Paediatr Croat. 2017;61:59-64
IZVORNI ZNANSTVENI RAD / *ORIGINAL SCIENTIFIC PAPER*
www.paedcro.com
http://dx.doi.org/10.13112/PC.2017.9

Do residual foreign bodies in terminal bronchioles require removal?

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We aimed to discuss whether residual foreign bodies in terminal bronchioles require further treatment. This retrospective study included patients younger than 13 years diagnosed with residual airway foreign bodies in terminal bronchioles during a 6-year-period (from May 2008 to December 2014). Parents were asked to complete questionnaires about complications caused by long-standing foreign bodies when followed-up. Thin-layer computed tomography (CT) images of the chest were analyzed before and after rigid bronchoscopy. There were 23 children (12 girls), mean age 17.17±6.35 (range 6-29) months, with residual foreign bodies incarcerated or wrapped in terminal bronchioles. The follow up after initial bronchoscopy ranged from 6 to 72 (mean 43.04±20.83) months. Four patients were lost during follow up. Nineteen children available for follow up experienced chronic recurrences of cough and fever, haemoptysis, chest tightness or dyspnoea after sports, or stridor and pain in the chest or back before operation. Initial chest thin-layer CT scan evaluations revealed that foreign bodies in the bronchus were frequently associated with pulmonary hyperinflation (14/19). Presenting symptoms and signs resolved after therapy, with statistically significant improvement. On follow up, the images of all children were normal. In conclusion, one or two small residual foreign bodies can potentially be spontaneously eliminated or probably coated by granulation tissue; thus, it may not be necessary to perform further invasive treatments. However, all such children need long time follow up.

Key words: children; foreign body aspiration; terminal bronchiole; rigid bronchoscopy; chest thin-layer computed tomography images

INTRODUCTION

Foreign body (FB) aspiration is a common cause of serious respiratory problems in children, especially among those younger than 3 years (1-4). Most FBs in the airway can be removed by different types of bronchoscopy, such as rigid bronchoscopy, which is considered to be the best method for FB removal (3, 5, 6). In clinical practice, larger FBs will contribute to airway obstruction or even sudden subsequent death (4), but small ones may just obstruct some small bronchial tract and do not lead to obstructing symptoms. However, some physicians suggest that a battery of complications, including pneumonia, bronchiectasis, lung abscesses and dyspnoea will be caused by even small residual FBs (7-9); therefore, all FBs must be removed using any means necessary, including thoracoscopy, thoracotomy, or pulmonary lobectomy. These procedures are associated with great surgical risks including long administration of intravenous anaesthesia, and postoperative complications, in addition to high costs. However, in our experience, very small FBs such as a piece of peanut or bone chip of less than 1.5 mm in diameter do not pose such a serious threat when they are incarcerated or wrapped by granulation tissues in the bronchioles. Those terminal bronchioles cannot be reached by the clip of a rigid bronchoscope and forceps. The reported incidence of very small FBs that cannot be removed with a rigid bronchoscope ranges from 1% to 18% (1). In our clinical work, we also found that children with residual small FBs of less than 1.5 mm in diameter (the smallest diameter of the rigid bronchoscope currently used in our hospital) in terminal bronchioles do not present with any lasting complications.

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Primljeno/Received: 18. 12. 2016., Prihvaćeno/Accepted: 27. 6. 2017.

In this article, we present analysis of children with residual FBs in terminal bronchioles and discuss whether it is necessary to remove small residual FBs in terminal bronchioles in any circumstance.

PATIENTS AND METHODS

All patients younger than 13 years were diagnosed with FB airway aspiration at the bronchus through bronchial airway FB removal with a rigid bronchoscope (Karl Storz, Germany, 10339EE) at the West China Hospital during a 6-year period (from May 2008 to December 2014) were enrolled in the study. They all had undergone thin-layer computed tomography (CT) scanning before rigid bronchoscopy to assess the condition of the lungs.

All children underwent operations under inhalation-intravenous combined anaesthesia in supine position. After general anaesthesia, direct laryngoscope was used to stir up the epiglottis to expose the laryngeal vestibule. Then amethocaine was used for superficial anaesthesia of vestibule mucosa of the larynx and trachea. Next, a rigid laryngoscope was inserted through the glottis to search for the FB and forceps was used to catch the FB and pull it out, followed by rigid bronchoscope. Finally, effusion was absorbed totally.

