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Clinical features and treatment outcomes of airway foreign body aspiration in adults

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Background: There are few reports comparing flexible and rigid bronchoscopy in adult foreign body (FB) aspiration. The aim of this retrospective study was to review the clinical characteristics, outcomes and factors associated with success in adult patients who underwent flexible or rigid bronchoscopy for airway FB removal.

Methods: We retrospectively reviewed the records of 103 patients who underwent bronchoscopy to remove airway FB at Samsung Medical Center, South Korea from January 1999 to March 2017.

Results: The median patient age was 64 years, and 70% were males. Among the 54 patients who underwent flexible bronchoscopy as first-line treatment, 43 (80%) patients had their FB successfully removed. Previous attempts at other hospitals was significantly associated with failed flexible bronchoscopy [9/11 (82%) *vs.* 3/43 (7%), P<0.001]. Delayed diagnosis (median 29 *vs.* 5 days, P=0.074) and peripherally located airway FB [9/12 (75%) *vs.* 23/48 (48%), P=0.115] were factors that trended towards flexible bronchoscopy failure. All of the 59 patients who underwent rigid bronchoscopy had their FB successfully removed. Rigid bronchoscopy was preferred to flexible bronchoscopy in patients with no comorbidities [38/59 (64%) *vs.* 18/44 (41%), P=0.018], previous attempts at other hospitals [34/59 (58%) *vs.* 4/44 (9%), P<0.001], delayed diagnosis (median 162 *vs.* 5 days, P<0.001), and hard FBs [48/62 (77%) *vs.* 21/49 (43%), P<0.001].

Conclusions: Our data suggest that previous failed attempts and delayed diagnosis are associated with flexible bronchoscopy failure. However, rigid bronchoscopy could be effective in removing an airway FB even in these cases. Further studies to identify factors to facilitate optimal patient selection will minimize failure rates and optimize resource utilization.

Keywords: Airway foreign body; rigid bronchoscopy; flexible bronchoscopy

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Introduction

Aspiration of foreign bodies (FBs) into the airway can be life-threatening. Patients may present with either acute symptoms like respiratory failure requiring urgent intervention or with non-life-threatening respiratory symptoms such as chronic cough, hemoptysis, dyspnea, and wheezing (1). Adult patients can remain asymptomatic for months to years leading to delayed diagnosis (2,3). Serious complications such as granulation tissue formation, recurrent pneumonia, atelectasis and endobronchial stenotic scarring can occur in cases of delayed diagnosis and removal (4,5).

Airway FBs can be successfully removed with either flexible or rigid bronchoscopy. Although the benefits of flexible bronchoscopy include ease of use, widespread availability and lack of requirement for general anesthesia, its disadvantages include difficulties in maintaining airway patency and patient cooperation. In contrast, airway patency is easily maintained with rigid bronchoscopy and a variety of rigid forceps available for FB extraction provide significant advantages. The primary limitations of rigid bronchoscopy are the need for general anesthesia and lack of availability. In pediatric patients, rigid bronchoscopy is the treatment of choice (6-9), mainly due to its ability to provide a secure airway, while 90% or more adult cases can be successfully resolved with flexible bronchoscopy at specialized centers (4,10,11). There are numerous discussions (12,13), but scarce data on what factors to consider when choosing between flexible or rigid bronchoscopy for FB removal in adults.

The aim of this study was to evaluate the clinical characteristics of adult patients with airway FBs and review the outcomes for flexible and rigid bronchoscopy. In addition, we aimed to identify factors associated with success or failure of each treatment modality.

Methods

Study population

A retrospective review of medical records was performed for all patients who underwent bronchoscopic removal of airway FBs at Samsung Medical Centre (a 1,960-bed, university affiliated, tertiary referral hospital in Seoul, Republic of Korea) between January 1999 and March 2017. Patients younger than 18 years were excluded. The study was approved by the Institutional Review Board of Samsung Medical Center (IRB No. 2017-08-033). Informed consent was waived because of the retrospective nature of the study.

