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Risk factors for granuloma formation in children induced by tracheobronchial foreign bodies

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ABSTRACT

Objective: The aim of this study was to analyze the risk factors for granuloma formation caused by plant-based tracheobronchial foreign bodies in children, and investigate the underlying pathogenesis.
Method: In this retrospective analysis of 153 cases with tracheobronchial foreign bodies (peanuts and watermelon seeds), 35 cases of granuloma formation as granulation group (G), and 118 cases of no granuloma formation as non-granulation group (NG) were studied. Clinical data pertaining to sex (S), age (A), foreign body surface smoothness (SF), foreign body shape (SH), foreign body oil release state (O), the location of foreign bodies (L), and foreign body retention time (T) were collected for statistical analysis.
Results: Univariate analysis showed no significant difference between the two groups (G and NG) with respect to S, A, SH and L. Significant factors based on univariate analysis included SF, O and T. Multivariate logistic regression analysis revealed that SF and T were independent risk factors associated with development of granuloma.
Conclusions: SF, O and T had relationship with the granuloma formation. Local trauma caused by an irregular and sharp foreign body, and extended period of time represent the main factors causing granuloma formation.

1. Introduction

Tracheobronchial foreign body is a common, life-threatening emergency in children. The course of disease is divided into four stages: foreign body aspiration, quiescent phase, inflammation, and complications. Clinical records suggest that most children consult a doctor at the aspiration stage. It is often accompanied with bronchitis, pneumonia and granulation hyperplasia, and children see a physician at the inflammation or complication stages [1].

Clinical findings demonstrate that the condition in children with granuloma associated with tracheobronchial foreign bodies is characterized by cough, asthma, and dyspnea, followed by increase in anaesthetization risk and surgical difficulty. Slow improvement in postoperative symptoms and long postoperative course of the disease are the other features. Currently, several reported cases of granuloma formation in involving tracheobronchial foreign bodies exist. However, reports highlighting the risk factors of granuloma formation are few. In this study, therefore, we sought to investigate these risk factors in a retrospective analysis.

2. Materials and methods

2.1. Clinical data

A total of 153 children with plant-based tracheobronchial foreign bodies were enrolled in our hospital from March 2012 to June 2014. The subjects were divided into a granulation group (G) and a non-granulation group (NG).

Inclusion criteria were as follows: foreign bodies include peanuts and watermelon seeds; children with or without clear foreign body cough history; clinical manifestations of cough, asthma, fever, and dyspnea; abnormal breath sounds, which were reduced or roughly doubled, wheezing and dry and wet rales; and imaging examination showing emphysema or atelectasis, and spiral computed tomography (CT) showing airway obstruction due to foreign body. After admission, bronchoscopy was conducted and foreign bodies were removed within 24 h. Granulomas were removed intraoperatively. After operation, the patients were treated and discharged. Exclusion criteria were: voluntarily expectoration of foreign body, no foreign body during surgery, bronchomalacia and bronchial stenosis, history of acute upper respiratory tract infection, inability to remove foreign body using rigid bronchoscope, and children requiring referral to other departments.

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2.2. Research methods

2.2.1. Operation and treatment

The patients were pre-oxygenated using a 100% oxygen mask and general anesthesia was induced by fentanyl 2 μg/kg and propofol 2–3 mg/kg. A metallic rigid bronchoscope (STORZE, Germany) was inserted through the throat into trachea and bronchus to remove the foreign bodies. Oxygen was administered at high frequency and anesthesia was maintained and breathing was controlled. If granuloma formation was discovered, granulation tissues were cleaned. If a foreign body was broken or mucosal bleeding was noticed, 2 ml of 1% lidocaine solution containing 1:100,000 adrenaline was sprayed into the trachea for 30 s, and the solution was evacuated using a vacuum suction unit (−50 to −70 mmHg). The lumen of trachea and bronchus was repeatedly washed free of foreign bodies. Intraoperative electrocardiogram (ECG) was conducted and blood oxygen saturation was monitored. Intravenous antibiotics (cefazolin 50 mg/kg twice per day), steroid (hydroprednisone 1 mg/kg once per day), and atomization inhalation with air pump (budesonide 1 mg twice per day) were used after the operation. Intravenous antibiotics lasted for 1–3 days in 138 cases, and 4–7 days in 13 cases, and over 8 days in two cases.

