



The Transition of Pediatric Tracheobronchial Foreign Body Cases in the Past 36 Years: A Retrospective Single-Center Study in Japan

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Tracheobronchial foreign bodies (TFBs) are pediatric airway emergencies frequently seen. We aimed to examine the changes in the clinical characteristics of pediatric TFB patients in a single institution within the past 36 years. We retrospectively reviewed the data of 85 patients aged 0-10 years with TFBs lodged in the trachea or bronchus admitted at the Department of Otolaryngology-Head and Neck Surgery at Tohoku University Hospital between 1986 and 2021. We also compared the characteristics, diagnostic methods, and treatments of the previous 64 cases (1986-2005) with those of the recent 21 cases (2006-2021). The number of TFB patients decreased later in this study (3.2 vs. 1.3 patients per year). The proportion of TFB patients aged > 3 years was significantly higher in the later period (6.3% vs. 23.8%, $p = 0.038$). Peanut was the most common cause of TFBs in both periods, and the overall incidence of peanut aspiration significantly decreased in the later period (68.8% vs. 38.1%, $p = 0.019$). No patient had an undetected TFB for more than 1 month after the onset of symptoms in the later period. Foreign body extraction using rigid bronchoscopy was performed in all patients earlier, whereas flexible bronchoscopy was used in 14.3% later. Our study revealed a recent trend in the clinical characteristics of pediatric TFB patients in a single institution in Northeast Japan. The prevention and treatment of pediatric TFBs should be considered following the recent trends.

Keywords: airway; aspiration; characteristics; children; tracheobronchial foreign body

Tohoku J. Exp. Med., 2023 October, 261 (2), 129-137.

doi: 10.1620/tjem.2023.J062

Introduction

Aspiration of foreign bodies is a potentially life-threatening problem in children worldwide, and airway obstruction caused by inhaled foreign bodies can result in serious sequelae or death by asphyxiation (Fidkowski et al. 2010). Airway foreign bodies are the leading global cause of accidental infant deaths and the fourth leading cause of death in preschool children (Salih et al. 2016). A previous study conducted in 2003, 2006, 2009, and 2012 using the United States Kids' Inpatient Database showed that the in-hospital mortality rate of foreign airway bodies is 2.5%. Similarly, the mortality rates of foreign body aspiration were 1.2% (aged 1-15 years) and 3.5% (< 1 year) in Germany in 2014

(Schramm et al. 2017). Tracheobronchial foreign bodies (TFBs) are often seen in infants owing to their tendency to play and run around while eating, the habit of putting things in the mouth, immature swallowing function, inadequate chewing of food, and incomplete dentition (Committee on Injury, Violence, and Poison Prevention 2010; Ding et al. 2020). Plant foreign bodies such as peanuts are the most frequent cause of aspiration among foreign bodies (Fidkowski et al. 2010). Because delayed diagnosis may lead to severe acute and chronic complications, such as pneumonia, bronchopneumonia, and atelectasis (Foltran et al. 2012), TFBs should be correctly diagnosed and promptly removed. The current gold standard treatment for pediatric TFBs is rigid bronchoscopy, and rigid instruments are pre-

Received June 9, 2023; revised and accepted July 23, 2023; J-STAGE Advance online publication August 3, 2023

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ferred for assessing the larynx and cervical trachea and performing TFB extraction (Faro et al. 2015; Chantzaras et al. 2022). In recent years, the use of flexible bronchoscopy for removing pediatric TFBs has gained attention owing to its availability in various hospitals and, although controversial, minimal complication rates (Schramm et al. 2017; Chantzaras et al. 2022).

Furthermore, many large-scale single-center studies (Saki et al. 2009; Tang et al. 2009; Gang et al. 2012) and several systematic reviews and meta-analyses (Foltran et al. 2012, 2013; Chantzaras et al. 2022) on pediatric airway foreign bodies have been published; however, only a few reported on the changes in the clinical characteristics of pediatric patients with TFBs in the same region. Brkic and Umihanic (2007) reported changes in the characteristics of children admitted to a university hospital in Bosnia and Herzegovina with TFBs between 1954 and 2004; however, to our knowledge, no study has conducted a follow-up on the clinical changes for such a long period in patients from high-income countries. Tohoku University Hospital is a central hospital in Miyagi Prefecture in Japan, with a population of 2,300,000. Notably, almost all pediatric TFB patients from local districts have been referred to our department (Saijo et al. 1979; Katori et al. 2005; Hidaka et al. 2013). To determine the changes in the recent trend of TFB cases in children, we reviewed the data of 85 pediatric TFB cases in the past 36 years in a single institution; the characteristics, diagnostic methods, and treatments of previously reported cases (64 cases, 1986-2005) (Katori et al. 2005) were compared with those of recent cases (21 cases, 2006-2021).

