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# Long term outcomes of bronchial artery embolization for hemoptysis in patients with cystic fibrosis

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**SUMMARY**

**Aim:** Bronchial artery embolization is known to be effective in the acute control of hemoptysis secondary to cystic fibrosis complication. In this retrospective study 14-year-experience of our clinic with embolization for treatment of hemoptysis in patients with cystic fibrosis is reviewed. The results with coil and polyvinyl alcohol microparticule embolizations are demonstrated.

**Material and Method:** 15 patients (age range 19-54) with cystic fibrosis presented with major or persistent hemoptysis that required 33 embolizations from September 1994 to November 2009.

**Results:** Hemoptysis stopped within a day after embolization in all fifteen patients. There were no major immediate complications within 24 hours for coil only or polyvinyl alcohol microparticule only sessions or the combination of these. Mean survival duration after the first embolization was 58 months (average follow up 72 months; range 3-168 months, including all patients). One patient died, two patients underwent lung transplant during the follow up period.

**Conclusion:** In our retrospective study with 15 patients and 33 embolization sessions which include 9 patients with more than one embolization demonstrated high success rate in short term. Long term results however showed that 9 out of 15 patients (60%) required repeated embolization.

**Key words:** *Angiography; Embolization; Lung*

**ÖZET**

**Kistik fibrozisi ve major hemoptizisi olan hastalarda bronkial arter embolizasyonun uzun dönem sonuçları**

**Giriş:** Bronkial arter embolizasyonu kistik fibrozise sekonder major hemoptizinin akut kontrolünde etkindir. Bu retrospektif çalışmada kliniğin kistik fibrozisli hastalarda hemoptizi icin embolizasyon tedavisindeki 14-senelik koil ve polivinil alkol mikropartikul embolizasyon deneyiminin sunumu amaçlandı.

**Gereç ve Yöntem:** Eylül 1994 tarihinden Kasım 2009`a kadar kistik fibrozisli major hemoptizili 15 hasta (yas 19-54) 33 tekrarlayan embolizasyon seanslarina gereksinim duydu.

**Bulgular:** Hemoptizi embolizasyonu takiben tüm hastalarda durduruldu. Koil ya da polivinil alkol mikropartikul embolizasyonundan sonra 24 saat içinde major komplikasyon gelişmedi. İlk embolizasyondan sonra ortalama yaşam süresi 58 ay oldu (mesafe aralığı 3-168 ay). Takip süresinde 1 hasta oldu, 2 hasta akciğer transplantasyonu oldu.

**Sonuç:** 15 hasta ve 33 embolizasyonlu retrospektif çalışmada erken dönemde başarı 100% iken, uzun dönemde 9 hastada (60%) tekrar embolizasyon gerekti.

**Anahtar kelimeler:** *Anjiografi; Embolizasyon; Akciğer*

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## Introduction

Hemoptysis is the expectoration of blood or blood stained sputum from the lungs or airways. Massive hemoptysis means exceeding 200 to 600 mL within a period of 24 hours or less is directly related with high mortality rate. Bronchial artery embolization has proved to be an effective method to control major, recurrent or life threatening hemoptysis particularly in patients with *Cystic Fibrosis (CF)* and has been in medical practice since 1973.

Major hemoptysis is an increasingly common complication of CF with improved survival of CF patients with current medical diagnostic and therapeutic techniques and increased survival. The pulmonary arterial circulation is the source of bleeding in less than 10% of patients with major hemoptysis. 90% of the time massive bleeding arises from the bronchial arteries and systemic arterial collaterals supplying the tracheobronchial tree.

The purpose of this study is to review our institution's 14 year experience in Bronchial Artery Embolization (BAE) and two interventional radiological BAE techniques; coil (C) and polyvinyl alcohol microparticle (PVA) embolization, usage of both, their advantages, disadvantages and outcomes.

## Material and Methods

15 CF patients with hemoptysis treated with BAE. Embolization was indicated since persistent or major hemoptysis despite of medical management.

*For patients who underwent only one type of BAE;*

Number of patients underwent only coil embolization (C): 9 (mean age 31, age range 20-54)

Number of patients underwent only microparticle embolization (PVA): 0 (3 patients had PVA only sessions however, they also had C or C plus PVA sessions

thereafter). Number of patient underwent only coil plus microparticle embolization (C+PVA): 1 (age 39)

*For patients who underwent different types of BAE in different times;* Number of patients underwent coil embolization (C) and microparticle embolization (PVA): 2 (mean age 26, age range 19-32). This first patient (female, 32) had coil embolization first, then 4 months later had PVA embolization, and five years later had coil embolization. Patient died 6 months after the last embolization.

