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Tracheobronchial foreign body aspiration in children – diagnostic value of symptoms and signs

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Summary

Objective: Tracheobronchial foreign body (TFB) aspiration is a common cause of respiratory compromise in early childhood. Research indicates that a high number of children are missed with TFB aspiration. The aim of this study was to identify predictors of potential TFB aspiration.

Study design: We analysed 370 endoscopic reports of children admitted to our emergency department who underwent explorative rigid bronchoscopy to exclude/remove a TFB (1989–2003). Patient characteristics, history, clinical, radiographic and bronchoscopic findings were noted. Sensitivities and specificities for TFB aspiration were calculated for patient history, clinical and radiographic findings.

Results: The median age was 1.8 years. In 59.7% of patients a TFB was found and removed. A group analysis was performed on children with symptoms less than 2 weeks (group A) and those more than 2 weeks (group B). The results showed that unilateral diminished breath sounds and unilateral overdistension on chest X-ray were the most sensitive (53–79%) and specific (68–88%) findings in both groups. The clinical triad of acute choking/coughing, wheezing and unilateral diminished breath sounds had a high specificity (96–98%) in both groups. In contrast, a positive history of acute choking/coughing in group A or a permanent cough in group B showed a low specificity (8–16%).

Conclusion: In a paediatric respiratory compromise, the presence of unilateral diminished breath sounds, pathological chest X-ray or clinical triad is a powerful indicator for occurred TFB aspiration. Since no single or combined variables can predict TFB aspiration with full certainty, bronchoscopic exploration should be performed if TFB aspiration is suspected.

Key words: foreign body; respiratory compromise; rigid bronchoscopy

Introduction

Tracheobronchial foreign body (TFB) aspiration is a common cause for a paediatric respiratory emergency, mainly appearing in early childhood [1, 2]. Especially in children whose parents do not recall a history of acute choking/coughing or a witnessed aspiration episode, the diagnosis of a TFB might be missed and delayed. Undiagnosed, retained TFBs may cause serious complications such as pneumonia, airway obstruction or atelectasis [1, 3, 4] or can secondarily dislodge and cause fatal airway obstruction even if signs for tracheobronchial aspiration have disappeared. Still, in case of an insecure diagnosis of a TFB aspiration the decision for explorative bronchoscopy is difficult as bronchoscopy itself bears some risks [3, 5].

Time related changes of diagnostic sensitivities and specificities of different clinical or radiographic findings in a large population of children have not been published so far.

The aim of this study was to identify specific or coincidental diagnostic symptoms and signs that indicate potential TFB aspiration in children and necessitate explorative bronchoscopy.

No potential, perceived, or real conflict of interest, especially any financial arrangement with any company was obtained for the present study.

Patients and methods

With hospital Ethical Committee approval we analysed completed bronchoscopic reports of children admitted to our emergency department that underwent rigid bronchoscopy to exclude or remove TFBs between January 1989 and December 2003. Patients with known chronic lung disease undergoing explorative bronchoscopy were not included in the study.

Patients were subdivided into two groups. Group A

had a history of an acute coughing/choking episode or the onset of a cough for less than 2 weeks. Group B exhibited prolonged cough or a pulmonary affliction unresponsive to medical treatment for more than 2 weeks.

Data were taken from a comprehensive documentation in our bronchoscopy report database, from patient charts and radiographic reports. Bronchoscopy report database consisted of reports from rigid bronchoscopy to exclude or confirm a TFB. They were systematically collected since 1989. Patient charts and radiographic reports were composed of hard copies; in those patients with charts and radiographic reports older than 10 years of microfilms. Patients' characteristics, history as well as clinical, radiographic and bronchoscopic findings were noted.

Rigid bronchoscopy was performed in all patients under general anaesthesia by trained paediatric anaesthesiologists. Interpretation of chest X-rays were performed throughout by paediatric radiologists.

This study was based on a large population of 370 patients over a period of 14 years. A precise documentation was used that either indicated or gave suspect for a bronchoscopy procedure and was based on the patient history, clinical or radiographic findings. Two independent reviewers performed the analysis.

