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The risks of postoperative complications and prolonged hospital stay in children receiving bronchoscopy

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ABSTRACT

Background: Foreign body aspiration (FBA) is a common problem among children that needs to be recognized and managed quickly. Our study aimed at comparing risk factors associated with adverse events in children receiving either flexible or rigid bronchoscopy, by reporting and analyzing our experience in the removal of airway FB primarily through flexible bronchoscopy.

Methods: A total of 3489 FBA patients were retrospectively examined. The clinical events, bronchoscopy findings, radiological findings and procedural complications were reported and analyzed.

Results: According to Fisher's exact test, preoperative cardiovascular instability, pre-operative pulmonary disease or need of lung assistance, operative time greater than 30 min, and history of ineffective rigid bronchoscopy were associated with postoperative adverse events. These same factors were also associated with prolonged hospital stay (more than 2 days). Using multivariate analysis, preoperative pulmonary disease or need of lung assistance and history of ineffective rigid bronchoscopy were associated with postoperative adverse events. These same factors were significantly associated with prolonged hospital stay.

Conclusions: Our study demonstrated that using flexible bronchoscopy to extract foreign bodies in children generally exhibits a low adverse events incidence. The risk of postoperative complications and prolonged hospital stay may significantly be higher for children with pre-operative pulmonary disease, prolonged operative time, and history of ineffective rigid bronchoscopy.

Type of study
Treatment Study.
Level of evidence
Level III.

In the childhood group, most aspirations occur with the tracheobronchial foreign body (FB). Tracheobronchial foreign body aspiration (FBA) could become a life-threatening emergency among children [1]. According to various studies, the mortality rate of inhalation of FBs ranges as high as 1.8% [2]. To reduce the incidence of mortality and post-operative complications, it is crucial to diagnose and remove FB early. In addition, the skill and experience of the operator are also very essential. Also, anesthetists and surgeons have to be aware of the incidence of complications, and have a plan to manage post-operative complications [3].

The diagnosis and treatment of aerodigestive tract disorders are now widely dependent on bronchoscopy [2]. While rigid bronchoscopy may give a better view of pharynx, hypopharynx and post-cricoid areas and allow airway ventilation [4], flexible bronchoscopy offers greater versatility [5]. The flexible devices have broad fields of view, allow for peripheral airways to be inspected and can be manipulated with a tracheostomy or stoma. In clinical practice, non-surgeons use flexible bronchoscopy more often, however, surgeons have been more relied on a rigid instrument [6]. However, in pediatric otolaryngological practice, flexible bronchoscope is widely used [6,7]. A flexible bronchoscope can be performed to examine the nasal cavity, nasopharynx, larynx, trachea, bronchi and esophagus. Also, in cases involving children and neonates, the small size of flexible bronchoscopes has contributed to its wide use. A flexible bronchoscopy can be used to diagnose and treat breathing tract problems in premature infants [8].

In our hospital, both rigid and flexible bronchoscopy have been used among pediatric otolaryngologists. We received 3489 cases between January 2008 and September 2018. Records have been reviewed retrospectively, and data for each patient have been recorded, namely age, sex, symptoms, findings in physical examination and chest radiation or fluoroscopy, locations and the types of FBs, complications associated with aspiration and extraction, methods of anesthesia and results. Our study reported primarily the short-term outcomes after bronchoscopy to remove foreign body, and our experience in these cases in terms of

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the location and type of FB, and associated complications, as well as anesthesia techniques and results.

1. Patients and methods

This is a retrospective study. A total of 3489 pediatric FBA patients underwent bronchoscopy from January 2008 to September 2018 in Children's Hospital of Nanjing Medical University. Flexible bronchoscopy (Olympus BF-XP40: external diameter: 2.8 mm, working channel: 1.2 mm, BF-3C30: external diameter:3.6 mm, working channel: 1.2 mm, and BF-P40: external diameter: 4.9 mm, working channel: 2.2 mm) or rigid bronchoscopy (Karl Storz Endoskope system caliber 3.5–4.5 mm) was used under general anesthesia for patients. Our study was approved by the Institutional Review Board at Children's Hospital of Nanjing Medical University.

