

## Foreign body aspiration in children

H. Schmidt, B. C. Manegold

Department of Surgical Endoscopy, Universitätsklinikum Mannheim, University of Heidelberg, Theodor Kutzer Ufer 1-3, 68135 Mannheim, Germany

Received: 2 June 1999/Accepted: 25 November 1999/Online publication: 15 May 2000

### Abstract

**Background:** There is still considerable controversy about the diagnostic procedure, the endoscopic approach, and the complication rate with foreign body aspiration in children.

**Methods:** Review of our data for 98 children suspected for foreign body aspiration between January 1990 and December 1998 was performed.

**Results:** In this data review, 78% of the children studied were younger than 2 years. A foreign body aspiration was identified in 70%, and 67% had a definite history of aspiration. Predominant clinical features were fever (46%), pneumonia (39%), and coughing (29%). Pathologic chest radiographs were found in 84% of the children. Sixty-two percent of the foreign bodies were trapped in the right lung, and 87% were of organic in origin. In 93%, a single endoscopic procedure was successful in removing the foreign bodies. The mean time between aspiration and bronchoscopic extraction was 5.4 days (range, 1 h to 36 weeks). The procedure-related morbidity rate was 0.96% and the mortality 0.

**Conclusions:** Outcome and complications were found to depend mainly on the time the foreign body stayed in the tracheobronchial system. Early bronchoscopy is paramount in any case of suspected foreign body aspiration, and it is mandatory to increase the awareness of the population and medical professionals.

**Key words:** Bronchoscopy — Children — Foreign body aspiration

Foreign body aspiration in children still is an extremely dangerous event, reported to be the most common cause of accidental death in children younger than 1 year [13]. In 1994, 180 children succumbed to foreign body aspiration in the United States, as demonstrated by the National Safety Council [15].

In general, the acute event after aspiration is character-

ized by serious coughing fits, acute respiratory distress, and choking. Complete obstruction or reflex laryngospasm may result finally in death by suffocation. Alternatively, this acute stage also may be self-limiting, and a symptom-free period can develop, which might be followed by further potentially life-threatening attacks. The lack of clinical features during the latent period, therefore, should never lead to the assumption that the foreign body has been coughed up. As a rule, the longer a foreign body stays in the tracheobronchial system, the more serious the developing complications will be [1, 6, 7, 8, 16, 18].

In any case of suspected tracheobronchial inhalation of a foreign body, early bronchoscopy should be performed because the medical history often is unreliable in children, and the expected complications might be grave [3, 6, 10, 12]. Bronchoscopy, including foreign body extraction in children, however, is accompanied by significant risks. Therefore, it should be performed by an experienced endoscopist [2, 8, 16, 17, 18, 20]. Because there still is considerable controversy about the diagnostic procedure, the endoscopic approach, and the procedure-related complication rate, we analyze our data in a retrospective study with respect to patient characteristics, diagnostic and therapeutic management, and complications.

### Patients and methods

Between January 1990 and December 1998, 98 children, 31 girls and 67 boys with a mean age of 2 years (range, 5 months to 12 years) were referred to our institution for bronchoscopy for suspected foreign body aspiration. Diagnosis was based exclusively on medical history, physical examination, and chest x-ray. No additional studies were carried out. All bronchoscopies were performed with the child under general anesthesia, usually after a fasting period of 6 h from the last meal.

After induction of anesthesia, the intubation was performed, preferably by insertion of a rigid bronchoscope under direct vision by the endoscopist, rarely first by the anesthesiologist with an endotracheal tube followed by flexible bronchoscopy through the tube. Occasionally, a combination of rigid and flexible instruments was used in the same session. Appropriate-size rigid bronchoscopes (outside diameter, 5.0–7.8 mm; Karl Storz, Tuttlingen, Germany), Hopkins telescopes, and flexible bronchoscopes (outside diameter, 4 and 5 mm; Olympus, BF LF 2, BF P 10) were available. Foreign body removal was accomplished with corresponding rigid optical forceps or flexible forceps. In few cases, a balloon catheter was applied.

