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ASSESSING THE COMPARATIVE OUTCOMES OF BRONCHIAL ARTERY EMBOLIZATION USING POLYVINYL ALCOHOL PARTICLES VERSUS EMBOSPHERES: A RETROSPECTIVE STUDY ON EFFICACY AND SAFETY

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ABSTRACT Bronchial artery embolization (BAE) is a critical procedure in the management of massive and recurrent hemoptysis. The choice of embolic material can significantly influence the outcomes of the intervention. PVA particles are non- spherical and can occlude vessels at various levels, while Embospheres are spherical and calibrated, designed for more targeted embolization. The study will delve into the procedural success rates, incidence of complications, and the need for repeat interventions, thereby guiding clinical decision-making for optimal patient outcomes. In this retrospective randomised controlled study, 61 patients of bronchial artery embolization for hemoptysis belonging to age group of 18-60 years undergoing the procedure were classified into 2 groups of patients each, Group A (with embolization agent polyvinyl alcohol) N=36 and Group B (embospheres) N=25. Group A were embolized by PVA (300–500 μm) and group B received 300–500 μm embospheres. Technical and clinical success were evaluated following the BAE procedure, while during the follow-up phase, the recurrence of hemoptysis and any adverse events were documented. The technical success rates were identical at 100% for both the microspheres group and the PVA group. The clinical success rate was 96.8% in the microspheres group compared to 100.0% in the PVA group (P = 0.165). Hemoptysis recurrence rates at 6 months were 9.7% for the microspheres group and 7.8% for the PVA group (P = 0.681). Similarly, mortality rates at 6 months were 4.8% for the microspheres group and 2.2% for the PVA group (P = 0.374). There were no significant differences in hemoptysis-free survival (P = 0.488) or overall survival (P = 0.321) between the two groups. Moreover, all adverse events were mild, with no significant differences in the occurrence of these events between the groups (all P > 0.05). Embospheres demonstrated similar efficacy and safety profiles to PVA in the BAE treatment of patients with hemoptysis.

KEYWORDS : Hemoptysis, Microspheres, Polyvinyl Alcohol, Bronchial Artery Embolization, Hemoptysis Recurrence,

INTRODUCTION

Bronchial artery embolization (BAE) is a critical procedure in the management of massive and recurrent hemoptysis. The choice of embolic material can significantly influence the outcomes of the intervention. Polyvinyl alcohol (PVA) particles and Embospheres are two commonly used embolic agents, each with distinct physical characteristics that may impact their efficacy and safety profile. PVA particles are non- spherical and can occlude vessels at various levels, while Embospheres are spherical and calibrated, designed for more targeted embolization. This retrospective study aims to compare the efficacy and safety of PVA particles and Embospheres in BAE, providing valuable data for interventional radiologists in selecting the appropriate embolic material. The study will delve into the procedural success rates, incidence of complications, and the need for repeat interventions, thereby guiding clinical decision- making for optimal patient outcomes.

MATERIAL AND METHODS

This retrospective comparative study was carried out on patients of Department of Interventional Radiology at a tertiary level care hospital in the Himalayan region from November 2023 to May 2024. A total 61 adult subjects (both male and females) of aged ≥ 18, years were for in this study.

Study Duration: November 2023 to May 2024.
Sample Size: 61 patients.
Sample Size Calculation: A total of 61 patients were selected for a retrospective study on bronchial artery embolization (BAE) because they met our specific inclusion criteria. These criteria ensured that only patients with confirmed hemoptysis, aged 18 or older, and scheduled for BAE treatment using polyvinyl alcohol (PVA) or microspheres were included. By adhering to these stringent criteria, we aimed to maintain the study's integrity and ensure that the results would be both relevant and reliable for this particular patient population. This careful selection process was crucial for obtaining accurate and meaningful data on the efficacy and safety of BAE in treating hemoptysis.
Subjects & Selection Method: The study population was drawn from patients who presented to Hospital with hemoptysis and underwent the procedure of bronchial artery embolization using either polyvinyl alcohol or embospheres between from November 2023 to May 2024. Patients were divided into two groups on the basis of embolic agent given -
Group A (N=36 patients) – polyvinyl alcohol (300–500 μm particle size) Group B (N=25 patients) – embospheres (300–500 μm particle size)

