ORIGINAL ARTICLE

Bronchial artery embolisation can be equally safe and effective in the management of chronic recurrent haemoptysis

CME

Samuel Lee 李明生
Johnny WM Chan 陳偉文
Susan CH Chan 陳慈欽
YH Chan 陳耀恆
TL Kwan 關鼎樂
MK Chan 陳文光
CK Ng 吳振江
MP Lee 李文寶
WL Law 羅偉霖
Thomas YW Mok 莫恩榮

Objective To examine the efficacy and safety of bronchial artery embolisation in patients with acute major haemoptysis and those with chronic recurrent haemoptysis.

Design Retrospective review of clinical records.

Setting Regional hospital, Hong Kong.

Patients Clinical records of 70 consecutive patients who had undergone bronchial artery embolisation in Queen Elizabeth Hospital from 1998 to 2003 were reviewed. Altogether 74 bronchial artery embolisation procedures were attempted, 46 (62%) for acute major haemoptysis, and 28 (38%) for chronic recurrent bleeding. Follow-up data were available for 32 patients.

Main outcome measures After bronchial artery embolisation, the Kaplan-Meier method and log-rank tests were used to compare the probability of recurrence in the two patient categories.

Results Overall immediate control was attained following 99% of the procedures, with a complication rate of 13%; all complications were mild and self-limiting. For the 32 patients (19 having acute major haemoptysis and 13 having chronic recurrent bleeding) with follow-up data available, the overall recurrence rate was 36% (26% in the acute and 47% in chronic group). No statistically significant difference in recurrence probability between the two groups was observed (P=0.24). Presence of active pulmonary tuberculosis was associated with increased risk of recurrence (P=0.005).

Conclusion Bronchial artery embolisation was noted to be effective and safe in both acute major and chronic recurrent haemoptysis.

Key words
Bronchial arteries; Bronchiectasis; Embolization, therapeutic; Hemoptysis; Recurrence

Hong Kong Med J 2008;14:14-20

Queen Elizabeth Hospital, 30 Gascoigne Road, Kowloon, Hong Kong:
Department of Medicine
S Lee, MB, BS, MRCP
JWM Chan, MB, BS, FRCP
YH Chan, MB, ChB, MRCP
CK Ng, MB, BS, MRCP
MP Lee, MB, BS, MRCP
WL Law, MB, ChB, MRCP
Department of Radiology and Imaging
SCH Chan, MB, BS, FRCR
TL Kwan, MB BS, FRCR
MK Chan, MB, BS, FRCR
Respiratory Medical Department, Kowloon Hospital, Argyle Street, Kowloon, Hong Kong
TYW Mok, MB, BS, FRCP

Correspondence to: Dr S Lee
E-mail: lms38422@hotmail.com

Introduction

Bronchial artery embolisation (BAE) involves selective bronchial artery catheterization and angiography, followed by embolisation of any identified abnormal vessels to stop the bleeding. Its role in the management of acute major haemoptysis has been well established and reported since 1970s.[1-6] Although some previous reports had also described BAE for chronic recurrent haemoptysis,[1,3,5-7] in the latter instances its efficacy has been less well-studied; their focus mainly being on patients with cystic fibrosis,[8] which is rare in Hong Kong. Chronic recurrent haemoptysis can also occur in other common chronic lung disorders such as bronchiectasis and tuberculosis (TB), in which haemoptysis is troublesome though not immediately life-threatening. This study therefore explored and compared the efficacy and safety of BAE in the management of these two groups of patients.

Methods

This was a retrospective study of consecutive patients who had undergone BAE over a 6-year period from January 1998 to December 2003 at Queen Elizabeth Hospital (QEH), a major general hospital and tertiary referral centre in Hong Kong. The subjects were in-patients and out-patients of the QEH and the Respiratory Medical Department of Kowloon Hospital (KH), the latter being a tertiary respiratory specialist centre. Apart from the patients of these two hospitals, in-patients and out-patients from other hospitals were also referred for BAE. After the procedure, most of the patients were followed up in their original

