Foreign Body Removal

46

Mark E. Lund

Introduction

Arguably, the birth of interventional pulmonology was on March 30, 1897. On that day, Gustav Killian first removed a pork bone lodged in the right main bronchus of a living human. Thus, the origin of mitigating aspirated foreign bodies coincides with the inception of interventional pulmonology. Subsequently, Chevalier Jackson brought the technique of rigid peroral bronchoesophagoscopy to the United States. While practicing in Philadelphia, Pennsylvania, he developed instruments and techniques to facilitate airway intervention.

Airway foreign bodies have been managed by multiple disciplines, including pulmonology, otorhinolaryngology, thoracic surgery, and interventional radiology. Chevalier Jackson's influence remains present as both otorhinolaryngologists and interventional pulmonologists lay some birthright claim to Dr. Jackson, and both specialties handle the majority of airway foreign bodies.

Timely diagnosis, driven by a high index of suspicion, and expedited removal improve the clinical outcome. This chapter will review the incidence and risk factors for inhalation of a foreign body. Its primary goal is to define the diagnostic evaluation and therapeutic approaches to removal of airway foreign bodies.

Epidemiology

In 2007, the National Safety Council reported 3,700 choking cases with an estimated 1.2 deaths per 100,000 in the United States. According to the US Centers for Disease Control and Prevention, foreign bodies resulted in an estimated 17,537 emergency room visits for children less than 14 years of age in 2001. Tracheobronchial foreign bodies occur much less frequently in adults with an estimated incidence of 0.66/100,000 in the United States. A retrospective evaluation by Debeljak noted only 0.2% of 37,466 bronchoscopies over 24 years were for foreign body removal.

Aspirated foreign bodies exhibit a bimodal age distribution. It is clear that young children explore the world with their mouths. Hence, it is not unexpected to find that children aged 1–2 are commonly at risk for aspiration of a foreign body. However, the second peak incidence varies significantly. According to the National Safety Council in the United States, the peak incidence of asphyxiating foreign bodies occurs in those younger than 1 year and the elderly aged over 75. In contrast, Hsu and colleagues reported, in a Taiwanese study including 459 airway foreign bodies over 27 years, peak incidences at age 2 and at age 21–30. This variation was thought to be related to alcohol consumption. These facts notwithstanding, age should not remove aspiration from the differential if other factors suggest the possibility.

Anything that impairs deglutition may result in predisposition to aspiration of a foreign body. Old age, impaired level of consciousness (trauma, alcohol intoxication, sedative hypnotic use, or other intoxicants), mental retardation, stroke, neuromuscular disease, Parkinson's disease, dental procedures, tracheal stoma, seizures, and brain tumors are common contributing factors. Iatrogenic increase in the risk of aspiration may occur after general anesthesia or conscious sedation. Interestingly, select populations are at increased risk for aspiration of particular foreign bodies due to cultural practices. For example, there is a noted prevalence of aspirated pins in women from regions that wear head scarves.

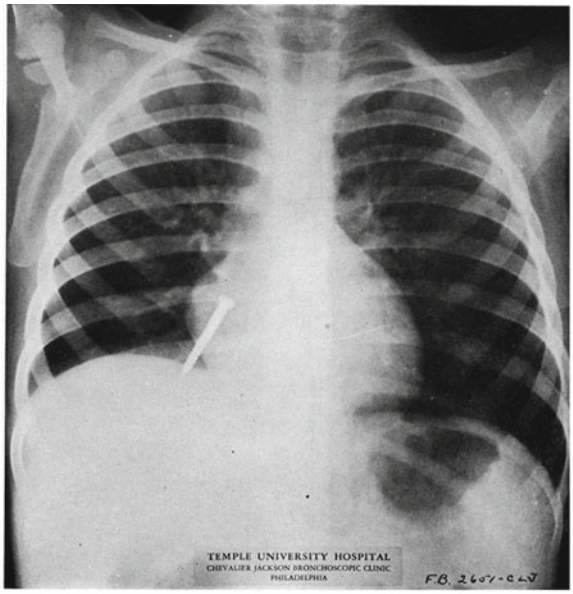
Virtually anything that can fit in the oropharyngeal cavity may be aspirated. In adults and children, foodstuff makes up the majority of aspirated material. Common foreign bodies include nuts, particularly peanuts, seeds, bones, and natural and false teeth. In some patient populations, unusual materials may be aspirated. Examples would include pins, stoma caps, and glass from crack pipes (see Table 46.1).

M.E. Lund, M.D., F.C.C.P. (✉)
Department of Interventional Pulmonary, Critical Care, & Sleep, Cancer Treatment Centers of America, 1331 East Wyoming Ave, Suite 3170, Philadelphia, PA 19124, USA
e-mail: marklundmd@yahoo.com; mark.lund@ctca-hope.com

A. Ernst and F.J.F. Herth (eds.), *Principles and Practice of Interventional Pulmonology*,
DOI 10.1007/978-1-4614-4292-9_46,

Table 46.1 Types of foreign bodies

Organic	Nuts (peanuts, almonds, walnut, pistachio, etc.)
	Seeds (watermelon, sunflower, chickpea)
	Fruits (apple, tangerine, peach)
	Coffee beans
	Dried cereals
	Popcorn
	Candy
	Rhubarb
	White cedar
Metallic inorganic	Pins
	Hypodermic needles
	Bullet
	Jewelry: earrings
	Dental crowns (Fig. 46.2), implants, bridges
	Coins (Fig. 46.4)
	Knife and razor blades
	Silver Jackson tracheotomy tube
	Nail clippers
	Nails
	Tweezers
Plastic inorganic	Endotracheal tube
	Nasopharyngeal Airway
	Intubating introducer
	Toys and pearls
	Condom
	Stoma button
	Dentures
	Plastic wrap
	Pen cap
	Drug delivery devices (Turbuhaler disc; spray cover)
Mineral	Natural teeth
	Bones (chicken, fish, etc.)
	Stone
	Glass (fragments – Fig. 46.3, cocaine pipe, etc.)
Endogenous	Broncholiths (Fig. 46.5)
Transbronchial erosion	Mediastinal FB: gauze, gauze pledget post-mediastinoscopy
	Rib used for tracheoplasty
	Esophageal stents
	Teflon pledget for reinforcing bronchial stump
Misc	Endoscopic video capsule
	Ascaris lumbricoides
	Shrimp
	Passalid beetle
	Medications: ferrous sulfate, aspirin, kaopectate, cholestyramine, phenobarbital, tetracycline, mineral oil, iron sulfate, fentanyl patch



