Respiratory Research

RESEARCH

Open Access

Multi-drug resistant Pseudomonas aeruginosa isolation is an independent risk factor for recurrent hemoptysis after bronchial artery embolization in patients with idiopathic bronchiectasis: a retrospective cohort study

Jibo Sun[1,2†], Xiang Tong[1,2†], Dongguang Wang[1,2], Lian Wang[1,2], Shijie Zhang[1,2], Sitong Liu[1,2], Xiu Li[1,2], Qingqing Jia[1,2], Jiehao Chen[3], Yao Ma[4*] and Hong Fan[1,2*]

Abstract

Background Currently, there is a lack of research on multi-drug resistant Pseudomonas aeruginosa (MDR-PA) isolation in bronchiectasis-related hemoptysis. The aim of this study to analyze the risk factors for recurrent hemoptysis following bronchial artery embolization (BAE) and compare the recurrent hemoptysis-free rates between MDR-PA, non-MDR-PA, and non-PA isolation.

Methods A retrospective study was performed of patients diagnosed with idiopathic bronchiectasis-related recurrent hemoptysis who underwent BAE at an university-affiliated hospital. Patients were categorized based on PA susceptibility tests into non-PA, non-MDR-PA, and MDR-PA groups. Univariate and multivariate Cox regression were conducted to identify independent risk factors for recurrent hemoptysis. The Kaplan-Meier curves was conducted to compare recurrent hemoptysis-free rates after BAE for non-PA, non-MDR-PA, and MDR-PA.

Results A total of 432 patients were included. 181 (41.90%) patients experienced recurrent hemoptysis during a median follow-up period of 25 months. MDR-PA isolation (adjusted hazard ratio (aHR) 2.120; 95% confidence interval (CI) [1.249, 3.597], $p=0.005$) was identified as an independent risk factor for recurrent hemoptysis. Antibiotic treatment (aHR 0.666; 95% CI [0.476, 0.932], $p=0.018$) reduced the risk of recurrent hemoptysis. The cumulative recurrent hemoptysis-free rates for non-PA, non-MDR-PA, and MDR-PA were as follows: at 3 months, 88.96%, 88.24%, and 75.86%, respectively; at 1 year, 73.13%, 69.10%, and 51.72%; and at 3 years, 61.91%, 51.69%, and 41.10% ($p=0.034$).

†Jibo Sun and Xiang Tong contributed equally to this work.

*Correspondence:
Yao Ma
mayao623@scu.edu.cn
Hong Fan
fanhong@scu.edu.cn

Full list of author information is available at the end of the article

Conclusion MDR-PA isolation was an independent risk factor of recurrent hemoptysis post-BAE. Reducing the occurrence of MDR-PA may effectively decrease the recurrence rates of hemoptysis.

Keywords MDR-PA, Isolation, Recurrent hemoptysis, BAE, Bronchiectasis

Background

Bronchiectasis is a chronic respiratory disease characterized by chronic cough, purulent sputum, and recurrent hemoptysis [1], with high global prevalence and economic burden [2]. Major aetiologies include post-infection, post-tuberculosis, chronic obstructive pulmonary disease(COPD), and the most common is idiopathic [3, 4].A national study in France showed that 6.8% of hemoptysis in adult patients was caused by bronchiectasis, second only to respiratory infections and lung cancer [5]. Severe hemoptysis is a life-threatening condition associated with frequent hospitalizations and increased mortality [6]. The previous studies have shown the incidence of severe hemoptysis in patients with bronchiectasis ranges from 2.2-16.09% [7, 8].

Bronchial artery embolization (BAE) is minimally invasive and highly effective as major treatment for bronchiectasis-related hemoptysis [6, 9]. However, recurrent hemoptysis still occurs in 17.5 to 46.9% of patients with idiopathic bronchiectasis after BAE [10, 11]. And there is a lack of investigations on recurrent hemoptysis after BAE currently. Yan et al. [10] reported that lung destruction and systemic arterial-pulmonary circulation shunts were important predictors of recurrent hemoptysis. A multicenter study showed Pseudomonas aeruginosa (PA) isolation and ectopic aberrant bronchial arteries (AbBAs) on computed tomography angiography(CTA) were risk factors for recurrent hemoptysis [11], which provided a new perspective in studying the role of pathogens in recurrent hemoptysis after BAE. PA is a leading global bacteria that is increasingly becoming multi-drug resistant (MDR) [12]. Previous research confirmed PA is strongly associated with recurrent hospitalization, decreased lung function and increased mortality in patients with bronchiectasis [13–15]. Nevertheless, there is still a lack of studies on the role of MDR-PA in recurrent hemoptysis post-BAE in patients with idiopathic bronchiectasis.

Therefore, the aim of this study was to analyze the risk factors for recurrent hemoptysis after BAE for patients with idiopathic bronchiectasis-related hemoptysis and to compare the recurrent hemoptysis-free rates of MDR-PA, non-MDR-PA and non-PA.

Methods

Study design and population

This retrospective analysis was conducted on the clinical data of patients diagnosed with idiopathic bronchiectasis-related hemoptysis who underwent BAE at the West China Hospital of Sichuan University from January 2018 to December 2022. Bronchiectasis was defined according to Hill et al. [16]. The inclusion criteria were as follows: a) patients aged 18 years or older; b) idiopathic bronchiectasis-related hemoptysis; c) BAE for patients with hemoptysis > 100mL/d or who have failed conservative management [10]. The following exclusion criteria were applied: (a) missing clinical data or lost to follow-up; (b) absence of chest CTA; (c) without qualified sputum or bronchoalveolar lavage fluid (BALF) culture; (d) patients cannot tolerate BAE due to poor cardiopulmonary function or comorbidities. Based on the PA susceptibility test, we categorized patients into the "non-PA", "non-PA-MDR" and "PA-MDR".