Bronchoscopic procedure

Flexible bronchoscopy (Olympus, Tokyo, Japan) was performed with topical anesthesia (lidocaine) and sedatives (midazolam). Rigid bronchoscopy (Karl-Storz, Tuttlingen, Germany) under general anesthesia as the first-line modality for airway FB removal was considered in patients who had a need for airway protection due to unstable vital signs or impacted FB identified on chest imaging. Accessories used to remove airway FBs included biopsy forceps (FB-21C-1 or FB-36C-1, Olympus, Tokyo, Japan), rat tooth grasping forceps (FG-26C-1, Olympus, Tokyo, Japan), snares (SD-7C/18C-1, Olympus, Tokyo, Japan), and optical forceps (10352U, Karl-Storz, Tuttlingen, Germany).

Data collection and analysis

Demographic and baseline patient characteristics including age, sex, comorbidities, symptoms, clinical course before admission to our hospital, duration between aspiration and bronchoscopic removal of airway FBs, radiographic findings and pulmonary function test results were collected. To assess the methods of airway FB removal, we collected the following data: location and types of airway FBs, equipment used to remove airway FBs, and clinical outcomes.

Continuous variables are presented as the median and interquartile range (IQR) and were analyzed using the Mann–Whitney U test. Categorical variables are presented as numbers (percentages) and were analyzed by Pearson's chi-square test or Fisher's exact test. A P value less than 0.05 was considered statistically significant. All statistical analyses were performed using SPSS software (IBM SPSS Statistics ver. 23, Chicago, IL, USA).

Results

Patients characteristics

During the study period, a total of 103 adult patients with airway FBs were hospitalized and underwent bronchoscopy. The baseline characteristics of the study population are summarized in *Table 1*. The median age was 64 years (IQR, 51–77 years) and 72 (70%) were male. Fifty-five (53%) patients had no comorbidities. The primary presenting symptoms were cough (75%), sputum production (49%), and dyspnea (36%), however, acute choking event only occurred in 5%. Fifty-eight (56%) patients presented immediately to the hospital for persistent respiratory symptoms after aspiration. The remaining 45 patients did

Table 1 Baseline characteristics

Variables	N=103
Age, years	64 [51–77]
Males, %	72 [70]
Comorbidities, %	
None	55 [53]
Diabetes	22 [22]
Chronic lung disease	18 [17]
Neurological disease	13 [13]
Malignancy	7 [7]
Chronic heart disease	6 [6]
Chronic kidney disease	5 [5]
Chronic liver disease	3 [3]
Others*	4 [4]
Symptoms, %	
None	7 [7]
Cough	77 [75]
Sputum	50 [49]
Dyspnea	37 [36]
Fever	19 [18]
Wheezing	14 [14]
Hemoptysis	10 [10]
Chest pain	8 [8]
Acute choking	5 [5]
Clinical presentation, %	
Persistent respiratory symptoms after aspiration	58 [56]
Recurrent pneumonia	31 [30]
Asymptomatic (routine health check-up)	7 [7]
Poor response to asthma treatment	7 [7]
Previous attempts to remove at other hospitals, %	38 [37]
Attempts by flexible bronchoscopy	35 [34]
Attempts by rigid bronchoscopy	3 [3]
Simple chest radiography (n=103)#, %	
No abnormality	26 [25]
Consolidation	36 [35]
Visible foreign body	31 [30]
Atelectasis	16 [16]
Pleural effusion	4 [4]
Chest computed tomography (n=77)#, %	
Visible foreign body	62 [81]
Consolidation	35 [45]
Atelectasis	15 [19]
Pleural effusion	7 [9]
Bronchial wall thickening and narrowing	2 [3]
Pulmonary function test (n=53)	
FEV_1/FVC, %	66 [57–75]
FEV_1, % predicted	79 [62–96]
FVC, % predicted	87 [70–104]
Duration between aspiration and bronchoscopic removal, days	21 [3–129]
Type of airway foreign body (n=111), %	
Food material	74 [66]
Bones	42 [38]
Food	24 [21]
Pills	8 [7]
Teeth, artificial teeth, and dental instruments	16 [15]
Others,	16 [15]
Metallic materials†	11[11]
Non-metallic materials‡	5 [4]
Unidentifiable materials	5 [4]
Hospital stay, days	3 [2–4]

Data are presented as median (interquartile range) or number (percentage). FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity. *, Kyphosis (n=1), rheumatoid arthritis (n=1), abdominal aortic aneurysm (n=1), and syndrome of inappropriate antidiuretic hormone secretion (n=1); #, radiological abnormalities are attributed to airway FB; †, metal screws and pieces of metal (n=9), needle (n=1), nail (n=1); ‡, plastic bottle caps and pieces of tube (n=4), cotton ball (n=1).

