

Hemorrhage Risk of Patients Receiving Bronchoscope Examination or Treatment

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Abstract

Background: The type of procedures has changed and become more complex and sophisticated with the development and extensive use of bronchoscopy. This study aimed to evaluate the safety, particularly the hemorrhage risk, of patients receiving bronchoscope examination or treatment.

Methods: The general information and bronchoscope procedures of patients who underwent bronchoscope examination or treatment in the respiration department were collected and analyzed.

Results: The incidence of complications and the mortality in bronchoscopy were 0.85% and 0.01%, respectively. The complication rate of different types of bronchoscope procedure varies significantly, and that of therapeutic bronchoscopies was higher than that of explorative examinations and biopsies. Moreover, the most common complication was severe bleeding. Bleeding rate was higher in the left upper lobe and bronchus intermedius, and a trend was observed in which the proportion of bleeding cases decreased as the number of biopsies increased.

Conclusions: Although bronchoscope procedure has become more complex and sophisticated, bronchoscopy is well tolerated. However, precautions should be taken because the risks of hemorrhage and pneumothorax were high and fatal.

Background

With the development of bronchial intervention technology in recent years, bronchoscope examination and treatment are extensively used by respiratory physicians or pulmonologists for diagnostic and therapeutic purposes^[1]. Hence, the safety of bronchoscopy has become a concern that cannot be neglected.

Nearly all of the previous studies^[2-4] concluded that bronchoscopy is well tolerated, and the most common complications were hemorrhage, oxyhemoglobin desaturation, pneumothorax, and pulmonary edema. The incidence of complications was between 1.08% and 5%, and the mortality was < 0.1%^[4-6]. However, bronchoscopy has undergone a great development and extensive use, and the types of procedures have changed and become more complex and sophisticated. Therefore, this study aimed to evaluate the safety, particularly the hemorrhage risk, of outpatients and inpatients receiving bronchoscope examination or treatment.

Methods

This was a retrospective study to evaluate the safety, particularly the hemorrhage risk, of outpatients and inpatients receiving bronchoscope examination or treatment. The Regional Ethics Committee of our hospital (Tangdu Hospital) approved this study. Consent to participate was not required, given the retrospective nature of this study. We collected the data of all patients who underwent bronchoscope examination or treatment in the respiration department, and these procedures were conducted during the period from January 1, 2008 to December 31, 2019. A total of 45,734 cases were included in this study. Their general information such as gender, age, and hospitalization were collected. The bronchoscope procedures were also recorded and information such as anesthesia type, bronchoscope type, biopsy methods, therapy methods, complications,

severity of bleeding, biopsy site, number of biopsies, and diameter of bronchoscope were extracted and analyzed.

To exclude the patients in whom bronchoscopy was contraindicated, routine blood test, blood coagulation, and electrocardiogram examination were conducted before operation. The patients were also contraindicated to take any anticoagulation or antiplatelet drugs 72 hours before the operation and had to abstain from food and water for 6 hours before the operation.

The anesthesia type includes local and general anesthesia. The local anesthesia was achieved by topical tetracaine. The bronchoscope procedures were divided into 3 categories: explorative examination, biopsies, and therapeutic bronchoscopy. Explorative examination was a simple bronchoscopy examination without any therapeutic operations or biopsy operations. Biopsy bronchoscopy included bronchial biopsy, transbronchial needle aspiration biopsy, bronchoalveolar lavage, and brush biopsy. Therapeutic bronchoscopy was a therapeutic operation through bronchoscopy that includes laser, argon plasma, freeze thawing, freeze cutting, using of foreign body forceps or basket, balloon dilatation, electric snare ligation, rigid bronchoscopic circumcision, and stent position. The reportable complications were classified as severe hypoxemia requiring increased ventilator support during the procedure, pneumothorax, severe arrhythmias requiring intervention or premature termination of the procedure, cardiac arrest, unplanned hospital admission or intensive care unit (ICU) transfer, severe bleeding requiring intervention (grades 3 and 4), death, and other severe complications. The distribution of complications associated with the types of procedure was arranged. There were no standard criteria for the evaluation of the severity of bleeding during bronchoscopy owing to airway secretion mixed with the blood and difficulty to quantify. Therefore, we classified the severity of bleeding during the procedure into 4 grades^[7, 8]: grade 0, no bleeding or extremely minimal bleeding that does not require suction; grade 1, mild bleeding that only requires suction; grade 2, bleeding requiring topical instillation of epinephrine or ice-cold saline; grade 3, moderate bleeding that requires pressure via an inflated balloon catheter or intravenous injection of pituitrin; and grade 4, bleeding requiring hemodynamic support, transfusion of blood products, or interventional or surgical therapy. The severity of bleeding associated with the types of operating procedure was also analyzed. The information on the biopsy site and the number of biopsies during the bronchoscopy procedures was also extracted, and the severity of bleeding associated with the biopsy site and the number of biopsies was analyzed. The outside diameter of the bronchoscope in every bronchoscopy operation was also recorded, and the distribution of complications by outside diameter of bronchoscope was presented.