Data collection

The clinical information was extracted from electronic medical records in hospitalized patients. Clinical data included patient demographics (age, gender), comorbidities (e.g. diabetes, chronic obstructive pulmonary disease, asthma), hemoptysis grade, radiological findings, and microbiological culture. Microorganisms isolated from sputum or BALF cultures included PA, Klebsiella pneumoniae, Acinetobacter baumannii, Escherichia coli, Haemophilus influenzae, Staphylococcus aureus, and Candida. The sputum was qualified with < 10 epithelial cells/ low-power field [lpf] and > 25 white blood cells /lpf [17].

Procedure

All operations were performed by experienced interventionalists under local anesthesia. Vascular hypertrophy, tortuosity, or proliferation, systemic arterial-pulmonary circulation shunts, and contrast extravasation were considered as abnormal angiographic signs [6]. All patients underwent preoperative chest CTA to initially identify the abnormal arteries. The exact location of the lesion was confirmed by 4-Fr or 5-Fr catheter angiography of the femoral arteries under digital subtraction angiography. The polyethylene glycol particles were utilized for super-selective embolization of related arteries. Procedure success was defined as successful embolization of the lesions of vessel, with no obvious distal vascular signs on angiography, and no serious procedure-related complications.

Definitions

The recurrent hemoptysis was defined as the occurrence of hemoptysis requiring medical intervention (e.g.

medicine, hospitalization, or BAE) following an initial successful BAE procedure, including mild, moderate, massive. The grade of hemoptysis was defined according to previous studies [18, 19]. MDR was defined according to established guidelines, encompassing resistance to at least one agent in three or more antimicrobial categories [20].

Statistical analysis

All statistical analysis was performed using R(version 4.2.3), with significance set at $p<0.05$. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as means±standard deviations or medians with interquartile ranges(IQR). The categorical variables were compared by Chi-square tests and Fisher's exact tests, while Kruskal-Wallis tests were employed for continuous variables. Univariate and multivariate Cox regression analysis were performed to identify independent predictors of recurrent hemoptysis post-BAE. The Kaplan-Meier curves was conducted to compare incidence of recurrent hemoptysis for non-PA, non-MDR-PA, and MDR-PA.

Results

Patient characteristics

A total of 432 patients were enrolled in this study, including 335 in the non-PA, 68 in the non-MDR-PA, and 29 in the MDR-PA (Fig. 1). The median age was 57.0 (49.4–65.7) years, with an average body mass index (BMI) of 21.30 kg/m^2 (19.05–23.31), and 52.55% was male. The median duration of hemoptysis was 4.5 years (range: 0.16-12.0 years). Specifically, the median duration in the non-MDR-PA group (10 years) was significantly longer than in the non-PA (3 years) and MDR-PA (7 years) groups ($p<0.001$). The common comorbidities included hypertention (16.20%), diabetes (11.81%), COPD (12.73%), and asthma (2.08%). 344 patients (79.63%) received antibiotic treatment after BAE ($p=0.311$). Before BAE, 111 (25.69%) patients experienced massive hemoptysis. There were no significant differences in the grades of hemoptysis among the three groups pre- and post-procedure. Chest computed tomography (CT) scans revealed bilateral lung lesions in 177 (40.97%), with ectopic AbBAs on CTA in 91 (21.06%). The non-PA, non-MDR-PA and MDR-PA were not statistically significant in radiology findings. The median length of hospital stay for patients was 10 days, with the MDR-PA demonstrating a higher median length of hospital stay (13 days) compared to the Non PA (10 days) and the non-MDR-PA