Demographics were determined in patients, including sex and age. Pulmonary disease, gastrointestinal disorders, renal, heart and neurological diseases, immunosuppression and nutritional deficits, hematological disorders or bleeding, pre-operative infection, and cardiovascular instability of pre-operation were classified as pre-operative complications. Characteristics of the operation were also analyzed, including operational specialty, anesthesia and operational time. In the categories of injury infection, pulmonary, neurological, heart, renal, and bleeding complications, vein thrombosis and death post-operative complications were pooled. Duration of stay and disposition of discharge have been established. Finally, the analyses of data on reoperation and re-admission were also carried out.

Data analysis

Adverse events included complications after 30 days of surgery, death, re-admission and reoperation. We combined all post-operative adverse events together as primary outcome due to the small number of events. Prolonged length of stay (more than 2 days) was considered as a secondary outcome. We used Fisher's exact test to determine the association of demographic factor, hospitalization, pre-operative complications, and surgical characteristic with adverse events. Multivariate analysis was also conducted. The normality of data distribution was determined using the Kolmogorov–Smirnov goodness-of-fit test. Then two tailed Student's T test was utilized to examine normally distributed data, and the Mann–Whitney test was utilized to examine non-normally distributed data. P value <0.05 was considered as statistically significant difference.

2. Results

Characteristics of patients

Our data analysis included a total of 3489 patients, among whom 60% were males. The average age was 3.44; 1688 patients (48.3%) were present with pre-operative comorbidities, as summarized in Table 1. Right bronchi (1590, 45.8%), followed by left bronchus (1259, 37.0%), bilateral bronchi (342, 9.7%), and trachea (262, 7.5%) were most common locations of FBs. As for the FBs, the segmental or smaller bronchi had accommodated 1538 (44.1%) FBs and the upper left or right lobes were presented with 694 (19.9%) FBs. Vegetable snacks were the most common FB (2857, 81.9%).

In total, the emergency room admitted 2997 (85.9%) cases. In short, 1849 (53.0%) of the patients were treated by pediatric otolaryngologists, 1625 (46.6%) by pediatric surgeons, and 52 (1.5%) by cardiothoracic surgery or general surgery. Moreover, 2194 bronchoscopies (62.9%) were performed emergently, 582 bronchoscopies (16.7%) were performed urgently and 708 were done electively (20.3%). The average surgical time was 25.6 min, with an additional mean time of 34.1 min for anesthesia.

Postoperative adverse events

Of the total 3489 patients, 48 had an unsuccessful rigid bronchoscopy due to inaccessible FB locations, and received flexible bronchoscopy, among whom there were 2 (0.05%) deaths in hospital. The other complications were all related to the pulmonary system, which represented 3.1% in all patients receiving bronchoscopy for extraction of FB (Table 2). In particular, 21 patients (0.6%) had new mechanical ventilation during 24-h periods; 31 patients (0.9%) were reintubated and 56 patients (1.6%) developed pneumonia postoperatively. No reoperations were performed. Re-admittances were observed in three patients (0.08%). Total 3039 patients (87.1%) had a hospital stay of between 0 and 1 day.

Risk factors for adverse events and prolonged hospital stay

According to Fisher's exact test, pre-operative cardiovascular instability, pre-operative pulmonary disease or need of lung assistance (additional oxygen or ventilation), operative time >30 min, and history of ineffective rigid bronchoscopy were associated with post-operative adverse events (Table 3). These factors were also associated with prolonged length of stay >2 days (Table 4). On multivariate analysis, pre-operative pulmonary disease or need of lung assistance, and history of ineffective rigid bronchoscopy were associated with post-operative adverse events (Table 3). These same factors were also associated with prolonged hospital stay (Table 4).

Table 1
Characteristics of patients who underwent bronchoscopy for foreign body aspiration.

