Original Article

ASIAN CARDIOVASCULAR & THORACIC ANNALS

Asian Cardiovascular & Thoracic Annals
2015, Vol. 23(1) 55–60

DOI: 10.1177/0218492314544310
aan.sagepub.com

SAGE

Bronchial artery embolization for massive hemoptysis: Long-term follow-up

Oren Fruchter[1,2], Sonia Schneer[1,2], Victoria Rusanov[1,2], Alexander Belenky[2,3] and Mordechai R Kramer[1,2]

Abstract

Aim: Bronchial artery angiography with embolization has become a mainstay in the treatment of massive hemoptysis. Whereas the immediate success rate is high, the reported long-term success rate varies widely among different groups. We aimed to explore the long-term outcome and clinical predictors associated with recurrent bleeding following bronchial artery embolization.

Methods: We reviewed the clinical characteristics, underlying etiologies, procedure details, and outcome of bronchial artery embolization performed for massive hemoptysis between 1999 and 2012.

Results: All 52 consecutive patients treated by bronchial artery embolization during the study period were included. The major etiologies of massive hemoptysis were bronchiectasis (mostly post-infectious) in 53.8%, and primary and metastatic lung cancer in 30.8%. The immediate success rate was high (48/52; 92%). Of 45 patients who survived more than 24 hours following bronchial artery embolization, recurrent bleeding did not occur in 19 (42.2%) during a median follow-up period of 60 months (range 6–130 months). Bleeding recurred in 26 (57.7%); within 30 days in 15 (33.3%) and after 1 month in the other 11 (24.4%). The average time to onset of early and late repeat bleeding was 2 and 506 days, respectively. Idiopathic bronchiectasis and lung cancer were associated with a high likelihood of late bleeding recurrence.

Conclusions: Bronchial artery embolization is an effective immediate treatment for massive hemoptysis. Because the bleeding recurrence rate is high in patients with lung cancer or idiopathic bronchiectasis, surgery should be considered in these patients following initial stabilization by bronchial artery embolization. For other underlying etiologies, the long-term outcome is excellent.

Keywords

Angiography, bronchial arteries, embolization, therapeutic, hemoptysis, lung diseases, lung neoplasms

Introduction

Whereas hemoptysis is a common clinical scenario, massive hemoptysis comprises only 1.5% of reported cases.[1–5] The definition of massive hemoptysis ranges from 200 to 1000 mL over a 24-h period, but >300 mL is the accepted definition of massive hemoptysis in most reports.[4] Following initial respiratory and cardiovascular stabilization, surgery on an emergency basis is usually indicated if the bleeding site is located and if the clinical status of the patient and pulmonary function tests permit a safe surgical intervention.[6] Because the bronchial arteries are the major source of bleeding in massive hemoptysis, bronchial artery angiography and embolization (BAE) is increasing used as a therapeutic alternative for hemoptysis control in patients who are poor surgical candidates.[7,8] Despite the high rate of immediate success in most studies, ranging from 80% to 90%, data regarding long-term success is spare, and the available results vary considerably among groups, ranging between 25% and 85%.[8–19] The main aim of this study was to investigate long-term

[1]The Pulmonary Institute, Rabin Medical Center, Petah Tiqwa, Israel
[2]Sackler School of Medicine, Tel Aviv University, Tel Aviv, Israel
[3]Department of Interventional Radiology, Rabin Medical Center, Petah Tiqwa, Israel

Corresponding author:
Oren Fruchter, MD, FCCP, The Pulmonary Division, Rabin Medical Center, Petach Tikva, Israel.
Email: orenfr@clalit.org.il

outcomes of BAE in a cohort of consecutive patients with massive hemoptysis. A secondary purpose was to evaluate the prognostic factors associated with a high likelihood of bleeding recurrence following BAE and hence identify patients who might benefit from early surgical intervention.

Patients and methods

In this retrospective investigation, we studied all consecutive patients treated in a 1000-bed tertiary care medical center for massive hemoptysis between January 1999 and January 2012. This study was conducted in accordance with the requirements of the institutional review board for such a retrospective analysis of medical records. Of 241 patients who presented with hemoptysis, 52 underwent BAE in the interventional radiology unit for massive hemoptysis. Twenty-nine were male (55.8%), and the mean age was 55 ± 18 years (range 25–80 years); 32 were inpatients and 20 were referred from other medical facilities. The clinical and demographic data of the cohort are summarized in Table 1.