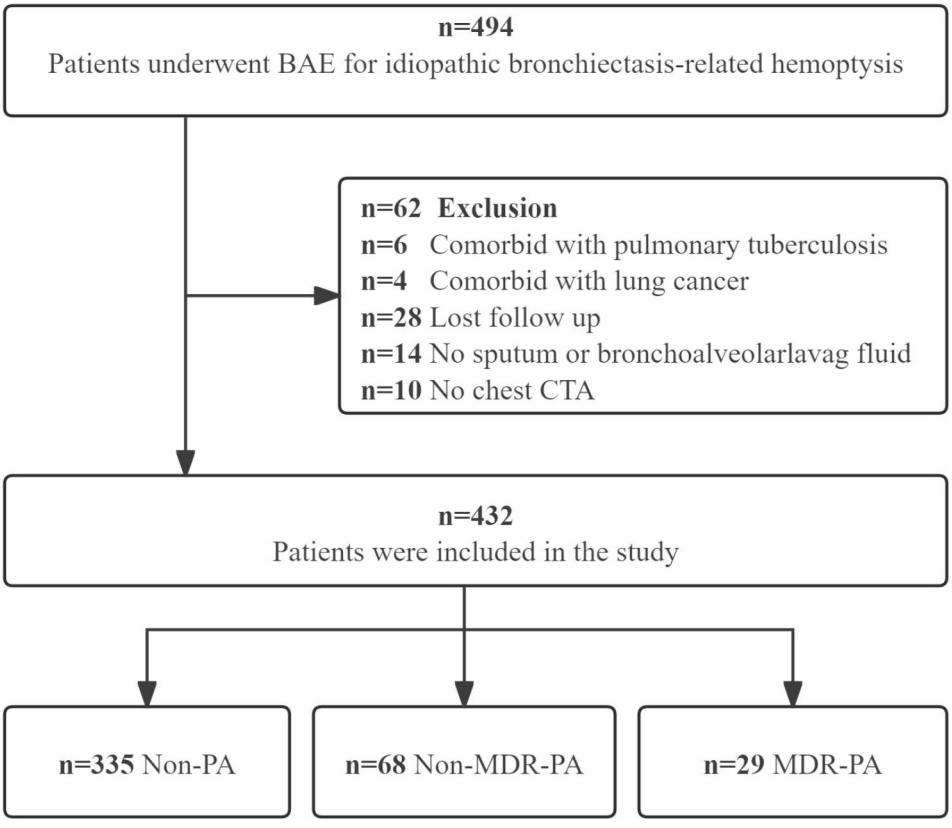

Fig. 1 Flow chart of the selected population. PA, Pseudomonas aeruginosa; MDR, multi-drug resistant

(10 days) ($p=0.013$). Population characteristics show in Table 1.

Microbiology

A total of 381 (88.19%) culture specimens were obtained from sputum. Microorganisms were isolated from sputum or BALF in 235 (54.40%) patients. Among bacteria, PA was the most commonly isolated pathogen, accounting for 22.45% (97) of cases. Notably, 6.71% (29) of PA isolates were identified as MDR-PA. Other common bacteria included 16 (3.70%) Escherichia coli, 15 (3.47%) Acinetobacter baumannii, 9 (2.08%) Klebsiella pneumoniae. The most common fungus was Candida albicans, identified in 66 (15.28%) cases. The detailed characteristics are presented in Table 2.

Risk factors of recurrent hemoptysis

Univariate Cox regression analysis identified several potential predictors of recurrent hemoptysis post-BAE, including MDR-PA isolation (hazard ratio (HR) 1.910 ;95% confidence interval (CI) [1.135, 3.216]; $p=0.015$), antibiotic treatment (HR 0.614 ;95% CI [0.442, 0.853]; $p=0.004$),moderate hemoptysis (HR 1.761 ;95% CI [1.246, 2.488]; $p=0.001$), ectopic AbBAs on CTA (HR 2.359 ;95% CI [1.726, 3.224]; $p<0.001$), duration of hemoptysis (HR 1.017; 95% CI [1.006, 1.028]; $p=0.002$), and BMI (HR 0.944 ;95% CI [0.901, 0.989]; $p=0.016$) (Fig. 2A). Multivariate Cox regression analysis further confirmed MDR-PA isolation (adjusted hazard ratio (aHR) 2.120; 95% CI [1.249, 3.597], $p=0.005$), moderate hemoptysis (aHR 1.710; 95% CI [1.203, 2.432]; $p=0.003$), and ectopic AbBAs on CTA (aHR 2.212; 95% CI [1.605, 3.048]; $p<0.001$) as independent risk factors of recurrent hemoptysis post-BAE. Antibiotic treatment (aHR 0.666; 95% CI [0.476, 0.932], $p=0.018$) reduced the risk of recurrent hemoptysis (Fig. 2B).

Cumulative recurrent hemoptysis-free rates

During a median follow-up period of 25 months (IQR 11–43 months), 181 patients (41.90%) experienced recurrent hemoptysis. This included 124 cases (28.70%) of mild, 40 cases (9.26%) of moderate, and 17 cases (3.94%) of massive hemoptysis post-procedure (Table 1). Kaplan-Meier curves were used to compare the cumulative recurrent hemoptysis-free rates after BAE among patients in the non-PA, non-MDR-PA, and MDR-PA groups. The results showed that patients with MDR-PA isolates had lower recurrent hemoptysis-free rates ($p=0.034$) (Fig. 3). The cumulative recurrent hemoptysis-free rates for non-PA, non-MDR-PA, and MDR-PA were as follows: at 3