Materials and Methods

Patients and baseline characteristics

According to the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, we selected patients with the following diagnoses: “foreign body in the respiratory tract, trachea, or bronchus.” We screened the data of all patients who visited the Department of Otolaryngology-Head and Neck Surgery at Tohoku University Hospital with any of the abovementioned diagnoses from the medical record system of our hospital. We selected 21 patients aged 0-10 years with foreign bodies lodged in the trachea or bronchus between January 2006 and December 2021. We collected the clinical data (age, sex, present history, symptoms, physical examination findings, radiographic findings, location and type of foreign body, treatment, and complications). We reviewed the data of 85 TFB cases, including 64 previous cases from a 20-year survey data set conducted in our department (Katori et al. 2005). We compared the differences in the characteristics of TFB cases between the earlier period (1986-2005) and the later period (2006-2021). The time of referral to our department was calculated by considering the data and time of witnessed aspiration or onset of symptoms such as cough and wheezing. This study was approved by the

Ethics Committee of our hospital (2022-1-638).

Statistical analyses

All statistical analyses were performed using Easy R version 1.55, based on R and R commander (<http://www.jichi.ac.jp/saitama-sct/SaitamaHP.files/statmed.html>). Fisher’s exact test was used for statistical treatment to compare the two groups. Statistical significance was set at a p-value < 0.05.

Results

Trends in patient numbers and time to hospital admission

A total of 85 pediatric patients aged 10 years or younger were included in this study; we compared the data of 64 cases in the earlier study period (1986-2005) with those of 21 cases in the later study period (2006-2021). The clinical characteristics of 21 cases in the later period are shown in Table 1. Approximately 3.2 TFB patients per year were treated in our department in the early period. However, 1.3 patients with TFB per year were treated in the later period, suggesting a 40.6% decrease in TFB cases. The age distributions are presented in Table 2. Among the 21 TFB patients in the later period, the ages ranged from 10 months to 9 years (median age: 2 years), and the male-to-female ratio was 17:4 (Fig. 1). Approximately 23.8% of the TFB patients were aged 3 years or older in the later period, and this rate was significantly high compared with the 6.3% of TFB patients in the earlier period ($p = 0.038$) (Table 2). Of the 21 children in the later period, 19 (90.4%) experienced episodes of foreign body aspiration. The intervals between foreign body inhalation and hospital admission are shown in Table 3. An interval within 24 h was observed in 10 patients (47.6%), while an interval of 1 to 2 days was observed in six patients (28.6%) in the later period. Compared with that in the earlier period, none of the patients had an undetected TFB for more than 1 month after the onset of symptoms in the later period.

Symptoms, examination data, and location of foreign body

Cough was the most common symptom of TFB aspiration (95.2%), followed by wheezing (65.0%) and dyspnea (47.6%) in the later period. Nineteen patients had abnormal findings on auscultation, including the loss or diminished breath sounds and wheezing; one had no findings, and another had no chart description. Seventeen patients (94.4%, 17/18) had abnormal CT findings suggestive of the presence of a foreign body. Twelve patients (63.2%, 12/19) had an elevated white blood cell (WBC) count, implying inflammatory lesions. Contrary to the WBC count, the C-reactive protein (CRP) levels were elevated in only five patients (26.3%, 5/19). In the later period, the locations of the foreign body were the right bronchus in 10 patients (47.6%), the left bronchus in nine patients (42.8%), and the trachea in two patients (9.5%), suggesting the absence of apparent change in the trend of TFB location during the overall study period (Table 4).

Table 1. Clinical characteristics of pediatric tracheobronchial foreign body patients in 2006-2021.