Children with residual small airway FBs in the bronchiole were included in this study. All medical history information on the children was summarized when they presented to the hospital and at follow up. A questionnaire was designed based on the reported complications of long-standing foreign bodies in the airway (1, 3, 6, 10-15). The survey was conducted by asking the parents the following questions at the time of follow up: How many times did your child get fever after foreign body removal? Does your child have recurrent cough? Does your child have purulent sputum? Does your child have chronic cough without reasons? Does your child have haemoptysis? Does your child have tightness of breath or dyspnoea after light sports activities? Does your child complain of pain in the chest or back? Does your child have stridor or swelling?

All the questions were asked by a respiratory physician. Additionally, we obtained chest thin-layer CT scans in each patient on follow up appointment at 6 months to 6 years after the operation and these follow up CTs were assessed by a radiologist.

RESULTS

A total of 1207 patients diagnosed with airway FB aspiration in lower respiratory tract underwent rigid bronchoscopy surgery in our hospital from May 2008 to December 2014. In 23 (2.24%) patients, difficulty was encountered on removing FB with rigid bronchoscope because the smallest working channel of 1.5 mm in diameter could not reach terminal bronchioles where FBs were incarcerated and wrapped. This group included 12 girls and 11 boys, mean age 17.17±6.35 (range 6-29) months. The lung-related symptoms in these patients assessed by respiratory physician before and after surgery were collected. The follow up ranged from 6 to 72 (mean 43.04±20.83) months, and 4 patients were lost to follow up, leaving a total of 19 participants.

All (100%) patients exhibited abnormal breath sounds, 19 (82.61%) had coughs, 7 (30.43%) had chest tightness, 4 (17.39%) had fever and 3 (13.04%) patients had mild dyspnoea. None of the children was diagnosed with any heart trouble, asthma, organ dysplasia, or any other congenital

TABLE 1. Characteristics of cases with small residual foreign bodies before and after rigid bronchoscopy recorded on follow up

Symptoms and signs	Before removal (n=23)	After removal (n=19)	p-value
Abnormal breath sounds	23	0	0.000
Coughs	19	0	0.000
Tightness	7	0	0.000
Fever	4	0	0.000
Mild dyspnea	3	0	0.000

TABLE 2. Type of food materials removed by rigid bronchoscopy

Type of foreign body	n	%
Nuts	15	65.22
Beans	5	21.74
Fish meat	1	4.35
Small bone	1	4.36
Longan aril	1	4.37
Total	23	100

TABLE 3. Location of foreign bodies before and after operation

Location	Before operation	After operation
Main bronchus + left bronchi + left terminal bronchus	2	0
Main bronchus + right terminal bronchus	1	0
Left bronchi + left terminal bronchus	7	0
Light bronchi + right terminal bronchus	1	0
Right bronchi + right terminal bronchus	12	0
Left terminal bronchus	0	9
Right terminal bronchus	0	14
Total	23	23