支氣管動脈栓塞治療法可以安全及有效地用於控制長期復發性咯血

目的 探討支氣管動脈栓塞治療法用於控制嚴重急性咯血和長期復發性咯血的安全性及效用。

設計 病歷紀錄的回顧研究。

安排 香港一所分區醫院。

患者 回顧1998到2003年期間，在伊利沙伯醫院接受支氣管動脈栓塞治療法的連續70位病人的病歷紀錄。共進行了74宗支氣管動脈栓塞術，其中46宗(62%)為嚴重急性咯血，28宗(38%)為長期復發性咯血。另有32位病人的隨訪報告可供研究。

主要結果測量 用Kaplan-Meier估計及log-rank檢驗方法，比較兩組病人進行支氣管動脈栓塞治療法後復發的機會率。

結果 在絕大多數情形下(99%)咯血得到即時控制。發生併發症的機會率為13%，全都是輕微和可自行消退的症狀。其中32位病人（19人為急性咯血患者，13人為長期復發性咯血患者）的隨訪報告顯示，總復發率為36%，而急性咯血和長期復發咯血組群的復發率並沒有重大分別（26%比47%，P=0.24）。數據顯示活性肺結核與高復發機會率有關(P=0.005)。

結論 支氣管動脈栓塞治療法對治療及控制急性咯血及長期復發性咯血同樣有效安全。

institutions. The clinical records were reviewed and the following data were collected: demographics, smoking history, co-morbidities, clinical features, results of investigations such as chest radiographs, and findings from computed tomography (CT) of the thorax and bronchoscopy. However, bronchoscopy and CT of the thorax were performed at the discretion of the attending physician. Because of considerations such as their lack of utility in the management of active TB, unstable haemodynamic status etc, these two investigations were not performed in every patient. The procedure actually performed, as well as findings, outcomes, and complications of their bronchial arteriograms and subsequent embolisations, were also recorded.

Patients were considered as having acute major haemoptysis if they had endured one of the following conditions: (1) haemoptysis precipitating emergency admissions, with significant bleeding (over 50 mL) being witnessed[9]; (2) more than 200 mL of blood expectorated in 24 hours[10]; (3) haemoptysis giving rise to haemodynamic compromise; (4) blood transfusion undertaken for significant drop in haemoglobin level; (5) the in-charge physicians regarded the haemoptysis as clinically threatening and uncontrolled by conservative measures. On the other hand, chronic recurrent haemoptysis referred to repeated bleeding episodes ensuing twice or more for over the past 6 months, not resulting in emergency admission even though associated symptoms could have been troublesome. In the latter cases BAE would have been carried out in an elective manner. The decision to offer BAE and its timing was usually jointly made after assessment by respiratory physicians, thoracic surgeons, and radiologists. The service was available on a 24-hour basis, with after office hours emergency requests being assessed by interventional radiologists. All elective cases were admitted on the day of the procedure and observed for possible complications for at least another 24 hours after the procedure. Since most cases were followed up after discharge in their respective original institutions, long-term follow-up data were only available for a limited number of patients, who were subsequently followed up in the study institutions (QEH and KH). 'Immediate control' of haemoptysis was defined as the absence of re-bleeding during the same admission, whereas 'recurrence' was defined as haemoptysis after discharge that was of a degree severe enough to warrant unanticipated medical attention (admission, emergency room visit, unscheduled clinic visits).

Diagnostic angiography was usually performed via the common femoral artery, and with an initial descending thoracic aortogram performed with a 5-F Pigtail catheter to obtain an image of the bronchial artery anatomy. This was followed by selective bronchial artery catheterization and bronchial arteriogram involving a digital subtraction technique with nonionic contrast. If no abnormal bronchial arteries were identified, selective subclavian arteriograms were performed to search for aberrant bronchial arteries or a non-bronchial systemic artery blood supply. Inferior phrenic arteries were also studied for lower lobe disease. Distal portions of abnormal bronchial and non-bronchial systemic arteries were superselectively catheterized with a microcatheter so as to bypass the possible origin of the spinal artery. This was to prevent inadvertent reflux of embolic agents into the aorta or subclavian artery. In most of the cases, polyvinyl alcohol particles (Interventional Therapeutic Corporation, Fermont, US) with a range of sizes from 355 to 500 μm were utilised for embolisation. Figures 1 and 2 illustrate the procedure in a patient with chronic haemoptysis due to a destroyed right upper lobe from old pulmonary TB.