Table 1 The characteristics of included patients

Variables	All patients (*N* = 432)	Non-PA (*N* = 335)	Non-MDR-PA (*N* = 68)	MDR-PA (*N* = 29)	*P* value
Demographics					
Age(years), median (IQR)	57.0 (49.4–65.7)	56.7 (48.8–65.2)	58.62 ± 11.37	60.33 ± 11.88	0.331
Male	227 (52.55%)	181 (54.03%)	32 (47.06%)	14 (48.28%)	0.515
BMI(kg/m^2)	22.32 (20.57–23.76)	22.32 (20.81–23.80)	21.80 (20.10-23.88)	22.37 ± 3.52	0.275
Smokers and ex-smokers	72 (16.67%)	59 (17.61%)	8 (11.76%)	5 (17.24%)	0.497
Duration of hemoptysis(years)	4.5 (0.16-12.0)	3.0 (0.10–10.0)	10.0 (1.0–25.0)	7.0 (5.0–12.0)	< 0.001
Comorbidities					
Hypertention	70 (16.20%)	59 (17.61%)	8 (11.76%)	3 (10.34%)	0.331
Diabetes	51 (11.81%)	38 (11.34%)	8 (11.76%)	5 (17.24%)	0.640
COPD	55 (12.73%)	41 (12.24%)	10 (14.71%)	4 (13.79%)	0.843
Asthma	9 (2.08%)	8 (2.39%)	1 (1.47%)	0 (0.00%)	0.639
Antibiotic treatment	344 (79.63%)	265 (79.10%)	58 (85.29%)	21 (72.41%)	0.311
Hemoptysis (Pre-BAE)					0.648
Mild	161 (37.27%)	124 (37.01%)	25 (36.76%)	12 (41.38%)	
Moderate	160 (37.04%)	123 (36.72%)	29 (42.65%)	8 (27.59%)	
Massive	111 (25.69%)	88 (26.27%)	14 (20.59%)	9 (31.03%)	
Hemoptysis (Post-BAE)					0.449
No	251 (58.10%)	203(60.60%)	35 (51.47%)	13(44.83%)	
Mild	124 (28.70%)	88 (26.27%)	25 (36.76%)	11 (37.93%)	
Moderate	40 (9.26%)	30 (8.96%)	6 (8.82%)	4 (13.79%)	
Massive	17 (3.94%)	14 (4.18%)	2 (2.94%)	1 (3.45%)	
Radiology findings					
Involved double-lung	177(40.97%)	129 (38.51%)	34(50%)	14 (48.28%)	0.152
Ectopic AbBAs on CTA	91 (21.06%)	74 (22.09%)	12 (17.65%)	5 (17.24%)	0.624
Lengths of hospital stay, median (IQR)	10 (8–13)	10 (8–13)	10 (8–12)	13 (9–15)	0.013

MDR-PA, multi-drug resistant Pseudomonas aeruginosa; IQR, interquartile range; BMI, body mass index; COPD, chronic obstructive pulmonary disease; BAE, bronchial artery embolization; AbBAs, aberrant bronchial arteries; CTA, computed tomography angiography

Table 2 Microbiological characteristics of patients

Variables	All patients (*N* = 432)	Non-PA (*N* = 335)	Non-MDR-PA (*N* = 68)	MDR-PA (*N* = 29)	*P* value
Culture specimen					0.655
Sputum	381 (88.19%)	298 (88.96%)	58 (85.29%)	25 (86.21%)	
Bronchoalveolar lavage fluid	51 (11.81%)	37 (11.04%)	10 (14.71%)	4 13.79%)	
Culture-positive	235 (54.40%)	138 (41.19%)	68 (100.00%)	29 (100.00%)	-
Bacteria					
Pseudomonas aeruginosa	97 (22.45%)	-	68 (100.00%)	29 (100.00%)	-
MDR-PA	29 (6.71%)	-	-	29 (100.00%)	-
Escherichia coli	16 (3.70%)	13 (3.88%)	2 (2.94%)	1 (3.45%)	0.930
Acinetobacter baumannii	15 (3.47%)	13 (2.25%)	0 (1.39%)	2 (6.90%)	0.163
Klebsiella pneumoniae	9 (2.08%)	9 (2.69%)	0 (0.00%)	0 (0.00%)	0.264
Staphylococcus aureus	4 (0.93%)	4 (1.19%)	0 (0.00%)	0 (0.00%)	0.557
Haemophilus influenzae	1 (0.23%)	1 (0.30%)	0 (0.00%)	0 (0.00%)	0.865
Candida					
Candida albicans	66 (15.28%)	45 (13.43%)	14 (20.59%)	7 (24.14%)	0.127
Candida glabrata	6 (1.39%)	5 (1.49%)	1 (1.47%)	0 (0.00%)	0.803
Candida tropicalis	5 (1.16%)	3 (0.90%)	2 (2.94%)	0 (0.00%)	0.296

MDR-PA, multi-drug resistant Pseudomonas aeruginosa

months, 88.96%, 88.24%, and 75.86%, respectively; at 1 year, 73.13%, 69.10%, and 51.72%; at 2 years, 66.30%, 55.55%, and 41.10%; and at 3 years, 61.91%, 51.69%, and 41.10%. During the follow-up period, 16 patients died. The causes of death included 4 from massive hemoptysis, 5 from severe pneumonia, 5 from lung cancer, 1 from cerebral hemorrhage, and 1 from colon cancer.

Discussion

The key findings of this study are as follows. First, MDR-PA isolation is an independent risk factor for recurrent hemoptysis. Second, non-MDR-PA isolation is not associated with an increased risk of recurrent hemoptysis, a result that has not been revealed in previous studies. Third, antibiotic treatment reduces the risk of recurrent hemoptysis.