not present to the hospital immediately, and their airway FBs were diagnosed during investigation for recurrent pneumonia (n=31), poor response to asthma treatment (n=7), or asymptomatic health screening (n=7). Thirty-eight (37%) were referred to our hospital after previous failed attempts to remove the airway FB at other hospitals. Of these 38 patients, three patients referred to our hospital after failure of rigid bronchoscopy and underwent rigid bronchoscopy without flexible bronchoscopy in our hospital

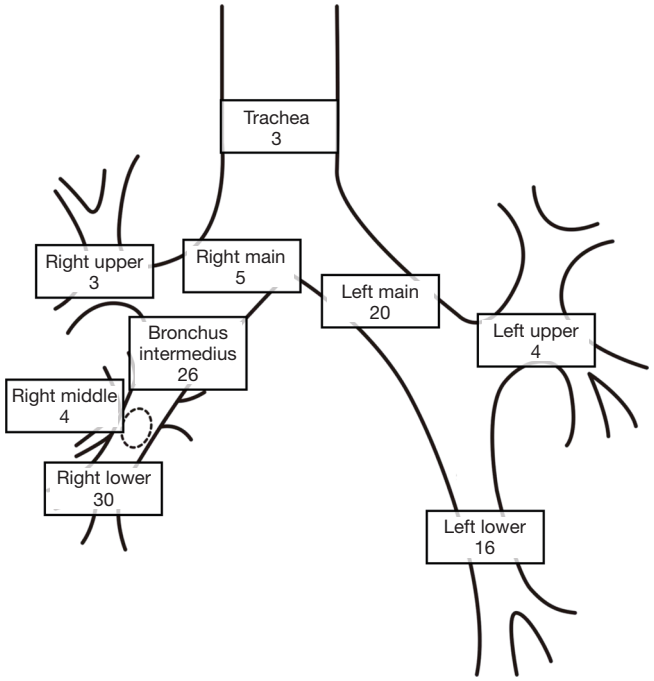

Figure 1 Location of 111 foreign bodies in the tracheobronchial tree in 103 patients. There was a total of 68 foreign bodies in the right lung, 40 in the left lung and 3 in the trachea.

due to impacted airway FB. The median duration between aspiration and bronchoscopic removal of the airway FB at our hospital was 21 (IQR, 3–129) days. Chest radiographs were normal for 26 (25%) patients, while 31 (30%) patients had a radio-opaque FB. The majority of patients (62/77, 81%) had a visible airway FB on chest computed tomography (CT).

Bronchoscopy findings

Locations of airway FBs are shown in *Figure 1*. Among the 103 total patients, there were 111 airway FBs (seven patients had two airway FBs and one patient had three airway FBs). Airway FBs were more commonly located in the right bronchi (61%). The most common types of airway FB were food material (66%) and teeth including dental prostheses and instruments (15%) (*Table 1*).

Removal technique and clinical outcomes

The clinical course of patients with FB aspiration is shown in *Figure 2*. Eleven of the fifty-four patients (20%) who underwent flexible bronchoscopy had a failed first attempt. If we exclude 12 patients referred from other hospital, failure rate of flexible bronchoscopy in our institution is 4.8% (2/42). Ten patients were converted to rigid bronchoscopy and one patient underwent a second attempt with flexible bronchoscopy under mechanical ventilation. The success rate of flexible bronchoscopy was 43 out of 54 cases (80%).

We compared clinical characteristics between patients with failed and successful FB removal by flexible bronchoscopy (*Table 2*). Previous attempt failure at another hospital was significantly more common among patients with a flexible bronchoscopy failure than in those with success [9/11 (82%) *vs.* 3/43 (7%), P<0.001]. In addition, patients with flexible bronchoscopy failure tended to have a longer duration between aspiration and bronchoscopic removal (median 29 *vs.* 5 days, P=0.074) and a more peripheral airway FB [9/12 (75%) *vs.* 23/48 (48%), P=0.115] than those with flexible bronchoscopy success; however, these differences were not statistically significant.

