Risk factors for preoperative respiratory complications in children with tracheobronchial foreign bodies

Yi-Hui Yang, Xin-Gang Zhang, Jian-Li Zhang, Yong-Bo Zhang and Cui-Ping Kou

Abstract
Objective: To identify risk factors for preoperative respiratory complications associated with tracheobronchial foreign body aspiration (TFBA) by retrospectively analysing paediatric cases presenting with or without complications.

Methods: Paediatric patients who presented with TFBA and were admitted to hospital were enrolled in the study. Patients were divided into two groups based on occurrence of preoperative respiratory complications as confirmed by computed tomography. Age, sex, TFBA symptoms, type of foreign body, retention time and location of the foreign body were documented and compared between the groups.

Results: In total, 223 children were included: group A (n = 161) included those with respiratory complications; group B (n = 62) included those without respiratory complications. Univariate and multivariate analyses found that type of foreign body and symptoms differed significantly between the two groups.

Conclusion: Respiratory complications of TFBA in children were correlated with the type of foreign body and symptoms.

Keywords
Children, tracheobronchial foreign body, preoperative, complication, risk factor

Date received: 17 April 2015; revised: 20 July 2015; accepted: 29 July 2015

Introduction
Tracheobronchial foreign body aspiration (TFBA) is one of the most common respiratory conditions, causing dyspnoea or other pulmonary complications; TFBA...
can become life threatening under severe circumstances.\(^1\) Delayed diagnoses are frequent and substantially increase the risk of respiratory complications.\(^2\) Respiratory complications of TFBA, including pulmonary infection (pneumonia), emphysema, atelectasis, mediastinal shift and pneumomediastinum, not only add difficulties to the bronchoscopy procedure but also contribute to long-term adverse consequences and harmful effects on children’s health.\(^3\)–\(^5\)

Research has reported a positive correlation between respiratory complications and the retention time of foreign bodies,\(^2\) but factors that influence the retention time have not been identified. The present study aimed to identify the risk factors for preoperative respiratory complications by retrospectively analysing cases of paediatric TFBA in order to compare age, sex, symptoms, type of foreign body, retention time and location of foreign body between groups with or without preoperative respiratory complications.

**Patients and methods**

**Patient population**

This retrospective study analysed data collected from consecutive paediatric patients with TFBA who attended the Department of Otolaryngology, Ningbo Women and Children’s Hospital, Ningbo, Zhejiang Province, China, between February 2012 and October 2014. All TFBA were diagnosed by rigid bronchoscopy based on a definitive history or suspicion of foreign body inhalation. Computed tomography (CT) was performed in all patients using a Brilliance CT 16-slice system (Philips Healthcare, Best, The Netherlands) to identify any pulmonary complications.

The study was approved by the Institutional Review Board of Ningbo Women and Children’s Hospital (no. 2015012). Parents or legal guardians of the study participants provided written informed consent.

**Study methods**

Enrolled patients were divided into two groups according to occurrence of preoperative respiratory complications (pulmonary infection [pneumonia], emphysema, atelectasis, mediastinal shift and pneumomediastinum) confirmed by CT. Group A included patients with preoperative respiratory complications; group B included patients without preoperative respiratory complications. Retention time, which was defined as the duration from onset of TFBA symptoms to hospital admission, was recorded for all study participants.

**Statistical analyses**

All statistical analyses were performed using the SPSS\(^\circledR\) statistical package, version 16.0 (SPSS Inc., Chicago, IL, USA) for Windows\(^\circledR\). Continuous data with a normal distribution were presented as mean ± SD. Between-group comparisons were conducted using Student’s \(t\)-test. Categorical data were analysed using \(\chi^2\)-test. All of the variables were assessed for normality using Kolmogorov–Smirnov test. A \(P\)-value < 0.05 was considered statistically significant. Univariate and multivariate analyses were performed using a Cox logistic regression model. Effects of different clinical parameters on the respiratory complications of TFBA in children were calculated by univariate analysis for each parameter. Parameters for which the unadjusted \(P\)-value was < 0.10 in the univariate analysis were identified as potential risk markers and were included in the multivariate analysis.