Our conservative medical measures included hospitalization, cough suppression, supplemental oxygen, blood transfusion when necessary, and continuous monitoring of vital signs. Following initial stabilization that included hemodynamic and respiratory support and correction of diathesis abnormalities, all patients underwent 16-slice multidetector row computed tomography (Light Speed 16; GE Medical Systems, Milwaukee, WI, USA). To identify the cause of bleeding and the affected side, scans were initially carried out without contrast and then with 100 mL of nonionic contrast medium containing iodine 370 mg mL^{-1} (Iopamilon 370; Bayer, Leverkusen, Germany) administered into an antecubital vein to add information about vascularization.[20] Based on multidetector row computed tomography and fiberoptic bronchoscopy findings, the bleeding site was confirmed in 52 patients.

Table 1. Demographic and clinical characteristics of 52 patients with hemoptysis treated by bronchial artery embolization.

Variable	No. of patients
Age (years)	55 ± 18
Male/female	29/23 (55.8%/44.2%)
Inpatient/referral	32/20 (61.5%/38.4%)
Bronchiectasis	
Idiopathic	17 (32.7%)
Cystic fibrosis	8 (15.4%)
s/p Tuberculosis	1 (1.9%)
s/p Non-tuberculosis mycobacteria	2 (3.8%)
Cancer	
Primary lung cancer	9 (17.3%)
Local invasion of thoracic cancer*	3 (5.8%)
Metastatic disease to lung	4 (7.7%)
Pulmonary hypertension, VSD, PS, s/p AVR	2 (3.8%)
Arteriovenous malformation	4 (7.7%)
Hereditary hemorrhagic telangiectasia	1 (1.9%)
Wegener granulomatosis	1 (1.9%)

*Other than lung cancer. AVR: aortic valve replacement; PS: pulmonary stenosis; s/p: status post; VSD: ventricular septal defect.

A standardized BAE procedure was used.[15,16] A 4 F catheter was introduced into the femoral artery using the Seldinger technique. Selective bronchial artery angiography was performed and embolization was undertaken when the bronchial arteries appeared to be the source of hemoptysis (tortuous hypertrophy, extravasation of contrast material). Embolization was carried out using micro-particles (Embozene; CeloNova, San Antonio, TX, USA; Embosphere; Merit Medical, South Jordan, UT, USA) or coils (Tornado; Cook Medical, Bloomington, IN, USA).

Data regarding clinical characteristics, etiology of hemoptysis, and follow-up was collected retrospectively. For the purpose of this study, massive hemoptysis was defined as expectoration of at least 300 mL of blood per 24 h or more than two episodes of moderate hemoptysis (at least 30 mL) within a 24-h period, in accordance with the definitions used by Mal and colleagues.[8] Immediate control of bleeding was defined as immediate bleeding cessation without recurrence within 24 h of BAE. Rebleeding, defined as recurrence of bleeding after immediate control, was categorized according to timing in relation to the initial procedure: early-onset, within 1 month; late-onset, more than 1 month after BAE. Descriptive data are presented as number and percentage unless otherwise specified. Correlations between bleeding recurrence and clinical factors were evaluated with Fisher's exact test. Survival curves of patients with and without stents were evaluated and compared by plotting Kaplan-Meier curves. Statistical analyses were performed using MedCalc version 9.3.0.0 (MedCalc Software, Ostend, Belgium).

Results

The major etiologies of massive hemoptysis were bronchiectatic disease, cancer, and vascular malformation (Table 1). Of the 52 patients, 7 (13.4%) were intubated and mechanically ventilated before BAE, 5 (9.6%) had noninvasive positive-pressure ventilation, and 40 needed supplemental oxygen by a nonrebreathing face mask ($n = 21$) or nasal cannula ($n = 19$). Multidetector row computed tomography