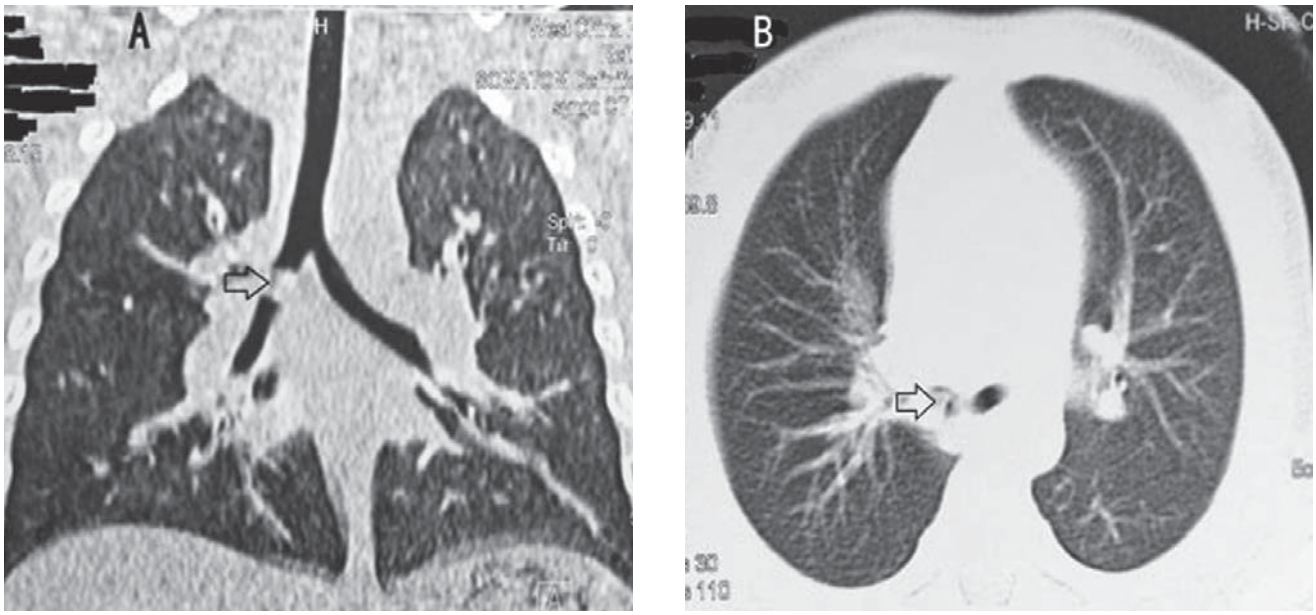

FIGURE 1. Preoperative chest thin-layer computed tomography (CT) scan showing pulmonary hyperinflation with a big peanut in the right main bronchus; CT shows clear location, shape and volume of the peanut (arrow) in the right main bronchus; CT coronal scan (A); CT axial scan (B).

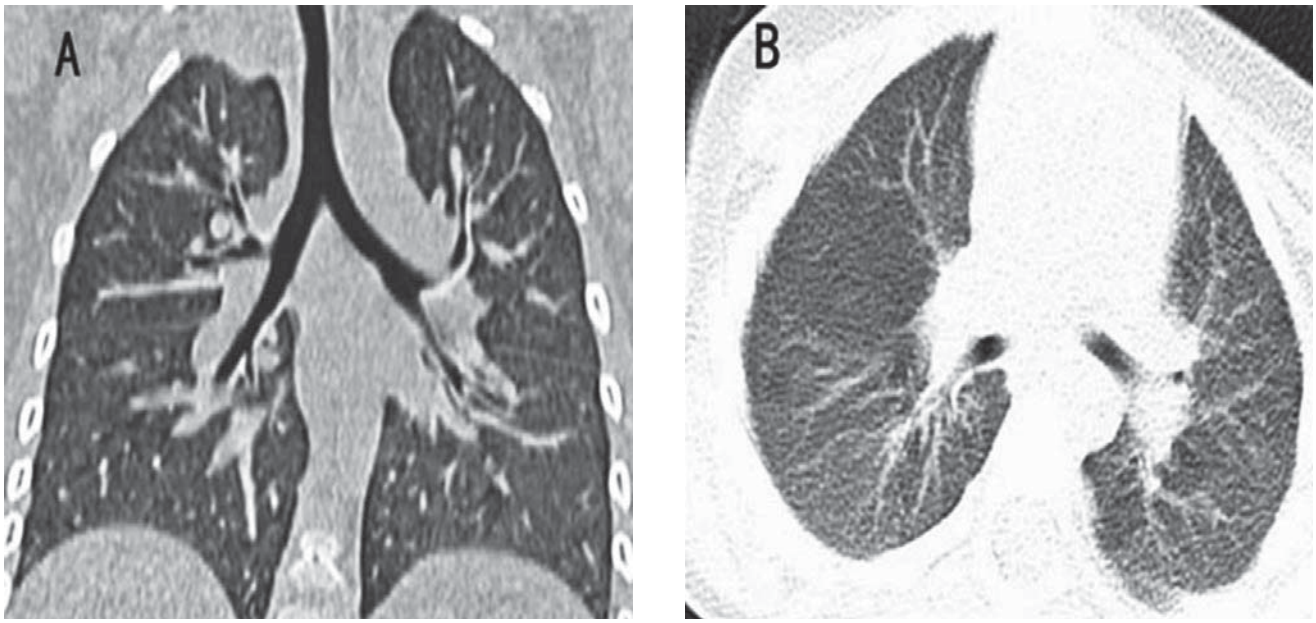

FIGURE 2. Computed tomography (CT) performed one year later; no abnormality was found; a small peanut fragment was not taken out on the surgery; CT coronal scan (A); CT axial scan (B).

disease. The recorded symptoms and signs resolved after therapy with a statistically significant improvement in the postoperative follow up period. Characteristics of the cases with small residual FBs compared to those with completely removed FBs are shown in Table 1. All FBs were food materials and are listed in Table 2. The location of FBs as detected by rigid bronchoscopy is shown in Table 3.