**Results**

A total of 223 children were enrolled in the study (150 male; 73 female, with a mean ± SD age of 1.8 ± 1.9 years [range, 7 months to 12 years]). The mean ± SD retention time was 5.9 ± 1.5 days (range, 30 min to 63 days). In total, 156 of 223 patients (70%) were referred from other hospitals in the local area.
Patients were divided into two groups based on the presence of preoperative respira-
tory complications as identified on CT: group A (n = 161; 106 male and 55 female patients) and group B (n = 62; 43 male and 19 female patients). Table 1 presents the demographic and clinical characteristics of the two groups. There were no significant between-group differences in terms of age or sex distribution. Age- and sex distributions of the patients in both groups A and B are presented in Figure 1. In group A, the age groups that were most likely to present with TFBA were the 0 to <1 (n = 40 patients) and ≥1 to <2 (n = 100) year groups. In group B, the age groups that were most likely to present with TFBA were 0 to <1 (n = 15 patients) and ≥1 to <2 (n = 36) year groups, which together accounted for 86% (191/223) of all patients.

The mean ± SD retention time was significantly longer in group A compared with group B (P < 0.05) (Table 1). Coughing and wheezing were the most common symptoms of TFBA in patients in both groups (Table 2). The proportion of patients with dyspnoea in group B was significantly higher compared with group A (P < 0.05). There were no other significant between-group differences.

Types of foreign body that were aspirated by patients in both study groups are listed in Table 3. The majority of aspirated foreign bodies were food items (145/161 [90%] in group A; 55/62 [89%] in group B), particularly peanut kernels and sunflower seeds. Anatomical locations of aspirated foreign bodies for both groups are shown in Table 4. Results of the CT scans for preoperative pulmonary complications for group A are shown in Table 5. Emphysema and pneumonia were the most common complications. A total of 121 of 161 patients (75%) in group A had several complications simultaneously.

Univariate and multivariate analyses of the effects of clinical parameters on respiratory complications of TFBA in children found that the type of foreign body and the symptoms of TFBA differed significantly between both groups (P < 0.05) (Table 6).

Table 1. Clinical and demographic characteristics of paediatric patients admitted to hospital with symptoms of tracheobronchial foreign body aspiration, with (group A) or without (group B) preoperative respiratory complications.

| Characteristic                | Group A (n = 161) | Group B (n = 62) |
|------------------------------|------------------|-----------------|
| Age, years                   | 1.8 ± 1.7        | 1.9 ± 1.5       |
| Age range, years             | 7 months to 12 years | 7 months to 12 years |
| Age categories               |                  |                 |
| 0 to <1                      | 40               | 15              |
| ≥1 to <2                     | 100              | 36              |
| ≥2 to <3                     | 8                | 5               |
| ≥3 to <4                     | 5                | 1               |
| ≥4 to <5                     | 3                | 3               |
| ≥5 to <12                    | 5                | 2               |
| Sex, male/female             | 106/55           | 43/19           |
| Retention time, days         | 13.40 ± 1.62     | 4.02 ± 5.62α    |
| Retention time, range days   | 3 h to 63 days   | 0.5 h to 15 days |

Data presented as mean ± SD or n patients.

αP < 0.05 compared with group A; Student’s t-test.

Discussion

Despite improvements in the general public’s knowledge of TFBA in recent years, this pulmonary condition remains life threatening for young children who cannot chew food thoroughly and tend to put foreign bodies into their mouths. Previous reports have demonstrated that children aged 0–3 years are most likely to experience TFBA, accounting for 65–75% of all cases.4, 6 In the current study, 86% (191/223) of the cases were children aged 0 to <2 years and the mean age of the study population was 1.8 years. The mean age was 1 year younger...
than in previous reports.\textsuperscript{6-8} Reasons for this decrease in the mean age of children experiencing TFBA are speculated to be an improved material life and increased availability of food at home. Some nutritionists recommend nuts to promote brain development in young children, prompting parents to add these foodstuffs to their children’s diets. There was no

\textbf{Figure 1.} Age and sex distributions of paediatric patients admitted to hospital with symptoms of tracheobronchial foreign body aspiration, with (A, group A; \(n = 161\)) or without (B, group B; \(n = 62\)) preoperative respiratory complications. Shaded lower boxes are male and nonshaded upper boxes are female patients.
significant difference in the mean age of groups A and group B (1.8 versus 1.9 years, respectively) in the present study.

In the present study, the male/female ratios in groups A and B were 1.9:1.0 and 2.3:1.0, respectively, which were similar to previously reported ratios. There is some evidence that male children may be more adventurous and careless than female children, which may heighten the risk of TFBA in male infants.