was performed in 49 patients and located the source of bleeding in 45 (91.8%). Twenty-two patients underwent fiberoptic bronchoscopy following initial stabilization, which located the bleeding site in 12/22 (54.5%). In 10 patients, endoscopic measures to control bleeding were attempted: cold saline instillation ($n = 8$), and topical adrenaline ($n = 2$). Angiography demonstrated pathology in the right bronchial arteries in 71.2% of cases, left bronchial arteries in 21.2%, and bilateral bronchial arteries in 7.7%. Angiography revealed the source of bleeding and identified the culprit vessel in all patients; a representative case is shown in Figure 1. The BAE procedures are listed in Table 2. Figure 2 displays the outcome of patients included in the study. The immediate success rate of BAE was 92% (48/52 procedures). In 4 patients, the procedure failed to control bleeding: 2 died of asphyxia and uncontrolled bleeding, and 2 underwent successful emergency surgical resection of the bleeding source (one pneumonectomy and one right upper lobe lobectomy). Three (6.25%) patients died of sepsis within 24 h of the procedure; the bleeding had been successfully controlled by BAE in all of them. Direct procedure-related complications of BAE included 2/45 (4.4%) patients who developed transient neurological events post-angiography, and 1/45 (2.2%) who developed a tracheal fistula. Respiratory failure and need for mechanical ventilation was observed in 5/45 (11.1%) patients, all of whom survived. Of 45 patients who survived more than 24 h following BAE, rebleeding did not occur in 19/45 (42.2%) in an extended median follow-up period of 60 months (range 6–130 months).

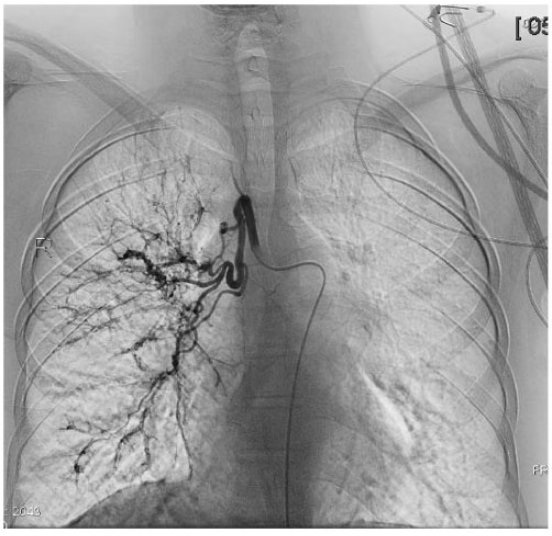

Figure 1. Selective arteriography of the right intercostal bronchial trunk in a 25-year-old man with cystic fibrosis and bleeding bronchiectasis, demonstrating a torturous vessel and an area of hypervascularity. The abnormal vessel was embolized with 250–1300 micron particles (Embozene).

Bleeding recurred in 26 (57.7%) of the 45 patients in whom the initial intervention was successful; within 30 days in 15 (33.3%), and more than a month after the procedure in 11 (24.4%). The average time to early rebleeding was 2 days (ranging from few hours post-procedure to 15 days), whereas the average time to late rebleeding was 506 days (range 60 days to 4.2 years; Table 3). Ten (22.2%) patients needed an additional angiographic procedure due to massive rebleeding within an average of 10.2 months (range 2 weeks to 2 years) following the initial procedure. The second BAE procedure was successful in 7 of these patients, and 3 underwent a surgical intervention (1 segmentectomy, 1 right upper lobectomy, and 1 left upper lobectomy). During the entire follow-up period, 32/52 (61.5%) patients died from underlying disease and/or massive hemoptysis. Two patients died following failed BAE, and one died following a surgical attempt to control bleeding. Of the 48 patients who underwent successful BAE, 3 died of sepsis within 24 h of the procedure. Of the 19 patients with long-term success, 7 died from their underlying disease, mostly cancer. Of 26 patients with rebleeding, 19 died during follow-up. According to the Kaplan-Meier analysis, 75% of the recurrent cases occurred within 1.5 years, and no cases recurred more than 3 years after the initial BAE (Figure 3). Among the potentially important predictors of late treatment failure, only lung cancer and idiopathic bronchiectasis were found to be significantly associated with rebleeding (Table 4).

Discussion

The major finding of our study was that BAE is a highly effective modality for immediate control of massive hemoptysis, with acceptable long-term efficacy in most patients. When the underlying etiology of bleeding is lung cancer or idiopathic bronchiectasis, recurrent bleeding is common and hence BAE is merely a

Table 2. Bronchial artery embolization procedure in 52 patients with massive hemoptysis.