After FB removal, all children were treated with clindamycin phosphate gel (50 mg/kg, bid) for 3 days and did not exhibit fever, cough, or abnormal breath sounds at discharge. Upon completion of the study, none of the children returned to the hospital for recurrent cough, fever, or any other symptoms of obstruction such as tightness or dyspnoea. Based on parental responses, none of the children presented with chronic recurrent cough and fever, haemoptysis, tightness or dyspnoea after sports, or stridor and pain in the chest or back.

Evaluations of CT scans before the procedure revealed pulmonary hyperinflation along with foreign bodies in the bronchus (Fig. 1) in the majority of patients (14 of 19 children). CT scans of three children (3/19) indicated only hype-

rinflation with no foreign bodies, and another 2 of 19 patients had normal findings. The FBs of five children whose CT scans did not reveal evidence of FBs were removed through rigid bronchoscopy.

All the 19 patients underwent CT scanning when they were back to the hospital for follow up. In all children, the postoperative CT images were normal (Fig. 2).

DISCUSSION

Some patients may retain FBs after bronchoscopy, and the reported incidence of this situation ranges from 1% to 18% (1, 9). Out of 1207 patients in the present study, 23 (2.24%) children had residual FBs in their terminal bronchioles following rigid endoscopy. Long-standing FBs in respiratory tract may lead to significant morbidity and even mortality (1, 3, 10), and those left untreated, as well as those with unrecognized airway FBs may experience obstructive pneumonitis, lung abscesses, pneumomediastinum, pneumothorax, atelectasis, or bronchiectasis. These conditions may cause symptoms such as recurrent fever, cough, or wheezing cyanosis (1). The most characteristic symptom or sign of lower airway obstruction is wheezing, which is caused by vibrations of the airways during the passage of air through the narrow lumen. Symptoms that indirectly indicate the existence of long-standing FBs in the airway include cough, acute dyspnoea, shortness of breath, haemoptysis, increase in breathing difficulty, decreased oxygen saturation, crackles, and death. This commonly held view suggests that all FBs in the tracheobronchial system need to be found and removed with various methods, such as rigid endoscopy, bronchofiberscopy, tracheotomy, and even thoracotomy and thoracoscopy. After long-standing FBs have been removed (16), most children recover from the symptoms listed above. However, few reports have discussed strategies for removal of small residual FBs in terminal bronchioles and their complications. Incomplete removal of a FB at initial bronchoscopy may cause migration of an FB fragment into the more distal bronchial tree. However, in our study, the 19 children with residual FBs did not present with recurrent cough, fever, haemoptysis, tightness or dyspnoea after sports, stridor and pain in the chest or back, or symptoms of obstructive lung infection, even when one or two of their bronchioles were blocked with residual FBs.

Exclusive use of the reported symptoms to assess the condition in children may not be sufficient; therefore, combining symptoms with the results of a CT scan appears to be more appropriate. Chest CT scanning is the most sensitive diagnostic imaging technique and is used to reach an accurate diagnosis in elusive cases of FB aspiration. Chest CT can also identify many radiolucent FBs (17). It can directly detect FBs that even chest radiography may occasionally fail to identify, such as FBs wrapped by granulation tissue and radiopaque organic FBs such as peanuts (Fig .1). If the FB cannot be found by chest CT scan because it is radiolucent, FBs also can be suggested by secondary signs, including segmental or lobar collapse, air trapping, especially in a unilaterally hyperlucent lung, postobstructive lobar hyperinflation, segmental infiltrates, or other chronic pulmonary changes (18). In our study, the FBs were organic in nature in all 19 cases, and peanuts were the most commonly aspirated objects. The preoperative chest CT scans in the present study revealed pulmonary hyperinflation along with FB in the bronchus in 14 of 19 patients. The CT scans of three children (3/19) did not show any FBs but revealed signs of hyperinflation, and 2 of 19 patients had normal findings on chest radiography. The sensitivity of CT scans was 89.47% (17/19), consistent with the findings by Bai *et al*., who report a sensitivity of 89% (18). The postoperative CT scans taken at follow up appointments were normal in all 19 children (Fig. 2). This finding suggests that the 19 children had no complications due to the small residual FBs.