Tracheobronchial foreign body aspiration is frequently misdiagnosed in children for the following reasons: (i) parents are absent when TFBA occurs and cannot provide a clear history; (ii) due to concern over being blamed, babysitting seniors may refuse to accurately report an incident; (iii) lack of

### Table 2. Symptoms of tracheobronchial foreign body aspiration in paediatric patients admitted to hospital with (group A) or without (group B) preoperative respiratory complications.

| Symptoms   | Group A    | Group B    |
|------------|------------|------------|
|            | n = 161    | n = 62     |
| Coughing   | 156 (96.9) | 52 (83.9)  |
| Wheezing   | 126 (78.3) | 55 (88.7)  |
| Fever      | 12 (7.5)   | 5 (8.1)    |
| Dyspnoea   | 5 (3.1)    | 17 (27.4)  |

Data presented as n (%) of patients.

\(^{a}P < 0.05\) compared with group A; \(\chi^2\)-test.

### Table 3. Types of aspirated foreign body in paediatric patients admitted to hospital with symptoms of tracheobronchial foreign body aspiration with (group A) or without (group B) preoperative respiratory complications.

| Category       | Group A    | Group B    |
|----------------|------------|------------|
|                | n = 161    | n = 62     |
| Peanut         | 52 (32.3)  | 10 (16.1)  |
| Sunflower seed | 22 (13.7)  | 27 (43.5)  |
| Walnut         | 15 (9.3)   | 2 (3.2)    |
| Pistachio nut  | 12 (7.5)   | 4 (6.5)    |
| Apple, peach   | 9 (5.6)    | 4 (6.5)    |
| Animal bone    | 8 (5.0)    | 3 (4.8)    |
| Rice           | 7 (4.3)    | 2 (3.2)    |
| Bean           | 7 (4.3)    | 3 (4.8)    |
| Chestnut       | 5 (3.1)    | 0 (0.0)    |
| Almond         | 3 (1.9)    | 0 (0.0)    |
| Meat           | 3 (1.9)    | 0 (0.0)    |
| Watermelon seed| 2 (1.2)    | 0 (0.0)    |
| Toy            | 8 (5.0)    | 5 (8.1)    |
| Whistle        | 0 (0.0)    | 1 (1.6)    |
| Cap of a pen   | 1 (0.6)    | 0 (0.0)    |
| Unknown        | 7 (4.3)    | 1 (1.6)    |

Data presented as n (%) of patients.

\(^{a}P < 0.05\) compared with group A; \(\chi^2\)-test.

### Table 4. Locations of aspirated foreign bodies in paediatric patients admitted to hospital with symptoms of tracheobronchial foreign body aspiration with (group A) or without (group B) preoperative respiratory complications.

| Site            | Group A    | Group B    |
|-----------------|------------|------------|
|                 | n = 161    | n = 62     |
| Left bronchus   | 82 (50.9)  | 17 (27.4)  |
| Right bronchus  | 75 (46.6)  | 13 (21.0)  |
| Trachea         | 4 (2.5)    | 32 (51.6)  |

Data presented as n (%) of patients.

### Table 5. Pulmonary complications identified by preoperative computed tomography in paediatric patients admitted to hospital with symptoms of tracheobronchial foreign body aspiration; patients presented with preoperative respiratory complications.

| Complication            | Group A    |
|-------------------------|------------|
|                         | n = 161    |
| Emphysema               | 156 (96.9) |
| Pneumonia               | 73 (45.3)  |
| Atelectasis             | 3 (1.9)    |
| Pneumomediastinum       | 2 (1.2)    |
| Subcutaneous emphysema  | 1 (0.6)    |
| Pneumothorax            | 1 (0.6)    |

Data presented as n (%) of patients.

\(^{a}\)Group B patients did not present with preoperative respiratory complications and are therefore not included in this analysis.

2.3:1.0, respectively, which were similar to previously reported ratios. There is some evidence that male children may be more adventurous and careless than female children, which may heighten the risk of TFBA in male infants.
medical knowledge, which leads to neglect of the serious situation and delay in seeing a physician; (iv) clinicians misdiagnose TFBA as upper respiratory infection, bronchitis or pneumonia.\(^2,3\) In the present study, the mean ± SD retention time was significantly longer in group A compared with group B (13.40 ± 1.62 days [range, 3 h to 63 days] versus 4.02 ± 5.62 days [range, 0.5 h to 15 days], respectively) (\(P < 0.05\)). Delayed treatment prolongs the retention time of the foreign body in the respiratory tract, resulting in pneumonia, emphysema, atelectasis, pneumomediastinum and other serious complications.\(^2,3\)