A total of 59 patients, including 10 patients who were converted from flexible to rigid bronchoscopy and 49 patients who underwent rigid bronchoscopy as the first attempt, underwent rigid bronchoscopy under general anesthesia. The success rate was 100%. Comparison of clinical characteristics according to successful procedure modalities (rigid *vs.* flexible bronchoscopy) to remove the airway FB are shown in *Table 3*. Rigid bronchoscopy was preferred to flexible bronchoscopy in patients with no comorbidities [38/59 (64%) *vs.* 18/44 (41%), P=0.018], a previous attempt to remove the airway FB at another hospital [34/59 (58%) *vs.* 4/44 (9%), P<0.001], longer duration between aspiration and bronchoscopy removal (median 162 *vs.* 5 days, P<0.001), and airway FB of hard consistency [48/62 (77%) *vs.* 21/49 (43%), P<0.001].

There were no acute procedure related complications. However, delayed complications occurred in two cases. A 26-year-old female who had no past medical history visited the hospital for four months of persistent cough and sputum production. After a failed attempt at FB (bean) removal from the left lower lobar bronchus using flexible bronchoscopy, she was referred to our hospital and had successful FB removal with rigid bronchoscopy. Three years later, the patient developed a broncho-esophageal fistula with recurrent pneumonia necessitating lobectomy. A 78-year-old male with chronic kidney disease was referred to our hospital for two weeks of fever. A FB (chicken bone) in the left lower lobar bronchus causing fibrosis and airway obstruction was removed with rigid bronchoscopy.

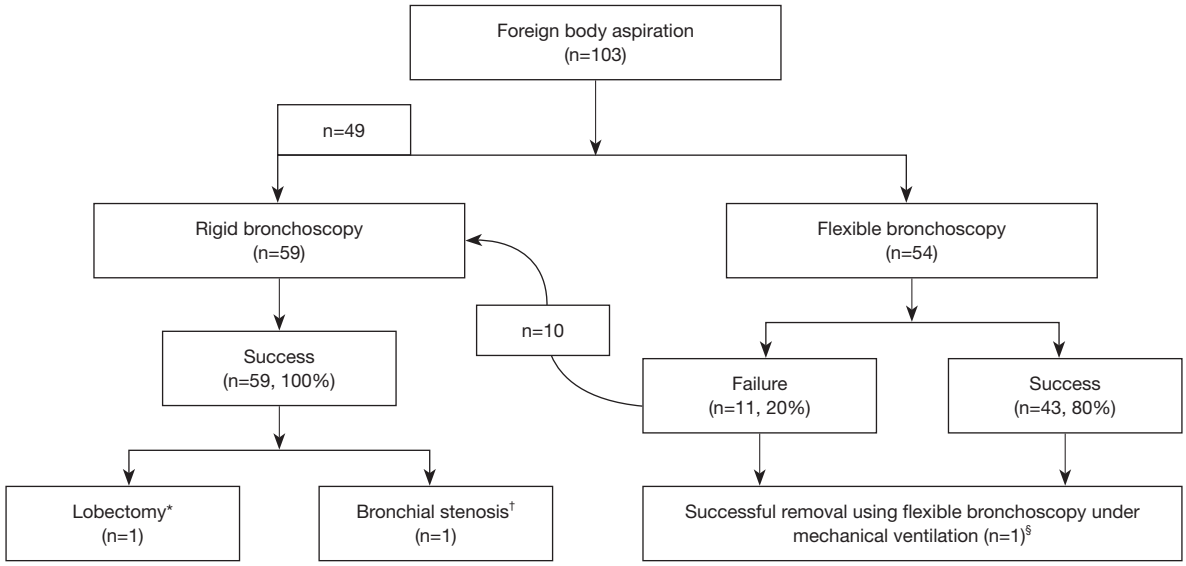

Figure 2 The clinical course of patients with airway foreign body aspiration. *, the patient underwent left lower lobectomy three years after airway foreign body removal because of a broncho-esophageal fistula causing recurrent pneumonia; †, initially, the FB caused a total airway obstruction, but it was successfully removed. However, six weeks later, bronchial stenosis occurred and an airway silicone airway stent was inserted; §, removed with flexible bronchoscopy under mechanical ventilation because of severe cough and noncooperation.

Although he was asymptomatic six weeks later, he developed obstruction of the left lower lobar bronchus and required airway stenting.