Statistical analyses

Data were analysed using the Statistical Package for the Social Sciences (Windows version 12.0; SPSS Inc, Chicago [IL], US). Continuous variables were presented as mean and standard deviation (SD), unless otherwise indicated. Categorical variables were expressed as percentages. Differences between groups were analysed using the Chi squared test or Fisher's exact test for categorical variables, and

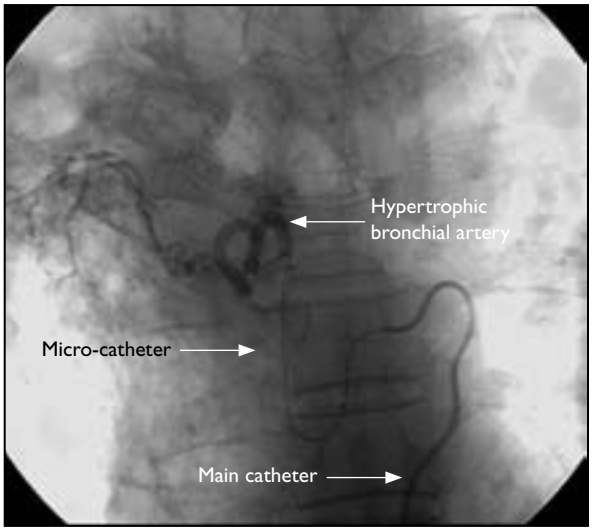

FIG 1. A 54-year-old man presented with recurrent haemoptysis due to old pulmonary tuberculosis and destroyed lung at right upper lobe
A hypertrophied right bronchial artery supplying the lobe is shown, which is selectively cannulated with micro-catheter

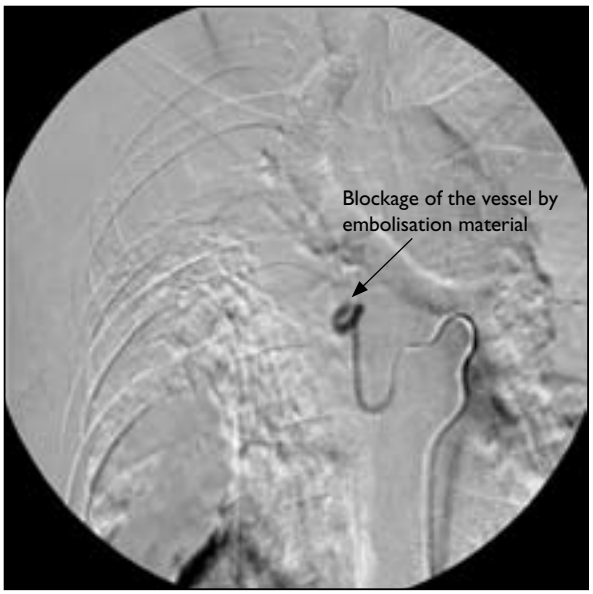

FIG 2. The post-embolisation figure demonstrated blockage of the vascular supply

Student's *t* test for continuous variables. The Kaplan-Meier survival method was used to estimate the recurrence-free probability of the patients after BAE. The log-rank test was used to compare the difference in the probability of recurrence between groups. Two-tailed tests were used for all analyses and a P value of smaller than 0.05 was considered statistically significant.

TABLE 1. Demographic and clinical characteristics of patients undergoing bronchial artery embolisation (n=70)

Characteristic	Data*
Mean (±SD) age (years)	65±13
Gender ratio (M/F)	53/17
Smoking history	
Current/ex-smoker	40 (57%)
Non-smoker	30 (43%)
Underlying medical diseases	
Hypertension	10 (14%)
Diabetes mellitus	6 (9%)
Ischaemic heart disease	3 (4%)
Previous cerebrovascular accident	4 (6%)
Anaemia	3 (4%)
Other	5 (7%)
Underlying lung diseases	
Bronchiectasis	47 (67%)
Pulmonary tuberculosis	
Active	5 (7%)
Old	42 (60%)
Carcinoma of lung	6 (9%)
Lung fibrosis	3 (4%)
Mycetoma	3 (4%)
Median (range) volume of haemoptysis (mL)	120 (20-800)
Hypotension	7 (10%)
Use of inotropic agents	2 (3%)
Blood transfusion	15 (21%)
Mechanical ventilation	13 (19%)
Intensive care unit admission	6 (9%)