Common symptoms of TFBA are coughing, dyspnoea, wheezing, and fever, which differ according to the stage of TFBA; these symptoms are generally experienced in a sequential manner.\(^1,2\) In the first stage (acute stage), the most common symptoms are violent coughing, dyspnoea, or even asphyxia due to complete airway blockage.\(^1,2\) In the second stage (quiescent stage), the symptoms are not obvious, which can lead to misdiagnosis.\(^1,2\) The third stage is a late stage accompanied by complications.\(^1,2\) In the present study, the most common symptoms of TFBA in patients in both groups were coughing and wheezing. Other symptoms included fever and dyspnoea. The proportion of patients with dyspnoea in group B was significantly higher compared with group A (\(P < 0.05\)) in the present study, a finding that might be attributed to the location of foreign bodies. Patients in group B were more likely to have their foreign body located in their trachea compared with group A (51.6% versus 2.5%, respectively), which in our experience cause severe symptoms such as dyspnoea, attracting more attention and causing patients and their parents to seek urgent medical help, thus facilitating early diagnosis and timely treatment.

Preoperative respiratory complications are related to the retention time of the foreign body.\(^3\) In our experience, plant foreign bodies such as peanuts and walnuts can cause complications if they are retained for \(>24\) h, while plastic foreign bodies require a longer period, several months or even years, to trigger complications. The type, size, shape and location of the foreign body also plays a role in the occurrence of preoperative respiratory complications.\(^3\) The type of foreign body is related to the local culture and dietary habits.\(^3,10,11\) Most studies have shown that nuts (particularly peanuts) and seeds (especially sunflower seeds) are most

### Table 6. Univariate and multivariate analyses of the effects of clinical parameters on respiratory complications of tracheobronchial foreign body aspiration in children (\(n = 223\)).

| Parameter               | Univariate analysis | Multivariate analysis\(^a\) |
|-------------------------|---------------------|---------------------------|
|                         | HR                  | 95% CI                    | HR                  | 95% CI                  | Statistical significance |
|                         | Statistical         |                           | Statistical         |                         |                           |
|                         | significance        |                           | significance        |                         |                           |
| Type of foreign body    | 1.434               | 1.122, 1.535              | 0.879               | 0.367, 0.987            | \(P = 0.001\)             |
| Symptoms                | 1.671               | 1.231, 1.878              | 1.457               | 1.123, 1.671            | \(P = 0.012\)             |
| Location of foreign body| 0.342               | 0.111, 0.567              | NS                  |                         |                           |
| Age                     | 0.876               | 0.567, 1.013              | NS                  |                         |                           |
| Sex                     | 1.097               | 0.876, 1.342              | NS                  |                         |                           |

\(^a\)Parameters for which the unadjusted \(P\)-value was <0.10 in the univariate analysis were identified as potential risk markers and included in the multivariate Cox logistic regression model. HR, hazard ratio; 95% CI, 95% confidence interval; NS, no statistically significant difference (\(P \geq 0.05\)).
commonly aspirated. In the present study, ~90% of the aspirated foreign bodies in both groups were food, particularly peanut kernels (group A: 32.3%; group B: 16.1%) and sunflower seeds (group A: 13.7%; group B: 43.5%). Peanut kernels are larger than sunflower seeds, so they are prone to cause airway blockage. After prolonged retention in the respiratory tract, during which time water is absorbed, the peanut can expand and worsen the condition. In addition, peanuts are abundant in unsaturated fatty acids, contributing to respiratory inflammation. These facts might explain the higher proportion of aspirated peanuts in group A compared with group B, in the present study. The majority of TFBA cases could be avoided by parents and carers keeping young children away from nuts and small toys.

In the long term, foreign bodies have a higher tendency to fall into the right bronchus. Recent research has shown that the right-side tendency exists in adults but not in children younger than 15 years. The left and right principal bronchi form similar angles within the main trachea, thus the likelihood of a foreign body falling into each should be similar. This present study supports this suggestion, as 50.9% of foreign bodies in group A were located in the left bronchus and 46.6% were in the right bronchus; in group B, 27.4% of foreign bodies were located in the left bronchus and 21.0% were in the right bronchus. Of special interest was the fact that in group B, 51.6% of the foreign bodies were located in the trachea, which was markedly higher than in group A (2.5%). These findings suggest that the symptoms associated with the presence of a foreign body in the trachea were more severe than in the bronchus, causing patients and their parents to seek medical help earlier.