Discussion

In our study, airway FB occurred more commonly in adult males and the FB was more frequently located in the right bronchus. Cough was the most common symptom and 30% of FBs were radiopaque on simple chest radiographs. These findings are consistent with published studies (1,11,14). About half of patients presented with chronic symptoms (recurrent pneumonia or poor response to asthma treatment) or no symptoms rather than with acute choking. In our study, acute choking events occurred in only 5%, which is in the lower range of 7–23% reported in previous studies on adult airway FBs (1,14). These low rates contrast with those of pediatric studies, which reported acute choking episodes in 46% of cases (15). This difference between pediatric and adult patients might be related to airway size and airway FB location. FBs may be more likely to be centrally located in children due to their smaller airways, while FBs in adults, who have larger airways, tend to be peripherally located. The other possible explanation is selection bias where patients with acute symptoms were treated at primary care clinics while those with less severe presenting symptoms and longer duration to FB removal developed complications and tended to present to tertiary centers.

About half of our patients (54/103, 52%) underwent flexible bronchoscopy as first line for FB removal. Our flexible bronchoscopy success rate of 80% is within the range of 61–100% reported by a recent large systematic review (11). In addition, we evaluated the differences between failed and successful flexible bronchoscopy cases. The only factor significantly associated with failure was a previous attempt to remove the airway FB at another hospital. We found trends toward association between longer duration from aspiration to removal attempt and peripherally located FB and flexible bronchoscopy removal failure, although these relationships were not statistically significant. Delayed diagnosis of FB aspiration and peripherally located FB frequently result in granulation tissue formation and FB impaction, which makes removal by flexible bronchoscopy more difficult (1,11,16).

In the present study, a total of 59 patients underwent rigid bronchoscopy, and 100% were successful. None of our patients required surgery to remove their airway FB. Of the 103 total patients, 49 (47%) were managed with rigid bronchoscopy as the first line. The proportion of

Table 2 Comparison of clinical characteristics between patients with failed versus successful foreign body removal by flexible bronchoscopy

Variables	Failure (n=11)	Success (n=43)	P
Age, years	64 [56–75]	66 [53–74]	0.942
Males, %	7 [64]	34 [79]	0.230
Comorbidities, %			0.088
No	8 [73]	17 [40]	
Yes	3 [27]	26 [60]	
Symptoms, %			1.000
No	2 [18]	8 [19]	
Yes	9 [82]	35 [81]	
Clinical presentation, %			
Persistent respiratory symptoms after aspiration	6 [55]	21 [49]	0.735
Recurrent pneumonia	4 [36]	13 [30]	0.726
Asymptomatic	0 [0]	5 [12]	0.571
Poor response to treatment for asthma	1 [9]	4 [9]	1.000
Previous attempts to remove the airway foreign body at other hospitals, %	9 [82]	3 [7]	<0.001
Duration between aspiration and bronchoscopic removal, days	29 [3–132]	5 [1–29]	0.074
Location of airway foreign body*, %			0.115
Central airway (above the lobar bronchus)	3 [25]	25 [52]	
Peripheral (lobar or segmental bronchus)	9 [75]	23 [48]	
Consistency of airway FB*, %			0.365
Hard materials†	7 [58]	21 [44]	
Soft materials‡	5 [42]	27 [56]	

Data are presented as median (interquartile range) or number (percentage). *, sixty foreign bodies were found in 54 patients. Because there were two or more foreign bodies in some patients, the number of foreign bodies and patients was not the same; †, hard materials included bones, teeth, artificial teeth, dental instruments, and metallic materials; ‡, soft materials included food, pills, and non-metallic materials.

adult patients managed directly with rigid bronchoscopy in practice can vary from 3% to 40% depending on practice setting and availability of rigid bronchoscopy (11,17).

Numerous publications have reported on the use of flexible or rigid bronchoscopy for airway FB removal. A recent systematic review yielded 107 articles on bronchoscopic airway FB removal (11). However, there are no studies on factors to consider when deciding between flexible and rigid bronchoscopy to maximize cost-effectiveness and minimize failure rate. It is not feasible for rigid bronchoscopy to be available in all hospitals; therefore, it would be valuable to have methods for identifying patients with airway FBs who should be referred to a tertiary hospital with rigid bronchoscopy capabilities. In our study, patients with successful airway FB removal by flexible bronchoscopy had fewer previous attempts to remove the airway FB at other hospitals (9% *vs.* 58%, P<0.001), shorter duration between aspiration and FB removal (median 5 *vs.* 162 days, P<0.001), and FB of soft consistency (57% *vs.* 23%, P<0.001) than those in whom rigid bronchoscopy was used. Therefore, we infer that rigid bronchoscopy could be considered in the patients with a previous failed attempt, longer duration from FB aspiration, and FB of hard consistency. Factors leading to use of rigid bronchoscopy as the first-line modality are often cited to be FB size, nature and chronicity (11,17). In addition to airway instability, rigid bronchoscopy tends to be the preferred first-line modality when FB are large, sharp and embedded in granulation tissue. Our