* Data are shown in No. (%) of patients, unless otherwise indicated

Results

A total of 74 BAE procedures were attempted on 70 patients. Thirty-one (44%) patients had co-morbidities other than underlying respiratory illnesses. Underlying diseases responsible for haemoptysis episodes were all identified as pulmonary. They included bronchiectasis (67%), previous pulmonary TB (60%), active (sputum smear or culture positive) pulmonary TB (7%), and carcinoma of lung (9%). Twenty-three (33%) patients had two co-existing underlying pulmonary diseases, mostly bronchiectasis and previous pulmonary TB. Their detailed clinical characteristics are summarised in Table 1.

The extent of haemoptysis was recorded in 46 patients; the median volume was 120 mL (in the 24 hours before the admissions for haemoptysis). However, most of such values were not available in patients admitted for elective procedures. In

TABLE 2. Summary of bronchial artery embolisation procedures attempted between 1998 and 2003

Procedure	Data
Total procedures attempted	
Acute major haemoptysis	46 (62%)
Chronic recurrent haemoptysis	28 (38%)
Bronchial arteriogram findings	
Bronchial artery hypertrophy	40 (54%)
Hypervascularity	24 (32%)
Shunting	13 (18%)
Soft tissue staining	6 (8%)
Extravasation of contrast	2 (3%)
Others	34 (46%)
Mean No. (range) of vessels embolised	2 (1-5)
Vessels embolised	
Bronchial arteries	66 (89%)
Bronchial trunks	8 (11%)
Intercostal arteries	16 (22%)
Internal mammary arteries	8 (11%)
No embolisation performed	5 (7%)
No abnormality	2
Aborted due to chest pain	1
Failed cannulation	2
Complications	
Mild dissection	6 (8%)
Haemomediastinum	2 (3%)
Perforation of vessel	1 (1%)
Chest pain	1 (1%)

* Data are shown in No. (%) of patients, unless otherwise indicated

a few patients, haemoptysis was associated with hypotension (10%), the use of inotropic agents (3%), and blood transfusion (21%). Tranexamic acid was used in 58 (83%) patients. Thirteen (19%) of the patients received mechanical ventilation for respiratory failure; six (9%) were admitted to an intensive care unit (Table 1).

Chest radiographs were available for all patients, and radiological abnormalities were identified in 60 (86%) of them. These included past fibrotic TB scars in 19 (32%) of the patients, consolidation in 17 (28%), bronchiectatic changes in 10 (17%), mass lesions in nine (15%), diffuse reticular shadows in three (5%) and pleural effusion in one (2%). Fibreoptic bronchoscopy was performed in 38 (54%) of the patients in the same admission before BAE; the bleeding side was lateralised in 27 (71%) of these. Computed tomography of the thorax was performed during the same admission in 20 (29%) of the patients.

Forty-six (62%) of the procedures were performed for acute major haemoptysis while 28 (38%) were for chronic recurrent haemoptysis. Bronchial arteriograms were always performed before attempting embolisation. The most common findings were bronchial artery hypertrophy (54%), hypervascularity (32%), and shunting (18%) [Table 2]. Bronchial artery embolisation was successfully performed in 69 (93%) of the episodes affecting 66 (94%) of the patients. Embolisation was not performed in five patients—two had no detected abnormality, one procedure was aborted due to chest pain during the angiography, and the remaining two were technical failures due to failed cannulations. The number of embolised vessels per procedure ranged from 1 to 5 (mean, 2). The vessels embolised included bronchial arteries (89%), bronchial trunks (11%), intercostal arteries (22%), and internal mammary arteries (11%). Polyvinyl alcohol was used in most patients (97%), except for one who received a coil and another who received a gelform sponge.

Complications were mild, all were being managed conservatively and resolved spontaneously (Table 2); four affected the right and two the left bronchial arteries. One patient suffered from dissection and perforation of a vessel and haemomediastinum, while another patient had vessel dissection, chest pain, and haemomediastinum. Major complications, such as spinal cord ischaemia, were not observed. Two patients with carcinoma of bronchus died during their index admission, but death was not related to haemoptysis or BAE.

