

Diagnostic Evaluation of Foreign Body Aspiration in Children

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ABSTRACT

Aim: The aim of this study was to evaluate the place of clinical symptoms and findings, and radiological imaging in the diagnosis of foreign body aspiration in children, and to investigate the validity of existing diagnostic algorithms.

Materials and Methods: Medical records of 120 children who underwent rigid bronchoscopy with the diagnosis of FBA were examined. The sensitivity and specificity of the parameters used in the diagnosis of FBA and their predictive values were calculated.

Results: 78.9% of the patients were younger than 3 years and 63.8% were male. The peak incidence was 18 months. The rate of negative bronchoscopy was 30.8% and 87.3% of these patients were younger than 3 years. It was observed that the value with the highest diagnostic sensitivity and diagnostic accuracy rate (sensitivity; 92.54% and diagnostic accuracy; 85.7%) had positivity of the any of the radiological findings, and among these, there was detection of one-sided excessive ventilation on chest X-ray (sensitivity; 70.0% and diagnostic accuracy; 70.01%) Patients with positivity of any of the radiological findings who additionally had wheezing together with cyanosis or dyspnea had 100% specificity.

Conclusion: Particularly, male children under age of 3 years have an increased risk of FBA. Neither clinical symptoms nor radiological findings alone are sufficiently specific and sensitive in the diagnosis of FBA. The most important factor in the decision to perform bronchoscopy is the evaluation of radiological findings together with physical examination and history.

Keywords: Foreign body, aspiration, children, algorithms

Introduction

Foreign body aspiration is the most common cause of deaths due to home accidents in children under 6 years of age, and is one of the major causes of mortality and morbidity in childhood[1-3]. The clinical features of foreign body aspiration can be life-threatening airway obstruction or lighter manifestations such as recurrent pulmonary infection, wheezing, and cough [4]. Therefore, it is important to diagnose immediately and provide appropriate treatment in order to reduce the mortality and morbidity rates. Foreign bodies can be removed by rigid or flexible bronchoscopy, but the prerequisite for this is suspecting foreign body presence

[5]. In this study, we aimed to evaluate the place of clinical symptoms, findings and radiological imaging in the diagnosis of foreign body aspiration in children, and to investigate the validity of existing diagnostic algorithms.

Materials and Methods

Before starting the study, the approval no.2018 / 1416 was obtained from the non-interventional clinical research ethics committee of Aydın Adnan Menderes University. In this study, 120 patients underwent rigid bronchoscopy with suspected foreign body aspiration in Aydın Adnan Menderes University Faculty of Medicine, Department of

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Pediatric Surgery between 2000-2019, were evaluated retrospectively. All patients were evaluated in terms of age, sex, time of admission, cough or symptoms of cyanosis (choking) in history, wheezing in physical examination, some symptoms of dyspnea; nasal flaring, presence of intercostal and suprasternal retractions, and presence of excessive ventilation and pneumonic infiltration on chest X-ray. The relationship between all findings and foreign body detection in bronchoscopy was evaluated statistically.

Statistical Analysis

Statistics were carried out with SPSS v12.0 statistical software (SPSS, Chicago, IL), we used that with the specific parameters of diagnostic accuracy, specificity, sensitivity to statistical analyses and $P < 0.05$ was considered significant.

Results

A total of 120 patients underwent rigid bronchoscopy with suspected foreign body aspiration between January 2000 and March 2019 at Aydın Adnan Menderes University Faculty of Medicine, Department of Pediatric Surgery. Foreign bodies in tracheobronchial tree were detected in 71 (59.2%), and were not detected in 49 (40.8%) patients. The mean age of all patients at admission was 2 years (5 months-14 years of age).

54 (76.0%) patients with foreign bodies and 40 (90.9%) patients without foreign bodies were under 3 years of age. 76 (63.3%) patients underwent bronchoscopy were male and 44 patients (36.6%) were female. 26 (36.6%) patients with foreign bodies were female and 45 (63.4%) were male; 19 (38.8%) patients without foreign bodies were female and 30 (61.2%) were male. There was no significant difference between gender distribution and presence of foreign bodies in tracheobronchial tree ($p > 0.05$). The mean admission time was 4 days (min; 1- max; 180 days). 45 (63.4%) patients with foreign bodies detected in bronchoscopy had cough, 23 (32.4%) had cyanosis (choking), and 18 (25%) had both cough and cyanosis (choking).