Inclusion Criteria:
1. Patients who underwent BAE for hemoptysis
2. Age 18 years or older
3. Complete medical and follow-up records available.
4. Use of PVA particles or Embospheres as the embolic agent

Exclusion Criteria:
1. Patients with incomplete data
2. BAE performed for indications other than hemoptysis
3. Previous lung surgery or transplantation
4. Patients with non-bronchial systemic collaterals
5. Previous BAE with different embolic materials
6. Lack of follow-up data

Procedure Methodology
Bronchial artery embolization (BAE) is a minimally invasive procedure designed to control hemoptysis (bleeding from the lungs). The process begins with a comprehensive pre-procedural evaluation, including clinical assessment, chest X-ray, thoracic computed tomography angiography (CTA), and bronchoscopy.

Upon admission, patients received necessary routine treatments such as oxygen inhalation, electrocardiogram monitoring, and hemostasis drugs. Routine examinations, including computerized tomography (CT) and bronchoscopy, were conducted to confirm the etiology. Prior to BAE, all patients underwent CT Chest to identify any lesion associated with the offending vessels causing hemoptysis.

The patients were positioned in DSA cathlab and local anesthesia was administered at the right femoral head region. A small incision is made to access the right femoral artery. A 6 French sheath is inserted to facilitate the introduction of selective catheters..

Guided by DSA, a 5F multipurpose MPA1 catheter was selectively

inserted into the offending vessels at various angles using a modified Seldinger technique. Digital Subtraction Angiography (DSA) was done using non ionic contrast medium. Under fluoroscopic guidance, the catheter was navigated to the bronchial arteries. The left main stem bronchus often served as a landmark. A selective bronchial arteriogram was performed to identify the bleeding site, characterized by abnormal angiographic findings such as tortuosity, hypervascularity, hypertrophy, extravasation, aneurysms, or shunting. BAE was performed using coaxial microcatheter technology under DSA guidance. To cannulate the small culprit vessel, a microcatheter and micro guide wire are employed. These tools allow for precise navigation and embolization of the target vessel. The procedure was conducted under digital subtraction angiography (DSA), ensuring real-time imaging and accuracy. Continuous monitoring of the patient's vital signs was maintained throughout the procedure to ensure safety and immediate response to any complications. A 2.7 F microcatheter was super-selectively inserted into the offending vessels with the help of a micro-guide wire. Once confirmed by DSA, the offending vessels were embolized using PVA (300–500 μm) or embospheres (300–500 μm). Once the bleeding site is identified, embolic agents are introduced through the catheter to occlude the abnormal vessels. Common embolic materials include polyvinyl alcohol (PVA) particles (300-500 μm), microspheres, gelatin sponge, thrombin, coils, and glue. The choice of embolic agent depends on the specific clinical scenario and the interventional radiologist's preference.

The procedure was deemed technically successful when all problematic vessels, including both bronchial and non-bronchial systemic arteries, were fully embolized. Clinically, success was marked by either a complete stop or a reduction of over 50% in hemoptysis during the hospital stay following bronchial artery embolization (BAE). Patients were closely monitored daily for hemoptysis and any adverse events while in the hospital. After discharge, they received regular follow-ups via phone or clinical visits to track hemoptysis, survival, and any side effects. Hemoptysis-free survival was calculated from the BAE date until hemoptysis recurrence or death, while overall survival was measured until death from the BAE date. To compare clinical features between the groups, Student's t test, Chi-square test, Fisher's exact test, or Wilcoxon rank sum test were used. Differences in technical success rate, clinical success rate, hemoptysis recurrence rate, mortality, and adverse events were assessed using Chi-square or Fisher's exact test. Kaplan–Meier curves illustrated hemoptysis-free and overall survival, with differences analyzed by log-rank test. A P value < 0.05 indicated statistical significance.

RESULTS

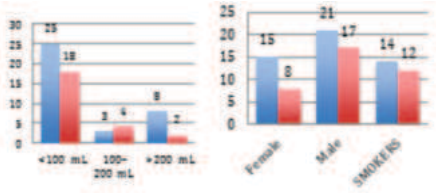
A total of 61 patients were analysed that underwent bronchial artery embolization using PVA or embosphere particles. The average age of patients was 56.1±11.5 years with 38 males (62.2%) with 23 females (37.7%). In Group A, the PVA group, the average age was 54.4□±□10.9 years, with 15 females (41.6%) and 21 males (58.8%). In contrast, the group B with embospheres as embolic agent had an average age of 57.8□±□ 12.2 years, with 8 females (32%) and 17 males (68%) (Table 1). There were no significant differences between the microspheres and PVA groups in terms of age, gender, smoking history, drinking history, etiology, comorbidities, hemoptysis volume, or offending vessels (all P>0.05). More detailed clinical characteristics are provided in Table.

