Flexible Bronchoscopic Management of
Airway Foreign Bodies in Children*

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Objectives: To evaluate experience with the flexible bronchoscopic management of tracheobronchial foreign bodies (TFBs) in children (age ≤ 16 years).

Design: All pediatric bronchoscopies performed by the bronchoscopy section at Mayo Clinic Rochester from 1990 through June 2001 for the suspicion of TFBs were reviewed. Information analyzed included the types of bronoscope (rigid vs flexible) and techniques used, success rates of extraction of TFBs, and complications.

Results: Of the 94 children suspected of having TFBs, 39 children (28 boys and 11 girls; mean age, 47.3 months) were found to have 40 TFBs. The flexible bronchoscope was used exclusively to extract TFBs in 24 patients, and in 2 patients in whom the rigid bronchoscopic procedure was unsuccessful. Flexible bronchoscopy was performed through an endotracheal tube in 19 children. In the other five children, the procedure was accomplished through a laryngeal mask airway (LMA). In two additional patients in whom the rigid bronchoscopic procedure was unsuccessful, the instrument served as a conduit for the passage of the flexible bronchoscope. The extraction instruments employed included ureteral stone baskets and stone forceps. Since 1994, all extractions of TFBs were successfully accomplished with the flexible bronchoscope. Complications occurred in four patients who underwent rigid bronchoscopy, and included postbronchoscopic laryngeal edema manifested by stridor, cough, and respiratory distress. These resolved quickly with medical therapy.

Conclusions: Flexible bronchoscopic extraction of pediatric TFBs can be performed safely with minimal risks and complications. In our experience, it was successful in all children in whom it was employed. Nevertheless, we caution that provisions be made to provide immediate rigid bronchoscopic management, should the attempts at flexible bronchoscopic extraction fail.

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Key words: airway foreign body; bronchoscopy; flexible bronchoscope; pediatric lung diseases; rigid bronchoscope; tracheobronchial foreign body

Abbreviations: LMA = laryngeal mask airway; TFB = tracheobronchial foreign body

Many accidental deaths in children are caused by aspiration of foreign bodies into the tracheobronchial tree. Among children in the United States in 1996, ingestion or lodging of a foreign body was responsible for 12% of all toy-related injuries.¹ In 1986, in the United States, aspirated foreign bodies accounted for 7% of all accidental deaths in children < 4 years old.² A delay in the diagnosis of an aspirated foreign body may increase morbidity and mortality, ranging from life-threatening airway obstruction to recurrent infection and wheezing or coughing. If the clinical history is suggestive of tracheobronchial foreign body (TFB) aspiration, even in the presence of a negative physical examination and radiographic imaging, bronchoscopic evaluation is indicated.

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The traditional instrument of choice for the management of TFBs in children is the rigid bronchoscope. Indeed, it is a maxim among physicians who specialize in the management of pediatric airway foreign bodies that they must be treated exclusively with the rigid bronchoscope, particularly if extraction is attempted. The ability to control the airway, ventilate, and the availability of a wide variety of extraction instruments have established rigid bronchoscopy as a safe method to remove TFBs in children. For these reasons, the rigid bronchoscope has been the favorite instrument in the management of pediatric airway foreign bodies.

The pediatric flexible bronchoscope has been used for several decades in the diagnosis and treatment of various respiratory disorders in children. However, its use for the extraction of airway foreign bodies in children has been hampered by the small caliber of the suction channel and lack of ancillary instruments available to grasp the airway foreign bodies. Our review of the literature revealed a paucity of published data on the use of flexible bronchoscopy to extract foreign bodies in children. The Bronchoscopy Section at Mayo Clinic Rochester has previously reported3 the experience with successful removal of foreign bodies with the pediatric flexible bronchoscope in six children. Others4 have also successfully used the flexible bronchoscope to retrieve airway foreign bodies in children.

Since our original publication in 1994,3 we have exclusively used flexible bronchoscopy to successfully remove airway foreign bodies in children. Herein we describe our extended experience in this technique over the past 10 years. This report includes data on the original cases.3

**Materials and Methods**

We retrospectively reviewed all bronchoscopies performed between 1990 and June 2001 in children ≤16 years of age. Patients were included in the study if the bronchoscopy was performed because of the clinical suspicion of aspiration of a foreign body or if bronchoscopy disclosed a TFB. Other information collected included the use of the flexible vs rigid bronchoscope in the extraction of TFBs, ancillary instruments and techniques utilized, methods for airway control during bronchoscopy and foreign body extraction, the success rate of the procedures, and complications.