History of cough in 21 (46.7%), cyanosis (choking) in 18 (40.9%), cough and cyanosis (choking) in 16 (36.4%) patients without foreign bodies were positive. The presence of cough in history sensitivity was 64.29%, whereas the presence of cyanosis (choking) sensitivity was 32.86%. When positive predictive values (PV+) were examined, it was found that both values were high, although cough value (68.18%) (PV+) was higher than cyanosis value (56.10%). There were no significant relations between the presence of foreign bodies and cough or cyanosis (choking) in history ($p > 0.05$). 38 (53.5%) patients with foreign bodies detected in bronchoscopy had dyspnea, 21 (29.6%) had wheezing, and 18 (25%) had dyspnea and wheezing.

18 (40.9%) patients without foreign bodies had dyspnea, 6 (13.6%) had wheezing, 4 (9.1%) had dyspnea and wheezing. While sensitivity and specificity of dyspnea were 54.29% and 63.27% respectively, sensitivity and specificity of wheezing were 30.0% and 87.76% respectively. When evaluated statistically, there was no significant relationship

between wheezing and detection of foreign bodies ($p > 0.05$), but there was a significant relationship between dyspnea and detection of foreign bodies ($p < 0.05$).

When preoperative PA chest X-ray was evaluated, it was observed that 5 (7.01%) of the patients with foreign body had normal radiological findings, 24 (33.80%) had pneumonic infiltration, and 49 (69.01%) had excessive ventilation. In the preoperative radiological evaluation of the patients without foreign bodies, it was observed that 9 (20.5%) patients had normal findings, 12 (27.3%) had excessive ventilation, and 9 (20.45%) had infiltration on PA chest X-ray. Foreign bodies were detected in 24 (33.80%) patients with infiltration on preoperative chest X-ray, and when evaluated statistically, there was a significant relationship between the detection of foreign bodies in tracheobronchial tree and the presence of infiltration on chest X-ray ($p < 0.05$). However, only 9 (20.45%) patients without foreign bodies had infiltration on preoperative chest X-ray. In other words, on preoperative chest X-ray of patients underwent bronchoscopy and had no foreign bodies, absence of infiltration rate was high (90.9%). When preoperative chest X-ray was evaluated in terms of excessive ventilation, 49 (69.0%) patients with foreign bodies and 12 (27.01%) patients without foreign bodies had excessive infiltration and a statistically significant relationship was found ($p < 0.05$). (figure 2)

Statistical analyses are shown in Table 1. Cough, cyanosis, wheezing and dyspnea were used as diagnostic parameters. Pneumonic infiltration, excessive ventilation, and presence of any radiological findings were used as radiological test. It was observed that the value with the highest diagnostical sensitivity and diagnostic accuracy rate (sensitivity; 92.54% and diagnostic accuracy; 85.7%) had positivity of the any

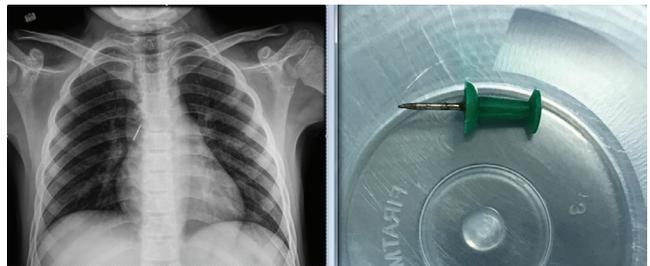


Figure 1. Chest x-ray with radiopaque foreign bodies and removed object

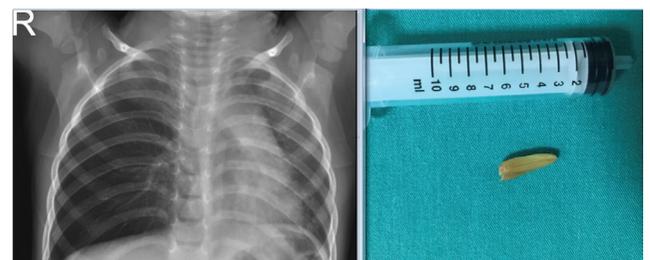


Figure 2. Chest x-ray with non-radiopaque foreign bodies and removed object

of the radiological findings, and among these, there was detection of one-sided excessive ventilation on chest X-ray (sensitivity; 70.0% and diagnostic accuracy; 70.01%). When the specificities of these findings were examined, it was observed that specificity of wheezing was 87.76%, and the highest specificity values other than wheezing were found to be infiltration on chest X-ray at 81.63% and detection of one sided excessive ventilation at 80.33%.

