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Clinical Investigations

Bronchial Artery Embolization for Hemoptysis: Immediate and Long-Term Results

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Abstract. The purpose of this study was to evaluate the immediate and long-term results in 63 patients who underwent transarterial embolization for control of hemoptysis. Overall immediate success rate was 86.1%. At long-term follow-up 50% of patients showed complete remission, 22% partial remission, and 28% recurrent hemoptysis. Hemoptysis remained controlled for a mean of 22 months and a median of 14 months. The long-term results among four disease groups differed substantially. Patients with bronchiectasis showed the best results, followed by those with idiopathic disease and with inflammation; patients with neoplasm showed the worst results.

Key words: Bronchial artery—Transarterial embolization—Hemoptysis, long-term results

Bronchial artery embolization (BAE) has been established as an effective means to control hemoptysis, especially in patients with decreased pulmonary function such as postpneumonectomy patients and those with advanced chronic obstructive pulmonary disease [1, 2]. However, there have been a few studies investigating the long-term results of BAE in a larger number of patients [3–6]. The purpose of the study was to evaluate the immediate and long-term results of BAE in 63 patients who underwent the procedure for the control of hemoptysis between 1977 and 1990. Length of hemoptysis control and recurrence and mortality rates were determined collectively for all patients as well as separately for four disease groups.

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Materials and Methods

Forty-three men and 20 women underwent a total of 80 embolization procedures for the management of hemoptysis between 1977 and 1990. Subjects ranged in age from 24 to 82 years. The age and gender distribution is noted in Table 1.

The patients were divided into the following four disease groups: pulmonary neoplasm, idiopathic hemoptysis, bronchiectasis, and pulmonary inflammation. The pulmonary neoplasm group (12 patients; mean age 62.8 years) consisted of 11 patients with lung cancer and 1 with bronchial carcinoid tumor. The idiopathic hemoptysis group consisted of 9 patients (mean age 51.9 years) without any underlying pulmonary disease. The bronchiectasis group (mean age 51.2 years) consisted of 10 patients with bronchiectasis. Patients having bronchiectasis secondary to obvious pulmonary diseases such as tuberculosis were classified into other groups and excluded from this group. The pulmonary inflammation group (32 patients, mean age 58.4 years) consisted of 25 patients with active or inactive tuberculosis, 2 with atypical mycobacterium infection, 2 with lung abscess, 1 with pneumonia, 1 with aspergillosis, and 1 with pulmonary sequestration.

BAE consisted of catheterization of a bronchial artery on the bleeding side and embolization of the bronchial artery thought to be the source of bleeding. When no such bronchial artery could be identified, an intercostal artery was embolized as described below. An aortogram was sometimes, but not always, performed particularly in patients with recurrent hemoptysis and in whom no bronchial artery could be identified as the bleeding source. The signs of bleeding were extravasation of contrast medium, hypertrophy of the supply artery, hypervascularity of the involved area, bronchial artery to pulmonary artery shunt, bronchial artery to pulmonary vein shunt, and any combination of these findings.

At first, bronchoscopy was performed to determine the site of bleeding. Transfemoral bronchial and/or intercostal arteriography was performed using initially a hand-made J-shaped catheter (KIFA-red and green, SIEREG, Sweden) and later a preshaped Rosch celiac type or Cobra-head type 6.5 or 7 French catheter (RC1-2, and C1-3, Cook, Bloomington, IN). Eight to 10 ml of 305 mgI/ml meglumine diatrizoate (Angiografin, Schering AG, Germany) or 370 mgI/ml iopamidol (Iopamiron, Bracco, Italy) was manually injected into the bronchial artery, and 3–7 ml into the intercostal artery. Embolization was performed with gelatin sponge (Gelfoam, Upjohn, Kalamazoo, MI) which was cut to 0.5–1.0 mm cubes soaked with contrast medium. The gelatin sponge particles were injected carefully and slowly under fluoro-

scopic guidance to avoid overflow into the aorta. Finally, postembolization arteriography was used to ascertain the extent of embolization. If it was insufficient, the embolization procedure was repeated until complete blockage of the supply circulation was obtained. Contraindication for embolization included opacification of spinal branches and significant shunt from the bronchial artery to the pulmonary vein. Five patients did not receive BAE, three because of a spinal artery and 2 because of significant shunt.