Photograph Courtesy Temple University Hospital

Fig. 46.1 Chest X-ray obtained for Chevalier L. Jackson, M.D. in the evaluation of a suspected foreign body at his bronchoscopy clinic at Temple University Hospital in the 1930s. (Photograph Courtesy Temple University Hospital)

The type of foreign body will usually influence the local tissue reaction. While inert foreign bodies may have an irritant effect, the overall inflammatory component is limited. There may be direct tissue injury from aspirated sharp objects such as pins, knife blades, razors, glass shards, or nail clippers. Conversely, some objects particularly organic substances, such as nuts, can create an intense inflammatory response. It has been reported that granulation tissue can result within a few hours of contact with the airway wall. Aspiration of various medications, including tetracycline and iron tablets, can also lead to significant inflammatory responses. Expansion of foreign bodies, both organic material and medications, is caused by rehydration. These rehydrated items can become wedged, thus compounding the difficulties of removal, especially when concurrent granulation tissue is present.

Broncholiths are an endogenous foreign body that can erode into the airway. Other eroding foreign bodies are iatrogenic. Examples have included an autologous grafted rib used for tracheoplasty, gauze pledgets, and esophageal stents. With newer technology, capsule endoscopes are a more common cause of iatrogenic foreign bodies. After snare cautery through the stalk of a pedunculated airway mass, distal escape of the excised tumor acts as a foreign body. These freed tumors may oscillate from side to side and occasionally present difficulties if they are calcified or very large.

Because of their shape and aerodynamic qualities, some foreign bodies may lodge very deep. This can be due to initial aspiration or distal migration. Once distal impaction occurs,

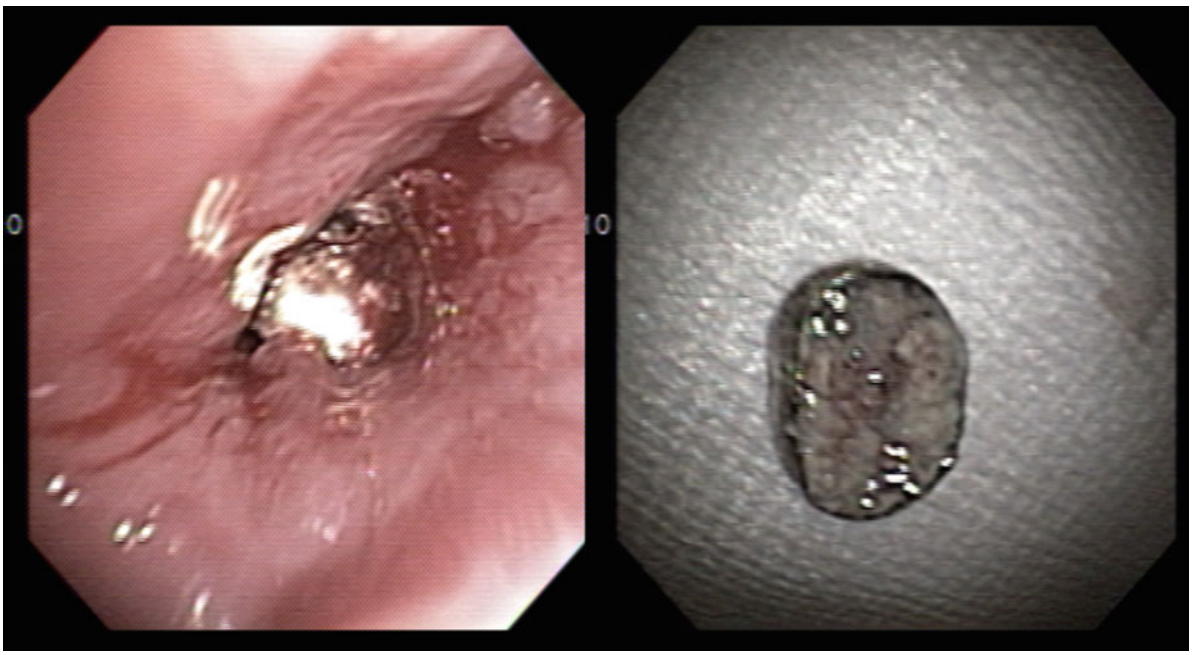


Fig. 46.2 Dental crown impacted in the airway and post removal. (Courtesy H. Colt and S. Murgu, UC Irvine, www.bronchoscopy.org)