To our knowledge, this is the first study to explore the role of MDR-PA isolation in the recurrence of hemoptysis after BAE in patients with bronchiectasis. Our findings indicate that the risk of recurrent hemoptysis with MDR-PA isolation is approximately twice that of non-PA. Additionally, non-MDR-PA isolation was not associated with an increased risk of recurrent hemoptysis. This finding differs from previous studies by Wang et al. [11], which indicated that PA increased the risk of recurrent hemoptysis. However, they did not differentiate between MDR and non-MDR PA, which may have exaggerated the role of non-MDR-PA isolation. PA can lead to chronic infection, increased inflammation, and subsequent damage to bronchial structures [13, 21]. A recent prospective study indicates that the presence of PA is significantly associated with airway neutrophilic inflammation, including interleukin (IL)-1β, IL-8,tumor necrosis factor-alpha, and increased severity of bronchiectasis [22]. One notable characteristic of PA is its tendency to form biofilms [23]. This biofilm formation involves intricate structural arrangements that protect the bacteria from conventional antibiotic treatment and contributes to the emergence of multidrug-resistant strains, complicating treatment and patient outcomes [24, 25]. PA-resistant strains, being among six major pathogens, were responsible for more than 250,000 deaths linked to antibiotic resistance in 2019 [26]. Previous research has indicated a significant correlation between PA-MDR and an increased 3-year mortality in patients with bronchiectasis [27]. Although eradication therapy for PA is recommended [28], MDR-PA presents significant challenges to eradication due to its robust biofilm formation and genetic adaptability [29, 30]. A vicious cycle of airway inflammation and infection further worsens clinical symptoms and increases airway damage, thereby predisposing patients to recurrent hemoptysis. Consequently, the persistent presence of MDR-PA greatly increases the risk of recurrent hemoptysis. Strict control of antibiotic use to reduce the emergence of MDR-PA is therefore a critical factor in managing recurrent hemoptysis in patients with bronchiectasis. Our study also showed that antibiotic treatment effectively reduces the risk of recurrence of hemoptysis, thereby highlighting the importance of eradicating PA. Furthermore, this study revealed that ectopic AbBAs on CTA were significant predictors of recurrent hemoptysis, highlighting the importance of thorough radiological assessment. In 2023, a prospective multicenter study also confirmed that ectopic AbBAs on CTA were important predictors for recurrent hemoptysis [11], which is consistent with our findings. Moreover, moderate hemoptysis was a predictor for recurrence, although the precise

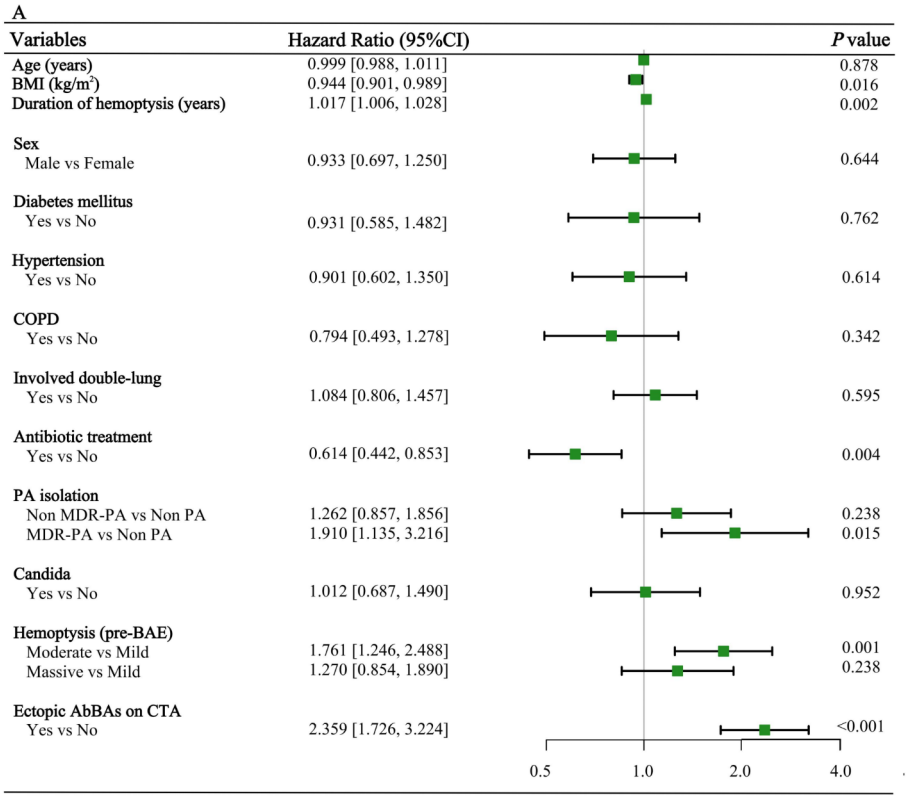

Fig. 2 **(A)**Univariate Cox regression of risk factors for recurrent hemoptysis. **(B)**Multivariate Cox regression of risk factors for recurrent hemoptysis. CI, confidence interval; BMI, body mass index; COPD, chronic obstructive pulmonary disease; PA, Pseudomonas aeruginosa; MDR, multi-drug resistant; BAE, bronchial artery embolization; CTA, computed tomography angiography; AbBAs, aberrant bronchial arteries