Initial embolization was performed in 63 patients for 70 arteries (65 bronchial and 5 intercostal arteries) following 96 selective arteriograms (87 bronchial and 9 intercostal arteriograms). Eleven of the 63 patients underwent 17 repeat embolization procedures for 19 arteries: 15 bronchial arteries, 2 intercostal arteries, 1 inferior phrenic artery, and 1 aberrant artery from the celiac axis.

The outcome of BAE was investigated retrospectively from inpatient and outpatient medical records at the end of April 1990. The observation period following embolization was assessed using the date of the last visit to the outpatient department. When hemoptysis was surgically managed following embolization, the observation period was defined as extending from the date of initial embolization to the date of surgical operation.

Immediate results were assessed based on careful observation of patients for 1 month post-BAE and were classified into two categories: successful, indicating complete cessation of hemoptysis during 1 month, and failed, indicating continued hemoptysis or recurrent hemoptysis within 1 month. Patients who had residual or occasional blood-streaked sputum (bloody sputum) within 1 month but not hemoptysis, which was defined as an expectoration of blood, were counted as controlled.

Long-term results were evaluated in patients who could be followed for at least 1 month and in whom results had been classified as successful. Patients were classified into the following three categories: complete remission (CR), indicating complete cessation of bleeding throughout the observation period; partial remission (PR), indicating complete cessation of hemoptysis with recurrent bloody sputum during the observation period, and recurrence (R), indicating recurrent hemoptysis.

The hemoptysis control period is defined as the period from the initial BAE to the first incident of recurrent hemoptysis, regardless of whether any episode of bloody sputum occurred. Mean and median hemoptysis control periods were assessed.

Cumulative hemoptysis control and survival rates were assessed using the Kaplan-Meier method for all 63 patients as well as for each disease group.

Table 1. Age and gender distribution

Age group	Male	Female	Total
20–29	1	1	2
30–39	0	3	3
40–49	7	4	11
50–59	16	4	20
60–69	12	4	16
70–79	5	4	9
80–89	2	0	2
Total	43	20	63

Results

Immediate results were analyzed in 58 patients. Five patients could not be followed during the first month and were excluded. Four patients who could not be followed for the entire month but in whom BAE was determined to have failed were included. BAE was successful in 50 patients and failed in 8. Outcome for patients with failed BAE included death from bleeding or asphyxia (4 patients), death from causes other than hemoptysis (1 patient), repeat embolization with survival (1 patient), and total pneumonectomy with survival (1 patient); and unknown outcome in 1 patient. Three patients died on the day of BAE and the mortality rate of patients with failed BAE was 62.5%. The underlying pulmonary diseases of patients with failed BAE included lung cancer (5 patients), aspergillosis (1), lung abscess (1), and pulmonary sequestration (1).

In all patients, duration of follow-up was as follows: 9 patients, less than 1 month; 23, from 1 to 12 months; 13, from 1 to 3 years; 8, from 3 to 5 years; 6, from 5 to 10 years; and 4, more than 10 years. In 50 patients in whom BAE had initially been evaluated as successful, mean hemoptysis control period with standard deviation was 22.1 ± 27.1 months, and the median period was 14 months (range 1–132 months). Twenty-five patients (50%) were rated as

Table 2. Results by four disease groups

	Neoplasm (n = 12)	Idiopathic (n = 9)	Bronchiectasis (n = 10)	Inflammation (n = 32)
Immediate result				
Successful	58.3% (7/12)	100% (8/8)	100% (9/9)	89.7% (26/29)
Failed	41.7% (5/12)	0%	0%	10.3% (3/29)
Long-term result				
CR	57.1% (4/7)	75% (6/8)	22.2% (2/9)	50.0% (13/26)
PR	28.6% (2/7)	25% (2/8)	33.3% (3/9)	15.4% (4/26)
R	14.3% (1/7)	0%	44.4% (4/9)	34.6% (9/26)
Hemoptysis control period				
Mean ± SD	5.1 ± 3.1 months	22.9 ± 35.3 months	41.3 ± 41.8 months	19.8 ± 17.5 months
Median	6 months	2 months	28 months	16 months
Range	0–9 months	1–99 months	6–132 months	1–74 months
Mortality rate	91.6% (11/12)	0%	22.2% (2/9)	10.3% (3/29)