Our statistical analysis evaluated the diagnostic value for patient history, a variety of pathologic clinical and radiographic findings or a combination of these variables. It included the following: diagnostic sensitivity and specificity was calculated for the different variables in order to indicate potential TFB aspiration for both group A and B. Diagnostic sensitivity was defined as the frequency of positive results of history, pathologic clinical and radiographic findings in patients with a TFB aspiration. Diagnostic specificity was defined as the frequency of negative results of these findings in the patients with a TFB aspiration. Pearson χ^2 test was used to compare sensitivity and specificity of the variables between both groups. A p-value <0.05 was considered significant. Data were presented as median (range).

Results

Patients' characteristics

A total of 370 children who underwent explorative rigid bronchoscopy for either exclusion or confirmation of a TFB aspiration was included in the study. Two-thirds were male (n = 242) and one third were female patients (n = 128). Median age was 1.8 years (0.2–14.2 y), 76% of the children were younger than 3 years of age. In 221 children a TFB was found and removed by rigid bronchoscopy, an equivalence of 59.7%. A total of 266 patients presented with an onset of symptoms less than 2 weeks (group A). The remaining 104 patients presented with prolonged cough or a pulmonary affliction unresponsive to medical treatment for more than two weeks and formed group B. Children of group A were either admitted to the emergency department by their parents or the treating physician. Children of group B were exclusively admitted by their physician or were referred by another hospital for further evaluation. Impending respiratory failure was present in a total of 16 children resulting in emergency intubation. Patients' characteristics for group A and B are presented in table 1.

Patient history, clinical presentation and radiographic findings

Patient history consisted of acute choking/coughing episode, witnessed episode of potential TFB aspiration and a permanent cough. Clinical data with documentation of unilateral diminished breath sounds, wheezing and stridor were complete for all but 16 children (4.3%) that resulted in emergency intubation. For seven of these children findings for auscultation were given in the bronchoscopy database under artificial ventilation. Radiographic findings on inspiratory posterior-anterior chest X-ray showed unilateral overdistension, segmental or total atelectasis, infiltration and a radiopaqued TFB. Chest X-ray was performed in a total of 332 (89.7%) children undergoing explorative bronchoscopy. For 16 children a chest X-ray was not performed due to emergency intubation and urgent bronchoscopy. In 22 children a radiograph was taken at an outside facility and not available for interpretation by our paediatric radiologists. Patient history, patients' clinical and radiographic findings after potential TFB aspiration are shown in table 2.

Bronchoscopic exploration for group A confirmed TFB aspiration in 187 of the 266 children (70.3%). In this group, 94.4% (n = 251) had an acute choking/coughing episode with broncho-

Table 1

Patient characteristics.

	All (n)	Group A (n)	Group B (n)
Total	370	266	104
Age [years], median (range)	1.8 (0.2–14.2)	1.8 (0.6–14.2)	2.0 (0.2–12.3)
Gender (male / female)	242/128	178/88	64/40
Total bronchoscopic confirmation of a TFB n (%)	221	187 (70.3)	34 (32.7)
Intubated patients outdoor/on ED	16	10/2	3/1

TFB = tracheobronchial foreign body; ED = emergency department

Table 2

Clinical and radiographic findings in patients with suspected TFB aspiration summarised for group A and B.

	Group A (n = 266)		Group B (n = 104)	
	All	bronchoscopic confirmation of a TFB	All	bronchoscopic confirmation of a TFB
	n	n (%)	n	n (%)
Witnessed episode of possible TFB aspiration	221	156 (70.6)	13	9 (69.2)
Acute choking/coughing	251	179 (71.3)	25	16 (64.0)
Permanent cough	22	15 (68.2)	89	30 (33.7)
Unilateral diminished breath sounds	154	139 (90.3)	49	27 (55.1)
Stridor	114	82 (71.9)	11	5 (45.5)
Wheezing	126	108 (85.7)	42	20 (47.6)
Clinical triad	83	80 (96.4)	10	9 (90.0)
Suspicious chest X-ray				
unilateral overdistension	114	103 (90.4)	25	17 (68.0)
atelectasis, infiltration	42	32 (76.2)	38	9 (23.7)
Radio-paque TFB on chest X-ray	19	19 (100)	–	–
Normal chest X-ray	62	19 (30.6)	28	4 (14.3)