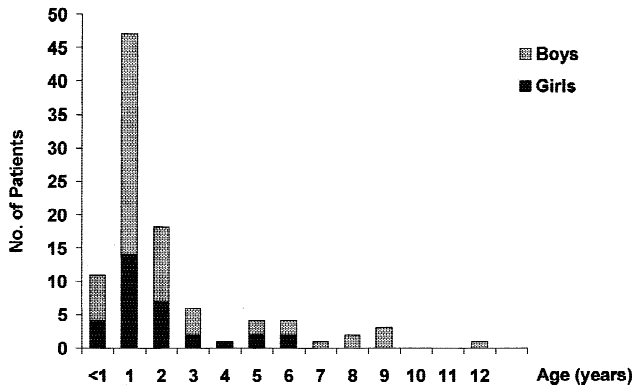


Fig. 1. Distribution of age and sex ( $n = 98$ ).

The medical records of the Department of Surgical Endoscopy and the admitting departments were analyzed retrospectively.

## Results

During the observation period, 98 children were admitted to our hospital with symptoms of foreign body aspiration. Most of these patients were referred by the in-house Departments of Pediatrics (92 patients) and Pediatric Surgery (3 patients). Three patients were referred by other hospitals. According to Fig. 1, most of these children were affected between the ages of 1 and 2, 78% of whom were younger than 2 years.

A foreign body aspiration was identified in 70% (69/98) of the children. Sixty-seven percent had a definite history of foreign body aspiration. In the latter cases, a foreign body was recovered during bronchoscopy in 92%. Nevertheless, even in patients with a negative history a foreign body was found in 25%.

Clinical features at admission were fever (46%), mostly in combination with pneumonia (39%), coughing (29%), bronchitis (11%), stridor (10%), and dyspnea (6%). In two children (2%), bronchoscopy had to be performed on an urgent basis because of acute respiratory distress. Five symptom free children (5%) were examined because of the clear history.

Ninety-five out of 96 chest radiographs prior to bronchoscopy were available for evaluation. In two cases, no radiographic studies were performed. Findings were air trapping in 32%, mediastinal shift in 16% (Figs. 2, and 3), atelectasis in 14%, infiltrates in 12%, pneumonia in 8%, and radiopaque foreign bodies in 2%. On the chest-x-ray 15 patients (16%) had no pathology, although a foreign body was identified during bronchoscopy in 42% (Table 1).

Altogether 104 bronchoscopies were performed, 83 with rigid instruments and 21 with flexible bronchoscopes, 14 children were examined by both methods. Further bronchoscopy was required in five patients, once in 4 children and twice in one child. The reasons for repeated bronchoscopies were removal of remaining foreign bodies (2 children), control after tracheal injury (1 child), and retention of secretion (3 children).

Foreign bodies were preferentially trapped in the right lung (62%) compared with the left lung (38%). In the majority, the right main bronchus was affected (46%), fol-

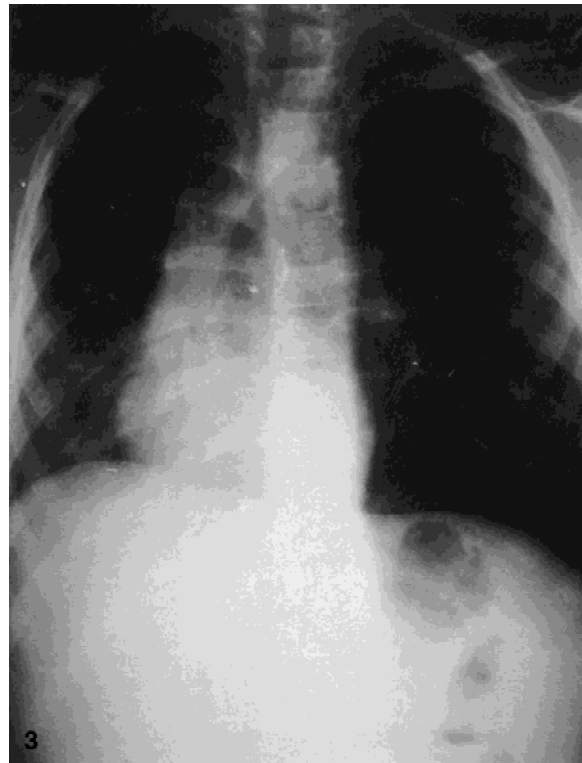
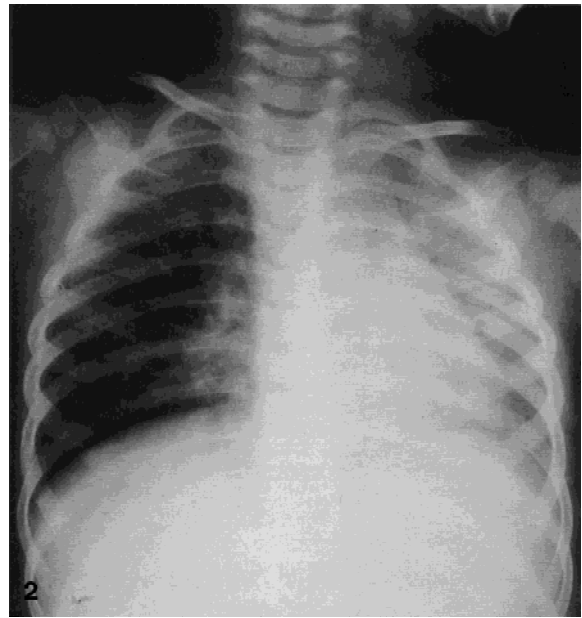