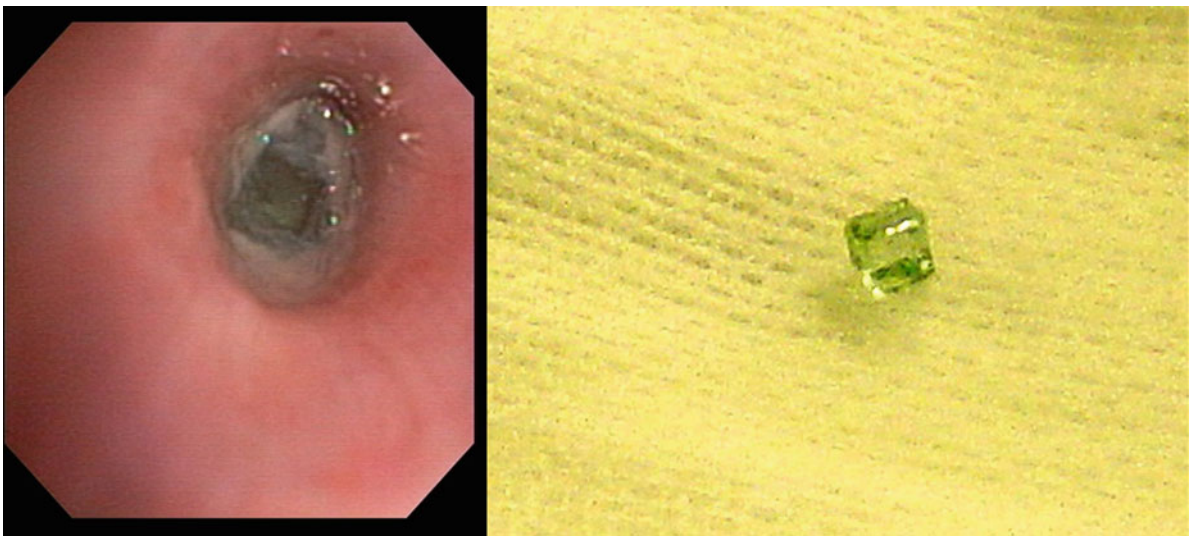


Fig. 46.3 Glass fragment impacted in the airway and post removal. (Courtesy H. Colt and S. Murgu, UC Irvine, www.Bronchoscopy.org)

as in grass inflorescence, the significant inflammatory response may require surgical wedge or lobar resection.

Clinical Presentation

Upon aspiration of a foreign object, patients present with various acuities and wide-ranging symptoms. Acute asphyxic choking with rapid decompensation and death may occur. Basic life support training suggests evaluating the oropharynx for obstructing material in evaluating a patient with cardiopulmonary arrest. Patients experiencing asphyxia will be unable to talk, usually be unable to cough, and commonly exhibit the universal choking sign of having their hands around their throat. Significant symptoms may also occur in acute non-asphyxic aspiration. If a foreign body is subglottic but extrathoracic, inspiratory stridor may result. Acute dyspnea and the sudden onset of wheezing may also occur with high-grade narrowing of either tracheal or main bronchial lumens. Although these symptoms may persist in many patients, the acute episode is often followed by a rather asymptomatic period. This period may be marked with an

Fig. 46.4 Coin impacted in the airway and post removal. (Courtesy H. Colt and S. Murgu, UC Irvine, www.bronchoscopy.org)

intermittent yet persistent cough, recurrent respiratory tract infections, or an asthmatic syndrome. Importantly, 25% of patients may present with no symptoms. Because an extensive history may reveal the likely diagnosis in only half of all patients, the highest index of suspicion must be maintained in order to pursue a proper diagnostic paradigm.

The examination of the patient may not reveal anything suggestive of a foreign body if the material is lodged distally. Alternatively, auscultation may reveal stridor, wheezing, rales, or simply decreased breath sounds.

Significant delay in presentation occurs for any number of reasons in some cases. Although it is not uncommon for delays in diagnosis to extend for weeks to months, years may even pass, with the longest delay reported by Chevalier Jackson at a staggering 45 years. Furthermore, delays in therapy may also arise. An extreme example was a diver who aspirated foreign body while working at a United Kingdom research base during the Antarctic winter that prohibited early removal or evacuation. Most patients do not encounter such hurdles; however, many rural hospitals and facilities do not have the local expertise, therefore necessitating transfer. Depending upon the type of foreign body, its location, and the inflammatory response, even larger centers may not have the experienced team to remove an impacted object, potentiating the delays before removal.

Complications of Long-Standing Foreign Bodies

As noted previously, a foreign body may incite a local inflammatory response or proliferation of granulation tissue. Secondary infectious complications occur due to impacted objects. Recurrent post-obstructive pneumonias or lung abscess can develop. Unusual infections including endobronchial actinomycosis and botryomycosis have been described. Regions subjected to chronic inflammation or infection may develop bronchiectasis or bronchomalacia. Bronchiectasis develops in 25% of children in whom the diagnosis was delayed greater than a month. The inflorescences of many grasses including “Timothy grass” are a well-known cause of bronchiectasis. Erosion through the bronchial wall may create a fistula. Foreign bodies have been reported to have migrated into the pleural space, the pericardium, and even into the intestine. Aspiration of some medications or chronic inflammatory states may cause stricture rather than bronchiectasis. Iron tablets can cause a severe chemical burn to the bronchial tree with subsequent necrosis and cicatricial scarring.

Migration of long-standing extrapulmonary foreign bodies may also cause chronic infection once in the airway. Such was the case of an infantry soldier who was found with a bullet in his airway after being shot 53 years before during World War II.

Yildizeli and associates evaluated an animal model for radiographic and histological correlation. They found a progressive effect of leukocyte infiltration with edema followed by mononuclear cells and macrophages. This infiltrative process created fibrosis and bronchial cartilage destruction. Tang and colleagues showed that foreign bodies may incite airway remodeling via matrix metalloproteinase's and hydroxyproline.