Surface smoothness of foreign bodies (SF), foreign body shape (SH), oil release state of foreign body (O), location of foreign bodies (L), granulation tissue, tracheospasm, hypoxemia ($SaO_2 < 80\%$), and bronchial mucosa bleeding and other complications were recorded, intraoperatively.

We selected the two most common clinical foreign bodies (peanuts and watermelon seeds) in China as the research objects. In addition to broken peanuts, intact watermelon seeds (IWS) and broken watermelon seeds (BWS) were found. IWS were classified as smooth foreign bodies (SF1); broken peanuts represented rough foreign bodies (SF2); and BWS were considered as sharp foreign bodies (SF3).

IWS and BWS were represented flat foreign bodies (SH1). The peanuts were broken, mainly into ball-shaped structures, representing non-flat foreign bodies (SH2).

O was divided into non-oil-releasing foreign bodies (O1) and oil-releasing foreign bodies (O2). Watermelon husk was mainly composed of cellulose and hemicellulose, and the fat content was minimal [2]. The hull of IWS was hard and intact, with delayed decay, without any oil release, and was classified as O1. Watermelon seeds and peanuts contained oil, with comparatively higher oil content. However, the quantity of the released oil could not be accurately evaluated, and therefore, BWS and peanuts were classified as O2.

According to the location of foreign bodies, they were divided into three categories: main trachea (L1), from hypolarynx to tracheal carina; right main bronchus (L2); and left main bronchus (L3). Foreign bodies with multiple locations were classified separately according to their location.

2.2.2. Retention time (T)

Retention time of foreign bodies with a clear history was calculated from the moment of aspiration until inpatient surgery, daily (less than 1 day was calculated as 1 day). Retention time of foreign bodies with unclear history was measured from the emergence of recurrent cough, dyspnea, and symptoms until surgery, with daily precision.

2.3. Statistical analysis

Data analysis was conducted using SPSS software (version 10.0). Measurement data were expressed as $\bar{x}\pm s$, and Student's t-test was used. χ^2 test was used for enumeration data. Logistic regression analysis was used for any related factors. A p value less than 0.01, was considered as statistically significant.

3. Results

3.1. Gender and age distribution

Eighty-three males and 70 females were enrolled in the study. The age of children ranged between 10 months and 6 years, with an average of 1.9 years. The age distribution of most patients ranged between 1and 3 years (Table 1).

3.2. Classification of surface smoothness of foreign bodies

No granuloma formation was seen in the intact watermelon seeds in the observed cases, while granuloma formation was observed in peanuts and broken watermelon seeds. The ratio of granuloma formation in the broken watermelon seeds was more than twice that of the peanuts (Table 1).

3.3. Classification of foreign body shape

Similar rate of granuloma formation was observed with flat and non-flat foreign bodies (Table 1).

3.4. Classification of oil release state of foreign bodies

Little difference was observed in the oil content of peanuts and broken watermelon seeds, and therefore, the two were classified under the same category. The released oil content was significantly different between the intact and broken watermelon seeds because of hull integrity. No granuloma occurred in the intact watermelon seeds, with no significant oil release (Table 1).

Table 1
Univariate analysis of risk factors for granuloma.

Variable	G	NG	p-Value
N	35	118	
Sex			0.443
Male	17	66	
Female	18	52	
Age			0.036
≤1 year	1	4	
1–3 years	28	103	
≥3 years	6	11	
Surface smoothness			<0.001
Smooth FB (IWS)	0	26	
Rough FB (peanuts)	21	75	
Sharp FB (BWS)	14	17	
Shape			0.702
Flat FB (IWS and BWS)	14	43	
Non-flat (peanuts)	21	75	
Oil release of FB			0.002
Non oil releasing FB (IWS)	0	26	
Oil releasing FB (BWS and peanuts[a])	35	92	
Location of FB			0.096
Main trachea	1	19	
Right main bronchus	15[b]	48	
Left main bronchus	20[b]	51	
Retention time			<0.001
<7 days	1	73	
7–30 days	24	36	
>30 days	10	9	

FB, foreign body; *N*, number of cases; G, granuloma formation; NG, non-granuloma formation; IWS, intact watermelon seeds; BWS, broken watermelon seeds.

[a] Oil content of the material, BWS (44.8) and peanuts (48.0) [3].

[b] In the granulation group, there was one case of bilateral bronchial foreign body, with bilateral granulation hyperplasia, which was classified into different classes.