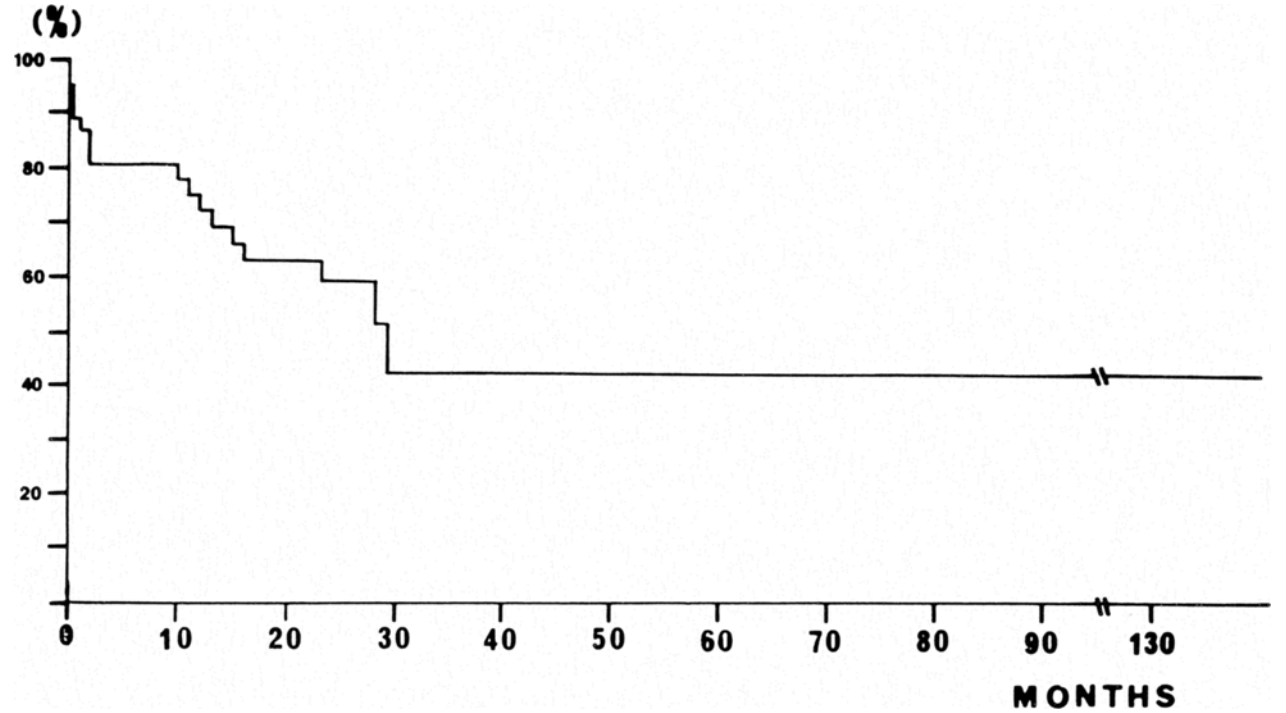

Fig. 1. Cumulative hemoptysis control rates for all patients calculated by the Kaplan-Meier method. Hemoptysis was controlled in 72.2% at 1 year, 59.3% at 2 years, and 42.8% at 3 years. There was no recurrence of hemoptysis after 29 months postembolization

showing CR, 11 (22%) as showing PR, and 14 (28%) as showing R.

Of the 11 patients who underwent 17 repeat embolization procedures, 9 patients underwent one, 1 underwent three, and 1 underwent four procedures. The immediate results of these 17 repeat embolizations were all successful. The long-term results of the repeat embolization procedures, where available, are as follows: CR(n = 2;13.3%), PR(n = 6;40%), and R(n = 7;46.7%). The hemoptysis control period, which was defined as the period from the repeat embolization to recurrent hemoptysis, was a mean of 25.9 months and a median of 12 months (range 1–120 months).

The results were also analyzed according to the disease groups (Table 2). The neoplasm group showed the worst results, and in about half the patients, BAE was evaluated as having failed. In the idiopathic group, no patient suffered recurrent hemoptysis, but the median hemoptysis control period was 2 months and the shortest, as the follow-up periods were relatively shorter. The bronchiectasis groups showed longer mean and median hemoptysis control periods (41.3 and 28 months) than the pulmonary inflammation groups (19.8 and 16 months).