Immediate control of haemoptysis was achieved in all but one of the individuals who underwent the embolisation procedure; failure being in a patient with carcinoma of bronchus. Available follow-up data till December 2004 from 32 patients (mean±SD age, 60±13 years; male, 21) accounted for 36 BAE procedures. Nineteen had acute major haemoptysis, while 13 (41%) had endured chronic recurrent bleeding. The median follow-up interval was 2 years (range, 15 days-5.74 years; the patient with the shortest follow-up died due to pneumonia 15 days after the procedure). The recurrence rates were 26% for the acute major group and 47% for the chronic recurrent group. The interval from the procedure to recurrence ranged from 60 days to 4.6 years (median, 1 year). Bronchial artery embolisation was repeated on seven occasions in six patients.

Kaplan-Meier curves for recurrence were plotted for the acute major and chronic recurrent groups (Fig 3). The recurrence-free survival times were 1640 days and 1200 days respectively, there being no statistically significant difference between the two groups (P=0.24). Presence of active pulmonary TB was a risk factor significantly associated with haemoptysis recurrence after BAE (P=0.005). Among the 32 subjects with follow-up data, seven (22%) patients died within the study period. The mortality

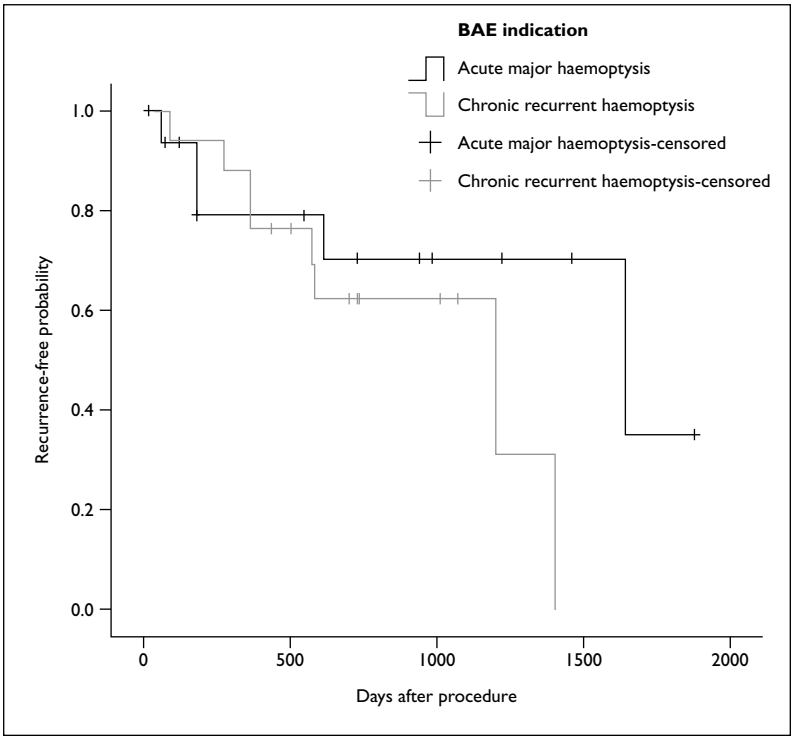

FIG 3. Kaplan-Meier curves of recurrence-free probability of patients after bronchial artery embolisation (BAE) for both acute major and chronic recurrent haemoptysis

rate was 32% and 8% for the acute major and chronic recurrent haemoptysis groups, respectively.

Discussion

Our study demonstrated that BAE is a highly efficacious procedure with a remarkable safety profile for the control of haemoptysis in a series with a sizable proportion (39%) of patients in the chronic recurrent group.