Table No 1 : Shows Metabolic Parameters Of Patients Of The Three Groups Before Treatment.

Items	PVA group (N=36)	Microspheres group (N=25)	P value
Demographic characteristics			
Age (years), mean±SD	54.4±10.9	57.8±12.2	-
Gender, No. (%)			
Female	15	8	15
Male	21	17	21
History of smoking, No. (%)	14	12	14
History of drinking, No. (%)	10	12	10
Etiology, No. (%)			
Bronchiectasis	1	0	1
Tuberculosis	29	21	29
Diffuse lesions in bilateral lungs	1	2	1
Hypertension	7	4	7
COPD	6	5	6
Chronic bronchitis	2	1	2
Diabetes mellitus	5	3	5
Hemoptysis volume, No. (%)			
<100 mL	25	18	25
100–200 mL	3	4	3
>200 mL	8	2	8
Offending vessels, No. (%)			
Bilateral BA	8	7	0.682
Right BA	10	10	0.162
Left BA	12	7	0.043
Venous Shunt	1	0	
IMMIDIATE POST PROCEDURE HEMETEMESIS			
· AVG COST OF PROCEDURE	40000	70000	
· COMPLICATIONS IF ANY	7	3	

Case Study

Both the microspheres and PVA groups achieved a technical success rate of 100.0%. The clinical success rates were also comparable, with the microspheres group at 96.8% and the PVA group at 100.0% (P□=□0.165). Additionally, the 6-month hemoptysis recurrence rates were similar between the microspheres group (9.7%) and the PVA group (7.8%) (P□=□0.681). Regarding mortality, the microspheres group showed comparable 6-month (4.8% vs. 2.2%, P□=□0.374) mortality rates compared to the PVA group. Further multivariate logistic regression analysis confirmed that the type of group (microspheres vs. PVA) was not associated with hemoptysis recurrence risk (P□=□0.669) or mortality risk (P□=□0.693).



Technical success, clinical success, hemoptysis recurrence rates. Comparison of technical success rate (A), clinical success rate (B) and hemoptysis recurrence rate (C) between microspheres group and PVA group. PVA, polyvinyl alcohol

Table No2

Items	PVA group (N=36)	Microspheres group (N=25)	P value
Cough/expectoration	12 (33.3)	6 (24)	0.394
Fever	4 (4.4)	8 (12.9)	0.071
Chest discomfort	5 (5.6)	3 (4.8)	1.000
Nausea/vomiting	2 (2.2)	0 (0.0)	0.514
Abdominal pain	1 (1.1)	0 (0.0)	1.000
Poor appetite and fatigue	1 (1.1)	0 (0.0)	1.000
Ecchymosis at the puncture site	0 (0.0)	1 (1.6)	0.408
Allergy and dyspnea	1 (1.1)	0 (0.0)	1.000

In both the microspheres and polyvinyl alcohol (PVA) groups, adverse events were common but well-tolerated (see Table 6). Notably, there were no statistically significant differences between the two groups in terms of cough/expectoration (P=0.394), fever (P=0.071), chest discomfort (P=1.000), nausea/vomiting (P=0.514), abdominal pain (P=1.000), poor appetite and fatigue (P=1.000), ecchymosis at the puncture site (P=0.408), or allergy and dyspnea (P=1.000).

Based on the etiology of hemoptysis, patients were divided into two subgroups: those with tuberculosis (n = 50) and those with other causes (n = 11). Among tuberculosis patients, there were no significant differences between the embospheres group and the PVA group in terms of technical success rate, clinical success rate, hemoptysis recurrence rate, hemoptysis-free survival, overall survival, or adverse events (all P > 0.05).

Similarly, in patients with other etiologies, no significant differences were observed between the embospheres group and the PVA group regarding technical success rate, clinical success rate, hemoptysis recurrence rate, mortality, overall survival, or adverse events (all P > 0.05). However, hemoptysis-free survival was notably lower in the microspheres group compared to the PVA group (P = 0.030). Cost played a strategic role, as embospheres were approximately 1.75 times more expensive than PVA.