Number of patients underwent coil embolization (C) and coil plus microparticle embolization (C+PVA): 2 (mean age 40, age range 28-51).

Number of patients underwent microparticle embolization (PVA) and coil plus microparticle embolization (C+PVA): 1 (age 37).

The most common etiologic features of hemoptysis arising from the systemic circulation include bronchiectasis, CF, neoplasm, tuberculosis and other lung infections, and congenital cardiac or pulmonary vascular anomalies.

In this study only CF patients were represented. Ten other patients with different causes of hemoptysis underwent BAE at the same time period (pulmonary metastasis, congenital heart disease, arteriovenous malformation, infections such as tuberculosis, coccidiomycosis) were excluded from the study.

BAE procedures were performed via the transfemoral artery catheterization with Seldinger technique. The descending thoracic aorta and intercostal and subclavian arteries were examined by angiography for identification of bronchial and large collateral arteries. Bronchial arteries are selected with mostly C2 Cobra catheters (other catheters uncommonly used were, Mikaelson, Simmons, H1H ).

Most commonly bronchial arteries originate from the thoracic aorta between the T5 and T6 vertebra. Variations of bronchial arteries may exist. For embolization of the bronchial artery microcatheters were used. Bilateral bronchial arteries, largest collaterals were embolized with either coil embolization (Cook, IN) or with polyvinyl alcohol microparticle 500 microns to 800 microns, slow injection under fluoroscopic control (Boston Scientific, Natick, MA).

Enlarged or abnormally tortuous vessels were embolized. The total number of embolized arteries is 69.

## Results

15 CF patients presented with 33 major hemoptysis episodes that required and treated with BAE. Average follow up time is 72 months (range 3 to 168 months). Two patients underwent lung transplantation and both had coil BAE prior to the lung transplantation. One other patient died during follow up period.

Demographic data, clinical status, early and late outcomes of patients with both techniques are demonstrated as follows (Table I).

Immediate success rate, cessation of hemoptysis and lack of recurrence of bleeding within the first day of BAE obtained with both techniques was 100% .

*Recurrence of Hemoptysis:*

9 of 15 patients (60%) underwent BAE presented with recurrent major hemoptysis and required repeated BAE. Out of those 9 patients who underwent more than one procedure regardless of the type of BAE procedure; 3 had BAE twice while 3 had three times and the other 3 had four times.

9 patients had more than one BAE procedure which is 27 BAE procedures in total. Out of 18 repeating BAE procedures; 7 were required within 6 months following a BAE; 3 were required within 6-12 months following a BAE; 7 were required within 1-5 years following a BAE; one was required after more than 5 years following a BAE.

The total number of BAE procedures and percentages are as follows: For 33 BAE procedures, 22 (67%) are coil embolizations, 5 (15%) are PVA embolizations, 6 (18%) are coil plus PVA embolizations.

Shortest hemoptysis free time is the shortest duration between two BAE procedures provided that there is no major hemoptysis, death or DLT.

For 18 procedures repeated after, *depending on the order of BAE procedure (Table II)*, the shortest hemoptysis free time between the BAE procedures is one month from 1$^{st}$ to 2$^{nd}$ BAE procedure (9 sessions, with average of 32 months and range of one month to 132 months), the shortest hemoptysis free time between the 2$^{nd}$ and 3$^{rd}$ BAE is one month (6 sessions, with average of 21 months and range of one month to 60 months), the shortest hemoptysis free time between the 3$^{rd}$ and 4$^{th}$ BAE is 3 months (3 sessions, with average of 25 months and range of 3 months to 36 months). (Table II)

Out of 18 BAE procedures that are repeated after, *depending on the type of BAE procedures (Table III)*; for 12 coil embolizations (66%); the shortest hemoptysis free time is one month (average of 20 months and range one month to 60 months); for 3 PVA embolizations (17%); the shortest hemoptysis free time is one

month (average of 24 months and range one month to 60 months); for 3 coil plus PVA embolizations, C+PVA (17%); the shortest hemoptysis free time is 12 months (average of 64 months and range 12 months to 132 months). (Table III)

Major complication (hemoptysis requiring repeat embolization) was seen in 60% of the patients (9 out of 15 patients). Minor complications such as thoracic pain, back pain, shoulder pain (one patient had right shoulder pain that lasted several months with unknown reason), fever, leukocytosis, dysphagia are best treated with analgesics and narcotics. Response was achieved in a few days.