TFB = tracheobronchial foreign body; Clinical triad = acute coughing/choking + wheezing + unilateral diminished breath sounds

scopic findings of a TFB in 71.3%. A permanent cough was reported in 8.3% (n = 22), in 68.2% a TFB was confirmed. The main clinical observation in children forming group A was unilateral diminished breath sounds (n = 154, 57.9%). Bronchoscopy confirmed a TFB aspiration in 90.3% of them. Other clinical presentations were wheezing (47.4%, n = 126) and stridor (42.9%, n = 114). In 85.5% of the children with wheezing and 71.9% of them with stridor a TFB was found. The clinical triad which includes acute coughing/choking, wheezing, and unilateral diminished breath sounds were present in only 31.2% of the children (n = 83). A TFB was confirmed in 96.4%.

In comparison, group B had a TFB aspiration confirmed by explorative bronchoscopy in 34 of the 104 children (32.7%). An acute choking/coughing episode was recalled in 24.0% of the children forming group B (n = 25) with bronchoscopic findings of a TFB in 64.0%. A permanent cough was reported in 85.6%, in 33.7% (n = 30) a TFB was confirmed. The predominant clinical presentations in group B were unilateral diminished breath sounds (n = 49) and wheezing (n = 42). Bronchoscopy confirmed a TFB aspiration in 55.1% of the children presenting with unilateral diminished breath sounds and 47.6% with wheezing. For children presenting with stridor (10.6%, n = 11) a TFB was confirmed in 45.5%. The clinical triad was present in 9.6% of group B (n = 10). In 90.0% of these children a TFB aspiration was found.

Predominant pathologic findings on chest X-ray for group A was unilateral overdistension in 114 children (42.9%), with a TFB aspiration confirmed in 90.4%. Atelectasis/ infiltration on chest X-ray in this group was present in 42 children (15.8%) with a TFB found in 76.2%. In children forming group B, pathologic findings on chest X-ray were unilateral overdistension in 25 (24.0%) and atelectasis/infiltration in 38 (36.5%). Bronchoscopy confirmed a TFB aspiration in 68.0% of the children with unilateral overdistension and 23.7% of those presenting with atelectasis/ infiltration. Remarkably, in a total of 90 children of group A and B a normal chest X-ray was documented. Bronchoscopy confirmed a TFB aspiration in 30.6% of the children forming group A and 14.3% of group B.

Bronchoscopic findings

Comprehensive endoscopic reports were available for all children. Endoscopic reports showed bronchoscopic findings which included the nature and location of foreign body. The TFBs observed were food products in 81.9%, with peanuts and other nuts the predominant findings in 51.6%. Altogether, 14.5% non-organic aspirates were found, mainly pieces of plastic toys (5.9%) and pins (5.0%). A total of 123 TFBs (55.7%) were located in the right main bronchus. For children in both groups A and B with bronchoscopic exclusion of a TFB aspiration the main bronchoscopic finding was acute/chronic tracheobronchitis in 48.1–49.4% (table 3).