Patient	Age (year)	Sex	The interval between the aspiration to hospitalization (day)	Place of occurrence	The type of foreign body material	Site of foreign body	Method of treatment	Hospitalization period (day)	Postoperative complications
1	0 y 10 m	Male	1 day to 2 days	House	Toy parts	Right bronchus	Rigid ventilation bronchoscopy	12	No
2	1	Male	1 day to 2 days	House	Plastic object	Right bronchus	Rigid ventilation bronchoscopy	2	No
3	1	Male	< 1	House	Mechanical pencil cap	Right bronchus	Rigid ventilation bronchoscopy	3	No
4	1	Male	< 1	House	Apple	Left bronchus	Rigid ventilation bronchoscopy	2	No
5	1	Male	< 1	House	Soybean	Right bronchus	Rigid ventilation bronchoscopy	3	No
6	1	Male	< 1	House	Soybean	Trachea	Rigid ventilation bronchoscopy	4	No
7	1	Male	1 day to 2 days	House	Peanuts	Left bronchus	Rigid ventilation bronchoscopy	7	Atelectasis
8	1	Male	1 day to 2 days	House	Peanuts	Left bronchus	Rigid ventilation bronchoscopy	9	No
9	1	Male	6	House	Peanuts	Right bronchus	Rigid ventilation bronchoscopy	11	No
10	1	Female	< 1	House	Fried chicken	Left bronchus	Rigid ventilation bronchoscopy	31	Atelectasis
11	2	Male	> 7	NA	Peanuts	Left bronchus	Rigid ventilation bronchoscopy	3	No
12	2	Male	14	House	Popcorn	Left bronchus	Rigid ventilation bronchoscopy	3	No
13	2	Male	2	House	Peanuts	Right bronchus	Rigid ventilation bronchoscopy	6	Pneumonia
14	2	Female	1 day to 2 days	House	Edamame	Trachea	Flexible bronchoscopy	3	Atelectasis
15	2	Female	3	House	Peanuts	Right bronchus	Rigid ventilation bronchoscopy	4	No
16	2	Female	< 1	House	Peanuts	Left bronchus	Rigid ventilation bronchoscopy	5	No
17	3	Male	1 day to 2 days	Kindergarten	Cheese	Right bronchus	Flexible bronchoscopy	4	No
18	5	Male	< 1	House	Persimmon	Right bronchus	Rigid ventilation bronchoscopy	4	No
19	7	Male	< 1	House	Toy parts (metallic tube)	Left lower lobe bronchus	Back blow under radioscopy	1	No
20	7	Male	< 1	House	Peanuts	Left bronchus	Rigid ventilation bronchoscopy	5	No
21	9	Male	< 1	Primary school	Mecanical pencil cap	Left bronchus	Flexible bronchoscopy	3	No

y, year; m, month.

In terms of the type of foreign body material, organic objects, such as various foods, were detected in 74 patients (87.1%) and inorganic objects in 11 cases (12.9%) throughout the study period (Table 5). The rate of inorganic object aspiration in the later period (23.8%, 5/21) tended to increase compared with that in the earlier period (9.4%, 6/64), but the difference was not significant ($p = 0.13$). In both study periods, peanuts were the most common cause of TFB aspiration (Table 5). Of the overall TFB aspiration rate, the rate of peanut aspiration significantly decreased from 68.8% (44/64) to 38.1% (8/21) between the earlier and

later periods ($p = 0.019$) (Table 5). However, no significant decrease was observed in the aspiration rates of other types of beans, including soybeans.

Emergency surgeries were performed under general anesthesia in all patients. Rigid bronchoscopy was conducted to remove the TFBs in all patients in the earlier period; however, flexible bronchoscopy was used in three recent patients (14.3%) in the later period ($p = 0.014$) (Table 6). In one patient, the TFB was removed by a pediatric surgeon by applying back blows while in the upside-down position under X-ray fluoroscopic guidance (a 7-year-

Table 2. Number of pediatric tracheobronchial foreign body patients in 1986-2005 and 2006-2021.

Age	Total (n = 85)	1986-2005 (n = 64)	2006-2021 (n = 21)	p value
0	8 (9.4%)	7 (10.9%)	1 (4.8%)	0.038
1	53 (62.4%)	44 (68.8%)	9 (42.9%)	
2	15 (17.6%)	9 (14.1%)	6 (28.6%)	
3-6	5 (5.9%)	3 (4.7%)	2 (9.5%)	
7-10	4 (4.7%)	1 (1.6%)	3 (14.3%)	
cases / year	2.4	3.2	1.3	

The rate of 3 years or older is significantly different between the earlier period and the later period ($p = 0.038$): 6.3% (4/64) and 23.8% (5/21), respectively. Data are shown as n (%).

