Retrieval of Endobronchial Foreign Bodies in Children: Involving the Cardiac Catheterization Lab

**abstract**

Endobronchial foreign body impaction is a common occurrence, especially in the pediatric population. Bronchoscopic techniques are the standard of care for their retrieval. However, the most distally located foreign bodies are often difficult to retrieve using these techniques. A novel approach using biplane fluoroscopy, with tools usually used for intravascular foreign body retrieval, has been recently described in adults by interventional radiologists. We are the first to report 2 cases in children using this approach for distally impacted endobronchial foreign body retrieval in the cardiac catheterization laboratory. We used a collaborative approach, using flexible bronchoscopy and fluoroscopically guided catheters to reach the foreign body. The first case involved a 16-year-old girl who presented with a 4-day history of aspiration of a staple pin, which we successfully retrieved. The second case involved a 10-year-old boy who presented with a 2-month history of aspiration of the plastic eraser cap of a mechanical pencil. We were successful in reaching the distal lobule where it was lodged. However, we were unable to grasp the foreign body because of the presence of a chronic inflammatory exudate around it owing to the subacute to chronic presentation. There were no complications in either case. Thus, a collaboration of the pulmonology and interventional cardiology teams in the cardiac catheterization laboratory represents a safe and effective alternative to bronchoscopy in the management of distally placed endobronchial foreign bodies in children. Early recognition and intervention is imperative for the successful retrieval of an endobronchial foreign body.
Endobronchial foreign body (EFB) extraction has been successfully performed in children and adults using a variety of endoscopic retrieval techniques. The standard of care is the use of rigid bronchoscopy for retrieval of EFBs. However, difficulties remain in the extraction of the most distally placed EFBs. Smaller EFBs in third or fourth generation airway branches cannot be easily identified or reached using the traditional approaches. A new approach using tools that are routinely used by interventional radiology for intravascular foreign body (FB) retrieval has been recently described in adult patients. We present the first report describing a joint effort by the pediatric interventional cardiology and pulmonology teams in adopting a similar approach to attempt retrieval of distal EFBs in the cardiac catheterization suite.

CASE PRESENTATION AND MANAGEMENT

Case 1
A 16-year-old girl was transferred to our institution for management of an aspirated foreign body. Four days before presentation she had aspirated a staple pin. A chest radiograph showed the staple lodged in the right main stem bronchus (Fig 1A). An attempt to extract the FB using rigid and flexible bronchoscopes in the operating room was unsuccessful and was complicated by a right-sided tension pneumothorax requiring chest tube placement. She was then transferred to our institution. A decision was made to attempt removal of the EFB in the cardiac catheterization laboratory under fluoroscopic guidance, before an elective surgical removal.

The patient was administered general anesthesia and was mechanically ventilated. We used a 7.5-mm endotracheal tube (ETT) to gain access to the bronchial tree. Using the side port of the ETT, a 6-Fr JR-4 guiding catheter was advanced over a 0.035-in angled glide wire (Terumo, Tokyo, Japan) and positioned proximal to the staple (Fig 1B). Our initial attempts using multiple micro-snare were unsuccessful, so 3-Fr vascular forceps were used to capture the staple. The entire staple-catheter unit was retracted into the trachea, below the level of the vocal cords (Fig 1C). As the relatively rigid staple repeatedly slipped from the grasp of the vascular forceps, the staple was firmly secured with a 10-mm Pfm multi-snare (Pfm Medical Inc, Oceanside, CA) against the distal opening of the ETT. The ETT, catheter, snare, and staple were then removed together as a unit (Fig 1D), with the sharp ends of the staple directed inward, thereby protecting the vocal cords from injury. The total fluoroscopy time was 22 minutes. There were no complications and the patient was discharged from the hospital the following day.

Case 2
A 10-year-old boy presented to the pulmonology department at our institution with a history of recurrent episodes of breathing difficulty for 2 months. A chest radiograph revealed the presence of a foreign body of unknown origin in the distal posterobasal segment of the left lower lobe (Fig 2A). There were early bronchiectatic changes in the adjacent areas suggesting chronic inflammation. Considering the peripheral location of the FB, the pulmonologist decided to involve the cardiac catheterization team in the retrieval, anticipating difficulty reaching it. The patient was intubated with a 6.5-mm ETT and administered general anesthesia for the procedure. Under fluoroscopic guidance, a 2.8-mm flexible bronchoscope was advanced using a bronchoscope dual-axis swivel.
adapter (Portex, Smiths Medical, Kent, United Kingdom) into the airway. It was then directed toward the left main bronchus and further distally until it could not be advanced any further. The bronchoscope was still several millimeters proximal to the foreign body (Fig 2B). A 3.6-mm bronroscope was then used with toothed biopsy forceps (FB-56-D1, Olympus Optical Co, Ltd, Tokyo, Japan) threaded through the suction channel of the bronroscope. Multiple attempts were made to grab the foreign body with the biopsy forceps advanced distally through the bronroscope tip under fluoroscopic guidance (Fig 2C). Thick, white secretions, noted in the region surrounding the foreign body, were suctioned out. At this point, the bronroscope was withdrawn. Through the bronroscope swivel adapter, a 4-Fr Terumo glide catheter (Terumo, Tokyo, Japan) was advanced over a Mallinckrodt 0.018-in Hi-Torque Flex-T wire (Mallinckrodt Medical Inc, St Louis, MO). The catheter was advanced, relatively easily, to the site of the impacted FB under fluoroscopic guidance (Fig 2D). The glide catheter was replaced by a larger caliber 6 Fr JR-4 guide catheter (Cook, Bloomington, IN). Multiple attempts to grab the FB using snares and biopsy forceps were unsuccessful. There was considerable resistance and rigidity around the foreign body, probably indicating growth of fibrous tissue/inflammatory exudate secondary to chronic FB impaction. We were unable to pass the catheter beyond this rigid covering. On fluoroscopy, the catheter and biopsy forceps were noted to be only 1 to 2 mm away from the FB (Fig 2D). We noted minimal bleeding in the catheter and distal end of the ETT, and further attempts to grasp the FB were felt to be unsafe. The distal bronchial segment was flushed with normal saline and suctioned to cleanse any residual bleeding. The snares, catheter, and ETT were withdrawn. There were no procedural complications other than the minor transient bleeding noted. The total fluoroscopy time was 45 minutes and the patient was then scheduled for an elective surgical segmental lobectomy.