Radiographic Investigation

While some of the most impressive images of foreign bodies are radiographic, such as knife blade or large screw in the main stem (see Fig. 46.1), most radiographic studies are of limited diagnostic assistance. Radiographic evaluation should never be used to exclude an airway foreign body. Overall, CT scanning is much better for identifying potential airway objects. However, as reported by Zissin, false positives do occur. Routine chest radiography and fluoroscopy may be helpful when looking for indirect evidence of obstruction but must never be used as an independent imaging modality. Most foreign bodies are radiolucent and hence not clearly visible on routine imaging. In the experience reported by Srppnath and later by Mise, only 2–7% of foreign bodies were radio-opaque on routine chest radiography. Indirect evidence to suggest a foreign body includes nonspecific signs such as segmental or lobar atelectasis, air trapping, infiltrates/consolidation, subcutaneous emphysema, or mediastinal shift. Only 4% had normal chest radiographs in Srppnath's retrospective series. These changes are best seen when comparing full inhalation and expiratory imaging. Newer multi-slice CTs and virtual bronchoscopy may provide clearer insight, as demonstrated by Cho and Sodhi, respectively.

Fig. 46.5 Broncholith eroding into a main stem airway. (Courtesy Daniel Sterman, MD)

Unusual anatomy may suggest a bronchogenic carcinoma. A mass near the trachea has been reported to be a foreign body with inflammatory changes in a tracheal bronchus. While this is a rare case, multiple reports show endoluminal biopsies for endobronchial cancer with foreign material and inflammation. Therefore, while rare in comparison to lung carcinoma, it is possible for an "endobronchial tumor" or "peripheral lung mass" seen on CT imaging to be a complication of an aspirated foreign body.

When presented with a nondiagnostic imaging evaluation, any history remotely suggestive of an aspirated foreign body warrants an airway inspection with flexible bronchoscopy.

Therapeutic Approaches

Bronchial anatomy predisposes the intermediate bronchus and right lower lobe to the majority of aspirations (see Table 46.2). This is due to its larger size and its more vertical orientation when compared to the left main stem. However, anatomy and body position during the aspiration event may alter this predisposition. In fact, any lobe, segment, or subsegment may be the site of impaction. The seven rules of bronchoscopy should always be considered when dealing with bronchoscopic removal of an airway foreign body (see Table 46.3).

In patients who present with stridor or severe dyspnea suggestive of proximal obstruction, heliox should be utilized. The titration of heliox can be based upon the predominant effect on the respiratory system. If the minute volume is most affected, a higher percentage of helium (80:20) may be more useful to reduce the viscosity of the gas. Patients with combined hypoxemia and ventilatory defects benefit from lower percentages of helium and increased oxygen. Use of 30–50% F_IO_2 may maximally balance oxygen needs and improved gas flow.

Preparation

Should all foreign bodies be removed? Chevalier Jackson reported a success rate of 98% and a consequent reduction in mortality from 24% to 2% using rigid bronchoscopy. As a general rule, all foreign bodies should be removed. Clinical expertise and an experienced team will substantially increase the likelihood of success. With the proper team, correct instrumentation, and an experienced bronchoscopist, virtually all foreign bodies are safely and successfully removed. While a multidisciplinary approach is helpful in most circumstances, the requirement for thoracotomy is minimal.

Table 46.2 Location of foreign body

	Trachea (%)	Right (%)	RMS/RBI (%)	RUL	RML (%)	RLL (%)	Left (%)	LMS (%)	LUL (%)	LLL (%)	Carina (%)
Zissin		74	16		11	47	26	11	4	11	
Athanasiadi	4	44	35			9	52	30	13	9	5
Eroglu	10.90	52.70					30				

Table 46.3 Mehta's seven rules of successful bronchoscopy

1	Complications occur when a bronchoscopy is performed for unclear reasons or the wrong indication
2	Preparation ensures 50% success rate
3	Bronchoscopy is a three-handed procedure
4	A good bronchoscopist has excellent skills, but an excellent bronchoscopist is surrounded by excellent support and backup
5	Time and commitment are essential
6	Know your limitations
7	Every case should be viewed as a teaching and training opportunity

In many cases, moderate sedation with opiates and benzodiazepines is insufficient. This is particularly true when there may be a need to change from flexible to rigid bronchoscopy. Monitored anesthesia care (MAC) or general anesthesia is frequently more appropriate. Consulting anesthesia is frequently a value-added use of time. Involving anesthesia allows safe titration of the sedation requirements as the procedure warrants. Furthermore, it allows the endoscopist to focus on the task at hand. When compared to inhaled anesthetics, total intravenous anesthesia (TIVA) is very helpful in maintaining a stable level of anesthesia when alternating between airway interventions and the potential tidal volume loss encountered during rigid bronchoscopy.

It is always best to use the oral approach rather than the trans-nasal approach because the foreign body may not traverse the turbinate's in the nose. Selection of the appropriate airway support is important. The choice of direct bronchoscopy, laryngeal mask airway, or endotracheal intubation should be based upon the medical condition of the patient and the foreign body being removed. In addition, the pre-sedation evaluation of the airway is critical even if intubation is not planned. What difficulties may be encountered if the patient requires urgent intubation or rigid bronchoscopic intubation? Pre-procedural assessment of the Mallampati score, thyromental distance, mandibular opening, and cervical range of motion are all important to the pre-procedural planning. Evaluation for loose teeth is also critical. Notwithstanding the medical-legal need to document their presence, it is important to understand the potential to leave a new foreign body in the airway.

Flexible Versus Rigid Bronchoscopy

Much has been written regarding the proper choice of bronchoscope. The standard of care had been rigid bronchoscopy for all foreign bodies. With the advent of large working channel bronchoscopes and a wider array of instruments, retrieval of impacted objects has become routine with the flexible bronchoscope. A success rate of 86% has been reported with the use of flexible bronchoscopy. There are institutional and practice preferences that drive the approach. For most patients, the decision must be made, taking into consideration both operator comfort and the circumstances presented in each unique situation. In patients with stridor and partially obstructing tracheal foreign bodies, a rigid bronchoscope is often the better instrument. In some cases, pushing the object distally to initially improve airflow is required. This may be difficult with a flexible bronchoscope. Any patient presenting with respiratory failure is best managed with a rigid bronchoscope. Operator inexperience or lack of training must never be the reason for failing to use a rigid bronchoscope when one is required. The patient should be transferred to a center with an experienced team before complications ensue, impairing removal or patient safety.