Data are reported as the mean values \pm standard error. Unpaired *t* test for measurement data or Fisher exact test for count data was used for comparisons between groups, and differences in the mean values were considered to be significant at $P < 0.05$.

Results

Patient characteristics

The characteristics of the study population are presented in Table 1. Of the 45,734 cases included in this study, 27,215 were inpatients and 18,519 were outpatients and the mean ages were 55.3 and 44.3, respectively.

Inpatients was significantly older than the outpatients ($P < 0.05$); 27,262 were males and 18,472 were females. A total of 11,206 cases underwent explorative examination, 26,895 cases underwent biopsies, and 7633 cases underwent therapeutic bronchoscopy. As for the type of anesthesia, most of the operations were performed under local anesthesia, and 1402 of the 45,734 cases were performed under general anesthesia. The incidence of complication in inpatients was significantly higher ($P < 0.01$) than that in outpatients, particularly bleeding and hemoptysis ($P < 0.01$), pneumothorax ($P < 0.01$), hypoxemia requiring termination of procedure ($P = 0.03$), and cardiac arrhythmias ($P = 0.03$).

Table 1
Characteristics of the study population

Items	Inpatients (n = 27215)	Outpatients (n = 18519)	Total (n = 45734)	Analytic result	P value
Male	18082(66.44%)	9180(49.57%)	27262	$\chi^2 = 1303,$ $df = 1$	< 0.01
Female	9133(33.56%)	9339(50.43%)	18472		
Age (year)	55.3 ± 15.25	44.34 ± 18.47		t = 63.7	< 0.05
Anesthesia type					
Local anesthesia	26224	18108	44332		
General anesthesia	991	411	1402		
Number of Complications					
Hypoxemia requiring termination of procedure	42	15	57		0.03
Bleeding and hemoptysis	173	64	237		< 0.01
Pneumothorax	36	4	40		< 0.01
Cardiac arrhythmias or cardiac arrest	25	7	32		0.03
Unplanned hospital admission or ICU transfer	12	2	14		0.06
Death	2	2	4		> 0.99
Others	4	0	4		0.15
Total	294	94	388		< 0.01
Bronchoscope type					
Explorative examinations	5667(20.82%)	5539(29.91%)	11206		
Biopsies	18056(66.35%)	8839(47.73%)	26895		
Therapeutic bronchoscopies	3492(12.83%)	4141(22.36%)	7633		
Data are presented as n/N (%) or mean ± standard deviation (n) (range)					

Distribution Of Severe Complications

We recorded a total of 388 severe complications of bronchoscopy including 57 cases of hypoxemia requiring increased ventilator support and termination of the procedure, 40 cases of pneumothorax, 32 cases of severe arrhythmias requiring intervention or premature termination of the procedure, cardiac arrest, 14 cases of unplanned hospital admission or ICU transfer, 237 cases of severe bleeding requiring intervention (grades 3 and 4), 4 cases of death, and 4 cases of other severe complications (Table 2, Table 3 and Table S1). The incidence of complications and the mortality in bronchoscopy were 0.85% and 0.01%, respectively. The complication rate of the different types of bronchoscope procedure varies significantly ($\chi^2 = 14.43$, $df = 2$, $P < 0.01$), and that of therapeutic bronchoscopies was higher than that of explorative examinations and biopsies (1.21% vs 0.72% vs 0.80%). Furthermore, the most common complication was severe bleeding, particularly during bronchial biopsy. As for the explorative examinations, the most common complication was hypoxemia with the incidence of 0.25%.

Table 2
Complications and severity of bleeding associated with types of procedures

Type of procedure	No. of complications	Tot cases	% out of Tot cases	No. of Bleeding cases	Tot cases	% out of Tot cases
Explorative examinations	81	11206	0.72	649	11206	5.79154
Biopsies	215	26895	0.80	11126	26895	41.36828
Therapeutic bronchoscopies	92	7633	1.21	2882	7633	37.75711
Analysis	$\chi^2 = 14.43$, $df = 2$, $P < 0.01$; Explorative examinations vs. Therapeutic bronchoscopies $P < 0.05$; Biopsies vs. Therapeutic bronchoscopies $P < 0.05$			$\chi^2 = 4735$, $df = 2$, $P < 0.01$; Explorative examinations vs. Biopsies vs. Therapeutic bronchoscopies $P < 0.05$		
Data are presented as n/N (%) or mean \pm standard deviation (n) (range)						