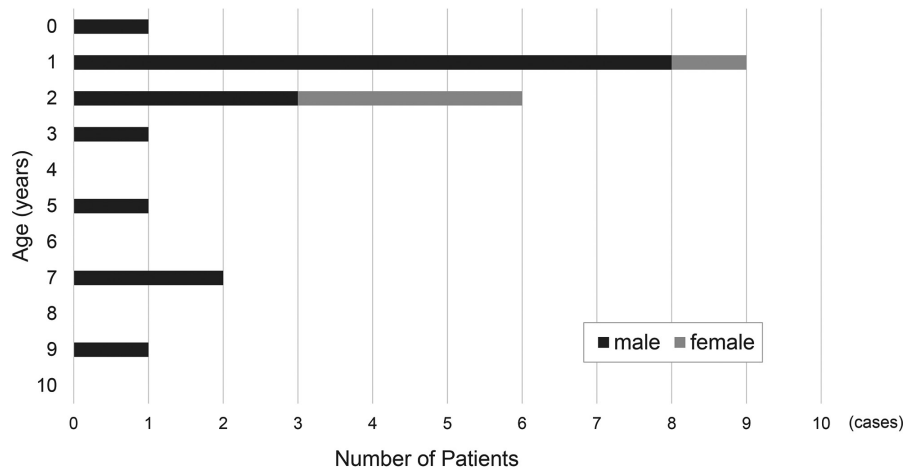


Fig. 1. Age and sex of pediatric tracheobronchial foreign body patients in 2006-2021.

Of the 21 patients diagnosed with tracheobronchial foreign bodies in the later period, those aged > 3 years were male.

old boy, toy parts in the left lower lobe bronchus). Three of the 21 patients with TFB in the later period had postoperative atelectasis. In contrast, one patient (aged 2 years) developed postoperative pneumonia due to the aspiration of a peanut in the right bronchus. All patients survived and were eventually discharged, with hospital stays ranging from 1 to 31 days (median, 4 days) in the later period.

Discussion

Foreign bodies lodged in the upper aerodigestive tract are a common clinical problem in otorhinolaryngology practice (Suzuki et al. 2020; Koizumi et al. 2021; Shishido et al. 2021). However, TFB is a relatively rare condition and has been reported in patients admitted in several medical centers owing to its emergent nature (Schramm et al. 2017). Therefore, it is difficult to standardize its treatments, especially rigid bronchoscopy, despite its life-threatening nature. To the best of our knowledge, no studies have investigated the trends in the clinical characteristics of patients with TFBs over several decades in a high-income country. In this study, we revealed the following changes in the characteristics and treatments of TFBs in Miyagi Prefecture, Northeast Japan, from a retrospective study of single-institution cases spanning 36 years. First, the inci-

dence of TFBs has decreased over the past 36 years. Second, the proportion of TFB patients aged 3 years or older, especially that of inorganic object foreign body aspiration patients, was significantly increased in the later period of this study. Third, peanuts were the most common cause of TFB aspiration in both study periods. However, the rate of peanut aspiration significantly decreased in the later period of this study (68.8% vs. 38.1%). By contrast, no significant decrease was observed in the incidence of aspiration of other types of beans. Fourth, none of the patients had an undetected TFB for more than 1 month after the onset of cough or other symptoms in the later period. Finally, flexible bronchoscopy was successfully introduced as a method to remove the TFBs in pediatric patients admitted to the institute, in which rigid bronchoscopes are used to remove TFBs. These results are essential for developing the appropriate prevention and treatment strategies for removing TFBs in children.

Since the introduction of rigid bronchoscopy to remove an aspirated pork bone by Gustav Killian, a German otolaryngologist, in 1897 (Zollner 1965), otolaryngologists have treated foreign airway bodies, including TFBs. Our department introduced ventilation bronchoscopy as a method for removing TFBs in 1966 and reported a review

Table 3. The interval between the foreign body aspiration and hospital admission in the two study periods.

Time frame	Total (n = 85)	1986-2005 (n = 64)	2006-2021 (n = 21)	p value
~24 hours	28 (32.9%)	18 (28.1%)	10 (47.6%)	0.724
1 day to 2 days	22 (25.9%)	16 (25.0%)	6 (28.6%)	
2 days to 7 days	24 (28.2%)	21 (32.8%)	3 (14.3%)	
7 days to 1 month	7 (8.2%)	5 (7.8%)	2 (9.5%)	
over 1 month	4 (4.7%)	4 (6.3%)	0 (0.0%)	

The rate of 7 days or less is not significantly different between the earlier period and the later period (p = 0.724): 85.9% (55/64) and 90.5% (19/21), respectively. Data are shown as n (%).