DISCUSSION

Endoscopic retrieval of foreign bodies lodged in the airways as well as the esophagus using rigid endoscopes has become standard practice for pulmonologists and otorhinolaryngologists. However, despite technological advances in the use of flexible bronchoscopy, substantial challenges remain in advancing additional instruments into peripheral, distal bronchial segments.8 This is further compounded in children, who have narrower airways with an increased propensity for complications, including significant bleeding and tension pneumothorax,9,10 as noted in our first case.

Several strategies and methods have been devised to attempt removal of complex distal EFBs. A technique using an inflatable Fogarty balloon catheter has been described as far back as 1968.11 This technique, however, carries the risk for catheter tip separation and embolization and is therefore used sparingly.12 Hight et al reported successful distal FB retrieval in the operating room in 8 patients using standard endoscopic techniques in conjunction with portable fluoroscopy, endobronchial contrast material, topical vasoactive medications, and a variety of retrieval instruments without resorting to surgical resection.13 Interventional techniques for EFB retrieval using instruments such as guide wires, catheters, and snares typically used for intravascular FB removal by interventional
radiology have been recently described in adult patients.\textsuperscript{5–7} It is cost-effective\textsuperscript{5} and also eliminates the risks associated with rigid and flexible bronchoscopy.\textsuperscript{6,10} However, there are a paucity of data regarding the use of this technique in the pediatric population. Lando et al have described the utility of this approach in a 7-year-old child, with successful retrieval of a distally impacted EFB under fluoroscopy by an interventional radiologist.\textsuperscript{8} They have outlined an algorithm for a stepwise approach to removal of complex distal EFBs in children with collaboration of various services.\textsuperscript{8}

Using a similar technique, we are the first to present 2 pediatric cases of distally placed EFBs with attempted removal in the cardiac catheterization laboratory by interventional cardiology and pulmonology. The first case, in which successful extraction was achieved, involved an acute presentation with a sharp FB. In the second case our attempts were unsuccessful owing to the very distal location, presence of chronic inflammatory changes, and impaction of the EFB. Reports have suggested using short-course steroids and/or antibiotics before extraction in chronic presentations.\textsuperscript{8} Our patient had already been on inhaled steroids before the procedure and the presence of thick granulation tissue around the EFB would not have responded to antibiotics. In addition, the FB was rounded and smooth in character. A “basket technique” using an extraction basket and a distally inflated balloon has been described to deal with smooth foreign bodies.\textsuperscript{7} We were unable to advance the catheter distal to the FB to use this technique.

Pediatric flexible fiberoptic bronchoscope sizes generally range from 2.2 mm to 4.9 mm and the selection of an ETT size to accommodate one can be estimated based on the general rule of thumb: ETT inner diameter = bronchoscope diameter (rounded up to nearest half-size) + 0.5.\textsuperscript{8} The ETTs used in children and adolescents vary from 4 to 7.5 mm, based on weight. Using a swivel adapter (Fig 3), this would allow the use of catheters up to 6 to 15 Fr, respectively, with at least 1 mm of space around the catheter. However, the required catheter size would likely range from 4 to 10 Fr. In our cases the largest catheter used was 6 Fr.

![Figure 3](image)

**FIGURE 3**
A. Demonstration of multiple catheters being advanced through the ETT. B. A 7-Fr sheath (outer diameter, 3.2 mm) is advanced through the 5-mm ETT using the bronchoscope swivel adapter. C. A 5-Fr Goodale-Lubin catheter is advanced through the 7-Fr sheath and both are seen easily passing the distal end of ETT (arrows).
The principle advantage of EFB retrieval in the catheterization suite is the ability to advance catheters directly through the ETT using a swivel adapter, reaching the distal EFB precisely using biplane fluoroscopy, and the technical expertise in the use of various retrieval devices (Figs 1 and 2). In addition, multiple catheters and devices can be advanced simultaneously (Fig 3) based on specific circumstances, such as withdrawing a sharp FB into a larger sheath, thus protecting the airway during extraction.

As described by Lando et al, the initial evaluation and attempt to retrieve an EFB should be with rigid and/or flexible bronchoscopy. Specific situations, such as failed retrieval owing to non-visualization or distal location of the EFB, should prompt involvement of an interventional radiologist or cardiologist. This may vary based on each institution’s practice, preferences, and availability of specialized services. An approach to a successful extraction would involve meticulous planning, experience, expertise, and coordination of care between specialties.

CONCLUSIONS
A collaboration of the pulmonology and interventional cardiology teams using various tools in the cardiac catheterization laboratory is feasible and represents a safe and effective second-line alternative to standard bronchoscopy in the management of distally placed endobronchial foreign bodies in children.

REFERENCES
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