of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual signs of pulmonary tuberculosis</td>
<td>18</td>
<td>33.96</td>
</tr>
<tr>
<td>Bronchial dilation</td>
<td>12</td>
<td>22.64</td>
</tr>
<tr>
<td>Non-operable bronchopulmonary cancer</td>
<td>5</td>
<td>9.43</td>
</tr>
<tr>
<td>Aspergilloma</td>
<td>5</td>
<td>9.43</td>
</tr>
<tr>
<td>Active pulmonary tuberculosis</td>
<td>5</td>
<td>9.43</td>
</tr>
<tr>
<td>Non-specific infectious pneumopathy</td>
<td>3</td>
<td>5.66</td>
</tr>
<tr>
<td>Arteriovenous malformation</td>
<td>1</td>
<td>1.88</td>
</tr>
<tr>
<td>Bronchogenic cyst</td>
<td>1</td>
<td>1.88</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>3</td>
<td>5.66</td>
</tr>
</tbody>
</table>

Figure 1. Major haemoptysis in a 52-year-old man with a past history of pulmonary tuberculosis. a: thoracic CT scan. The right upper lobe is destroyed with right intercostal systemic hypervascularisation (arrow); b: the selective arteriography confirms the hypertrophy of the fourth right intercostal artery.

product was described in two cases (3.77%). The arteriography was normal in four patients. One patient had dilation lesions of the cylindrical segmental bronchi, two patients had residual signs of minor localised tuberculosis and one patient had primary bronchopulmonary cancer. The haemoptysis was moderate in these four cases. On the anatomic level, 64 arteries were responsible for the haemoptysis. In decreasing order of occurrence they involved:

- the right bronchial artery in 30.18% of the cases (16 patients);
- the left bronchial artery in 28.30% of the cases (15 patients);
- the non-bronchial systemic arteries in 24.52% of the cases (13 patients): the intercostal arteries in 12 patients (Fig. 2) and a collateral branch of the left scapular artery (Fig. 3), the thyro-bicervico-scapular trunk in another patient (Fig. 4);
- the right broncho-intercostal trunk in 18.86% of the cases (10 patients);
- the right-left common trunk in 16.98% of the cases (nine patients);
- one patient had a left superior bronchial artery that arose from the left internal mammary artery (Fig. 5).

Forty-six patients had a first embolisation (86.79%). Six of them had two embolisations and one had three embolisations. Our statistical study only took the first embolisation into account. Complete stagnation of the contrast product was obtained in 45 of the 46 patients that had a first embolisation (84.90%). We noted eight failures (15.09%) in embolisation. In one case, the bleeding did not completely stop with incomplete stagnation of the contrast product. The failure was technical in the seven other cases (13%):

- four patients had a normal arteriography;
- one patient, in whom we detected an anterior spinal artery arising form the TBICD, required surgery (right superior lobectomy for dilation of the bronchi);
- in two cases, the failure was due to the impossibility of catheterisation of the bronchial artery responsible for the bleeding. One patient required surgery and another evolved well with medical treatment.

The first embolisation was carried out with Curaspon® particles in 38 cases (82.60% of the cases), embospheres in six cases (13.04% of the cases), the association of embospheres and coil in one case and Curaspon® and coils in one case. A micro-catheter was used in 30.43% of the cases (14 patients). Only one complication was noted: it consisted of
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left brain ischemia forming 7 days after embolisation in a 65-year-old smoker. In view of this delay, it is not certain that it may be attributed to the endovascular procedure. A long-term recurrence was not noted in 28 of the 46 patients benefiting from embolisation (60.08%) after more than 3 years. Four patients dropped-out 10, 12, 18 and 20 months after the embolisation without a recurrence of the haemoptysis during this period. Two patients died after 12 and 18 months from the underlying disease. Twelve patients presented a recurrence of haemoptysis:

- eight patients (17.39%) who had a short-term recurrence of the haemoptysis ($\leq 1$ month), including one death 10 hours after the embolisation in a picture of severe respiratory failure by alveolar flooding. Half of these early recurrences occurred in patients presenting aspergilloma;
- four patients (8.69%) had a medium-term recurrence.

The results of the embolisation according to the aetiology of the haemoptysis are reported in Table 2. The evolution after the recurrence of the haemoptysis is detailed in Table 3. There is a statistically significant relationship between aspergilloma and short-term recurrence.