Patient characteristic	n	%
Sex		
Male	2093	60
Female	1396	40
Age		
<1	297	8.5
1 ≤ y < 2	1469	42.1
2 ≤ y < 3	596	17.2
3 ≤ y < 4	251	7.2
≥ 4	876	25.1
Pulmonary disease or compromise	1092	31.3
Ventilation requirement	147	4.2
Oxygen supplementation	45	1.3
Pneumonia	265	7.6
Cystic fibrosis	52	1.5
Asthma	38	1.1
Tracheostomy	66	1.9
History of chronic lung disease	167	4.8
Structural pulmonary abnormalities	276	7.9
Cardiovascular instability	66	1.9
Inotrope support	17	0.5
Cardiopulmonary resuscitation	49	1.4
Cardiac disease	160	4.6
Neurologic disease	248	7.1
Gastrointestinal disease	122	3.5
History of rigid bronchoscopy	48	1.4
Admission		
Clinic visit	492	14.1
Emergency room	2997	85.9

Table 2
Postoperative adverse events

Adverse Event	n	%
Length of stay, day		
0	1294	37.1
1	1745	50.0
2	314	9.0
>2	202	5.8
Pulmonary complications	108	3.1
New pneumonia	56	1.6
Reintubation	31	0.9
New mechanical ventilation 24 h	21	0.6
Death	2	0.05
Reoperation	0	0.0
Re-admission	3	0.08

Table 3
Risk factors for adverse events

Factor	Univariate			Multivariate		
	OR	95% CI	P	OR	95% CI	P
Male	2.01	0.51–15.1	0.39	1.36	0.21–16.4	0.67
Age <3 years	1.2	0.12–3.64	0.44	1.05	0.11–6.01	0.27
Pulmonary compromise	18.9	3.81–48.6	<0.01*	10.05	2.13–54.3	0.01*
Cardiac disease	1.94	0.24–5.57	0.28	1.28	0.14–5.69	0.47
Cardiovascular instability	74	9.67–91.9	<0.01*	41.8	9.24–87.9	0.01*
Gastrointestinal disease	1.24	0.19–5.01	0.49	2.30	0.12–7.32	0.19
Neurologic disease	2.18	0.97–17.3	0.25	3.44	0.44–16.9	0.27
Emergent case	4.36	0.29–14.9	0.53	2.48	0.19–11.9	0.24
ER admission	0.19	0.01–1.89	0.68	0.27	0.01–3.54	0.79
Operative time >30 min	8.37	1.84–19.4	<0.01*	9.19	0.84–18.3	0.01*
History of rigid bronchoscopy	9.38	1.94–25.9	<0.01*	11.4	1.81–38.3	<0.01*

ER = emergency room; OR = odds ratio. Asterisks represent significance (P < 0.05).

3. Discussion

The highest rate of tracheobronchial FB inhalation occurs among children under 3 years of age [9]. Rigid bronchoscopy is an effective and safe treatment procedure for these patients [9,10]. During rigid bronchoscopy, however, mortality or complications may occur. Factors that affect the complications may include the FB type, experience of the operator, anesthesia methods, instruments, and the patient's condition, etc. [9].

According to different studies, the current rate of mortality from inhaling FB is below 1.8% [1]. Our study reported a mortality rate of 0.05%. We consider FB type as a mortality-related risk factor during bronchoscopy. In the two cases of mortality observed in this study, the FB type was bean (edamame). In tracheobronchial trees, the bean can expand, making its removal very difficult as the grasping tool cannot easily grab a round object. Death can happen when the bean blocks the airway leading to suffocation, therefore in such bean types of foreign body careful examination is of critical importance to assure the safety of the patients.

The anesthesia method is another important factor in reducing complications and mortality [11,12]. General coupled with topical anesthesia can provide safety in the treatment of patients. In general anesthetic, propofol, sodium γ-hydroxybutyrate, ketamine, diazepam and fentanyl are often used [13,14]. For topical anesthesia, lidocaine or tetracaine is often used [15,16]. In addition, muscle relaxation and spontaneous breathing during the operation are often needed. If the patient is seriously hypoxic, ventilatory support is necessary [11]. Laryngospasm may also occur, however, if anesthesia is not adequate. One of the key points to avoid laryngospasm is to use topical tetracaine or lidocaine anesthesia. In our earlier practice, procedure was often performed under inhaled anesthesia in combination with topical anesthesia. This was associated with higher rate of laryngeal edema, particularly in rigid bronchoscopy. To prevent laryngeal edema, operator may choose to use glucocorticoid prior to surgery. Since 2000, we have stopped using the combination of inhaled anesthesia with topical anesthesia. In this study, all bronchoscopies were performed under general anesthesia only.