DISCUSSION

Hemoptysis refers to the expectoration of blood originating from the lower respiratory tract. It can be life-threatening or non-life-threatening. Common causes include acute bronchitis, bronchiectasis, and bronchial neoplasms. In developed countries, malignancy, pneumonia/lung abscess, and bronchiectasis are prevalent causes. In contrast, developing countries often see infections due to Mycobacterium tuberculosis and Paragonimus westermani. The volume of hemoptysis is crucial for risk assessment. Larger volumes of fresh red blood are more concerning, especially if there is an acute-onset or accelerating pattern.

There is a pivotal role of Bronchial Artery Embolization (BAE) in management of Hemoptysis. BAE is a game-changing intervention. The bronchial arteries, although responsible for only 2% of total lung vascular supply, cause life-threatening hemoptysis in 90% of cases. BAE selectively occludes these high-pressure bronchial arteries, reducing the need for high-risk emergency lung resections. It is effective in stopping bleeding during the initial admission and offers long-term success. BAE has become a valuable adjunct to control bronchial bleeding2.

Polyvinyl alcohol (PVA) particles are permanent embolic agents used in interventional radiology. When injected, PVA particles adhere to vessel walls, activating the coagulation cascade and leading to thrombus formation. Their advantages include permanence, cost-effectiveness, and ease of use. However, they can inadvertently embolize end organs and aggregate within microcatheters. PVA particles come in different sizes (ranging from 90 to 2800 μm) and require rehydration before injection.

Embospheres are microspheres used in BAE. They offer an alternative to PVA particles. Unlike PVA, embospheres have symmetrical sizes (e.g., 700–900 μm). A retrospective study compared 500–750 μm and 700–900 μm embospheres in bronchiectasis-related hemoptysis. Both sizes showed similar efficacy and safety profiles, with no major complications. However, the larger embospheres were associated with reduced costs.

Polyvinyl alcohol (PVA) particles offer several advantages. They are permanent, cost-effective, and easy to handle. However, they come with risks, including the potential for end organ embolization, aggregation, and recanalization.

On the other hand, embospheres have symmetrical sizes, making them effective and safe for use. However, they tend to be costlier than PVA particles.

In our study, we observed comparable 6-month (PVA vs. embospheres: 9.7% vs. 7.8%) hemoptysis recurrence rates between bronchial artery embolization (BAE) using embospheres and BAE using polyvinyl alcohol (PVA). Interestingly, our study reported slightly lower hemoptysis recurrence rates compared to previous data, where BAE recurrence rates ranged from 10% to 29%[26]. Possible reasons for this discrepancy include our relatively short follow-up duration and the exclusion of lung cancer patients, who are at higher risk of bleeding recurrence [29, 30].

Previous evidence suggests that PVA particles tend to aggregate more than embospheres, potentially leading to premature embolization proximal to the intended vascular level and contributing to long-term hemoptysis recurrence risk [14]. Surprisingly, our study did not find an increased hemoptysis recurrence rate with PVA compared to embospheres, possibly due to our small sample size and limited follow-up. Moreover, recurrent hemoptysis is primarily influenced by factors such as incomplete vessel embolization, collateral revascularization, and progression of underlying pulmonary disease, rather than the specific embolic agent used [14].

Subgroup analysis revealed no significant differences in clinical success rates, hemoptysis recurrence rates, or overall survival between PVA and embospheres in patients with tuberculosis or other etiologies. However, in the subgroup of patients with other etiologies, hemoptysis-free survival was higher in those receiving BAE with PVA, likely influenced by our relatively small sample size.

As for adverse events, both PVA and embospheres showed similar incidence rates, and the main adverse events were relatively minor and well-tolerated. These included cough, fever, chest discomfort, nausea, abdominal pain, fatigue, ecchymosis at the puncture site, and allergic reactions. These findings align with previous studies, emphasizing the safety profile of BAE procedures [31]. Factors contributing to the absence of major complications include the appropriate size of PVA and microspheres (300–500 μm), which prevents distal occlusion of normal peripheral branches, and the use of routine CTBA evaluation combined with angiography to identify spinal collaterals during the procedure.

CONCLUSION

In summary, the choice between PVA particles and embospheres depends on individual patient factors, cost considerations, and procedural preferences. Both agents play a crucial role in bronchial artery embolization for managing hemoptysis.

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