Table 2 shows coexisting rates of two or three of the parameters evaluated in history, physical examination and radiological findings, and their statistical values. In case of cough with dyspnea or cough with wheezing, the specificity values were 81.25% and 92.31%, respectively. Likewise, sensitivity values were found to be high in case of cough presence with excessive ventilation, which is one of the radiological findings, and these values were 83.33%. Among these, the highest diagnostic accuracy was found to be presence of dyspnea with cough (68%), followed by presence of infiltration with cough (60%). Specificity of infiltration together with the presence of cough, cyanosis, wheezing or dyspnea was found to be 90% or more. Presence of wheezing with cyanosis specificity was calculated as 96.30%. When patients with radiologically pneumonic infiltration or excessive ventilation were evaluated with these data, if the radiological findings of patients with

cyanosis and wheezing and patients with wheezing and dyspnea were positive, their specificity were 100% (Table 3).

Patients with cyanosis(choking) and/or cough history, wheezing and/or dyspnea on physical examination, were bronchoscopically evaluated for the presence of foreign bodies, even if they had suspicious history and excessive ventilation on chest X-ray. Total of 120 patients underwent bronchoscopy and foreign bodies were detected in 71. Foreign bodies were detected in the right main bronchus in 34 (47.88%) patients with foreign bodies, in the trachea in 13 (18.30%) and in the left main bronchus in 24 (33.80%). (Table 4) When evaluated statistically, detecting foreign bodies in the right main bronchus was significantly high (p <0.05). In 49 patients, no foreign bodies were detected in bronchoscopy, but 12 of these 49 patients had mucus plugs in the bronchi, and washing with saline was performed. Other 37 patients (30.8%) were considered as negative bronchoscopy. In patients with mucus plugs, clinical and radiological findings significantly improved after bronchoscopic washing and they were discharged without any problem.

Discussion

Foreign bodies were detected in 71 (59.2%) patients, and no foreign bodies were detected in 49 (40.8%) patients. The

Table 1. Statistical values of history, physical examination and radiological findings individually

	Cough		Cyanosis		Wheezing		*Dyspnea		*Infiltration		*EV		Radiology	
	+	-	+	-	+	-	+	-	+	-	+	-	+	-
FBA +	45	25	23	47	21	49	38	32	24	46	49	21	62	5
FBA -	21	28	18	31	6	43	18	31	9	40	12	37	40	9
DA %	55.5		35.4		22.7		47.1		34.3		70.0		85.7	
Sensitivity %	64.29		32.86		30.00		54.29		34.29		70.00		92.54	
Specificity %	57.14		63.27		87.76		63.27		81.63		75.51		18.37	
PV+	68.18		56.10		77.78		67.86		72.73		80.33		60.78	
PV-	52.83		39.74		46.74		49.21		46.51		63.79		64.29	
*p<0.05														

Table 2. Coexisting rates of two or three of the parameters evaluated in history, physical examination and radiological findings, and their statistical values

	CI		CEV		Cyl		CyEV		WI		WEV		DI		DEV		CW		CD		CyW		CyD	
	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
FBA +	17	18	30	6	9	32	16	14	9	34	16	16	12	20	29	12	18	22	24	11	5	31	18	27
FBA -	2	21	6	22	2	24	4	23	2	36	4	35	3	25	3	22	2	24	3	13	1	26	9	22
DA %	60 (46-72)		56 (43-68)		61 (48-72)		52 (34-71)		53 (41-64)		45 (33-57)		53 (40-66)		62 (49-73)		60 (47-72)		68 (54-80)		57 (44-69)		59 (47-70)	
Sensitivity %	48.57		83.33		21.95		53.33		20.93		50.00		37.50		70.73		45.00		68.57		13.89		40.00	
Specificity %	91.30		78.57		92.31		85.19		94.74		89.74		89.29		88.00		92.31		81.25		96.30		70.97	
PV+ %	89.47		83.33		81.82		80.00		81.82		80.00		80.00		90.62		90.00		88.89		83.33		66.67	
PV- %	53.85		78.57		42.86		62.16		51.43		68.63		55.56		64.71		52.17		54.17		45.61		44.90	