Fig. 2. Chest x-ray in 1-year-old girl showing mediastinal shift to the left, air trapping to the right, extended intercostal spaces on the right, and compressed lung on the left. The cause was an aspirated piece of a pumpkin seed in the right main bronchus.

Fig. 3. Chest radiography demonstrating mediastinal shift to the right side caused by an aspirated Lego® brick in the left main bronchus of a 9-year-old boy.

lowed by the left (25%). In contrast, peripheral segments were affected rarely (Table 2). As Table 3 shows, 87% of the recovered foreign bodies were of organic in origin.

The time between the acute event (i.e., aspiration of the foreign body) and the bronchoscopical extraction varied considerably, ranging from 1 h to 36 weeks (mean, 5.4

**Table 1.** Findings of chest radiographs

Radiological findings	%
Air trapping	32
Mediastinal shift	16
Atelectasis	14
Infiltrates	12
Pneumonia	8
Radiopaque foreign bodies	2
Without pathology	16

**Table 2.** Lodgment site of foreign bodies found

%	%
Trachea 4%	
Both main bronchi 4%	
Right main bronchus 42%	Left main bronchus 21%
Right superior lobe 0%	Left superior lobe 3%
Right middle lobe 3%	
Right inferior lobe 13%	Left inferior lobe 10%

**Table 3.** Kinds of foreign bodies found (*n* = 69)

Kind of foreign body	No. of cases
Nuts, seeds	54
Pieces of fruits/vegetables	6
Piece of bone	1
Thumb tack, needle	2
Lego® brick, bead	3
Chalk, powder	3

days). Of all foreign bodies, 42% could be removed within 24 h after aspiration and 77% within 1 week. The average hospital stay was 5 days if a foreign body was identified and 9 days if it was not.

In 93%, a single endoscopic procedure was successful in removing the foreign bodies. In two children, retaining fragments required further bronchoscopy. In another patient, a little piece of nut retained initially was coughed up spontaneously before a second bronchoscopy. Two inhaled foreign bodies (a piece of chalk and some cooked cauliflower) were transformed by pulmonary secretion such that it was impossible to extract them. Here, we performed careful lavage and administered intravenous antibiotics, thereby achieving a complete recovery without further complications. Nevertheless, the patients could be discharged on the third day after admission.

One serious complication, a tracheal injury, occurred in an 18-month-old boy during rigid bronchoscopy for aspiration of an almond. It was repaired using histocompatible fibrin glue (Tissucol®). Complete closure of the dehiscence could be demonstrated 13 days later. On day 17, the boy was discharged. This being our only complication, the overall morbidity rate was 0.96% (1/104) and the mortality rate 0.

## Discussion

### Age and sex distribution

Our finding of a male preponderance (male to female ratio, 2:1) for foreign body aspiration is consistent with the lit-

erature. This finding is best explained by the usually more impulsive nature and more adventurous play of boys [1, 2, 7, 9, 16, 20, 21]. Correspondingly, we noticed that aspiration of foreign bodies did not occur in girls older than 6 years. In contrast to our male to female ratio, Mu et al. [14] reported a nearly balanced ratio of 1.2 to 1.