Table 4
Risk factors for prolonged hospital stay

Factor	Univariate			Multivariate		
	OR	95% CI	P	OR	95% CI	P
Male	2.78	0.59–13.1	0.35	1.66	0.28–13.6	0.62
Age <3 years	0.72	0.22–2.65	0.49	0.85	0.15–5.01	0.77
Pulmonary compromise	11.6	2.88–41.6	<0.01*	6.55	1.13–44.3	0.02*
Cardiac disease	0.94	0.19–4.55	0.88	0.91	0.21–4.69	0.87
Cardiovascular instability	55	5.67–81.2	<0.01*	6.01	0.24–49.9	0.29
Gastrointestinal disease	1.12	0.18–5.61	0.41	1.33	0.12–6.12	0.35
Neurologic disease	4.18	0.87–20.3	0.18	4.74	0.45–18.9	0.25
Emergent case	2.36	0.28–17.9	0.68	0.48	0.09–8.99	0.48
ER admission	0.14	0.01–2.39	0.78	0.19	0.01–4.52	0.89
Operative time >30 min	5.35	1.44–18.4	<0.01*	3.89	0.54–12.3	0.01*
History of rigid bronchoscopy	10.34	2.04–31.9	<0.01*	12.1	5.77–39.3	<0.01*

ER = emergency room; OR = odds ratio. Asterisks represent significance (p < 0.05).

When considered, FB needs to be quickly identified and located. The gold standard for airway FB identification and localization is bronchoscopy, which is also an important way of removing FB. While the first choice to extract FB was rigid bronchoscopes, accumulated data have demonstrated the promising value of flexible bronchoscopy in airway FB extractions [17–20]. A previous study examined the results from the 1970s to the 1990s among adult patients with FB respiratory tract extraction, and showed that the success rate was 61% to 97% with an average of 83.6%. Flexible bronchoscopy of 23 and 24 children with FB was also used by Ramirez-Figueroa and Swanson, who demonstrated that the success rates were higher than 91.3%. In our study, we used flexible bronchoscopy primarily to remove FB with a high success rate of 94.1%.

Flexible bronchoscopy has many advantages over rigid bronchoscopy. First of all, due to the low diameter and flexibility, certain locations which are not easy to access using a rigid bronchoscope (like a deeper or grade III bronchus, the upper right or left bronchus, and the lower bronchus basal segments) become accessible by using a flexible bronchoscope. In our study, 48 patients had a history of ineffective rigid bronchoscopy. Second, more easily than rigid bronchoscopy, flexible bronchoscopy with vacuum aspiration or bronchoalveolar lavage can retrieve FB types such as powder or fluid [21]. Third, it is also helpful to clear up local inflammatory secretion, to administer the drug locally, and to study pathogens that could help to prevent inflammation and shorten duration. Fourth, flexible bronchoscopy is appropriate for patients in intensive care unit and/or with serious complications [22]. Martinot et al. showed that flexible bronchoscopy might be the first choice compared to rigid bronchoscopy in the management of 83 children with suspected FB [23].

4. Conclusion

In conclusion, our study demonstrated that using flexible bronchoscopy to extract foreign body in children generally exhibits a low adverse events incidence. The risk to develop post-operative complications may be significantly higher for children with pre-operative pulmonary disease, prolonged operative time, and history of ineffective rigid bronchoscopy. These factors are also linked to prolonged hospital stay. Of note, the current study had its own limitations: (1) 44.1% of the patients had FBs in the distal bronchial tree, for which rigid bronchoscopy was the preferred first line of treatment, which could have reduced the respiratory and ventilatory related complications with continued oxygenation; (2) 81.9% of FB were of vegetable snacks (not visible on radiology), for which the rigid bronchoscopy was also a safer approach; (3) a prospective study with a good quality cohort study comparing rigid versus flexible bronchoscopy should be performed to verify the conclusion in the current study.

Disclosure statement

The authors declare that they have no competing interests.

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