Table 3
General table of complications recorded

Complications	No.	% of total complications	% of total procedures
Hypoxemia requiring termination of procedure	57	14.69	0.12
Bleeding and hemoptysis	237	61.08	0.52
Pneumothorax	40	10.31	0.09
Cardiac arrhythmias or cardiac arrest	32	8.25	0.07
Unplanned hospital admission or ICU transfer	14	3.61	0.03
Death	4	1.03	0.01
Others	4	1.03	0.01
Data are presented as n/N (%) or mean \pm standard deviation (n) (range)			

Severity Of Bleeding During Operations

Because bleeding was a dangerous and the most common complication during bronchoscopy, we studied the risk of bleeding during bronchoscopy in detail. We first analyzed the severity of bleeding associated with the types of operating procedure (Table 2 and Table S2). The incidence of hemoptysis during biopsies was significantly higher ($\chi^2 = 4735$, $df = 2$, $P < 0.01$) than that during explorative examinations and therapeutic bronchoscopies (41.37% vs 5.79% vs 37.76%). Nearly half of the cases (41.37%) that conducted biopsy, particularly bronchial biopsy, had varying degrees of bleeding, and most of them were mild bleeding, 1.47% of which were severe bleeding. As for therapeutic bronchoscopies, the incidence of hemoptysis and severe bleeding was 37.76% and 1.63%, respectively.

Severity of bleeding associated with biopsy site and number of biopsies

The severity of bleeding associated with biopsy site and number of biopsies was also explored. Bleeding rate (including mild and severe bleeding) was higher in the left upper lobe (62.50%) and bronchus intermedius (62.79%) (Table 4 and Table S3). In addition, severe bleeding rate was higher in the bronchus intermedius (2.07%). The total bleeding rate and severe bleeding rate (84.08% and 4.33%) were both higher when the number of biopsy was 1 (Table 5 and Table S3). We also found a trend ($\chi^2 = 51.61$, $df = 1$, $P < 0.01$) in which the proportion of bleeding cases decreased as the number of biopsies increased.

Table 4
Severity of bleeding associated with biopsy site

Type of procedure	No. of Bleeding cases	Tot cases	% out of Tot cases	G3 + G4	% out of Tot cases
Biopsy site					
Right upper lobe	2616	4447	58.83	33	0.74
Right middle lobe	1009	1775	56.85	15	0.85
Right lower lobe	1509	2821	53.49	15	0.53
Left upper lobe	2858	4573	62.50	48	1.05
Left lower lobe	1957	3447	56.77	26	0.75
Trachea	116	285	40.70	0	0
Right main bronchus	130	226	57.52	1	0.44
Left main bronchus	230	411	55.96	5	1.22
Bronchus intermedius	243	387	62.79	8	2.07
Lingula	269	487	55.24	3	0.62
Unclear	11	158	6.96	0	0
Analysis	$\chi^2 = 106.7, df = 9, P < 0.01$			$\chi^2 = 17.64, df = 9, P = 0.04$	
Data are presented as n/N (%) or mean \pm standard deviation (n) (range)					

Table 5
Severity of bleeding associated with biopsies number

Type of procedure	No. of Bleeding cases	Tot cases	% out of Tot cases	G3 + G4	% out of Tot cases
Biopsies number	17938				
1	486	578	84.08	25	4.33
2	587	822	71.41	19	2.31
3	900	1516	59.37	15	0.99
4	1062	2431	43.69	10	0.41
5	6569	11071	59.34	66	0.60
6	594	988	60.12	7	0.71
7	62	125	49.60	0	0.00
>7	238	407	58.48	3	0.74
Analysis	$\chi^2 = 51.61, df = 1, P < 0.01$			$\chi^2 = 64.62, df = 1, P < 0.01$	
Data are presented as n/N (%) or mean \pm standard deviation (n) (range)					

Distribution Of Complications By Outside Diameter Of Bronchoscope

Although the incidence of complications was not completely consistent ($\chi^2 = 21.33, df = 5, P < 0.01$) when the bronchoscopes' outside diameter were different, there was no obviously association between distribution of complication and diameter of bronchoscope ($\chi^2 = 7.473e-005, df = 1, P = 0.09931$) (Table 6).