Sensitivities and specificities

Diagnostic sensitivities and specificities for a variety of abnormal clinical or radiographic findings are given in table 4. Unilateral diminished breath sounds or unilateral overdistension in the chest X-ray in both group A and B were found to be the most sensitive and specific findings in our study in comparison to other variables. For unilateral diminished breath sounds we observed a diagnostic sensitivity of 75.1–79.4% with a specificity of 68.1–81.3%. Calculations concerning unilateral overdistension on the chest X-ray showed a

Table 3

Bronchoscopic findings in children with suspected TFB in group A and B

	Group A (n = 266)		Group B (n = 104)	
	bronchoscopic confirmation of a TFB (n)	bronchoscopic exclusion of a TFB (n)	bronchoscopic confirmation of a TFB (n)	bronchoscopic exclusion of a TFB (n)
Total	187	79	34	70
TFB right main bronchus	109		14	
TFB left main bronchus	57		19	
TFB in the trachea	21		1	
Acute/chronic tracheobronchitis		39		50
Purulent secretion		5		13
Laryngotracheitis		5		3
Inconspicuous tracheobronchial tree		30		4
Peanuts and other nuts	92		22	
Other food products	35		–	
Other organic, non-food products	29		11	
Plastic toys	12		1	
Pins	11		–	
Other non-organic products	8		–	
Oesophageal foreign body		8		1

TFB = tracheobronchial foreign body

Table 4

Sensitivity and specificity of symptoms and signs in group A and B

Variable	Group A (n = 266)		Group B (n = 104)		P-value	
	Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)	Sensitivity	Specificity
Unilateral diminished breath sounds	75.1	81.3	79.4	68.1	0.53	0.07
Chest X-ray: unilateral overdistension	60.2	82.5	53.1	87.7	0.45	0.43
Clinical triad	42.6	96.2	26.5	98.6	0.08	0.22
Wheezing	57.5	76.9	58.8	68.1	0.86	0.29
Stridor	43.9	59.0	13.9	92.2	0.002	<0.001
Witnessed episode of possible TFB aspiration	83.4	17.7	29.4	95.7	<0.001	<0.001
Acute choking/coughing	97.7	7.6	48.6	88.6	<0.001	<0.001
Permanent cough	8.0	91.1	88.2	15.7	<0.001	<0.001
Chest X-ray: atelectasis/infiltration	18.8	84.4	25.0	52.4	0.51	<0.001

TFB = tracheobronchial foreign body, Clinical triad = acute choking/coughing + wheezing + unilateral diminished breath sounds

sensitivity of 60.2–68.6% and specificity of 82.5–83.9%. Diagnostic sensitivity for the clinical triad in both groups was low (26.5–42.6%), whereas this variable had a high specificity of 96.2–98.6%.

Wheezing in both groups had a calculated sensitivity of 57.5–58.8% and specificity of 68.1–77.2%. Stridor had a low sensitivity (13.9%) but high specificity (92.2%) in group B. For this variable there was a significant difference in children forming group A with a diagnostic sensitivity of 43.9% and specificity of 59.0% (p <0.001). A history of acute choking/coughing was highly sensitive (97.7%) in group A, but showed low specificity (7.6%). In contrast, for children forming group B we found a sensitivity of 48.6% (p = 0.002) and a specificity of 88.6% (p <0.001). Permanent cough reported in group A had a calculated specificity of 91.1%. In group B this clinical finding showed low specificity (15.7%; p <0.001). A pathologic chest X-ray with atelectasis or infiltration had a low sensitivity in both groups (18.8–25.0%). If this radiographic change was present, diagnostic specificity in group A was 84.4%, in group B it was 52.2% (p <0.001).

Discussion

In this study we reviewed the records of a total of 370 children undergoing rigid bronchoscopy due to potential TFB aspiration. Our aim was to evaluate the diagnostic value of clinical symptoms and signs in order to predict a potential TFB aspiration. Children with referral before and beyond a 2-week-interval of respiratory compromise were compared.

The main finding in our study was that there are no specific or coincidental symptoms and signs that predict potential TFB aspiration with full certainty, especially if a history of acute choking or sudden onset of coughing is absent.

Our study confirms the results of others studies [1, 2], ie that children carry the highest risk for a TFB aspiration in the first three years of life. Food products were found to be the predominate nature of TFBs. This is suggested to be caused by a poor chewing ability of young children as well as the parents' unawareness of the danger of feeding nuts in young children. The ratio of male to female in our population was 2:1 as was consistently observed by others [1, 2, 6–9].