Table 3. Coexisting rates of two or three of the parameters evaluated in history, physical examination and radiological findings, and their statistical values

	RC		RCy		RW		RD		RCCy		RCW		RCD		RCyW		RCyD		RWD	
	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
FBA +	40	3	22	7	19	6	35	5	4	4	11	0	12	1	7	4	7	2	7	4
FBA -	13	1	14	5	6	9	15	6	10	1	4	1	14	0	0	21	8	4	0	21
DA %	75 (62-85)		60 (45-74)		62 (47-77)		65 (52-77)		42 (20-66)		68 (41-88)		48 (28-68)		34 (18-53)		42(21-65)		34 (18-53)	
Sensitivity %	93.02		75.86		76.00		87.50		50.00		100.00		92.13		63.64		77.78		63.64	
Specificity %	7.14		26.32		60.00		28.57		9.09		20.00		0.00		100.00		33.33		100.00	
PV+ %	75.47		61.11		76.00		70.00		42.11		73.53		46.15		100.00		46.67		100.00	
PV- %	25.00		41.67		60.00		54.55		28.57		100.00		0.00		84.00		66.67		84.00	

Table 4. Patients whose foreign bodies were removed by bronchoscopy and the locations of foreign bodies

Location of foreign body	Number of patients	%
*Right main bronchus	34	47.88
Trachea	13	18.30
Left main bronchus	24	33.80
TOTAL	71	100
*p<0.05		

mean age was 2 years (7 months- 14 years), the majority (n = 94, 78.3%) was under age of 3 years and it was found that more men had foreign bodies. All these data were consistent with the literature information[1;6;7]. According to all these data, we can say that children under 3 years of age have the highest risk for foreign body aspiration. As the distal airways are narrower, aspirated foreign bodies are most commonly located in the proximal airways and are directed to the right main bronchus as it has more vertical course and larger diameter than left[5;7-9]. In our patients, the most common site was the right main bronchus (47.88%), the second most common was the left main bronchus (33.80%) and the third was trachea (18.30%). It was observed that the right main bronchus rate was significantly high. (p <0.05).

In a review of Metrangolo et al., in which they presented their 8-year experiences in foreign body aspiration in children, they reported that the foreign bodies were most frequently encountered in the right main bronchus, but found that the encountering rate in the left main bronchus was very close to the rate of the right. They explained this as bronchial anatomy alone was not effective on the location of foreign bodies, these foreign bodies can be displaced by cough or ventilatory effort[7]. In our patients, the foreign bodies encountering rate in the left main bronchus was second, and this can be explained by the fact that foreign bodies can be displaced by cough or ventilatory efforts, and this has parallelism with the results of Metrangolo et al. Black et al. retrospectively evaluated 548 patients underwent bronchoscopy with suspected foreign body aspiration and reported that choking, cough and wheezing were present in 95% of the patients, and bronchoscopy was required[4].

In another study, it was reported that especially in patients with choking history, this was the most valuable data for diagnosis, and cough and wheezing were present in 95% of the patients[7]. When we evaluated our patients in terms of cough, cyanosis (choking), wheezing and dyspnea presence; cough was the parameter with the highest sensitivity and diagnostic accuracy (64.29%), followed by dyspnea at a sensitivity rate of 54.29%.When examined their specificities, the highest value was found to be wheezing at 87.76%, followed by cyanosis(choking) and dyspnea at 63.27%. However, in the statistical evaluation of all these data, only dyspnea was found to be significantly high in patients with foreign bodies (p<0.05). We also attributed the fact that such a small number of patients, in discordance with literature, had cyanosis(choking) history because aspiration occurred at a time when the family was not with child or family’s attention was distracted. These results suggest that the presence of dyspnea among clinical findings supports the suspected foreign body aspiration.