The overall cumulative hemoptysis control rate was 72.2% at 1 year, 59.3% at 2 years, and 42.8% at 3, 5, and 10 years (Fig. 1). Cumulative hemoptysis control rates of the four disease groups are illustrated in Figure 2. The overall cumulative survival rate was 91.7% at 1 month, 83.3% at 6 months, 74.1% at 1 year, 71.6% at 2 and 3 years, and 62.3% at 5 and 10 years.

The complications of 80 embolization procedures in 63 patients consisted of four instances of subintimal injection of contrast medium into the aorta (4 patients), which occurred at the time of postembolization arteriography in 3 patients and at the time of the initial diagnostic arteriography in 1 patient. Two of these patients complained of no symptoms, and 1 patient complained of transient back pain, which recovered spontaneously. A 52-year-old woman who received a subintimal injection of contrast medium during initial diagnostic bronchial arteriography complained of sudden back pain at the time of extravasation, and hoarseness and dysphagia appeared later on that evening. An esophagogram the next day revealed a mediastinal hematoma. She was treated conservatively, and discharged, free of symptoms, about 2 weeks after BAE. No patient suffered any neurological complication.

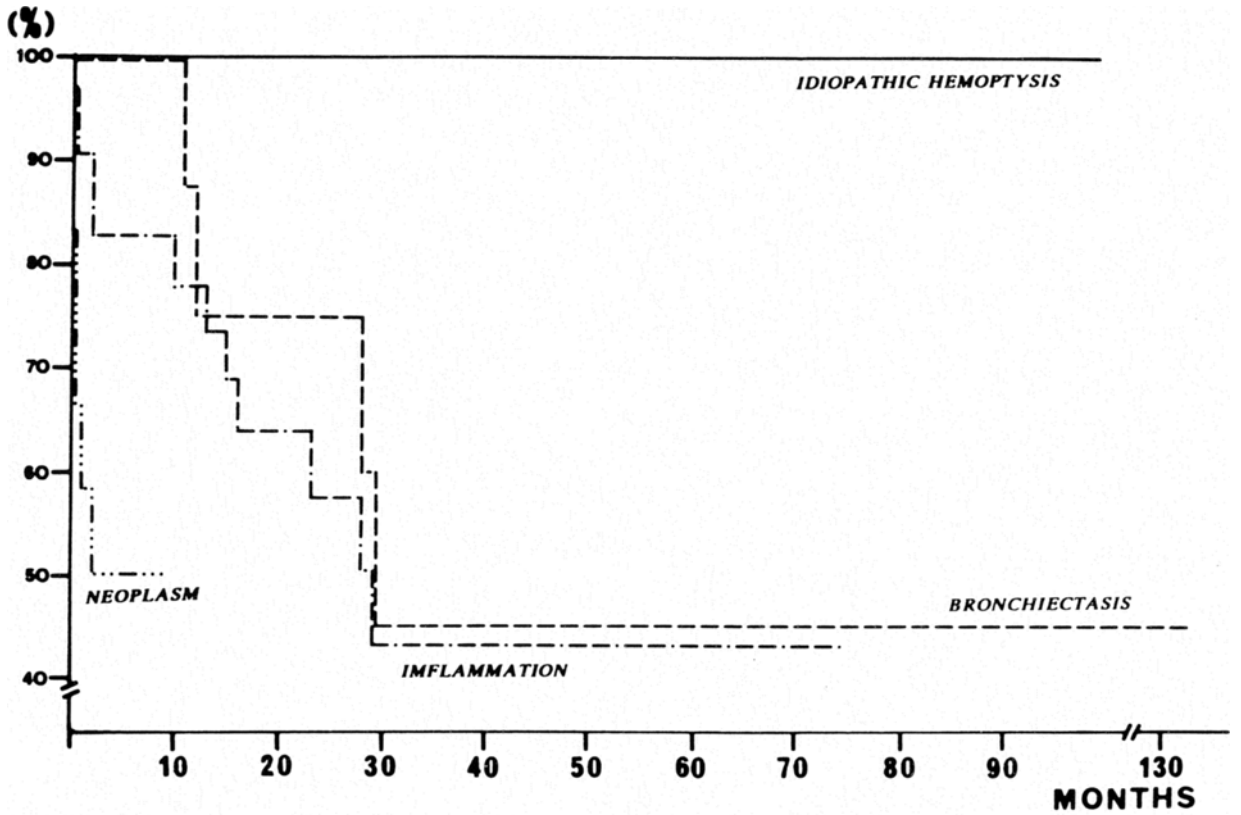

Fig. 2. Cumulative hemoptysis control rates of four disease groups. Early recurrence was typical in the neoplasm group. No recurrent hemoptysis was noted in the idiopathic group