Removal Procedure

Regardless of which endoscopic approach is taken, an initial surveillance of the entire visible tracheobronchial is required. The exception to this rule is when tracheal foreign bodies are found or the patient is in extremis. If able, the bronchoscopist should understand what other anatomical variations or potential secondary foreign bodies are present that may complicate the primary procedural goal.

Proper preparation is a significant indicator of success, and this includes the airway itself. As noted previously, granulation tissue may initially suggest a tumor or may limit the approach to an impacted foreign body. When presented with exuberant granulation tissue, several potential approaches may be helpful. Preparing the airway is critical in some circumstances. Granulation may be reduced by use of argon plasma coagulation or low wattage use of the Nd:YAG laser. Caution must be observed when using thermal techniques if one is unsure of the foreign body and its inflammability.

When available, cryotherapy may also be utilized to reduce the granulation tissue and limit the risk of fire with unknown materials. Endobronchial injections may be beneficial. Use of a 23–25 gauge sclerotherapy needle with 1:10,000 epinephrine can be helpful in preemptively controlling bleeding from these vascular tissues. Intralesional and submucosal injection of triamcinolone acetonide can help reduce the inflammatory response if waiting for a second procedure is a viable option.

When preparing to remove an object, consideration of its substance must be undertaken. Different instrumentation will be required for soft material in comparison to metallic or calcified objects. Similarly, if an object is easily fractured, the operator must limit the possibility of pieces breaking off and moving distally, preventing complete removal.

Grasping Forceps and Graspers

There are a number of different forceps on the market that can be useful in retrieving airway objects. Biopsy forceps are almost universally of limited value. Whether using a flexible or rigid bronchoscope, the design of the forceps is very similar. The variation is the size and the grasping force. The degrees of freedom for operating in the airway are limited. Forceps are generally dividable into two categories based upon jaw movement. Single action forceps have one movable jaw and a stationary jaw. The dual action forceps have two mobile jaws that open at roughly 40° from the original plane. There are benefits to both depending upon the material and the airway location. In addition, there are several varieties of grasping surface. There are coarse serrations, finer serrations, typically with a broader surface area (peanut forceps), and toothed forceps. Most forceps are straight; however, there are curved, serrated grasping forceps available for use with a rigid bronchoscope. Rotatable instrument designs are available for both flexible and rigid bronchoscopy. However, most rotatable forceps require rigid bronchoscopy (see Fig. 46.10). It should be noted that use of various instruments is limited or expanded by the diameter of the working channel. Using a therapeutic bronchoscope with a 2.8–3.2-mm working channel opens the utilization of almost all current gastrointestinal endoscopic forceps, graspers, and baskets.

The rigid bronchoscope also permits optical forceps to be utilized. This increases the visualization of the object when maneuvering and grasping by placing the telescope at the distal end and having the forceps angled to bring the grasping action into direct visualization.

There are several graspers on the market, utilizing from two to five grasping fingers. These can be useful in grasping objects too large for the standard jaws of flexible instruments. Forceps are also available with soft latex-free rubber-coated jaw to assist in removing fine objects such as needles.

The selection for any procedure is dictated by institutional availability, location of the object, and the material to be removed. Individual experience will determine the most appropriate instrument.

Snares

Snares are loops of wire deployed through a flexible tube via the working channel. The snares vary by deployed diameter, wire stiffness, wire design (twisted and smooth), and the availability of electrocautery. A snare may be used to encircle many objects of varying shape and using the operating handle to grasp it tightly. Electrocautery would rarely be used in foreign body retrieval; however, cautery snares may be safely utilized when not attached to an electrosurgical generator. Electrocautery may be useful in reducing the volume of granulation tissue.

Baskets

Baskets are essentially more complex snares, without electrocautery potential. There are an increasing number and variety of baskets available for foreign body retrieval. Many of these have been designed for removal of resected colonic polyps but are very adept at grasping many foreign materials (Fig. 46.6). The difficulty with many of these is their size, with some so large as to preclude effective use in the airway. Almost universally, these baskets are small, deployable, and retractable cages created with three or more wires. They vary in structure by their overall shape, wire stiffness, and tip structure, as well as wire count. Some are spiraled and others more half clam shelled (see Fig. 46.7). All designs offer good ability to capture and secure an object. Utility is based upon the size and location of the foreign body and the operators' experience. The lack of a "tip" on one currently available device makes it useful in more distal airways or at airway trifurcations (see Fig. 46.8).

When using these baskets, care must be taken with softer or macerated materials. The wires have the ability to cut through some objects, simply creating three, four, or more foreign bodies to retrieve. One potential solution to these softer materials is the use of retrieval nets. These are essentially snares that have fine netting secured to the snare wire (see Fig. 46.7). This allows a very flexible netting to encompass the object providing a secure hold. Care must still be exercised, as some very gelatinous materials may still be forced through the netting.