Table 6
Distribution of complications by diameter of bronchoscope

Complications	No.	3.6 mm	4.0 mm	4.9 mm	5.6 mm	5.9 mm	6.9 mm	Unknown
Hypoxemia requiring termination of procedure	57	2/2133	0/2429	39/27262	2/2558	12/9679	0/366	2/1307
Bleeding and hemoptysis	237	2/2133	17/2429	159/27262	3/2558	40/9679	1/366	15/1307
Pneumothorax	40	1/2133	0/2429	24/27262	1/2558	12/9679	0/366	2/1307
Cardiac arrhythmias or cardiac arrest	32	2/2133	1/2429	20/27262	0/2558	8/9679	0/366	1/1307
Unplanned hospital admission or ICU transfer	14	0/2133	1/2429	8/27262	1/2558	4/9679	0/366	0/1307
Death	4	0/2133	0/2429	2/27262	0/2558	2/9679	0/366	0/1307
Others	4	0/2133	0/2429	3/27262	0/2558	1/9679	0/366	0/1307
Total	388	7/2133	19/2429	255/27262	7/2558	79/9679	1/366	20/1307
Analysis	$\chi^2 = 21.33$, $df = 5$, $P < 0.01$ Trend: $\chi^2 = 7.473e-005$, $df = 1$, $P = 0.09931$							
Data are presented as n/N (%) or mean \pm standard deviation (n) (range)								

Discussion

In the past decades, bronchoscopy has undergone a great development and extensive use, and the types of procedures have changed and become more complex and sophisticated^[1]. Because of the noncontemporaneous nature of previous studies, it is necessary to reanalyze the incidence and type of complications. Therefore, this study aimed to evaluate the safety, particularly the hemorrhage risk, of outpatients and inpatients receiving bronchoscope examination or treatment.

A few studies reported the complications and the incidence in bronchoscopy^[2, 9-12]. According to a study of 20,986 bronchoscopies^[4], the most common complications were hemorrhage, oxyhemoglobin desaturation, pneumothorax, and pulmonary edema. The incidence of complications and the mortality were 1.08% and 0.02%, respectively. According to Sympson^[6] and Smyth's survey^[13], the incidence of complications and mortality were 0.12% and 0.04%, respectively. However, there was also some reported higher incidence of complications of approximately 5%^[14]. For some type of procedure such as cryobiopsy, only the incidence of hemorrhage could reach 42.1%^[15, 16]. Nearly all of these studies concluded that bronchoscopy is well tolerated, but the specific incidence of complications of different operations has not been studied in detail. In addition, the risk factors of bleeding during bronchoscopy were rarely comprehensive analyzed.

According to our results, the incidence of complications and the mortality in bronchoscopy were 0.85% and 0.01%, respectively, which was consistent with previous studies. The most common complication was severe bleeding. Bleeding occurs in one-third of cases, but most of them were mild and stopped soon after treatment. What needs our attention is that the bleeding rate was higher in the left upper lobe and bronchus intermedius, particularly when biopsy or treatment was performed in the bronchus intermedius where severe bleeding rate was higher. The reason might be that the bronchus intermedius is adjacent to the vessels.

The total bleeding rate and severe bleeding rate (84.08% and 4.33%) were both higher when the number of biopsy was 1. Moreover, there was trend in which the proportion of bleeding cases decreased as the number of biopsies increased. The reason was unclear, but this might be because the bronchoscopist stops further biopsy procedure when bleeding occurs although ≤ 4 block specimens might be not sufficient for diagnosis.

There was another point that needs attention. The complication rate of inpatients was higher than that of outpatients (1.08% vs 0.51%). This might be because inpatients were significantly older than the outpatients ($P < 0.05$) and had more comorbidities.

Our study has several limitations. First, this is a retrospective study and there might be some biases. Second, the total cases of some operation such as transbronchial needle aspiration biopsy, laser, freeze cutting, and rigid bronchoscopic circumcission were less to evaluate the safety. Third, owing to the difficulties in collecting the detailed examination result such as prothrombin time, activated partial thromboplastin time, and other, we did not comprehensively analyze the risk factors of hemorrhage.

Conclusions

Although bronchoscope procedure has become more complex and sophisticated, bronchoscopy is well tolerated. However, the incidence of complications and mortality did not decrease during these years and precautions should be taken because the risks of hemorrhage and pneumothorax were high and fatal.

Abbreviations

ICU

intensive care unit

Declarations

Ethics approval and consent to participate

The procedures of this study were approved by the Regional Ethics Committee of Second Affiliated Hospital (Tangdu Hospital) of Air Force Military Medical University the Fourth Military Medical University and were carried out in accordance with the approved protocol. Consent to participate was not required, given the retrospective nature of this study.

Consent for publication

Not applicable.

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

All authors contributed to the study design. LB also contributed to the data collection and manuscript composition. YL contributed to the data analysis. CL and FJ were responsible for the integrity of this work and contributed to the study design and manuscript review. All authors contributed to drafting the manuscript and have read and approved the final manuscript.

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