Acute massive haemoptysis is considered a respiratory emergency and has been associated with a mortality rate of up to 30 to 50%.[11-13] Since the early reports of BAE's successful use in the control of acute massive haemoptysis,[1,2] it has been increasingly utilised as the first-line treatment for such cases. Its efficacy and safety have been shown in several studies.[3-6] Earlier reports of BAE had demonstrated relatively low popularity,[14] as it was considered a temporary or palliative means of control, whilst surgery was considered the more definitive treatment whenever possible.[15] However, with more promising results detailing its reliability and safety, a substantial increase in BAE's acceptance was observed in a more recent survey.[16] Although once regarded as an alternative treatment in those who refuse or are not fit for surgery (due to cardiopulmonary compromise), increasingly it has been carried out in otherwise operable patients.[16] The recent introduction of multi-detector row CT has offered a comprehensive non-invasive method of evaluating the entire thorax, which allows clear depiction of origins and courses of abnormally dilated bronchial or non-bronchial systemic arteries, which may be the source of the haemorrhage[17] and require embolisation.[18,19] The presence of non-bronchial systemic arteries can be predicted on the basis of pleural thickening greater than 3 mm, with the revelation of enhancing arteries within the extra-pleural fat on axial images. Underlying causes of haemoptysis such as bronchiectasis, lung malignancy, TB, and chronic fungal infections can be detected with CT, which can help guide subsequent embolotherapy.[20] In view of the high mortality rates (about 40%) of emergency surgery for massive haemoptysis,[13] BAE has been proposed as a useful adjunctive treatment to allow scheduled rather than emergency surgery to control haemoptysis.[21]

Most earlier literature had focused on the role of BAE in acute massive haemoptysis, which was defined in a variety of ways, including volumes of 100 mL/24 hours or higher, 1000 mL/24 hours or higher, and the 'need' of transfusion.[22] It had been noted that the reported volume of haemoptysis does not necessarily correlate with severity[23] and there is always a risk of recall bias from the patients (concerning the exact volume being expectorated). Apart from the amount and rate of bleeding, the amount of blood retained in the lungs and the underlying pulmonary reserve have also been correlated to the risk of death.[23] We therefore adopted a relatively practical definition when offering BAE to acute major cases. On the other hand, no standard definition has been used for chronic recurrent cases.

Although many series of 'massive haemoptysis' also contained a small number of chronic recurrent haemoptysis, the role of BAE in these cases is less well-described.[1,3,5-7,24,25] The only reports on the 'non-massive' category were mainly focused on patients with cystic fibrosis,[8] a disease which is rare in Hong Kong. Although most cases of chronic recurrent haemoptysis are not immediately fatal, they are by no means clinically insignificant and should not be neglected. They can be associated with significant morbidity such as anaemia, in addition to the alarming distress and associated nuisance. Antonelli et al[8] suggested that controlling recurrent haemoptysis potentiated psychological well-being and compliance to treatment in patients with cystic fibrosis. Also, mild haemoptysis may serve as a warning of impending major haemoptysis.[24] Bronchial artery embolisation might be the only treatment option available to patients who are not fit to undergo surgery. The relatively large number of chronic recurrent cases in our series also reflects the magnitude of the clinical problem in Hong Kong and the need for a potentially useful treatment modality for managing such cases.

In the present study, BAE was effective in

controlling haemoptysis in both groups, with no statistical difference in terms of the immediate and long-term control of haemoptysis. Overall immediate control was achieved in 99%, which was similar to 94% in a recent report by Swanson et al[5] that also included chronic recurrent cases. The initial success rate of earlier reports ranged from 73 to 98%,[1,3] and better recent success rates could be related to more refined techniques and better embolic agents.[26]

Our recurrence rate of 26% in the acute group was similar to that reported by Uflacker et al[2] but better than the 45% long-term (beyond 3 months) control rate reported by Mal et al.[4] Swanson et al[5] reported a 1-month recurrence rate of 11%. However, most of the studies (including ours) were retrospective case series with relatively small patient numbers, which invariably confounded the accuracy and reliability of findings about the long-term efficacy of BAE. The varied follow-up periods detailed in these reports also rendered interpretation of results difficult. The relatively high observed recurrence rate has prompted some investigators to follow up such patients for 3 years, especially those with bronchiectatic changes on the CT scan and/or pulmonary-bronchial artery shunting detected by pulmonary angiography.[9]