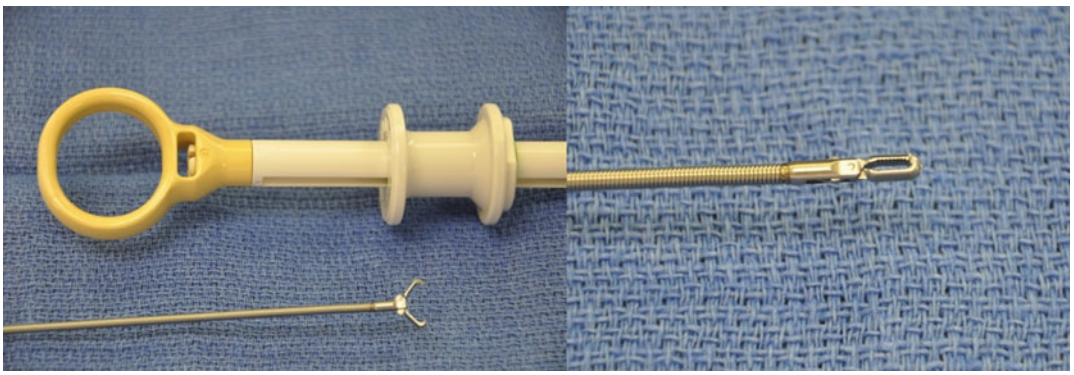


Fig. 46.6 Flexible grasping forceps open and closed

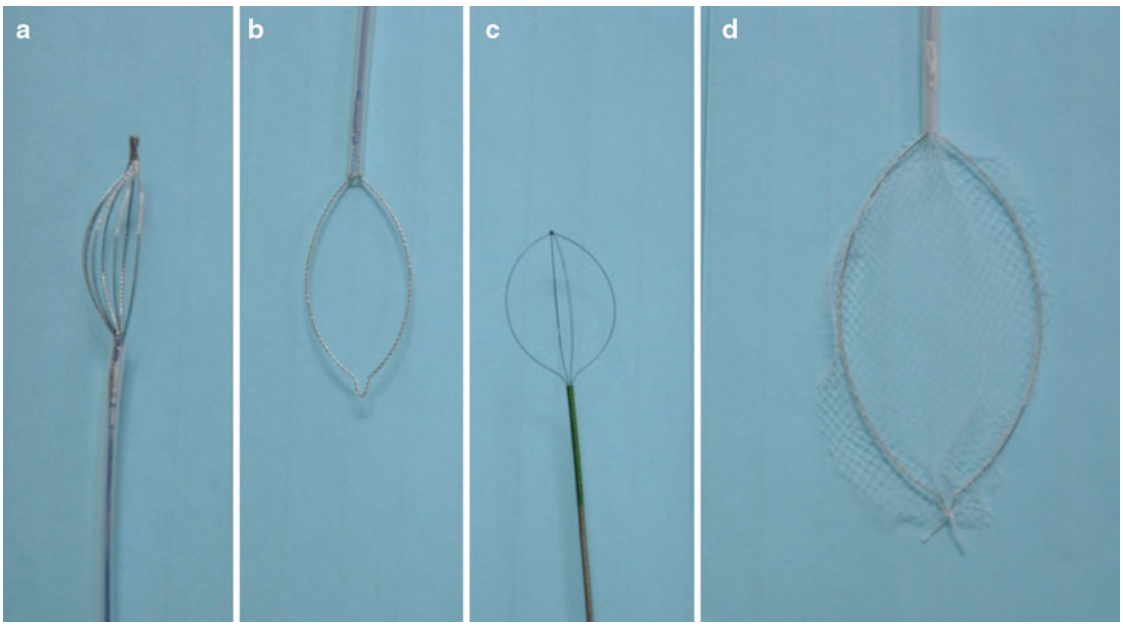


Fig. 46.7 Flexible bronchoscopic snares and baskets. (**a**) Twister™ rotatable polyp retrieval (Boston Scientific, Natick, MA). (**b**) Rotatable snare 13 mm (Boston Scientific, Natick, MA). (**c**) ZeroTip™ airway basket (Boston Scientific, Natick, MA). (**d**) Roth Net™ (US endoscopy, Mentor, OH)

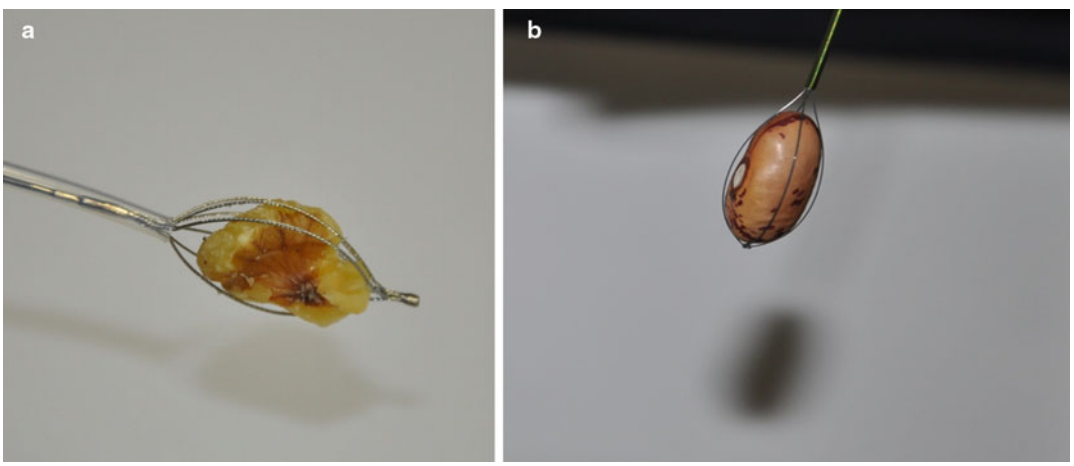


Fig. 46.8 (**a**) Twister™ rotatable polyp retrieval (Boston Scientific, Natick, MA.) basket with a walnut. (**b**) Zero Tip™ (Boston Scientific, Natick, MA.) basket with a bean

Cryotherapy

Cryotherapy probes may be of great assistance in management of certain foreign bodies. Not only can they help with granulation tissue but those objects with high water content can be frozen to the therapeutic probe and removed, frequently intact. These foreign bodies typically include fruits, vegetables, and insects (see Fig. 46.9). Occasionally, a material has been saturated with airway secretions or can be saturated with sterile water and frozen to the cryoprobe. Nuts, metallic, or ceramic objects commonly are resistant to this technique. However, there are some anecdotal reports of using sterile water to freeze an "ice block" around the object, hence allowing removal with the probe. The cryoprobe can be very helpful in removal of these obstructive mucoid plugs. Further case reports have shown the potential to remove broncholiths with a cryoprobe.