The highest incidence of foreign body aspiration occurs in children between 1 and 2 years of age [1, 7, 9, 14, 16, 20, 21]. This is attributed to the following facts: children are used to putting things into their mouths for exploration when they pass the oral stage; the molars have not yet come through; and the swallowing reflex is still incomplete [1, 21]. Further factors associated with foreign body aspiration are parental negligence and a low level of parent education [14].

### Medical history

It is important to note that many foreign body aspirations occur unwitnessed because they cannot be reported by the small children themselves. A positive history usually is obtained only in 48% to 98% of the time [1, 9, 14, 16, 21], as found also in the current study. Correspondingly, Wood et al. [22] found unexpected foreign bodies in 1% of all flexible bronchoscopies performed for different indications in children.

### Time of treatment

The time between foreign body aspiration and extraction has been unchanged for years, ranging from less than 1 h to several months [2, 7, 12, 14]. Consistent with other reports [1, 7, 9, 14, 16, 21], in the current study, 42% of all foreign bodies were removed within 24 h and 77% within 1 week. Vane et al. [20] reported a delay in diagnosis of more than 2 weeks in 15% of cases, Laks and Barzilay [9] more than 3 weeks in 18% of cases, and Wolach et al. [21] more than 1 month in 7% of cases. The reason for this delay is an unwitnessed aspiration, the misinterpretation of the latent period, the resemblance of the symptoms to those of bronchial asthma or bronchiolitis [7], the undue procrastination of professional colleagues [1], or a trial of conservative treatment, despite a clear history [7].

### Symptoms and signs

Clinical features depend on type, location, and size of the foreign body [9, 14, 21], as well as on the duration and degree of obstruction. As reported previously, the most common symptoms (in 65% to 95% of pediatric patients) are coughing, stridor, respiratory distress, fever, and choking [2, 7, 18]. Yet, in 5% to 40% of patients, the physical examination can be normal [1, 9, 10]. This is significant because even when chronic symptoms are absent, death might occur after a foreign body aspiration [6].

### Radiologic examinations

The value of chest radiography in making a diagnosis remains controversial. Whereas Vane et al. [20] reported that

97% of the chest x-rays performed were diagnostic or at least suggestive of an aspirated foreign body, other investigators noticed a much lower diagnostic sensitivity for chest x-rays (9–62%) in the case of foreign body aspiration [2, 3, 9, 10, 14, 18, 19, 21]. The detection of a radiopaque foreign body is easy and reliable, but 66% to 94% of the foreign bodies are of radiolucent organic material [1, 3, 7, 9, 14, 21].

Strong suspicion of foreign body aspiration should be raised if atelectasis, infiltrates, emphysema, mediastinal shift, pneumomediastinum, or pneumopericardium are present [12]. However, it should be kept in mind that these signs are not pathognomonic [19]. As a result, plain film radiology alone is neither sufficiently sensitive nor a specific method for diagnosing foreign body aspiration [19], but it has been found helpful in supporting the diagnosis and may be important during the course. If history and clinical findings suggest foreign body aspiration, a normal chest radiograph should never deter the physician from carrying out a bronchoscopy [3, 21]. Therefore, several authors have reported the use of supplementary fluoroscopies. For special cases, others have reported computed tomography (CT) scans, contrast studies, and magnetic resonance imaging (MRI) [3, 8, 9, 20, 21]. In deciding whether an aspiration had taken place, these examinations did not prove to be of additional value to a careful history taking, a thorough physical examination, and inspiratory/expiratory chest roentgenograms. It is notable, however, that these time-honored procedures require a lot of compliance difficult to obtain from a small child, expose the pediatric patient unnecessarily to radiation, and finally delay definite therapy [1, 2, 8, 9, 10, 20]. Therefore, in any case of plausible suspicion for foreign body aspiration, endoscopy is the ultimate answer, diagnostically and therapeutically [1, 2, 8, 10, 12, 16].

### *Instruments*

Many authors recommend rigid bronchoscopy for foreign body extraction in children [1, 2, 5, 8, 14, 16, 17, 18, 20, 21]. Some prefer diagnostic flexible bronchoscopy if the evidence of foreign body aspiration is not convincing [11, 22], whereas others believe flexible bronchoscopy is relatively contraindicated for foreign body extraction [5, 11]. Still others advise diagnostic flexible bronchoscopy for examination, then rigid bronchoscopy if a foreign body is found [22], or the combination of both methods [3]. Flexible bronchoscopy has the advantage of a greater peripheral range than the rigid technique, allowing foreign bodies otherwise missed to be seen sometimes [8, 22]. Whereas flexible bronchoscopy can be performed even in newborn and small children with intravenous sedation and topical anesthesia only [22], rigid bronchoscopy needs to be performed with the patient under general anesthesia.