A history of acute choking/coughing or a witnessed aspiration episode is considered to be an important key for the correct diagnosis of a TFB aspiration. Still, there was a significant difference between children forming group A and B with regard to the presence of a history of acute choking/coughing. In children admitted within 2 weeks after the onset of symptoms (group A) this variable was highly sensitive (97.7%) but not specific (7.6%). In contrast, if this episode was reported in children with a delay of more than 2 weeks (group B) a TFB aspiration was likely with a calculated specificity of 88.6%. Previous studies showed sensitivities of 81–85% and specificities of 21–37% [5–7]. They did not give separate analysis for children with obviously delayed admission.

The presence of the clinical triad which includes acute coughing/choking, wheezing, and unilateral diminished breath sounds was absent in about 53–69% of the children with a TFB in a previous report [10] comparable to our population. If the clinical triad was present, a TFB aspiration was likely in both groups A and B. We observed a low sensitivity (26.5–42.6%) but high specificity (96.2–98.6%).

The absence of a patient history of acute choking/coughing or a witnessed aspiration episode constitutes a risk factor for diagnostic delay. Unfortunately, even the evaluation of clinical symptoms and radiographic findings can be manifold. From a statistical point of view, unilateral diminished breath sounds or unilateral overdistension on chest X-ray were the findings with the highest sensitivity and specificity in both groups in comparison to other variables. If auscultation did not reveal unilateral diminished breath sounds or the radiographic finding was lacking unilateral overdistension a TFB aspiration was unlikely in both group A and B. For unilateral diminished breath sounds we found a sensitivity of 75.1–79.4% and a specificity of 68.1–81.3%. Two study groups [7, 8] observed comparable sensitivities of 65–80% and specificities of 72–88% for this diagnostic tool. Two others [4, 6] also reported of a sensitivity of 78–86% but lower specificities of 26–50% for pathologic auscultation. As pathologic auscultation included unilateral diminished breath sounds, wheezing and stridor this might result in lower diagnostic specificity.

Concerning unilateral overdistension chest X-rays, we observed a sensitivity of 53.1–60.2% and a specificity of 82.5–87.7%. Previous reports [4, 6, 7] found higher sensitivities of 66–88% but lower specificities of 30–51% for pathological chest X-rays. These reports did not distinguish between unilateral overdistension or atelectasis/ infiltration on chest X-ray. A pathologic chest X-ray with atelectasis or infiltration had a low diagnostic sensitivity in both groups (18.8–25.0%) in our study. Remarkably, if this radiographic change was present in group A, a TFB aspiration was likely with a calculated specificity of 84.4%. As pulmonary infection in children with prolonged cough for more than two weeks may lead to the same radiographic finding due to mucosal plugs, this variable was not helpful in group B showing a specificity of 52.4%.

According to Barrios et al. [9] specificity for respiratory auscultation and chest X-ray is poor with a reported figure of 9%. There is a systematic discrepancy in the calculation of specificity by this study group. In contrast to our study and others, Barrios included all forms of pathological auscultation as well as normal and abnormal radiographic findings for his calculations.

The results in our study confirm that children with normal chest X-ray scheduled for explorative bronchoscopy may harbour a TFB. Despite normal chest X-ray, bronchoscopy confirmed a TFB in 30.6% of the children in group A and 14.3% in group B. The proportion of normal chest X-rays in a TFB aspiration reported in literature varies from 12–34% [4, 8, 10, 11]. Eren et al. [2] even found an incidence as high as 61.3% for normal chest X-rays in children with a TFB. They suggested that this might be due to early referral in most of the children of their study population.