Bronchial artery embolized	No. of patients
Bilateral	4 (7.7%)
Left bronchial artery	11 (21.2%)
Right bronchial artery	37 (71.2%)
Agent used for embolization	
Embozene	19 (36.5%)
Embosphere	17 (32.6%)
Coils	
Length of procedure (min) [range]	28 [21–40]

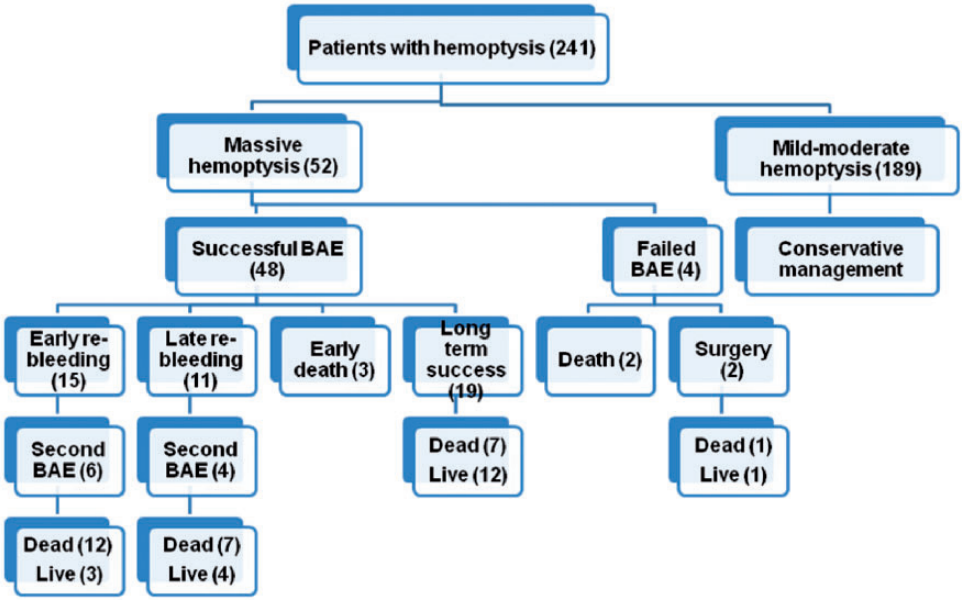

Figure 2. Illustrated summery of study patients' outcomes. BAE: bronchial artery embolization.

Table 3. Bronchial artery embolization outcome.

Outcome	No. of patients
No bleeding recurrence	19 (36.5%)
Bleeding recurrence < 30 days of procedure	15 (28.8%)
Bleeding recurrence >30 days of procedure	13 (25.0%)
Death within 24 h of procedure	5 (9.6%)

temporary measure for stabilization prior to surgical intervention. Worldwide, the most common cause of hemoptysis remains active tuberculosis, whereas in developed countries, hemoptysis most often results from bronchiectasis or lung cancer.[1,5] In most cases, the hemoptysis is mild and resolves with conservative treatment. However, massive hemoptysis can cause asphyxia leading to 10%–60% mortality.[1–5] Conservative treatment for hemoptysis includes correcting coagulation abnormalities, cardiovascular support, and most importantly, protection of patent airways. Bronchoscopy in mild or moderate hemoptysis is an additional treatment option for performance of procedures including iced saline instillation through a fiberoptic bronchoscope, topical medications such as tranexamic acid, laser therapy, and electrocautery.[3–5]

The most effective approach to control massive hemoptysis is surgical resection: segmentectomy, lobectomy or pneumonectomy. However surgical intervention carries a mortality rate of 18% when performed electively, rising to 40% when performed on an emergency basis.[6] Bronchial artery embolization, first described by Rémy and colleagues,[7] is an ideal first-line treatment for poor surgical candidates. In addition, unlike surgical resection, BAE often preserves pulmonary function. According to our results based on a large cohort of patients, the immediate success rate of BAE in controlling massive hemoptysis was high (90%) and similar to that in previous reports.[8–11] Recurrent bleeding following successful BAE may result from recanalization of embolized vessels, collateral circulation that feeds the bleeding lesion, and underlying disease progression.[12–21]

The major strength of the current report is the long-term data obtained over a median follow-up of more than 5 years, which enabled us to assess the incidence of both short-term and delayed bleeding events. The early and late rebleeding rates in our study were slightly higher than previously reported. For example, Racils and colleagues[11] noted a short-term (up to 30 days post-procedure) rebleeding rate of only 17.4%. Kim and colleagues[20] investigated the long-term efficacy of BAE and the factors associated with failure to control bleeding in an Asian setting with a high prevalence of tuberculosis; among 118 patients, 32 (27.1%) had rebleeding. The recurrence of bleeding in our cohort was 31.2% in the first 30 days after the procedure, and 22.9% at more than a month following the procedure. A possible explanation for the observed high rate of early rebleeding in our study is that more than a third of the patients had been referred following treatment failure in other facilities, because our medical center operates as a tertiary care referral hospital. Consequently, the early recurrence rate in these