Table 4. Sites of foreign bodies reported in 1986-2005 and 2006-2021.

Sites	Total (n = 85)	1986-2005 (n = 64)	2006-2021 (n = 21)	p value
Right bronchus	38 (44.7%)	28 (43.8%)	10 (47.6%)	p > 0.999
Left bronchus	38 (44.7%)	29 (45.3%)	9 (42.8%)	
Trachea	9 (10.6%)	7 (10.9%)	2 (9.5%)	

Data are shown as n (%).

Table 5. Type of foreign body materials reported in 1986-2005 and 2006-2021.

	Total (n = 85)	1986-2005 (n = 64)	2006-2021 (n = 21)	p value
Food	74 (87.1%)	58 (90.6%)	16 (76.2%)	0.130
Peanut	52 (61.2%)	44 (68.8%)	8 (38.1%)	0.019
Soybean	6 (7.1%)	4 (6.3%)	2 (9.5%)	0.634
Edamame	8 (9.4%)	7 (10.9%)	1 (4.8%)	0.673
Corn	2 (2.4%)	1 (1.6%)	1 (4.8%)	0.435
Orange seed	1 (1.2%)	1 (1.6%)	0 (0.0%)	p > 0.999
Fishbone	1 (1.2%)	1 (1.6%)	0 (0.0%)	p > 0.999
Apple	1 (1.2%)	0 (0.0%)	1 (4.8%)	0.247
Persimmon	1 (1.2%)	0 (0.0%)	1 (4.8%)	0.247
Cheese	1 (1.2%)	0 (0.0%)	1 (4.8%)	0.247
Fried chicken	1 (1.2%)	0 (0.0%)	1 (4.8%)	0.247
Inorganic objects	11 (12.9%)	6 (9.4%)	5 (23.8%)	0.130
Plastic object	4 (4.7%)	3 (4.7%)	1 (4.8%)	p > 0.999
Dental filling	2 (2.4%)	2 (3.1%)	0 (0.0%)	p > 0.999
Sponge	1 (1.2%)	1 (1.6%)	0 (0.0%)	p > 0.999
Toy parts	2 (2.4%)	0 (0.0%)	2 (9.5%)	0.059
Mechanical pencil caps	2 (2.4%)	0 (0.0%)	2 (9.5%)	0.059

Data are shown as n (%).

of 110 TFB patients (1966-1974), including 97 patients aged < 10 years (Saijo et al. 1979). Since the introduction of ventilation bronchoscopy, most individuals with TFBs in Miyagi Prefecture have been treated at our hospital, except for those who experienced choking or respiratory arrest before arrival. The numbers of TFB patients aged < 10 years treated in our department at different time points were as follows: 10.8 patients per year in 1966-1974, 3.2 patients per year in 1986-2005, and 1.3 patients per year in 2006-

2021. Even considering the decrease in the child population (aged 0-14 years) of Miyagi Prefecture (approximately 450,000 in 1970, 400,000 in 1995, and 300,000 in 2010), the incidence of TFB appears to have declined.

In general, foreign body aspiration typically occurs in children aged < 3 years and their peak frequency occur at 1-2 years (Ciftci et al. 2003; Salih et al. 2016). Our results showed that the incidence of TFB aspiration in children aged 3 years or older significantly increased, and all of the

Table 6. Surgical treatment of foreign body materials in 1986-2005 and 2006-2021.

Removal	Total (n = 85)	1986-2005 (n = 64)	2006-2021 (n = 21)	p value
Flexible bronchoscopy	3 (3.5%)	0 (0.0%)	3 (14.3%)	0.014
Rigid ventilation bronchoscopy	81 (95.3%)	64 (100.0%)	17 (81.0%)	
Back blow under radiology	1 (1.2%)	0 (0.0%)	1 (4.8%)	

Rigid bronchoscopy was conducted to remove the tracheobronchial foreign bodies (TFBs) in all patients earlier; however, flexible bronchoscopy was used in three recent patients (14.3%) in the later period ($p = 0.014$). In one patient, the TFB was removed by a pediatric surgeon by applying back blows while in the upside-down position under X-ray fluoroscopy (a 7-year-old boy, toy parts in the left bronchus). Data are shown as n (%).