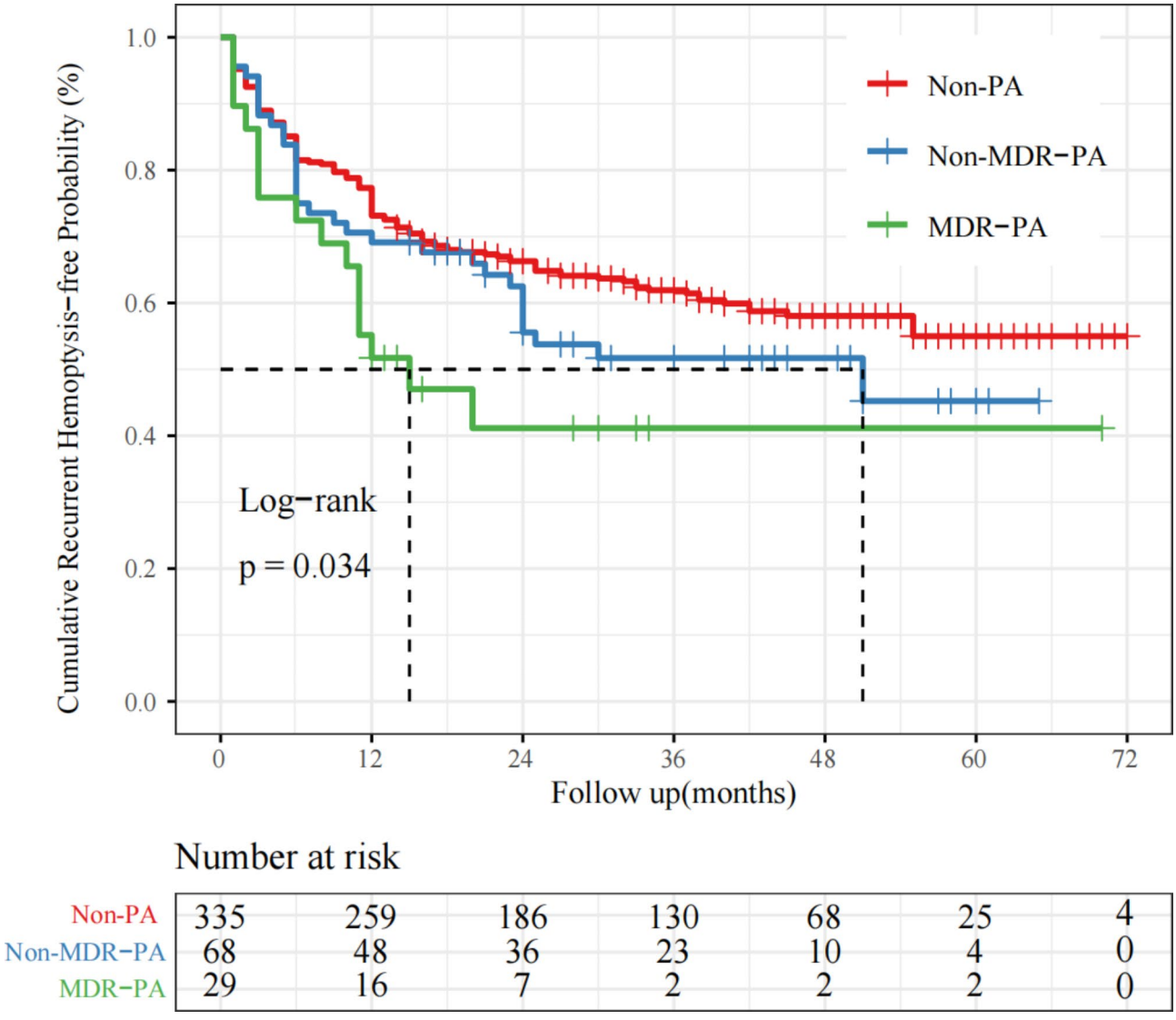

Fig. 3 Kaplan-Meier curves showed recurrent hemoptysis-free rates after BAE for non-PA, non-MDR-PA, and MDR-PA. BAE, bronchial artery embolization; PA, Pseudomonas aeruginosa; MDR, multi-drug resistant

mechanisms remain unclear. Consequently, prospective research is crucial to confirm these findings.

The recurrent hemoptysis rate was 41.90% after BAE in this study. Currently, there is a lack of clinical research on patients with idiopathic bronchiectasis experiencing hemoptysis after BAE. Two previous studies have shown that the recurrence rates of hemoptysis in patients with idiopathic bronchiectasis post-BAE ranged from 17.5 to 45.4%, which is consistent with our findings. The isolation of MDR-PA is associated with lower recurrent hemoptysis-free rates compared to non-PA and non-MDR-PA. The primary reason is the compromised effectiveness in PA clearance due to increased PA resistance. PA infection is associated with persistent and worsening lower airway inflammation [13, 31], which can lead recurrent hemoptysis and compromise treatment outcomes. These findings highlighted the imperative for proactive management approaches in patients with MDR-PA isolation. In our study, the 1-year and 2-year cumulative recurrent hemoptysis-free rates for MDR-PA isolation were 51.72% and 41.10%, respectively. However, previous studies have indicated that the 1-year and 2-year cumulative recurrent hemoptysis-free rates ranged from 67.5 to 90.5% and 57.6–82.8%, respectively [10, 11]. This is significantly higher than the 51.72% and 41.10% observed in MDR-PA isolation, suggesting a higher rate of hemoptysis recurrence with MDR-PA isolation.

This study has several limitations that should be considered. First, the retrospective and single-center nature of the study may have introduced selection bias and limited the generalizability of the findings. Thus, prospective multi-center studies are imperative to validate these

findings and offer a broader perspective on the influence of MDR-PA isolation and other pathogens on recurrent hemoptysis. Second, given the limited sample size of our study, we did not perform a subgroup analysis of recurrent hemoptysis grade after BAE, resulting in no observed differences among major, moderate, and minor hemoptysis outcomes. Subgroup analysis of hemoptysis severity post-BAE in future large-scale studies will be necessary. Third, the study focused on the impact of pathogen isolation on recurrent hemoptysis and did not further conduct a subgroup analysis of abnormal bronchial arteries, thus overlooking the influence on outcomes. Futher research should prioritize investigating the influence of abnormal bronchial arteries on the recurrence of hemoptysis. Finally, the reliance on electronic medical records and telephone follow-ups may have led to incomplete or inaccurate clinical data. Further prospective studies with larger sample sizes and longer follow-up periods are warranted to validate our findings.