In the present study, active pulmonary TB was identified as a risk factor associated with recurrence after BAE. Recurrence of bleeding probably indicates underlying pathology that has not been definitively cured by BAE alone, for which either surgery[15] or medical therapy[7] might be necessary. Active, persistent mucosal inflammation, which is a factor identified by Mossi et al[27] that might lead to recurrence of bleeding, would also be present in airways with active tuberculous infection. Being an endemic disease in Hong Kong, TB is a common aetiology for haemoptysis, with approximately one third of patients presenting with this symptom at different stages of the disease.[28] Besides being a feature of active TB, haemoptysis can also be a manifestation of complications such as cavitation, fibrosis, bronchiectasis, and mycetoma. Seventy per cent of our patients had pulmonary TB and over 60% had clinical evidence of bronchiectasis. Although microbiological status was not reported in that study, extensive tuberculous pleural involvement was associated with poor bleeding control after BAE.[29] Suboptimal results with extensive pleural involvement are probably related to the increased development of systemic collateral blood vessels, other than from the bronchial artery.[17,29] Since adequate medical treatment of the underlying lung problems is important to achieve long-term control after BAE,[1,5,7] issues related to treatment of TB, including compliance, drug resistance and side-effects, might also be important. However, such data were not available in our study population nor were they reported in other similar studies. Other adverse factors affecting the long-term results that had been noted in the literature include mycetoma,[15,25] neoplasm,[30] and complications of pneumonia (like abscess and pyothorax).[7] Presence of numerous feeder vessels other than the bronchial arteries and invasion of vascular structures might be the underlying reason for bleeding recurrences after BAE in these conditions. However, recanalisation of embolised vessels,[31] incomplete embolisation and formation of systemic collaterals might be alternative explanations.[17]

In our series, the procedure was safe and well-tolerated, with a complication rate of 13%. All complications were mild and self-limiting and included chest pain and minor arterial dissections. Spinal cord ischaemia, the most sinister complication reported in the medical literature,[1,4,17,32,33] was not encountered in our series. Nor was it noted in other more recent reports.[5,6] This may be related to accumulation of experience and improved techniques, such as the introduction of superselective embolisation.[33] In light of the more recent results like ours, the earlier pessimism about the use of BAE in patients with minor haemoptysis or in those with bleeding that has already stopped[4] is no longer justified.

In conclusion, this study demonstrated that BAE was effective in a series with a sizable proportion of patients suffering from chronic recurrent haemoptysis, which is a common problem with a clinical significance akin to acute major bleeding. The procedure is well-tolerated and associated with relatively few and mild complications. However recurrences did occur and multiple interventions were needed in certain patients. The limitations of our study included the relatively small number of patients with available long-term follow-up data, and its retrospective nature. More data, preferably prospectively collected and with a longer follow-up period, may be able to identify the types of chronic haemoptysis that benefit most from this procedure.

Declaration

No conflicts of interest were declared by the authors.

Acknowledgement

We would like to thank Ms Maggie Lit for her contribution in the clerical support and preparation of the Chinese abstract.