Table 3 Comparison of clinical characteristics between patients who underwent successful rigid versus flexible bronchoscopy for airway foreign body removal

Variables	Rigid (n=59)	Flexible (n=44)[#]	P
Age, years	65 [57–75]	66 [53–74]	0.708
Males, %	37 [63]	35 [80]	0.065
Comorbidities, %			0.018
No	38 [64]	18 [41]	
Yes	21 [36]	26 [59]	
Symptoms, %			0.142
No	5 [8]	8 [18]	
Yes	54 [92]	36 [82]	
Clinical presentation, %			
Persistent symptoms after aspiration	37 [63]	21 [48]	0.129
Recurrent pneumonia	17 [29]	14 [32]	0.829
Discovered incidentally (asymptomatic)	2 [3]	5 [11]	0.134
Poor response to treatment for asthma	3 [5]	4 [9]	0.602
Previous attempts to remove the airway foreign body at other hospitals, %	34 [58]	4 [9]	<0.001
Duration between aspiration and bronchoscopic removal, days	162 [73–445]	5 [1–29]	<0.001
Location of airway foreign body*, %			0.705
Central airway (above the lobar bronchus)	29 [47]	25 [51]	
Peripheral (lobar or segmental bronchus)	33 [53]	24 [49]	
Consistency of airway FB*, %			<0.001
Hard materials[†]	48 [77]	21 [43]	
Soft materials[‡]	14 [23]	28 [57]	

Data are presented as median (interquartile range) or number (percentage). [#], one case had failed the first attempt of flexible bronchoscopy, however, subsequently underwent mechanical ventilation and had successful removal of airway FB on the second attempt of flexible bronchoscopy. This case was included in failure group in *Table 2* and flexible group in *Table 3*; *, one hundred and eleven foreign bodies were found in 103 patients. Because there were two or more foreign bodies in some patients, the number of foreign bodies and patients was not the same. [†], hard materials included bones, teeth, artificial teeth, dental instruments, and metallic materials; [‡], soft materials included food, pills, and non-metallic materials.

practice is similar to those of tertiary referral centers with an established rigid bronchoscopy practice (6,17,18). However, unlike the retrospective study by Hsu (17), we did not include stent removal as the source of iatrogenic airway FBs in our analysis.

Our study has several limitations. First, our study was retrospective and observational in design therefore the factors we found to be associated with successful rigid bronchoscopy may not be causal. We are unable to account for confounding factors such as size, shape, and nature of margin of airway FB, which could potentially be associated with outcomes. Our findings should be confirmed by larger and higher quality studies. Second, our center is a tertiary referral center, which likely led to some selection bias. In addition, our conclusions cannot be easily applied to other centers where rigid bronchoscopy may not be readily available. In particular, significant bias could potentially have been introduced through clinical selection of patients for rigid bronchoscopy as the first attempt. In our institute, rigid bronchoscopy was considered as the first-line modality

for airway FB removal in patients who had a need for airway protection or impacted FB identified on chest imaging. Although these situations are generally considered as the indications for the rigid bronchoscopy (12,13), there could be a selection bias that might have influenced the significance of our results.

Conclusions

In conclusion, we found that previous attempts to remove airway FBs at other hospitals, delayed diagnosis of FB aspiration, and peripherally located FB could be associated with failure of flexible bronchoscopy for airway FB removal. In contrast, rigid bronchoscopy could be used to successfully remove airway FBs even in patients with previous failed attempts, delayed diagnosis of FB aspiration, and FB of hard consistency. Although these findings should be confirmed by further studies, these associations may serve as a basis for further work to identify factors that can assist us in selecting patients for expedited rigid bronchoscopy in order to avoid multiple interventional attempts and for selecting patients most appropriate for flexible bronchoscopy to minimize the cost of excessive utilization of rigid bronchoscopy.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study was approved by the Institutional Review Board of Samsung Medical Center (IRB No. 2017-08-033). Informed consent was waived because of the retrospective nature of the study.

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