We propose that residual FBs be removed or prevented from causing any complications through two pathways. The first involves removal of residual FBs by mucociliary clearance of the airway (19). The airway has three protective mechanisms, i.e. the mucociliary transport system, the cough reflex, and the immune mechanism. These three mechanisms can eliminate small residual FBs from the bronchiole. The second is the formation of granulation tissue around the small residual FB. Small residual FBs will be surrounded by granulation tissues after an inflammatory reaction (20). FBs that remain in the bronchial tree for a prolonged period of time have been noted to become embedded in granulation tissue or surrounded by fibrotic bands, which suggests that removal would be difficult (21-23). These granulation tissues will become scar tissues that block the single terminal bronchiole. The impaired drainage of secretions due to obstruction may cause pneumonia in these patients (23), but when only a single bronchiole or a small number of bronchioles are blocked, breathing may not be affected. If the patient lung capacity is reduced, even up to 20%, they can compensate for it, and they receive normal respiration scores on assessments.

A limitation of our study was that it was a retrospective analysis and included only 23 cases. In the future, larger numbers of patients and animal study should be undertaken to affirm our conclusion in the future.

CONCLUSION

Probably, complications such as cough, tightness, fever and dyspnoea may not be caused by residual FBs released or

coated by granulation tissue. Our experience showed that one or two small residual FBs were incarcerated and wrapped in terminal bronchiole; therefore, it is not necessary to perform further invasive treatments. However, all these children need long time follow up indeed.

NOVČANA POTPORA/*FUNDING*

Nema/*None*

ETIČKO ODOBRENJE/*ETHICAL APPROVAL*

Nije potrebno/*None*

SUKOB INTERESA/*CONFLICT OF INTEREST*

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SAŽETAK

Treba li uklanjati ostatna strana tijela u terminalnim bronhiolama?

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Cilj nam je bio raspraviti zahtijevaju li ostatna strana tijela u terminalnim bronhiolama daljnje liječenje. Ovo retrospektivno istraživanje obuhvatilo je bolesnike mlađe od 13 godina u kojih su dijagnosticirana ostatna strana tijela u terminalnim bronhiolama tijekom 6 godina (od svibnja 2008. do prosinca 2014.). Roditelji su zamoljeni da ispune upitnik o komplikacijama koje su na kontrolnim pregledima izazivala dugo prisutna strana tijela. Snimke tankoslojne kompjutorizirane tomografije (CT) analizirane su prije i nakon rigidne bronhoskopije. Bilo je ukupno 23 djece (12 djevojčica) srednje dobi 17,17±6,35 (raspon 6-29) mjeseci s ostatnim stranim tijelima uklještenim ili omotanim u terminalnim bronhiolama. Razdoblje praćenja nakon početne bronhoskopije bilo je 6-72 (srednje trajanje 43,04±20,83) mjeseca. Tijekom praćenja nedostupna su postala 4 bolesnika. Preostalih 19 bolesnika imalo je kronične epizode kašlja i vrućice, hemoptizu, težinu u prsima ili dispneju nakon športskih aktivnosti ili pak stridor i bolove u prsima ili leđima prije operacije. Početne tankoslojne CT snimke pokazale su da su strana tijela u bronhima često bila udružena s plućnom hiperinflacijom (14/19). Ovi simptomi i znakovi ublažili su se nakon terapije, uz statistički značajno poboljšanje stanja. Kontrolne snimke bile su normalne kod sve djece. Zaključuje se da zapravo može doći do spontanog uklanjanja jednog ili dva manja ostatna strana tijela ili ona bivaju prekrivena granulacijskim tkivom pa stoga ne mora biti potrebno nastaviti s invazivnim postupcima. Međutim, sva djeca s ovakvim problemima zahtijevaju dugotrajno praćenje.

Ključne riječi: djeca; aspiriranje stranih tijela; terminalna bronhiola; rigidna bronhoskopija; tankoslojna tomografija prsnog koša