Embolectomy Balloons

Vascular embolectomy balloons are used to move distal to an impacted object and upon inflation enable it to be pulled into a more proximal airway or dislodged. The importance of maneuvering a distal foreign body into more proximal airways cannot be underestimated. Sizes 4–7 are most frequently helpful. These balloons are commonly inflated with saline or contrast media rather than air to create a more rigid platform. When the bronchoscopist is unable to get a solid grasp on an object, using the balloon may be helpful to position it into a more favorable location. When used through a rigid bronchoscope, the balloon may be positioned distally to prevent further migration while using other instrumentation to grasp the object. Balloons are subject to rupture, particularly when used with sharp objects such as teeth or crowns. Caution should be exercised to prevent rupture or loss of fragments after rupture of a balloon, creating a secondary foreign body. In very unusual circumstances, the controlled radial expansion balloons may be helpful; however, the balloon length almost always precludes their safe deployment and utility.

In cases where the operator wants to maneuver an object into better position but is concerned about balloon integrity, an articulated endobronchial curette can be used. These curettes allow passage via the working channel of a thin, metallic probe. This probe is articulated at one or two locations, allowing a fingerlike motion once past the object. The sharper edge of the curette helps with manipulating the object. These instruments are also rotatable, allowing finer manipulation.

Nd: YAG Laser

The medical use of lasers is covered in detail in other chapters. The use of a laser in the management of foreign bodies is somewhat limited. As described previously, a lower wattage of 10–20 W may be used to judiciously reduce granulation tissue. Care must be undertaken to avoid airway fire, by not only reducing the F_IO_2 to less than 40% but also understanding the potential for the foreign body to ignite.

Another potential use of the laser is to help with manipulation and removal of the object. The Nd:YAG laser is able to cut many metals. Cutting a pin or needle that is imbedded may make it more easily removable and induce less tissue trauma. This use of the laser requires higher wattage; however, there are no defined wattage settings for this purpose. Many Nd:YAG lasers have maximal wattage settings up to 100 W. Use of wattages from 40 to 60 W or greater may be required. In addition, closer approximation of the laser fiber to the material, decreasing the circumscribed area of the beam, hence increasing the power density, should be considered. Changing the pulse duration may also be needed. Cautious titration up, by effect, is advisable. Understanding the tissue effects of the laser, the concept of power density, and careful aiming are all critical to safe utilization of the laser in this manner. Initial unseen injury from deeper more absorbent tissues or from reflected laser light must be considered.

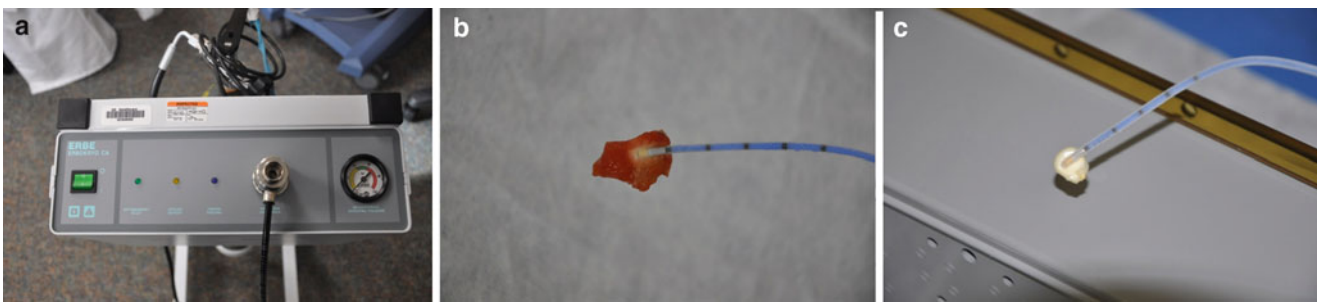


Fig. 46.9 Cryotherapy. (**a**) ERBE cryotherapy unit. (ERBE-USA Marietta, GA). (**b**) Tomato frozen to tip of Cryoprobe. (**c**) Corn frozen to the cryoprobe