Figure 2. Major haemoptysis in a 50-year-old man with a past history of tuberculosis. Global aortography revealing hypertrophy of the fourth right intercostal artery (arrow) and the right broncho-intercostal trunk (head of arrow).

Figure 3. Recurrent haemoptysis in a 65-year-old man with a past history of pulmonary tuberculosis. Selective catheterisation of the left subclavian artery revealing a collateral branch of the left scapular artery feeding a vascular blush (arrow).

Figure 4. Systemic hypervascularisation of the right pulmonary apex fed by the branches arising from the right thyro-bicervico-scapular trunk (arrow).

Figure 5. Origin of the upper left bronchial artery from the left internal mammary artery with transpleural route (arrows).
Table 2  Result of the embolisation according to the underlying disease.

| Underlying disease                                           | BAE  
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Residual signs of tuberculosis (excluding aspergilloma graft)</td>
<td>BAE (n = 46)</td>
</tr>
<tr>
<td>Bronchial dilation</td>
<td>16</td>
</tr>
<tr>
<td>Non-operable bronchopulmonary cancer</td>
<td>8</td>
</tr>
<tr>
<td>Aspergilloma</td>
<td>4</td>
</tr>
<tr>
<td>Active pulmonary tuberculosis</td>
<td>5</td>
</tr>
<tr>
<td>Non-specific infectious pneumopathy</td>
<td>5</td>
</tr>
<tr>
<td>Arteriovenous malformation</td>
<td>1</td>
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<tr>
<td>Bronchogenic cyst</td>
<td>1</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>3</td>
</tr>
</tbody>
</table>
| No recurrence  
| BAE (n = 34)a (%)                                             | 13    |
| Recurrence  
| BAE (n = 12) (%)                                              | 3     |
| P value                                                      | 0.3   |

BAE: bronchial artery embolisation.

Table 3  Evolution after first recurrence of the haemoptysis.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>n = 12</th>
<th>Date of recurrence</th>
<th>Treatment of the recurrence</th>
<th>Evolution</th>
</tr>
</thead>
</table>
| Residual signs of tuberculosis                  | 1st patient D4  
|                                               | 2nd patient D2 years after 2nd BAE  
|                                               | 3rd patient D12 months | 2nd BAE (D4) | 3rd BAE | No recurrence  
| Bronchopulmonary cancer                        | 1 patient D2  
|                                               | 2nd patient D9 after 2nd BAE  
|                                               | 3rd patient D18 | 2nd embolisation surgery | No recurrence  
|                                               | 4th patient D30 | 2nd embolisation surgery | No recurrence  
| Aspergilloma                                   | 1st patient D0  
|                                               | 2nd patient D9 | 2nd embolisation surgery | No recurrence  
|                                               | 3rd patient D18 | 2nd embolisation surgery | No recurrence  
|                                               | 4th patient D30 | 2nd embolisation surgery | No recurrence  
| Active pulmonary tuberculosis                  | 1 patient D2 months | 2nd embolisation | No recurrence  
| Infectious pneumopathy                         | 1 patient D30 | Surgery | No recurrence  
| Bronchogenic cyst                              | 1 patient D13 months | 2nd embolisation | No recurrence  
| Idiopathic                                     | 1 patient D13 months | 2nd embolisation | No recurrence  

BAE: bronchial artery embolisation.

(P = 0.013). We calculated the cumulate survival without recurrence using the Kaplan-Meier method in the patients that did not have a recurrence more than 30 days after the embolisation. The mean survival without recurrence is 43 months. The risk of medium and long-term recurrence was multiplied by 8.2 when the age was more than or equal to 60 years. There is a significant difference in the survival curves without recurrence (P = 0.0041). The survival without recurrence was statistically better when the age was less than 60 years (Fig. 6).

Discussion

The treatment of haemoptysis, in particular by BAE, depends on the aetiology, abundance and tolerance. The aetiologies

Figure 6. Cumulate survival curves without recurrence as a function of age.
of haemoptysis are numerous in the series by Cremaschi [5], Zhang [6] and Karen [7]. Bronchial dilation is the leading cause of haemoptysis, followed by tuberculosis. Nevertheless, in our series, tuberculosis is the leading cause of haemoptysis, given that tuberculosis is still endemic in Tunisia.