patients in the later period of our study were boys. TFB aspiration more frequently occurs in boys than in girls, with a male-to-female ratio of 1.5-2.5:1 (Mansour and Elias 2015; Salih et al. 2016; Ding et al. 2020). This male sex predominance may be attributed to the boys' impulsive and adventurous nature (Chiu et al. 2005; Salih et al. 2016). Our male-to-female ratio of 4.3:1 within 16 years was much higher than that reported in previous studies. This might be caused by decreased food aspiration cases in toddlers, with minor differences in incidence rates between boys and girls owing to social and educational programs providing information to parents and caregivers about the risk of aspiration of beans, especially peanuts, and nuts. Despite the consumer protection policies implemented to prevent aspiration in children, small toys or toy parts still account for 5%-15% of airway foreign bodies (Murray and Walner 2002; Ambrose and Raol 2017). The types of inhaled foreign bodies vary globally (Salih et al. 2016); however, our trend in TFB aspiration may also apply to other developed countries. Based on the Prevention of Choking Among Children Policy Statement (Committee on Injury, Violence, and Poison Prevention 2010), choking prevention counseling and social and educational activities should be provided to parents to enlighten them not only regarding the danger of food aspiration but also that of inorganic object aspiration, such as coins, toys, and stationery parts, which are necessary to prevent choking from airway foreign bodies and its fatal complications.

According to a previous review of 12,979 children with TFB, most (81%) aspirated materials were organic, and peanuts, nuts, and seeds were the most commonly reported organic materials in almost all studies analyzed (Fidkowski et al. 2010). In this study, peanuts were the most frequent TFB (61.2%, 52/85) during the entire study period, and the peanut aspiration rate significantly decreased from 1986-2005 to 2006-2021. The risk of peanut aspiration is indicated in the mother and child health handbook issued by a public office after delivery in Japan. It is also posted in magazines and websites concerning childcare, and this measure might have contributed to this change. Recent studies with solid evidence on the prevention of peanut allergy suggested the advantage of early exposure to peanut proteins to avoid the development of

peanut allergy in children (Du Toit et al. 2015; Perkin et al. 2016). This finding is valuable but poses a risk of aspiration among infants and young children fed with whole peanuts, not peanut butter. Hence, healthcare professionals should provide detailed information on how to prevent peanut allergy to avoid the occurrence of peanut aspiration.

By contrast, the incidence of aspiration caused by soybeans and other types of beans remained high (15% in the earlier and later periods of this study). Edamame, a boiled green soybean, is a common type of bean found in Japan, the second most common TFB-causing aspiration in this study (9.4%, 8/85). Edamame has gained popularity globally as a snack owing to its taste, nutritional value, and price. An edamame is usually eaten after removal from the pod; therefore, its consumption among children may carry a risk of aspiration. As edamame has become popular worldwide, attention should be paid to the risk of accidental aspiration.

TFB aspiration requires immediate hospitalization and treatment; even if the patient's respiration is stable, coughing or body movements can trigger the movement of foreign bodies, rapidly obstructing the respiratory tract and leading to death (Steen and Zimmermann 1990). In the later period of the study, none of the patients had an undiagnosed TFB for more than 1 month after the onset of symptoms. Besides the high rate of witnesses of foreign body inhalation episodes (90.4%, 19/21), the widespread use and development of CT scans, for example, three-dimensional spiral CT scans (Hong et al. 2008), might facilitate the detection of TFBs within a shorter time and prompt referral to our hospital. Furthermore, more than 30% of children with bronchial foreign bodies had normal findings on chest X-rays (Mu et al. 1991); however, the sensitivity of CT is close to 100%, with specificity ranging from 66.7% to 100% in terms of the detection of bronchial foreign bodies (Haliloglu et al. 2003; Hong et al. 2008). In one of 21 patients (patient No.8 in Table 1), a foreign body could not be detected on CT, possibly because the patient was not sedated and the foreign body could not be identified due to artifacts from body movement. CT with sedation is often not the first choice for children with unstable respiratory status, and CT may not demonstrate a foreign body, as in our case, but it is still valid. Moreover, chest CT can identify TFB-associated complications such as emphysema and

atelectasis (Xu et al. 2018; Wang et al. 2023). Hence, future improvements in radiological imaging accuracy and prompt access to appropriate diagnostic equipment would lead to the earlier detection of TFBs.