At our institution, we prefer rigid bronchoscopy using general anesthesia, as do most authors [1, 2, 5, 8, 14, 16, 17, 18, 20, 21]. Especially in small children, the fiberbronchoscope will subtotally obstruct the tube during examination using under general anesthesia, with the risk of hypoxia [5]. Flexible bronchoscopy has other disadvantages. The optics are of lower quality, and the small working channels tech-

nically can hinder foreign body removal in that only small forceps unsuitable for grasping the foreign body securely can pass the channel [5, 8]. In contrast, rigid bronchoscopes guarantee open airways, offer excellent visibility, allow the use of appropriately designed optical grasping forceps, and provide the necessary working space in case of complication [2, 8, 16, 20]. A disadvantage of rigid bronchoscopy is a greater degree of technical difficulty, involving the necessity of a qualified endoscopist. In our opinion, it is advisable that only skilled endoscopists perform bronchoscopy if there is suspicion of foreign body aspiration because even if the examination started with a flexible bronchoscope, it may result in a risky situation, in which rigid bronchoscopy and special training are needed immediately.

### *Lodgement site and type of foreign body*

Both size, shape, and surface of the inhaled foreign body as well as the patient's anatomic condition determine both the site where the foreign body will be located [12, 14]. The upright junction of the right main bronchus in a line with the trachea would explain a preference of the right lung compared with the left [3, 14, 16, 18]. However, an equal distribution can be noticed as well [7, 9], and Vane et al. [20] found more foreign bodies on the left side. 66%. According to the findings of others, 66% to 94% of the foreign bodies are of organic origin [1, 2, 3, 7, 9, 14, 18, 21]. Local eating habits are reflected by the recovered material: watermelon seeds in Egypt, dry pumpkin seeds in Greece, peanuts in China, and sunflower seeds in Turkey [14, 16, 21].

### *Length of hospitalization*

The average hospital stay was 5 days for children with positive foreign body identification and 9 days for those without such positive identification. This is explained by the fact that the group without foreign body identification underwent bronchoscopies mainly to exclude foreign body aspiration in case of continuous or recurrent pneumonias, whereas the other group contained more children with a positive history for foreign body aspiration, resulting in an earlier examination and recovery.

### *Complications*

In 86% to 99% of cases, foreign body extraction is successful at the first attempt [1, 2, 14, 18, 21]. Occasionally, a second examination is required for residual fragments [21]. Thoracotomy must be performed in 0.2% to 11% of cases [1, 2, 9, 12, 16, 18, 21], and when diagnosis has been delayed (>7 days), this procedure is required in up to 27% [4]. Rarely, a laryngeal foreign body demands a tracheotomy.

Bronchoscopies in children have certain risks. An experienced endoscopist, short manipulations, appropriate instruments, and good communication between endoscopist and anesthesiologist are recommended to reduce the risk. [2, 8, 16, 17, 18, 20].

Complication rates in the literature are 1.2% to 44%, but they are difficult to compare because of distinct definitions

[12]. Major complications are pneumothorax, cardiac arrest, perforation, and hemorrhage [5, 12, 16, 21]. Large surveys report complication rates of 1.9% for rigid bronchoscopies in children independent of the indication [5], and 2.9% for flexible bronchoscopies [22]. In general, the complication rate is related to the time the foreign body stays in the tracheobronchial system [7, 12]. Complications occur in only 3% of bronchoscopies performed within 12 hours after the acute aspiration event, but in more than 50% if the diagnosis was delayed [18]. Mortality is reported to be 0% to 1.6% [1, 2, 7, 14, 16, 20, 21].

### Conclusions

Foreign body aspiration in children is an extremely dangerous event, which may result in a life-threatening situation each time. In our study we did not find significant differences regarding patient characteristics, diagnostic and therapeutic management, and complication rate when compared to previous studies. The outcome and the rate of complications depend mainly on the time the foreign body stays in the tracheobronchial system. Therefore, in any case of suspected foreign body aspiration, early bronchoscopy is paramount and it is mandatory to increase the awareness of the population and of medical professionals. Bronchoscopy performed by an experienced endoscopist is a safe and effective procedure.