In 49 (40.8%) patients underwent rigid bronchoscopy due to FBA, no foreign bodies were found. No foreign bodies were found in 49 (40.8%) patients underwent rigid bronchoscopy due to FBA. According to the literature, detection range of foreign bodies in children with suspected FBA is very wide (25%- 90%). In Even Lea et al.’s study, foreign bodies were found in 57% of 98 children, and it was indicated that this ratio, close to the ratio in our study, is in accordance with the literature [10;11]. Similarly, Oncel et al. reported in their study that no foreign bodies were found during rigid bronchoscopy at the rate of 25.7% [12]. We think that the negative bronchoscopy rate is similar due to the vital risks that may occur usually in emergency conditions if bronchoscopy, a procedure that must be decided quickly, is not performed. It has been reported in the literature that computed tomography can also be a good alternative in the suspicion of foreign body diagnosis, and even can be used with a diagnostic accuracy rate at 94.5%. Therefore, in our retrospective series, FBA detection rate in bronchoscopy is in accordance with the literature.It can be said that negative bronchoscopy rate may be increased due to vital risks that occur in emergency conditions if bronchoscopy, a procedure that must be decided quickly, is not performed. It has been

stated in the literature that computed tomography can be a good alternative and even be used at a diagnostic accuracy rate of 94.5%[13]. No computed tomography was used diagnostically in our patient series. Considering radiation exposure in the pediatric age group, we think that using computed tomography routinely in the diagnosis of FBA is arguable. No computed tomography was used diagnostically in our patient series. When considering radiation exposure in the pediatric age group, we think that using computed tomography routinely in FBA diagnosis is arguable. However, considering the risks of anesthesia and procedure during bronchoscopy, the place of CT in the diagnostic algorithm should be reassessed with prospective studies. If cyanosis (choking) history is positive, bronchoscopy is recommended in diagnostic approach to patients with suspected foreign body aspiration, even if physical examination and radiographic findings are negative[2;14;15]. When we evaluated our patients in the light of this information, there were two patients underwent bronchoscopy, had negative physical examination and radiological findings, and positive cyanosis (choking) history, and they had no foreign bodies. Again, it was observed that the sensitivity value of history positivity, which is the most valuable diagnostic criterion when compared to the literature information, was 25% lower in our cases. In parallel with this information, in discordance with literature, we thought that positive history alone would not be sufficient, and we evaluated the relationship between history together with any physical examination or radiological findings and the presence of a foreign bodies. In our patients, if there was wheezing as a physical examination finding with cyanosis (choking) history, or history with wheezing and positivity of any radiological findings, the specificity was found to be 100%. In this case, according to our data, we think that history may not be sufficient for indication of bronchoscopy alone, and bronchoscopy should be performed if any radiological findings (pneumonic infiltration or excessive ventilation) is positive.

Metallic foreign bodies can be diagnosed directly by X-ray. However, since foreign bodies are non-opaque, the diagnosis is based on secondary findings[16]. (figure 1) In addition, DA (diagnostic accuracy) rate (85.70%) was found to be high in patients with any radiological findings detected in chest X-ray. Detection sensitivity (92.50%) of the radiological findings was also found to be high. However, no foreign bodies were observed in 40 (39%) patients with pathological findings. With these findings, radiological finding detection alone is not sufficient to indicate bronchoscopy. However, it is seen that there is 100% specificity value with history and physical examination findings.

Conclusion

If patients with suspicious history, the most important parameter for diagnosis in foreign body aspirations, have also dyspnea and pneumonic infiltration on chest X-ray, the possibility of foreign body aspiration presence should

definitely be considered, even though the first thing comes to mind in diagnosis is pneumonia. We believe that these patients with suspicious history should be evaluated bronchoscopically if they have suspicious history together with wheezing and/or pneumonic infiltration on chest X-ray and/or excessive ventilation.

Ethics

Ethics Committee Approval: The approval no.2018/1416 was obtained from the non-interventional clinical research ethics committee of Aydın Adnan Menderes University.

Informed Consent: In this study, 120 patients underwent rigid bronchoscopy with suspected foreign body aspiration in Aydın Adnan Menderes University Faculty of Medicine, Department of Pediatric Surgery between 2000-2019, were evaluated retrospectively.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors have no financial relationships relevant to this article to disclose.

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