Rigid bronchoscopy is the current gold standard for treating foreign body aspiration in children (Tang et al. 2009; Faro et al. 2015; Eber et al. 2017; Chantzaras et al. 2022); however, it has a complication rate of 2%-22% (Ciftci et al. 2003; Hitter et al. 2011). Recently, many studies have shown the usefulness of flexible bronchoscopy for airway foreign-body removal (Tang et al. 2009; Mansour and Elias 2015; Wang et al. 2021; Chantzaras et al. 2022). A flexible bronchoscope is easier to insert in the trachea and bronchus peripherally and is considered gentler for the airway than a rigid bronchoscope (Suzen et al. 2019; Chantzaras et al. 2022). A recent systematic review indicated that flexible bronchoscopy successfully removed foreign bodies in 87.1% of the patients (Chantzaras et al. 2022). Complications such as migration or loss of foreign bodies, fragmentation, and oxygenation impairment commonly occur with flexible bronchoscopy than with rigid bronchoscopy (Rodrigues et al. 2012); however, flexible bronchoscopy has several advantages, such as minimal complication rates during or after the procedure (Li et al. 2020), allowing multiple retrieval manipulations (Suzen et al. 2019), accessibility to distal locations (Li et al. 2020), and enabling a secure and detailed inspection of the airway after foreign body removal (Tenenbaum et al. 2017).

On the contrary, rigid bronchoscopy is the most preferred treatment for respiratory-unstable patients as it ensures safe ventilation in those with highly positioned and asphyxiating foreign bodies and large and/or sharp foreign bodies (De Palma et al. 2020; Chantzaras et al. 2022). Moreover, rigid bronchoscopy is preferred when massive bleeding disturbs the visualization of the surgical field (Gang et al. 2012; Chantzaras et al. 2022). As flexible bronchoscopy and rigid bronchoscopy have advantages and disadvantages, both instruments should be prepared in the operating room.

In all three cases in which flexible bronchoscopy was used for TFB removal, supraglottic airway devices (SGAs) were used to secure an airway. In the case of tracheal intubation, the diameter of the tube is narrower than that of the SGA tube, resulting in reduced ventilation when fibers are used and less space for pharyngeal and tracheal manipulation. Therefore, in children whose tracheal diameters are narrower than adults, it is desirable to use a flexible bronchoscope under an SGA to maintain ventilation and operability. Regarding the age at which removal is possible with flexible bronchoscopy, the minimum age is 2 years in our institution. Many cases of flexible bronchoscopy being used for TFB removal have been reported in children aged 1 year and older worldwide (Suzen et al. 2019); therefore, flexible bronchoscopy should be considered for the removal of pediatric foreign bodies in Japan. However, to safely achieve a high success rate, careful preoperative planning is

required to determine whether rigid bronchoscopy or flexible bronchoscopy is a better option, taking into consideration the location and size of the foreign body, the tracheal diameter on CT, and the diameter of flexible bronchoscopes available at the facility. Even if flexible bronchoscopy is used first, it is important to prepare a transition to rigid bronchoscopy, if necessary.

This study has some limitations. Our study was a retrospective observational study using clinical records of TFB patients in a university hospital, and 85 TFB patients in 36 years is a small sample size. The comparison period differs between the earlier period and the later period. This period was set because the previous paper (Katori et al. 2005) covered 20 years from 1986 to 2005, and it was difficult to reorganize the time because some medical record information before 2005 is currently unavailable for reference. Our university hospital has been a center for treating pediatric TFBs in the Miyagi medical area, which serves 2,300,000 people, owing to the availability of medical staff and equipment, such as a ventilation bronchoscope. Therefore, our results reflect the recent trends in TFB aspiration in the Miyagi medical area. However, this is a single-center study and may not represent the trend in Japan as a whole.

In conclusion, TFB is a rare pediatric emergency in Japan. We revealed recent trends in the clinical characteristics of pediatric TFB patients in a single institution over 36 years. Engagement in effective educational activities and providing updated diagnosis and treatment to pediatric TFB patients must be considered following the recent trends.

Acknowledgment

We thank Editage (<https://www.editage.jp>) for English language editing.

Author Contributions

H.T. collected and analyzed the data and wrote the manuscript draft. J.S. designed the study, analyzed the data, and wrote the manuscript. R.I., T.O., J.O., and A.H.K. reviewed the manuscript. Y.K. supervised the study. All authors have read and approved the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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