### References

- Banerjee A, Subba Rao KSVK, Khanna SK, Narayanan PS, Gupta BK, Sekar JC, Rajendra Retnam C, Nachiappan M (1988) Laryngo-tracheo-bronchial foreign bodies in children. *J Laryngol Otol* 102: 1029–1032
- Black RE, Johnson DG, Matlak ME (1994) Bronchoscopic removal of aspirated foreign bodies in children. *J Pediatr Surg* 29: 682–684
- Caversaccio MD, Zbären P, Vischer M, Tschäppeler H (1996) Tracheobronchial foreign bodies in children. *HNO* 44: 440–444
- Hamilton AH, Carswell F, Wisheart JD (1989) The Bristol children's hospital experience of tracheobronchial foreign bodies 1977–1987. *Bristol Med Chir J* 104: 72–74
- Hoeve LJ, Rombout J, Meursing AEE (1993) Complications of rigid laryngobronchoscopy in children. *Int J Pediatr Otorhinolaryngol* 26: 47–56
- Humphries CT, Wagener JS, Morgan WJ (1988) Fatal prolonged foreign body aspiration following an asymptomatic interval. *Am J Emerg Med* 6: 611–613
- Inglis AF, Wagner DV (1992) Lower complication rates associated with bronchial foreign bodies over the last 20 years. *Ann Otol Rhinol Laryngol* 101: 61–66
- Johnson DG, Condon VR (1998) Foreign bodies in the pediatric patient. *Curr Probl Surg* 35: 279–332
- Laks Y, Barzilay Z (1998) Foreign body aspiration in childhood. *Pediatr Emerg Care* 4: 102–106
- Losek JD (1990) Diagnostic difficulties of foreign body aspiration in children. *Am J Emerg Med* 8: 348–350
- Martinot A, Closset M, Marquette CH, Hue V, Deschildre A, Ramon P, Remy J, Leclerc F (1997) Indications for flexible versus rigid bronchoscopy in children with suspected foreign body aspiration. *Am J Crit Care Med* 155: 1676–1679
- Merkenschlager A, Nicolai TH, Joppich I, Mantel K, Sanktjohanser L (1993) Surgical complications caused by tracheobronchial foreign bodies in childhood. *Kinderärztl Prax* 61: 97–103
- Mofenson HC, Greensher J (1985) Management of the choking child. *Pediatr Clin North Am* 32: 183–192
- Mu L, He P, Sun D (1991) Inhalation of foreign bodies in chinese children: a review of 400 cases. *Laryng* 101: 657–660
- (1995) National Safety Council Accident facts. National Safety Council, Itasca, Ill, pp 154
- Pasaoglu I, Dogan R, Demircin M, Haptipoglu A, Bozer AY (1991) Bronchoscopic removal of foreign bodies in children: retrospective analysis of 822 cases. *Thorac Cardiovasc Surg* 39: 95–98
- Puhakka H, Kero P, Erkinjuntti M (1987) Pediatric bronchoscopy during a 17-year period. *Int J Pediatr Otorhinolaryngol* 13: 171–180
- Schimpl G, Weber G, Haberlik A, Höllwarth ME (1991) Aspirated foreign bodies in children: advantages of emergency endoscopy and forceps removal. *Anaesthesist* 40: 479–482
- Svedström E, Puhakka H, Kero P (1989) How accurate is chest radiography in the diagnosis of tracheobronchial foreign bodies in children. *Pediatr Radiol* 19: 520–522
- Vane DW, Pritchard J, Colville CW, West KW, Eigen H, Grosfeld JL (1988) Bronchoscopy for aspirated foreign bodies in children. *Arch Surg* 123: 685–688
- Wolach B, Raz A, Weinberg J, Mikulski Y, Ben Ari J, Sadan N (1994) Aspirated foreign bodies in the respiratory tract of children: eleven years experience with 127 patients. *Int J Pediatr Otorhinolaryngol* 30: 1–10
- Wood RE, Gauderer MWL (1984) Flexible fiberoptic bronchoscopy in the management of tracheobronchial foreign bodies in children: the value of combined approach with open tube bronchoscopy. *J Pediatr Surg* 19: 693–696