Discussion

The criteria for success and failure adopted in this study were very strict, as the effect of BAE had to last at least 1 month to be considered successful. In this regard, we believe our success rate of 86.1% is excellent compared with Uflacker et al's [5] reported initial success rate of 76.6% in 64 patients, Rabkin et al's [6] rate of 90.8% in 306 patients, and Remy et al's [3] rate of 83.7% in 49 patients. Some would argue that patients with a bloody sputum were classified as successful. But it was not uncommon that patients had residual blood-streaked sputum or dark blood-stained sputum for several days after BAE. If such patients are regarded as failures, our immediate success rate would have dropped to 76.2%, as 2 of 50 patients had such episodes during the first month.

Retrospective analysis of the reason for failure in 8 patients disclosed that 4 had received embolization of vessels which did not show signs of bleeding, that the extent of embolization was insufficient in 3, and that only 1 patient had received complete embolization.

Repeat embolization showed immediate and long-term results similar to those of the initial embolization procedures. But the recurrence rate of 46.7% after repeat embolization was higher than the 28% recurrence rate after the initial embolization. Repeat angiograms revealed that previously embolized arteries had all recanalized, therefore, embolized Gelfoam particles can be resorbed within 1 month.

The long-term results were quite different among the four disease groups. The neoplasm group showed the highest failure rate and the worst long-term results, followed by the inflammation group, the idiopathic group, and the bronchiectasis group. These differences were related to the BAE procedure as well as to the treatment for the underlying pulmonary disease. In this regard, patients with neoplasms were the most difficult to manage, as most neoplasms were malignant and advanced. The neoplasm received blood supply from multiple sources other than the bronchial artery and had invaded the vascular structures aggressively.

Analysis of the cumulative hemoptysis control rate

disclosed that there were two peak times of recurrence, the first being from 1 to 2 months post-BAE and the second being from 1 to 2 years post-BAE. After 29 months, no patient had recurrent hemoptysis.

The first peak reflects the incomplete BAE. In retrospect, we did not search diligently enough for nonbronchial arteries. Nonbronchial systemic arteries have been suggested to be significant sources of bleeding in patients with pleural involvement of disease [7, 8]. Several authors have stressed the importance of pulmonary arteries as a bleeding source, particularly in the case of tuberculosis and mycetoma [9–12]. Accordingly, efforts to search completely for arteries potentially responsible for hemoptysis should improve the immediate results. The present results suggest that the effect of Gelfoam continues for only a limited time. Recurrence within 1 month could be caused by recanalization of the vessels embolized; this was particularly true in our patients with tuberculosis or aspergillosis. In these patients, other embolic materials such as polyvinyl alcohol (Ivalon) could be used [13, 14].

The second peak reflects a recruitment of vasculature by the underlying pulmonary disease and indicates a relapse. Adequate treatment of the underlying pulmonary disease is important for improvement of long-term results. However, the present results indicate that BAE with resorbable Gelfoam provides an excellent long-term effect in the management of hemoptysis when the procedure is complete.

In conclusion, BAE with gelatin sponge is an effective method for managing hemoptysis. The long-term results differ according to the underlying pulmonary disease. Patients with bronchiectasis show the best results, followed by those with idiopathic hemoptysis, then those with inflammation; patients with neoplasms have the worst results. For improvement of long-term results it is important to search widely for supply arteries responsible for the bleeding.

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Commentary

Bronchial artery embolization (BAE) is now a standard treatment for massive or recurrent hemoptysis. Originally devised as an alternative method of treatment to be used in desperate situations in patients with bilateral widespread disease or with poor surgical risk, BAE gradually reached the status of primary method of treatment for hemoptysis, either by itself or as a temporary measure to control bleeding in patients in preparation for surgery.

Although the bronchial arteries were already visualized angiographically back in the sixties, it was not before 1974 that Remy et al. [1] published the first article introducing the technique of transcatheter BAE using gelatin sponge, followed by the report by Wholey et al. [2] in 1976 extending the indications of BAE for the treatment of hemoptysis related to trauma, radiation therapy, and bronchogenic carcinoma. Since that time a number of arti-