When patients present with TFBA at our institution, CT is routinely used to ascertain the location of the foreign body and confirm preoperative complications, because severe complications must be detected in order to provide timely treatment and reduce surgical risks. All 223 patients in the present study underwent CT and 161 patients (group A) were confirmed to have preoperative respiratory complications. Emphysema and pneumonia were the most common complications, accounting for 96.9% and 45.3% of all cases, respectively. Less common complications included atelectasis, pneumomediastinum, pneumothorax and subcutaneous emphysema.

The present study had a number of limitations. First, there was no sample-size calculation undertaken prior to commencement of the study and the authors randomly chose the number of patients to include. Secondly, analyses were not undertaken according to the different age groups. Thirdly, the study did not present the results of treatment and different treatment modalities. Finally, the imbalance between male and female participants might have had an impact on the results.

In conclusion, respiratory complications of TFBA in children are correlated with type of foreign body, retention time and symptoms, but showed no relationship with location of the foreign body, age or sex. Aspiration of peanuts and prolonged retention time may cause preoperative complications. Dyspnoea and trachea-located foreign bodies appeared to urge the patient and their parents to seek medical help earlier, thus reducing preoperative respiratory complications. Early diagnosis and treatment are considered to be key factors in improving the clinical response to TFBA, and in reducing the incidence of complications associated with TFBA in children.

Declaration of conflicting interest
The authors declare that there are no conflicts of interest.

Funding
This research was supported by grants from the Social Development Project of Ningbo
(no. 2013C50009) and the Innovative Team of Key Technology about Birth Defect Early Screening and Intervention (no. 2014B82003).

References

1. Hariga I, Khamassi K, Zribi S, et al. Management of foreign bodies in the aero-digestive tract. Indian J Otolaryngol Head Neck Surg 2014; 66(Suppl 1): 220–224.
2. Sirmali M, Türüt H, Kisacik E, et al. The relationship between time of admittance and complications in paediatric tracheobronchial foreign body aspiration. Acta Chir Belg 2005; 105: 631–634.
3. Hidaka H, Obara T, Kuriyama S, et al. Logistic regression analysis of risk factors for prolonged pulmonary recovery in children from aspirated foreign body. Int J Pediatr Otorhinolaryngol 2013; 77: 1677–1682.
4. Metrangelo S, Monetti C, Meneghini L, et al. Eight years’ experience with foreign-body aspiration in children: what is really important for a timely diagnosis? J Pediatr Surg 1999; 34: 1229–1231.
5. Shafi M, Suhail Z, Asrhafi SK, et al. Frequency of tracheobronchial foreign bodies and their management in urban population of Sindh. J Pak Med Assoc 2012; 62: 896–899.
6. Steen KH and Zimmermann T. Tracheobronchial aspiration of foreign bodies in children: a study of 94 cases. Laryngoscope 1990; 100: 525–530.
7. Shubha AM and Das K. Tracheobronchial foreign bodies in infants. Int J Pediatr Otorhinolaryngol 2009; 73: 1385–1389.
8. Paşaoğlu I, Doğan R, Demircin M, et al. Bronchoscopic removal of foreign bodies in children: retrospective analysis of 822 cases. Thorac Cardiovasc Surg 1991; 39: 95–98.
9. Behera G, Tripathy N, Maru YK, et al. Role of virtual bronchoscopy in children with a vegetable foreign body in the tracheobronchial tree. J Laryngol Otol 2014; 128: 1078–1083.
10. Mu L, He P and Sun D. Inhalation of foreign bodies in Chinese children: a review of 400 cases. Laryngoscope 1991; 101(6 Pt 1): 657–660.
11. Asif M, Shah SA, Khan F, et al. Foreign body inhalation – site of impaction and efficacy of rigid bronchoscopy. J Ayub Med Coll Abbottabad 2007; 19: 46–48.
12. Goyal R, Nayar S, Gogia P, et al. Extraction of tracheobronchial foreign bodies in children and adults with rigid and flexible bronchoscopy. J Bronchology Interv Pulmonol 2012; 19: 35–43.
13. Saki N, Nikakhlagh S, Rahim F, et al. Foreign body aspiration in infancy: a 20-year experience. Int J Med Sci 2009; 6: 322–328.
14. Pan H, Lu Y, Shi L, et al. Similarities and differences in aspirated tracheobronchial foreign bodies in patients under the age of 3 years. Int J Pediatr Otorhinolaryngol 2012; 76: 911–914.
15. Baharloo F, Veyckemans F, Francis C, et al. Tracheobronchial foreign bodies: presentation and management in children and adults. Chest 1999; 115: 1357–1362.