The severe morbidity and mortality rates associated with massive hemoptysis are most often due to asphyxiation. Many of these patients have underlying chronic lung disease with diminished pulmonary reserve.

## Discussion

Despite the effectiveness of BAE to control bleeding, the risk of mortality or lung transplantation is still a greater risk in patients with BAE for major hemoptysis. Patients probably have worse pulmonary status, multidrug resistant Pseudomonas infection, chronic inflammatory changes in BAE required

**Table I. Bronchial Artery Embolization Table**

| *Type of BAE / Name of the Patient* | *(Mean) Age* | *Sex* | *Recurrent Hemoptysis (Major com)* [a] | *Minor com* | *Agent Used: Coil, PVA or C-PVA* [b] | *No of Sessions* | *Lung Tx* | *Death* [c] | *Survival / Follow Up Time After the First BAE* | *Shortest Hemoptysis Free Time* [d] | *Patients with CF* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Coil | 31 | 5M, 4F | | | Coil | 22 | 2 | 1 | | | 9 |
| PVA | - | - | | | PVA | 5 | | 1 | | | 1 |
| Only C+PVA | 39 | 1M | | | C+PVA | 6 | | 0 | | | 1 |
| Other (more than one BAE) | 33 | 3M, 2F | | | C and PVA, C and C+PVA, PVA and C+PVA | | | | | | 5 |
| Patient 1 | 23 | M | no | | C (2004) | 1 | DLT (2006) | | 5 years | 2 years | |
| Patient 2 | 31 | F | no | shoulder pain | C (1998) | 1 | | | 6 years then lost track | 6 years then lost track | |
| Patient 3 | 35 | M | no | backpain | C (2005) | 1 | | | 4 years | 4 years | |
| Patient 4 | 39 | M | yes | | C+PVA (1994), C+PVA (1995), C+PVA (1999) | 3 | | | 10 years then lost track | *shortest 1 year, longest 5 years, then lost track* | * |
| Patient 5 | 32 | F | yes | | C (1999), PVA (1999), C (2004) | 3 | | 6 months | 5 years | *shortest 6 months, longest 5 years* | * |
| Patient 6 | 51 | F | yes | backpain | C (1996), C (2001), C (2001), C+PVA (2004) | 4 | | | 13 years | *shortest 1 month, longest 5 years* | * |
| Patient 7 | 30 | F | yes | thoracic pain | C (2001), C (2005), C (2005), C (2008) | 4 | | | 8 years | *shortest 4 months, longest 4 years* | * |
| Patient 8 | 37 | M | yes | | C+PVA (1995), PVA (2006) | 2 | | | 14 years | *14 years* | * |
| Patient 9 | 22 | M | no | | C (2001) | 1 | | | 8 years | 8 years | |
| Patient 10 | 20 | F | yes | | C (2000), C (2000) | 2 | DLT (2001) | | 9 years | *4 months* | * |
| Patient 11 | 28 | M | yes | backpain | C (2007), C (2009) | 2 | | | 2 years | *2 years* | * |
| Patient 12 | 54 | M | no | | C (2005) | 1 | | | 4 years | 4 years | |
| Patient 13 | 28 | M | yes | | C (2008), C (2009), C+PVA (2009) | 3 | | | 1 year | *shortest 1 month, longest 1 year* | * |
| Patient 14 | 19 | M | yes | | PVA (2008), PVA (2008), C (2009), PVA (2009) | 4 | | | 1 year | *shortest 1 month, longest 1 year* | * |
| Patient 15 | 40 | F | no | | C (2009) | 1 | | | 3 months | 3 months | |

Abbreviations: BAE, Bronchial Artery Embolization; PVA, Poly Vinyl Alcohol; DLT, Double Lung Transplant; CF, Cystic Fibrosis; C, Coil

[a] Other major complications: Lung CA, Metastatic Hypervascular Lung Mass, Chronic Pulmonary Infection, Cocci Pnemonia, Arteriovenous Malformation

[b] The years of the BAE is indicated in paranthesis on the bottom portion of the column.

[c] This column on the top part shows the number of cases occurred after type of BAE and on the bottom shows time passed until patient's death after the last BAE procedure. The patient who died had both coil and PVA embolizations in her patience history.

[d] Hemoptysis free time is the duration between two BAE procedues provided that there is no major hemoptysis, DLT or death in that period. According to our data, the patient who died was included in hemoptysis free time calculations since the death was 6 months after the last BAE procedure.