References

1. Remy J, Arnaud A, Fardou H, Giraud R, Voisin C. Treatment of hemoptysis by embolization of bronchial arteries. Radiology 1977;122:33-7.
2. Uflacker R, Kaemmerer A, Picon PD, et al. Bronchial artery embolization in the management of hemoptysis: technical aspects and long-term results. Radiology 1985;157:637-44.
3. Cremaschi P, Nascimbene C, Vitulo P, et al. Therapeutic embolization of bronchial artery: a successful treatment in 209 cases of relapse hemoptysis. Angiology 1993;44:295-9.
4. 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.
5. Swanson KL, Johnson M, Prakash UB, McKusick MA, Andrew JC, Stanson AW. Bronchial artery embolization: experience with 54 patients. Chest 2002;121:789-95.
6. de Gregorio MA, Medrano J, Mainar A, Alfonso ER, Rengel M. Endovascular treatment of massive hemoptysis by bronchial artery embolization: short-term and long-term follow-up over a 15-year period [in Spanish]. Arch Bronconeumol 2006;42:49-56.
7. Kato A, Kudo S, Matsumoto K, et al. Bronchial artery embolization for hemoptysis due to benign diseases: immediate and long-term results. Cardiovasc Intervent Radiol 2000;23:351-7.
8. Antonelli M, Midulla F, Tancredi G, et al. Bronchial artery embolization for the management of nonmassive hemoptysis in cystic fibrosis. Chest 2002;121:796-801.
9. Osaki S, Nakanishi Y, Wataya H, et al. Prognosis of bronchial artery embolization in the management of hemoptysis. Respiration 2000;67:412-6.
10. Muthuswamy PP, Akbik F, Franklin C, Spigos D, Barker WL. Management of major or massive hemoptysis in active pulmonary tuberculosis by bronchial artery embolization. Chest 1987;92:77-82.
11. Conlan AA, Hurwitz SS, Krige J, Nicolaou N, Pool R. Massive hemoptysis. Review of 123 cases. J Thorac Cardiovasc Surg 1983;85:120-4.
12. Corey R, Hla KM. Major and massive hemoptysis: reassessment of conservative management. Am J Med Sci 1987;294:301-9.
13. Gourin A, Garzon AA. Operative treatment of massive hemoptysis. Ann Thorac Surg 1974;18:52-60.
14. Haponik EF, Chin R. Hemoptysis: clinicians' perspectives. Chest 1990;97:469-75.
15. Katoh O, Kishikawa T, Yamada H, Matsumoto S, Kudo S. Recurrent bleeding after arterial embolization in patients with hemoptysis. Chest 1990;97:541-6.
16. Haponik EF, Fein A, Chin R. Managing life-threatening hemoptysis: has anything really changed? Chest 2000;118:1431-5.
17. Wong ML, Szkup P, Hopley MJ. Percutaneous embolotherapy for life-threatening hemoptysis. Chest 2002;121:95-102.
18. Remy-Jardin M, Bouaziz N, Dumont P, Brillet P, Bruzzi J, Remy J. Bronchial and nonbronchial systemic arteries at multi-detector row CT angiography: comparison with conventional angiography. Radiology 2004;233:741-9.
19. Bruzzi JF, Remy-Jardin M, Delhaye D, Teisseire A, Khalil C, Remy J. Multi-detector row CT of hemoptysis. Radiographics 2006;26:3-22.
20. Yoon W, Kim YH, Kim JK, Kim YC, Park JG, Kang HK. Massive hemoptysis: prediction of nonbronchial systemic arterial supply with chest CT. Radiology 2003;227:232-8.
21. Fernando HC, Stein M, Benfield JR, Link DP. Role of bronchial artery embolization in the management of hemoptysis. Arch Surg 1998;133:862-6.
22. Dweik RA, Stoller JK. Role of bronchoscopy in massive hemoptysis. Clin Chest Med 1999;20:89-105.
23. Cahill BC, Ingbar DH. Massive hemoptysis: Assessment and management. Clin Chest Med 1994;15:147-67.
24. Brinson GM, Noone PG, Mauro MA, et al. Bronchial artery embolization for the treatment of hemoptysis in patients with cystic fibrosis. Am J Respir Crit Care Med 1998;157:1951-8.
25. Lampmann LE, Tjan TG. Embolization therapy in haemoptysis. Eur J Radiol 1994;18:15-9.
26. Yoon W, Kim JK, Kim YH, Chung TW, Kang HK. Bronchial and nonbronchial systemic artery embolization for life-threatening hemoptysis: a comprehensive review. Radiographics 2002;22:1395-409.
27. Mossi F, Maroldi R, Battaglia G, Pinotti G, Tassi G. Indicators predictive of success of embolization: analysis of 88 patients with haemoptysis. Radiol Med (Torino) 2003;105:48-55.
28. Teklu B, Felleke G. Massive haemoptysis in tuberculosis. Tubercle 1982;63:213-6.
29. Kwon W, Kim YJ, Lee YH, Lee WY, Kim MS. The effectiveness of embolotherapy for treatment of hemoptysis in patients with varying severity of tuberculosis by assessment of chest radiography. Yonsei Med J 2006;47:377-83.
30. Hayakawa K, Tanaka F, Torizuka T, et al. Bronchial artery embolization for hemoptysis: immediate and long-term results. Cardiovasc Intervent Radiol 1992;15:154-9.
31. Tomashefski JF Jr, Cohen AM, Doershuk CF. Longterm histopathologic follow-up of bronchial arteries after therapeutic embolization with polyvinyl alcohol (Ivalon) in patients with cystic fibrosis. Hum Pathol 1988;19:555-61.
32. Ramakantan R, Bandekar VG, Gandhi MS, Aulakh BG, Deshmukh HL. Massive hemoptysis due to pulmonary tuberculosis: control with bronchial artery embolization. Radiology 1996;200:691-4.
33. Tanaka N, Yamakado K, Murashima S, et al. Superselective bronchial artery embolization for hemoptysis with a coaxial microcatheter system. J Vasc Interv Radiol 1997;8:65-70.