**Results**

During the study period, 94 children underwent bronchoscopy for the suspicion of foreign body aspiration. All procedures were performed by the members of the Bronchoscopy Section in the Division of Pulmonary and Critical Care Medicine at Mayo Medical Center in Rochester, MN. A total of 40 TFBs were identified in 28 boys and 11 girls with a mean age of 47.3 months (range, 9 to 183 months). One patient, a 22-month-old boy, had aspirated peanut halves that were found in both right and left lower lobes. For the sake of simplifying estimations, we considered this case to represent a single foreign body.

The following foreign bodies were removed: peanuts (n = 12), food fragments (n = 5; apple, carrot, pecan, soybean), Lego blocks (Lego Company; Billund, Denmark) [n = 3], sunflower seeds (n = 3), popcorn husks (n = 3), corn kernels (n = 2), Lite Brite pegs (Lite Brite Manufacturing Company; Brooklyn, NY) [n = 2], plastic pieces (n = 2), pen parts (n = 2), and a plastic bullet, glass, aluminum foil, gravel, straight pin, and a rubber fragment (n = 1 each). Overall, 21 foreign bodies were located on the right side (53%), 18 were located on the left side (45%), and 1 was located in the subglottic space. Table 1 illustrates the location of the foreign bodies at the time of extraction.

Bronchoscopy was performed under general anesthesia in 38 of the 39 patients (97%). IV propofol was used for conscious sedation in one patient. Sixteen of these 39 procedures (41%) were performed on an emergency basis. Between 1990 and 1994, 13 foreign bodies (33%) were successfully removed by rigid bronchoscopy. Twenty-four foreign bodies (62%) were removed by flexible bronchoscopy, all after 1993 with the exception of one extraction that was performed in 1991. Extraction with the flexible bronchoscope was successful in all 24 patients. In two additional patients, the foreign bodies could not be retrieved with the rigid bronchoscope due to distal migration. These were removed with the flexible bronchoscope inserted through the rigid bronchoscope. One of these patients had aspirated a straight pin and required two bronchoscopy sessions.

<table>
<thead>
<tr>
<th>Location</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trachea</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Right bronchial tree</td>
<td>9 (23)</td>
</tr>
<tr>
<td>Mainstem bronchus</td>
<td>9 (23)</td>
</tr>
<tr>
<td>Bronchus intermedius</td>
<td>6 (15)</td>
</tr>
<tr>
<td>Right lower lobe</td>
<td>4 (10)</td>
</tr>
<tr>
<td>Right middle lobe</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Right upper lobe</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Left bronchial tree</td>
<td>16 (40)</td>
</tr>
<tr>
<td>Mainstem bronchus</td>
<td>16 (40)</td>
</tr>
<tr>
<td>Left lower lobe</td>
<td>2 (5)</td>
</tr>
</tbody>
</table>

*Data are presented as No. (percentage of foreign bodies in the particular location).*
to remove it. The pin had migrated more deeply into the right middle lobe and was removed with fluoroscopic guidance (Fig 1). The second patient had a second bronchoscopy performed for recurrent cough after successful foreign body removal. Significant granulation tissue was found. None of the patients experienced respiratory distress during the procedure itself. Two patients experienced transient hypoxia requiring removal of the bronchoscope. Oxygen saturations quickly increased to > 95%, and the procedure was successfully completed. One patient had bleeding develop with manipulation of a significant amount of granulation tissue. This was controlled with epinephrine treatment, and the foreign body was successfully extracted.

Several of our techniques of flexible bronchoscopic extraction of airway foreign bodies in children have been described elsewhere.3 The airway was controlled with an endotracheal tube in 19 patients. In 15 patients, a pediatric flexible bronchoscope was used; in 4 patients (older children), an adult flexible bronchoscope was used. In five additional patients, flexible bronchoscopy was performed through a laryngeal mask airway (LMA). The pediatric flexible bronchoscope was used through the LMA in four patients and the adult bronchoscope was used in one patient. Foreign bodies were grasped with a urologic forceps or a basket (Fig 2), designed for the removal of ureteral stones. The instrument was passed through the 1.2-mm suction channel of the pediatric flexible bronchoscope with an outer diameter of 3.6 mm or, when the ultrathin bronchoscope was used (outer diameter of 2.2 mm), alongside it since the ultrathin bronchoscope has no suction channel. The foreign body was grasped and pulled up against the end of the endotracheal tube, and then the bronchoscope, foreign body, and endotracheal tube were pulled out en masse. When the LMA was used, the foreign body was grasped with a basket or forceps and pulled up and brought out through the LMA without difficulty. No foreign body was dropped while utilizing this technique.