* In this study, hemoptysis free time is calculated for 9 patients who underwent more than one procedure.

group. Recurrent hemoptysis is not infrequent after BAE in CF, ranging from 30% to 60% depending on the length of follow up. Recurrent bleeding is not surprising since the underlying disease is unaffected by the embolization procedure and collateral arteries are readily recruited.

Gelatin sponge (provides temporary occlusion), polyvinyl alcohol particles, tris-acryl gelatin microspheres, acrylic glue, and steel coils have been all reported for BAE embolization. Many authors favor nonspherical polyvinyl alcohol particles or calibrated microspheres when microcatheters are used [1,2,3,4]. Tanaka et al recommended usage of superselective microcatheter coaxial system which is more effective and reach beyond the spinal or mediastinal branches [4]. Pelage [1] claims that recurrence of bleeding is reported in up to 30% of patients, use of coils may prevent future re-embolization since coils occlude the bronchial arteries proximally. Several authors including Vidal et al [3] favor microspheres over coils with similar reason. However, they also indicate that extreme care must be used to avoid reflux of embolic particulate agents into the spinal artery distribution.

Although several articles claim PVA is superior to coil in BAE, coil was used more than PVA in this study with a thought process of that coil embolization is more controllable; including prevention of reflux, non target embolization, accidental infarction of lung segments, accidental embolization of pulmonary artery, or spinal artery. We do not tend to occlude arteries proximally but distally with coils.

Technical failure of attempted embolization can be observed in about 10-20% of cases because of catheterization failure, catheter instability, or visualization of dangerous branches such as the anterior spinal artery. Special attention should be paid to identification of a spinal artery since embolizing a spinal artery without recognizing it may cause of ischemic complications, chemotoxic transverse myelitis resulting in paralysis. Spinal cord injury related to invisible anastomotic connections between the bronchial circulation and the anterior spinal artery has been reported [1-5]. Other potential serious adverse events are bronchial infarction and esophagobronchial fistula.

Although short term (24 hours) survival of 100% looks promising, long term survival does demonstrate 60% of recurrent major hemoptysis in our study. This is not far different then similar other study groups (30% to 60% in different articles, varies with follow up time) [3,5,6,7.8].

In our retrospective study with 27 BAE sessions using coil, PVA and also both (C+PVA) techniques, statistically C+PVA was found superior to single coil or PVA embolizations with calculations of shortest hemoptysis free time 12 months with an average of 64 months. Hemoptysis free time and average months for coil embolization and PVA embolization are as follows respectively; one month and average of 20 months, one month and average of 24 months. Since their shortest hemoptysis free time are the same, one can conclude that PVA embolization has better re-

**Table II.** For Repeated 18 BAE Procedures According to the Order of BAE

| Type of BAE | Number of Patients | % in Total Number of Patients | Hemoptysis Free Time | | | |
|---|---|---|---|---|---|---|
| | | | Shortest Time | Number of Sessions | Average Time | Range |
| 1st to 2nd BAE Procedure | 9 | 50% | 1 month | 9 | 32 months | 1 to 132 months |
| 2nd to 3rd BAE Procedure | 6 | 33% | 1 month | 6 | 21 months | 1 to 60 months |
| 3rd to 4th BAE Procedure | 3 | 17% | 3 months | 3 | 25 months | 3 to 36 months |

**Table III.** For Repeated 18 BAE Procedures According to the Type of BAE

| Type of BAE | Number of Patients | % in Total Number of Patients | Hemoptysis Free Time | | | |
|---|---|---|---|---|---|---|
| | | | Shortest Time | Number of Sessions | Average Time | Range |
| Coil Embolization | 7 | 66% | 1 month | 12 | 20 months | 1 to 60 months |
| PVA Embolization | 2 | 17% | 1 month | 3 | 24 months | 1 to 60 months |
| Coil Plus PVA Embolization | 2 | 17% | 12 months | 3 | 64 months | 12 to 132 months |

sults than coil embolization depending on the average month without a major complication.

Study limitations: This study group is a retrospective evaluation a period of 14 years. The number of BAE patients for major hemoptysis with CF patients is limited to 15 with a total of 33 BAE sessions, 27 BAE sessions that belong to patients with more than one BAE procedure and 18 BAE sessions that are repeated after in order to calculate the hemoptysis free time.

*Conclusion*

BAE demonstrated high success in short term. Long term embolization results show that slightly more than half of the patients required repeated embolizations.

The results of this retrospective study show that BAE is a safe and effective method for treating major hemoptysis in patients with CF in short term.

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