Conclusions

In conclusion, MDR-PA isolation, moderate hemoptysis, ectopic AbBAs on CTA, and duration of hemoptysis were independent risk factors for recurrent hemoptysis following BAE in patients with idiopathic bronchiectasis-related hemoptysis. Antibiotic treatment reduced risk of recurrent hemoptysis. Isolation of MDR-PA was associated with lower cumulative recurrent hemoptysis-free rates compared to non-PA and non-MDR-PA. These significant findings suggest that enhancing the management of antibiotic to reduce the emergence of MDR-PA may effectively decrease recurrent hemoptysis rates.

Abbreviations

AbBAs	Aberrant bronchial arteries
aHR	Adjusted hazard ratio
BAE	Bronchial artery embolization
BALF	Bronchoalveolar lavage fluid
BMI	Body mass index
CI	Confidence interval
Coef	Coefficient
COPD	Chronic obstructive pulmonary disease
CT	Computed tomography
CTA	Computed tomography angiography
HR	Hazard ratio
IQR	Interquartile ranges
MDR-PA	Multi-drug resistant Pseudomonas aeruginosa
PA	Pseudomonas aeruginosa

Acknowledgements

None.

Author contributions

JB Sun, X Li, L Wang, QQ Jia, JH Chen and SJ Zhang collected the clinical data. JB Sun, Y Ma, X Tong, and H Fan, contributed to interpretation of results and revision of the manuscript. JB Sun, X Tong, L Wang, DG Wang, ST Liu and Y Ma wrote the manuscript. Y Ma and H Fan supervised the conceptualization, writing, and review process of the article. All authors reviewed and approved the final manuscript.

Funding

This work was supported by 1.3.5 project for disciplines of excellence-Clinical Research Incubation Project, West China Hospital, Sichuan University (2019HXFH008).

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the Ethics Committee on Biomedical Research at the West China Hospital of Sichuan University (No. 2022455). Individual consent for this retrospective analysis was waived.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Department of Pulmonary and Critical Care Medicine, West China Hospital, Sichuan University, Chengdu 610041, China
[2]State Key Laboratory of Respiratory Health and Multimorbidity, Chengdu 610041, China
[3]Animal Laboratory Center, West China Hospital, Sichuan University, Chengdu 610041, China
[4]Department of Geriatrics and National Clinical Research Center for Geriatrics, West China Hospital, Sichuan University, Chengdu 610041, China

Received: 1 June 2024 / Accepted: 20 October 2024
Published online: 26 October 2024

References

1. McShane PJ, Naureckas ET, Tino G, Strek ME. Non-cystic fibrosis bronchiectasis. Am J Respir Crit Care Med. 2013;188(6):647–56.
2. Guan WJ, Han XR, de la Rosa-Carrillo D, Martinez-Garcia MA. The significant global economic burden of bronchiectasis: a pending matter. Eur Respir J 2019, 53(2).
3. Dhar R, Singh S, Talwar D, Mohan M, Tripathi SK, Swarnakar R, Trivedi S, Rajagopala S, D'Souza G, Padmanabhan A, et al. Bronchiectasis in India: results from the European Multicentre Bronchiectasis Audit and Research Collaboration (EMBARC) and Respiratory Research Network of India Registry. Lancet Global Health. 2019;7(9):e1269–79.
4. Aksamit TR, O'Donnell AE, Barker A, Olivier KN, Winthrop KL, Daniels MLA, Johnson M, Eden E, Griffith D, Knowles M, et al. Adult patients with bronchiectasis: a First look at the US Bronchiectasis Research Registry. Chest. 2017;151(5):982–92.
5. Abdulmalak C, Cottenet J, Beltramo G, Georges M, Camus P, Bonniaud P, Quantin C. Haemoptysis in adults: a 5-year study using the French nationwide hospital administrative database. Eur Respir J. 2015;46(2):503–11.
6. Davidson K, Shojaee S. Managing massive Hemoptysis. Chest. 2020;157(1):77–88.
7. Mondoni M, Carlucci P, Job S, Parazzini EM, Cipolla G, Pagani M, Tursi F, Negri L, Fois A, Canu S et al. Observational, multicentre study on the epidemiology of haemoptysis. Eur Respir J 2018, 51(1).
8. Luo L, Luo J, Jiang Y. A retrospective analysis of risk factors for massive hemoptysis in patients with bronchiectasis. BMC Pulm Med. 2022;22(1):214.
9. Kathuria H, Hollingsworth HM, Vilvendhan R, Reardon C. Management of life-threatening hemoptysis. J Intensive care. 2020;8:23.
10. Yan HT, Lu GD, Huang XZ, Zhang DZ, Ge KY, Zhang JX, Liu J, Liu S, Zu QQ, Shi HB. A Nomogram to predict recurrence after bronchial artery embolization for Hemoptysis due to Bronchiectasis. Cardiovasc Intervent Radiol. 2021;44(10):1609–17.