Certain complementary examinations are indispensable when faced with haemoptysis. The association of bronchial fibroscopy and ATMC, in most cases, provides a topographic diagnosis and the aetiology of the haemoptysis [8,9]. However, the role of bronchial fibroscopy is currently highly debated, in particular since the arrival of the multi-slice angio-CT (ATMC). The ATMC provides a pulmonary vascular map as well as an exhaustive study of the mediastinum and the parenchyma during the same acquisition [10]. The ATMC identifies all of the catheterisable bronchial arteries in angiography that are the source of the bleeding, as well as detects pulmonary arterial anomalies and therefore, avoids useless bronchial angiographies and correctly indicates the therapeutic attitude [11,12]. Nevertheless, the ATMC does not identify certain collateral bronchial arteries, in particular the anterior median spinal artery. Only the anterolumbar spinal artery can be detected at this time [12]. In our series, the ATMC detects the dilated bronchial and non-bronchial systemic arteries, attesting to hypervascularisation in 82.35% of the cases. However, it is difficult to determine reliable criteria, through an analysis of the literature, in order to assess the efficacy of embolisation. There are two reasons for this:

- on the one hand, the heterogeneity of the different series in the literature in terms of abundance of the haemoptysis, does not always allow for reliable comparison;
- on the other hand, the criteria selected in the different series in the literature vary: immediate arrest of the haemoptysis (active haemoptysis), a satisfactory post-embolisation arteriographic aspect, or even the absence of short and long-term recurrence. This most often accounts for the difficulty in data gathering.

In our series, the immediate efficacy was 84.90%. Our results are similar to those presented in the literature. In fact, a very high immediate efficacy has always been reported in the different series, oscillating between 73% and 99% [13–19]. BAE is an effective procedure to stabilise many patients and definitively treat others [7,10]. Nevertheless, its short-term efficacy (< 30 days) is reported less often. Several studies have reported a risk of recurrence ranging from 10 to 29% during the first month after embolisation [14,16,19]. In our series, the short-term recurrence was noted in 15.21% of the cases.

The short-term recurrence depends on the aetiology. A favourable evolution was noted in case of active pulmonary tuberculosis after antitubercular therapy and embolisation with a high rate of immediate success and a low rate of recurrence [19,20]. An unfavourable prognosis was noted in patients presenting aspergilloma [17,19,21–24]. A recent study reports a recurrence in 100% of the cases in these patients. Most of the recurrences occur within 2 weeks after embolisation with a mortality of up to 50% during the first month [19]. Aspergilloma is therefore correlated with a statistically significant risk of haemoptoic recurrence both in the literature and in our series [23] requiring repeated embolisation at best associated with surgery.

In our series, 50% of the short-term recurrences were related to aspergilloma and 80% of the patients with aspergilloma presented a short-term recurrence. Neoplastic pulmonary disease is also the cause of the immediate and long-term recurrence of haemoptysis (which was not found in our series) and is associated with a mortality related to the progressive nature of the underlying disease [15,17]. The long-term recurrence of haemoptysis is secondary to re-canalisation of the previously embolised vessel or the revascularisation of the collaterals as related to the progression of the underlying pulmonary disease, in particular aspergilloma [14,15,19,20]. This recurrence may occur after a period of 2 to 5 years [19,20]. Therefore, it is important to identify and embolise all vessels that may contribute to an abnormal vascular replacement. Repeated embolisations may thereby help improve the prognosis in case of the recurrence of haemoptysis after a first embolisation. A second embolisation was carried out in seven patients, including three for aspergilloma graft. One patient had BAE on three occasions.

In our study, we noted that age may also be a factor in the prognosis.

In addition to predisposition-related factors, the efficacy of embolisation also depends on the material used. Gelatine is cheap, easy to use and the size of the particles can be controlled. However, due to its non-absorbable nature, certain authors think that it may foster medium and long-term recurrence [15,25]. In our study, gelatine seems to be as effective as the other embolisation agents. In fact, the difference in the cumulative survival without recurrence in the patients treated with Curaspon® and in those treated with emphospheres is not statistically significant. A recent study has demonstrated the possibility of using the ethylene-vinyl alcohol copolymer, which seems to be beneficial in patients presenting recurrent haemoptysis [26].

Conclusion

Our study confirms the safety and value of BAE in the treatment of haemoptysis. The nature of the underlying disease and the underlying predisposition, in particular age, are important factors to take into account in the therapeutic decision. We noted that aspergilloma is the major factor of risk at the origin of haemoptoic recurrences after embolisation. Another embolisation may be proposed for these patients.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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