Complications were seen in four patients who underwent rigid bronchoscopy. The symptoms included stridor and cough thought to be from postbronchoscopy laryngeal edema. In three patients, these symptoms resolved with inhalation of racemic epinephrine; in the other patient, symptoms resolved spontaneously. Temperature to 39.6°C occurred in two of these patients within 24 h of the procedure and resolved spontaneously. With the use of the flexible bronchoscope, the average time of the procedure was 27.2 min (range, 10 to 65 min). The average time of the procedure with the rigid bronchoscope was 31.3 min (range, 15 to 60 min); the average time using both instruments in the same patient was 60 min (range, 30 to 105 min). There was no correlation between complications and the length of time of the procedure in this study.

Discussion

Traditionally, rigid bronchoscopy has been the procedure of choice for the removal of TFBs in children.5 Major noteworthy advantages of the rigid bronchoscope, when used in children, are its ability to function as an endotracheal tube ensuring “control” of the airway and as a conduit through which the foreign body can be removed. The availability of

![Figure 1](image-url)

**Figure 1.** A foreign body (straight pin, arrows), aspirated into the right middle lobe of a 6-year-old girl, is seen on posteroanterior (left, A) and right lateral (right, B) radiographs. The foreign body could not be visualized by pediatric flexible bronchoscopy. It was, however, extracted by using a pediatric flexible bronchoscope and a ureteral stone forceps under fluoroscopic guidance.
a wide range of sizes of rigid bronchoscopes, superb optical telescopes for visualization, and the large array of ancillary instruments to retrieve TFBs has made it the preferred instrument for the removal of pediatric airway foreign bodies.6–8

Even though the rigid bronchoscope is established as a safe and effective means to remove TFBs, the equipment and technique are not available in all medical centers. However, flexible bronchoscopy is widely available. The standard flexible bronchoscope has been used increasingly in the treatment of TFBs in adults.9,10 Some of the flexible bronchoscopes have large channels that permit suctioning of smaller foreign bodies from the distal airways. Currently, the standard Olympus 5.0- to 6.0-mm flexible bronchoscope (Olympus; Tokyo, Japan) has the capacity to remove almost any type of TFB in adults because of the availability of several ancillary instruments.11 Furthermore, the flexible bronchoscope allows the retrieval of foreign bodies that have migrated deeper into the subsegmental bronchi.

In contrast to the standard flexible bronchoscope used in adults, the pediatric flexible bronchoscope (external diameter of 3.6 mm) inserted through an endotracheal tube with a smaller diameter (required in children) may interfere with ventilation to a significant degree. The standard pediatric bronchoscope requires an endotracheal tube with a minimal internal diameter of 4.5 mm. Even with this combination, it becomes necessary to momentarily halt ventilation during instrumentation. Ventilation by hand with the use of an anesthesia bag may adequately overcome the added airway resistance caused by the bronchoscope in the endotracheal tube. To avoid the complication of ventilatory difficulty, an ultrathin bronchoscope (outer diameter of 2.2 mm) may be used. However, since the ultrathin bronchoscope does not have a suction or working channel, the basket or forceps should be passed alongside the bronchoscope to extract the foreign body.

Our group is fortunate to work with personnel dedicated to bronchoscopy but who also assist in urologic procedures. It was their familiarity with smaller instruments used by urologists for retrieval of ureteral stones that was the impetus for our use of flexible bronchoscopic retrieval of airway foreign bodies in children. Our experience with successful flexible bronchoscopic extraction of airway foreign bodies in six children was published in 1994.3 In one child, a straight pin that had lodged in the periphery of the right middle lobe could not be visualized directly with the pediatric flexible bronchoscope. Pediatric flexible bronchoscopy with fluoroscopic guidance permitted the extraction of the pin with a ureteral stone forceps. In two children in our series, foreign bodies that had migrated distally could not be extracted by rigid bronchoscopy, but were suc-

Figure 2. Flexible bronchoscopic view of a large foreign body (a Lite-Brite peg) lodged in the right main bronchus of a 7-year-old boy (left, A). In vitro demonstration of bronchoscopic extraction of the foreign body using the pediatric flexible bronchoscope through an endotracheal tube. The ureteral stone basket inserted through the 1.2-mm working channel of the bronchoscope has grasped the foreign body (right, B), and the proximal portion of the foreign body is pulled into distal end of the endotracheal tube by the flexible bronchoscope (right, C). Once the foreign body is thus secured, the entire apparatus (endotracheal tube, flexible bronchoscope, and basket with the foreign body in it) is removed en masse from the airways.
cessfully removed by flexible bronchoscopy. There were no complications associated with any of the procedures in these six children. Despite success, our technique was referred to as an unorthodox method at that time.