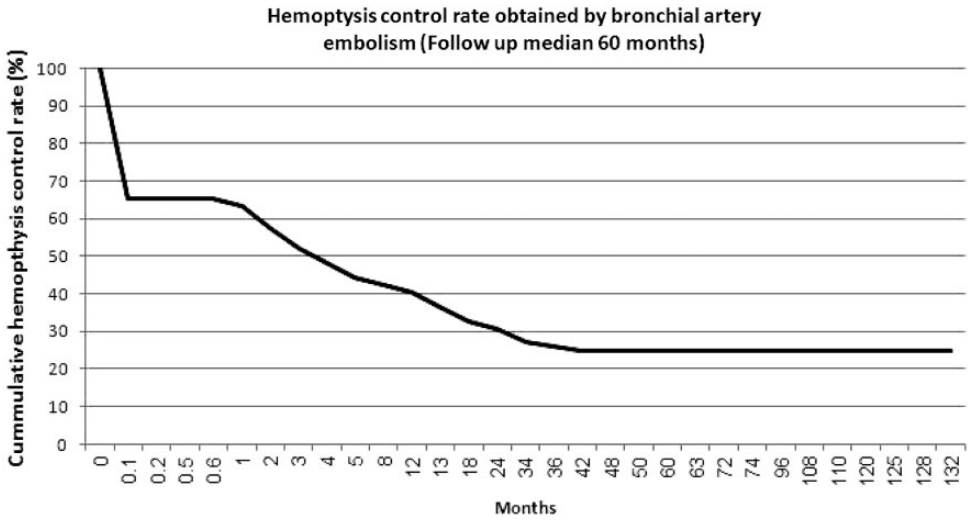

Figure 3. Cumulative hemoptysis control rate in 52 patients who underwent bronchial artery embolization, calculated by the Kaplan-Meier method.

Table 4. Clinical characteristics of patients treated by bronchial artery embolization, with and without recurrence of bleeding.

Variable	Bleeding	No bleeding	*p* value
Age >65 years	32	20	0.2932
Idiopathic bronchiectasis	14	3	0.0169
Cystic fibrosis bronchiectasis	3	5	0.3241
Cancer			
Primary lung cancer	8	1	0.0245
Local invasion of cancer*	2	1	0.4231
Metastatic disease to lung	2	2	0.5732
Arteriovenous malformation	3	1	0.0728

*Other than lung cancer.

refractory cases would be expected to be higher than in other series.

In a study conducted more than 15 years ago, Hirshberg and colleagues[1] assessed the etiology, evaluation, and outcome of 208 patients with hemoptysis in a tertiary referral hospital. They found that the most common causes of hemoptysis included bronchiectasis (20%), lung cancer (19%), and bronchitis (18%). Mal and colleagues[8] demonstrated that cancer-related hemoptysis had the highest failure rate and the worst long-term results. According to most of the studies to date, in cancer-related hemoptysis, BAE is most successful as a temporary measure prior to surgical resection.[8–12] The results we obtained are in accordance with these observations. We demonstrated that lung cancer was associated with a significantly higher likelihood of late bleeding recurrence. In patients with primary and metastatic lung cancer, the vasculature is disrupted due to the malignant process and local invasion, thus it is expected that collateral arteries will cause recurrent bleeding even after the culprit artery has been embolized. Patients with idiopathic bronchiectasis were found to be at a significantly higher risk of rebleeding following successful BAE, and should also be offered surgical intervention to prevent late occurrence of life-threatening hemoptysis. Seven (13.4%) of our patients required a surgical intervention for massive hemoptysis that was not controlled by BAE. Because of poor pulmonary reserve and other comorbidities, many patients with massive hemoptysis are not surgical candidates. In patients who are potential surgical candidates, BAE is effective in preparing them for semielective rather than high-risk emergency surgery.[21]

The major limitation of the current study is that the results and conclusions were derived from a retrospective analysis of data from a single center. Our conclusions should be verified by prospective randomized multicenter studies which are unfortunately difficult to conduct. We consider that BAE is an acceptable immediate treatment for massive hemoptysis as a substitute for surgery in poor surgical candidates. Because the bleeding recurrence rate is relatively high, especially in patients with lung cancer and idiopathic bronchiectasis, surgery should be considered in selected patients following initial stabilization by BAE. Following successful BAE, if rebleeding does not occur within the first 3 years, the long-term prognosis is excellent.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest statement

None declared.