11. Wang LL, Lu HW, Li LL, Gao YH, Xu YH, Li HX, Xi YZ, Jiang FS, Ling XF, Wei W, et al. Pseudomonas aeruginosa isolation is an important predictor for recurrent hemoptysis after bronchial artery embolization in patients with idiopathic bronchiectasis: a multicenter cohort study. Respir Res. 2023;24(1):84.
12. Reyes J, Komarow L, Chen L, Ge L, Hanson BM, Cober E, Herc E, Alenazi T, Kaye KS, Garcia-Diaz J, et al. Global epidemiology and clinical outcomes of carbapenem-resistant Pseudomonas aeruginosa and associated carbapenemases (POP): a prospective cohort study. Lancet Microbe. 2023;4(3):e159–70.
13. Finch S, McDonnell MJ, Abo-Leyah H, Aliberti S, Chalmers JD. A comprehensive analysis of the impact of Pseudomonas aeruginosa colonization on prognosis in Adult Bronchiectasis. Annals Am Thorac Soc. 2015;12(11):1602–11.
14. Pieters A, Bakker M, Hoek RAS, Altenburg J, van Westreenen M, Aerts J, van der Eerden MM. Predicting factors for chronic colonization of Pseudomonas aeruginosa in bronchiectasis. Eur J Clin Microbiol Infect Diseases: Official Publication Eur Soc Clin Microbiol. 2019;38(12):2299–304.
15. Araujo D, Shteinberg M, Aliberti S, Goeminne PC, Hill AT, Fardon TC, Obradovic D, Stone G, Trautmann M, Davis A et al. The independent contribution of Pseudomonas aeruginosa infection to long-term clinical outcomes in bronchiectasis. Eur Respir J 2018, 51(2).
16. Hill AT, Sullivan AL, Chalmers JD, De Soyza A, Elborn SJ, Floto AR, Grillo L, Gruffydd-Jones K, Harvey A, Haworth CS, et al. British thoracic Society Guideline for bronchiectasis in adults. Thorax. 2019;74(Suppl 1):1–69.
17. Wolff BJ, Bramley AM, Thurman KA, Whitney CG, Whitaker B, Self WH, Arnold SR, Trabue C, Wunderink RG, McCullers J, et al. Improved detection of respiratory pathogens by Use of High-Quality Sputum with TaqMan array Card Technology. J Clin Microbiol. 2017;55(1):110–21.
18. Hirshberg B, Biran I, Glazer M, Kramer MR. Hemoptysis: etiology, evaluation, and outcome in a tertiary referral hospital. Chest. 1997;112(2):440–4.
19. Ibrahim WH. Massive haemoptysis: the definition should be revised. Eur Respir J. 2008;32(4):1131–2.
20. Magiorakos AP, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, Harbarth S, Hindler JF, Kahlmeter G, Olsson-Liljequist B, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clin Microbiol Infect. 2012;18(3):268–81.
21. Chalmers JD, Smith MP, McHugh BJ, Doherty C, Govan JR, Hill AT. Short- and long-term antibiotic treatment reduces airway and systemic inflammation in non-cystic fibrosis bronchiectasis. Am J Respir Crit Care Med. 2012;186(7):657–65.
22. Chen YF, Hou HH, Chien N, Lu KZ, Lin CH, Liao YC, Lor KL, Chien JY, Chen CM, Chen CY, et al. The clinical impacts of lung microbiome in bronchiectasis with fixed airflow obstruction: a prospective cohort study. Respir Res. 2024;25(1):308.
23. Sharma S, Mohler J, Mahajan SD, Schwartz SA, Bruggemann L, Aalinkeel R. Microbial Biofilm: a review on formation, infection, Antibiotic Resistance, Control measures, and innovative treatment. Microorganisms 2023, 11(6).
24. Xiu W, Dong H, Chen X, Wan L, Lu L, Yang K, Yuwen L, Li Q, Ding M, Zhang Y, et al. Metabolic modulation-mediated antibiotic and Immune activation for treatment of chronic lung infections. ACS Nano. 2024;18(23):15204–17.
25. Zeng T, Liu S, Zou P, Yao X, Chen Q, Wei L, Wang Q, Zhang C, Zheng Y, Yu R. Create artilysins from a recombinant library to serve as bactericidal and antibiofilm agents targeting Pseudomonas aeruginosa. Int J Biol Macromol. 2024;273(Pt 2):132990.
26. Antimicrobial Resistance C. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. Lancet. 2022;399(10325):629–55.
27. Chang CH, Chang CH, Huang SH, Lee CS, Ko PC, Lin CY, Hsieh MH, Huang YT, Lin HC, Li LF, et al. Epidemiology and outcomes of multidrug-resistant bacterial infection in non-cystic fibrosis bronchiectasis. Ann Clin Microbiol Antimicrob. 2024;23(1):15.
28. Conceicao M, Shteinberg M, Goeminne P, Altenburg J, Chalmers JD. Eradication treatment for Pseudomonas aeruginosa infection in adults with bronchiectasis: a systematic review and meta-analysis. Eur Respir Rev 2024, 33(171).
29. Oliveira VC, Macedo AP, Melo LDR, Santos SB, Hermann PRS, Silva-Lovato CH, Paranhos HFO, Andrade D, Watanabe E. Bacteriophage cocktail-mediated inhibition of Pseudomonas aeruginosa Biofilm on Endotracheal Tube Surface. Antibiot (Basel Switzerland) 2021, 10(1).
30. Amankwah S, Adisu M, Gorems K, Abdella K, Kassa T. Assessment of phage-mediated inhibition and removal of Multidrug-Resistant Pseudomonas aeruginosa Biofilm on Medical implants. Infect drug Resist. 2022;15:2797–811.
31. Vidaillac C, Chotirmall SH. Pseudomonas aeruginosa in bronchiectasis: infection, inflammation, and therapies. Expert Rev Respir Med. 2021;15(5):649–62.

Publisher's note