Our experience in these 26 children shows that flexible bronchoscopic extraction of airway foreign bodies can be safely performed with minimal complications. Even large foreign bodies can be captured and removed by utilizing appropriate retrieval aids. The ureteral forceps and baskets used to extract the foreign bodies are externally coated with Teflon, which permits frictionless passage of these instruments through the narrow suction channel of the pediatric flexible bronchoscope. If the nature of the foreign body is known, then obtaining an identical foreign body may allow scope. If the nature of the foreign body is known, suction channel of the pediatric flexible bronchoscope, and/or emergency tracheotomy must be immediately available to extract the foreign body should there be difficulty with the attempt using the flexible bronchoscope. In the last 10 years at our institution, all attempts at removing TFBs with the flexible bronchoscope have been successful without the use of the rigid equipment. There have been no episodes of airway obstruction caused by losing the foreign body in our experience.

The complete success of flexible bronchoscopy in this series in the extraction of airway foreign bodies has its drawbacks. The observation that our group has not used rigid bronchoscopy for the extraction of airway foreign bodies in children since 1994 has created a dilemma for us. The opportunity to use the rigid bronchoscope in the 24 children has been lost. To wit, we may have lost the opportunity to train junior faculty and trainees in the use of the rigid bronchoscope in children.

These observations lead to the question: what is the best approach to the management of TFBs in children? To address this, one prospective study evaluated the roles of flexible and rigid bronchoscopy and the predictive values of clinical and radiographic findings in 83 consecutive children with suspected airway foreign bodies. Based on the results, the authors proposed the following algorithm: (1) rigid bronchoscopy if any of the following were present—asphyxia, a radiopaque foreign body, or associated unilaterally decreased breath sounds and obstructive emphysema; and (2) flexible bronchoscopy in all other cases. If flexible bronchoscopy identifies a foreign body, a rigid bronchoscopic extraction should be performed. Even though the authors were trained in both rigid and flexible bronchoscopy, no attempt was made to extract the foreign body with the flexible bronchoscope. In our opinion, the recommendations from this study unfortunately relegate flexible bronchoscopy to a lesser role than it is capable of accomplishing.

Another factor to consider in an effort to answer the above-mentioned question pertains to the training in bronchoscopy. Most pulmonologists, at least in the United States, are trained in flexible bronchoscopy but have no training or experience in rigid bronchoscopy. As a result, surgical specialists trained in rigid bronchoscopy have treated almost all documented airway foreign bodies in children. This may be true even after the foreign body is identified by flexible bronchoscopy by a physician without training in rigid bronchoscopy. Instead of immediate rigid bronchoscopic removal, the child is scheduled either for rigid bronchoscopy at a separate session in the same medical facility or transferred to another facility where there is a physician trained in rigid bronchoscopy. We believe that two separate procedures for the same problem can be avoided with our
Having stated this, we recognize that most current training programs in pulmonology in the United States do not provide training in rigid bronchoscopy. This creates a quandary and makes it difficult for physicians not trained in rigid bronchoscopy who encounter pediatric foreign bodies to adhere to our recommendation. A solution to this is to coordinate a team of physicians, trained in both flexible and rigid bronchoscopy, who can perform the extraction of the airway foreign body as a single procedure.

In summary, our experience shows that airway foreign bodies in children can be safely removed by flexible bronchoscopy with minimal complications. We hasten to caution that if an attempt at flexible bronchoscopic extraction of an airway foreign body is to be made, it is crucial that personnel and equipment be available to immediately proceed with rigid bronchoscopic extraction of the foreign body should the flexible bronchoscopic effort fail. The cooperation and coordination of the entire team consisting of anesthetists, technicians, nurses, and bronchoscopists is important for both the safety of the patient and the success of the procedure. Facilities should be immediately available if the emergent need for tracheotomy or surgery arises. Following the extraction, a complete examination of the tracheobronchial tree should be performed to exclude other foreign bodies and/or abnormalities.

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