References

1. Hirshberg B, Biran I, Glazer M and Kramer MR. Hemoptysis: etiology, evaluation, and outcome in a tertiary referral hospital. *Chest* 1997; 112: 440–444.
2. Jean-Baptiste E. Clinical assessment and management of massive hemoptysis [Review]. *Crit Care Med* 2000; 28: 1642–1647.
3. Lordan JL, Gascoigne A and Corris PA. Assessment and management of massive haemoptysis. *Thorax* 2003; 58: 814–819.
4. Ibrahim WH. Massive haemoptysis: the definition should be revised. *Eur Respir J* 2008; 32: 1131–1132.
5. Fartoukh M, Khoshnood B, Parrot A, et al. Early prediction of in-hospital mortality of patients with hemoptysis: an approach to defining severe hemoptysis. *Respiration* 2012; 83: 106–114.
6. Ayed A. Pulmonary resection for massive hemoptysis of benign etiology. *Eur J Cardiothorac Surg* 2003; 24: 689–693.
7. Rémy J, Arnaud A, Fardou H, Giraud R and Voisin C. Treatment of hemoptysis by embolization of bronchial arteries. *Radiology* 1977; 122: 33–37.
8. Mal H, Rullon I, Mellot F, et al. Immediate and long-term results of bronchial artery embolization for life-threatening hemoptysis. *Chest* 1999; 115: 996–1001.
9. Mossi F, Maroldi R, Battaglia G, Pinotti G and Tassi G. Indicators predictive of success of embolisation: analysis of 88 patients with haemoptysis. *Radiol Med* 2003; 105: 48–55.
10. Swanson KL, Johnson CM, Prakash UB, McKusick MA, Andrews JC and Stanson AW. Bronchial artery embolization: experience with 54 patients. *Chest* 2002; 121: 789–795.
11. Racil H, Rajhi H, Ben Naceur R, Chabbou A, Bouecha H and Mnif N. Endovascular treatment of haemoptysis: medium and long-term assessment. *Diagn Interv Imaging* 2013; 94: 38–44.
12. Yoon W, Kim JK, Kim YH, Chung TW and Kang HK. Bronchial and nonbronchial systemic artery embolization for life-threatening hemoptysis: a comprehensive review. *Radiographics* 2002; 22: 1395–1409.
13. Lorenz J, Sheth D and Patel J. Bronchial artery embolization. *Semin Intervent Radiol* 2012; 29: 155–160.
14. Garcia-Olivé I, Sanz-Santos J, Centeno C, et al. Predictors of recanalization in patients with life-threatening hemoptysis requiring artery embolization. *Arch Bronconeumol* 2013; 7: 51–56.
15. Burke CT and Mauro MA. Bronchial artery embolization. *Semin Intervent Radiol* 2004; 21: 43–48.
16. Sopko DR and Smith TP. Bronchial artery embolization for hemoptysis. *Semin Intervent Radiol* 2011; 28: 48–62.
17. Yu-Tang Goh P, Lin M, Teo N and En Shen Wong D. Embolization for hemoptysis: a six-year review. *Cardiovasc Intervent Radiol* 2002; 25: 17–25.
18. Osaki S, Nakanishi Y, Wataya H, et al. Prognosis of bronchial artery embolization in the management of hemoptysis. *Respiration* 2000; 67: 412–416.
19. Kim YG, Yoon HK, Ko GY, Lim CM, Kim WD and Koh Y. Long-term effect of bronchial artery embolization in Korean patients with haemoptysis. *Respirology* 2006; 11: 776–781.
20. Mori H, Ohno Y, Tsuge Y, et al. Use of multidetector row CT to evaluate the need for bronchial arterial embolization in hemoptysis patients. *Respiration* 2010; 80: 24–31.
21. Alexander GR. A retrospective review comparing the treatment outcomes of emergency lung resection for massive haemoptysis with and without preoperative bronchial artery embolization. *Eur J Cardiothorac Surg* 2013; 45: 251–255.