Our data show that there are no clinical symptoms or signs predicting a TFB aspiration with a high degree of certainty – independent of the time from potential TFB aspiration to presentation. Diagnostic specificity for stridor was found to be high (92.2%) with delayed referral of more than two weeks after onset of symptoms. Still, we did not detect any helpful key for the correct diagnosis of a TFB in these children if their parents did not recall a history of acute choking/coughing. Even the absence of pathologic changes on chest X-ray in

children that presented with a prolonged cough not responsive to medical treatment did not rule out the possibility for a TFB aspiration. Physicians need to be aware of the risk of a TFB aspiration especially in the absence of a patient history. Unilateral diminished breath sounds or unilateral overdistension on the chest X-ray are the most predictive symptoms for the potential diagnosis of a TFB aspiration. This was shown for referrals before and beyond a 2-weeks-intervall of respiratory compromise. The presence of wheezing or stridor as a presenting symptom should alert physicians for potential TFB aspiration.

If a TFB aspiration is suspected then explorative rigid bronchoscopy is the traditional procedure of choice without further delay. Nowadays, especially if done by experts in this field, rigid bronchoscopy is a safe method with a reported morbidity of 2–17% [3–5, 13] and mortality of 0–0.8% [2, 4, 5, 13]. As shown by others [3, 5, 12], complication rates for bronchoscopy and the TFB itself increases with the duration of the TFB in situ: Lima et al. [12] observed a 3.8-fold higher risk for bronchial sequelae in children with delayed diagnosis and extraction of a TFB more than 7 days after the aspiration event compared to those with earlier diagnosis. Inglis et al. [3] observed similar findings with a time-depending trend for increased complication rates of 15–36% after a delay of more than 7 days. Especially secondary injuries initiated by organic aspirates are related to diagnostic delay. They cause mucosal irritation and inflammation resulting in mucosal oedema [1, 3, 5]. It definitely seems alarming that an aspirated TFB was bronchoscopically confirmed in 32.7% of the children in our population referred with symptoms of more than two weeks.

A limitation of this study is its retrospective design with regard to completeness and reproducibility of the collected variables. A prospective study of 98 children recently published by Lea et al. [14], presented diagnostic sensitivities and specificities of clinical data and radiographic findings. In accordance to the literature, the observed specificity for abnormal auscultation was 59.5%, and for radiographic findings it was 71.4% [4, 6]. These were lower than the specificities found in our study. As mentioned above, the lower specificities may origin from an analysis given comprehensively and not from a variety of different clinical or radiographic findings.

In conclusion, in a paediatric respiratory compromise the presence of unilateral diminished breath sounds or a pathological chest X-ray as well as the clinical triad necessitates a bronchoscopic exploration to exclude an inhaled TFB. Even if a history of an acute choking/coughing episode is absent. However, in our study population neither history nor clinical and radiographic findings prove or exclude TFB aspiration. If physicians are in doubt whenever a TFB is suspected then an explorative bronchoscopy should be performed since morbidity of explorative bronchoscopy is certainly lower than the morbidity of undiagnosed TFBs with delayed extraction.

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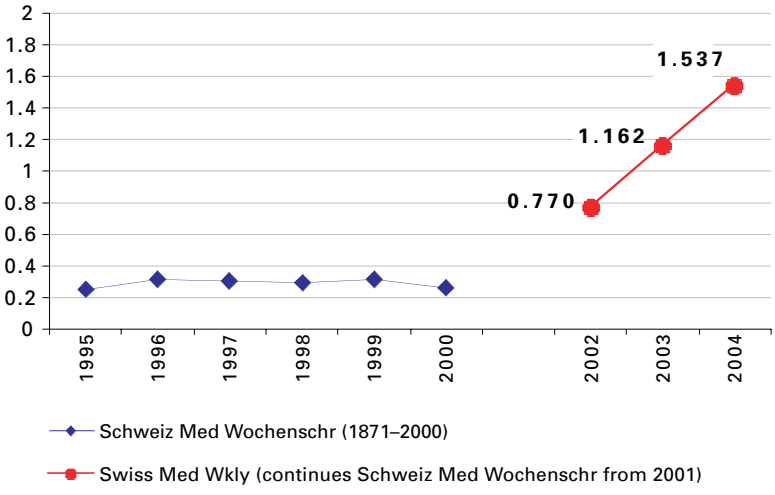

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