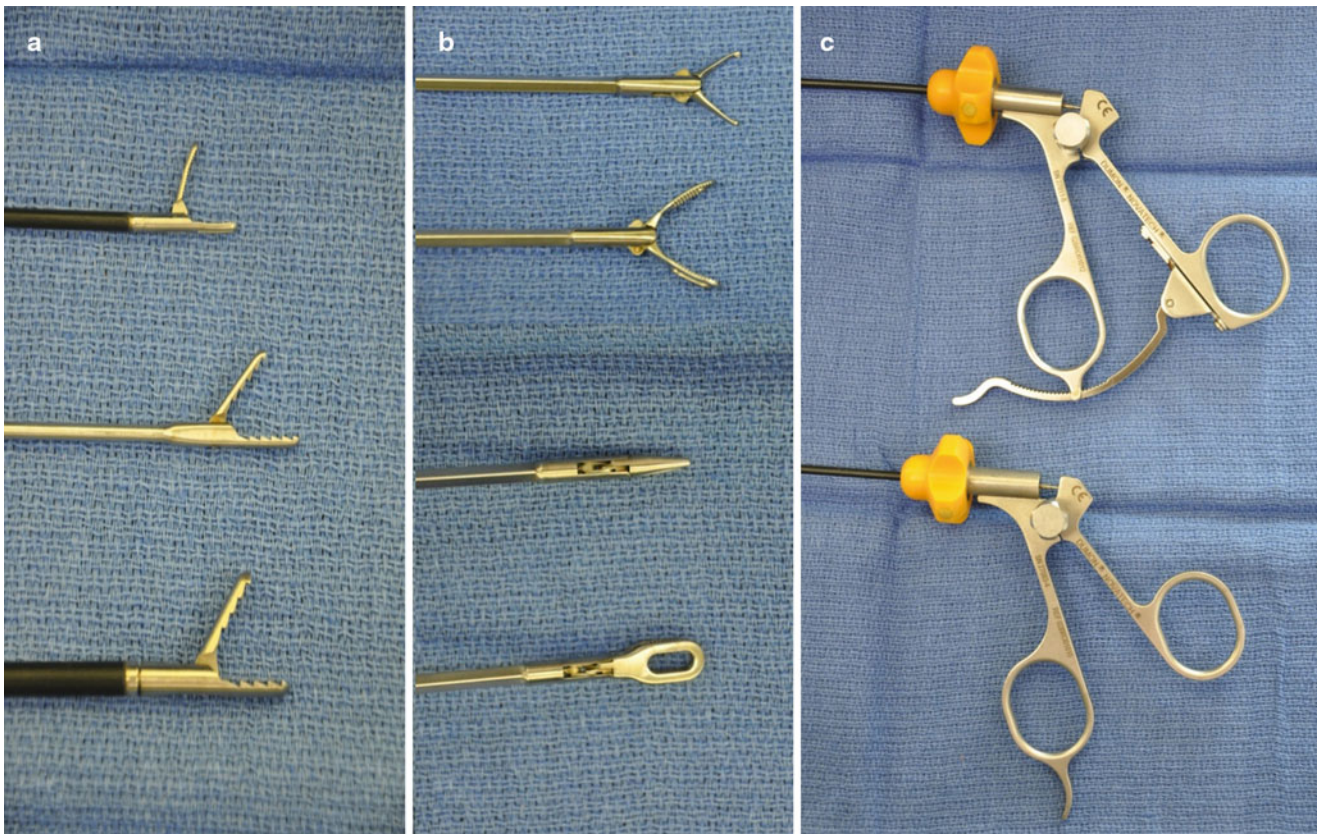


Fig. 46.10 Rigid bronchoscopic instruments. (**a**) *Top–Bottom*: fine serrated forceps, coarse serrated forceps, heavy coarse serrated forceps. (**b**) *Top–Bottom*: toothed grasper (*side view*), peanut grasper (*side view*), toothed grasper (*top view*), peanut grasper (*top view*). (**c**) *Top–Bottom*: ratcheting and non-ratcheting handles. The *yellow* knob allows rotation of the forceps without rotating the operator's hand

Management of large broncholiths may be difficult but can be safely removed. There are several reports in the literature that suggest the utility of laser therapy. Broncholiths have been fractured into smaller, more easily extracted objects with the Nd:YAG and the holmium laser. It may be that the holmium laser is the better approach based upon its history in urologic calculi; however, data is very limited.

Distal Impaction

When foreign bodies are distal, the challenge is greater. Small radiolucent objects may not be removable endoscopically. As previously noted, an object that is being pushed distally in removal attempts may be pulled proximally by use of a vascular embolectomy catheter. When radiopaque objects are not visible, use of interventional radiologic instruments may be helpful. As an example, the localization by guidewire and snare with an Amplatz GooseNeck® snare (ev3 Endovascular, Inc., Plymouth, MN) has been reported by Nalaboff and colleagues. The use of navigation bronchoscopy to these distally lodged foreign bodies has yet to be evaluated.

Surgery

Surgery is the avenue of last resort for virtually all foreign bodies. Thoracotomy with bronchotomy or lobectomy is rarely required. The indication for surgery would include those objects that have induced serious airway injury that must be repaired or will probably do so in an attempted removal. Rare objects that cannot be removed by bronchoscopy will require surgical intervention. Patients with long-standing foreign bodies that have destroyed significant parenchyma or those causing unremitting infection after removal may require surgical resection. Mediastinoscopy has been used in case reports to assist in removal of sharp foreign bodies that have penetrated the anterior mediastinum. This approach may avoid a full thoracotomy.

Complications of Therapy

Intraoperative complications are very unusual but can occur even with a highly trained proceduralist. Being aware of the potential occurrence and rapid determination of its presence

is critical to mitigating the complication. Care must always be exercised not to push a foreign body too distal in the attempt to remove it. In addition, it is possible to lose control of an object more proximally after it is retrieved. This creates a potential for rapid decompensation of the patients' respiratory status. If a foreign body becomes stuck while removing, it must be pushed distally immediately if causing central airway obstruction. These objects may then migrate into other locations.

Although rare, disruption of the airway may occur either because of a rigid bronchoscopy or because of removal attempts. Airway perforations are best evaluated with an experienced thoracic surgeon. Sharp or rigid objects such as needles, pins, and metallic objects increase the risk of airway penetration. Much more prevalent than airway perforation is the risk of bleeding with eroding broncholiths, ingrown objects, or granulation tissue.

While uncommon, the ability to control significant bleeding and protect ventilatory function is required. Management of life-threatening intraoperative hemorrhage may require endobronchial blocker placement. This can be complicated by the location of the foreign body. Rigid bronchoscopy is frequently required to control massive airway bleeding. The bronchoscopist should have contemplated an action plan at the start of the therapeutic attempts based upon the airway anatomy and location of the object.

Flooding of the airway with purulent material after decompressing a post-obstructive pneumonia is also a possibility. Decanting of this fluid into the contra-lateral lung can be catastrophic. If there is preoperative concern regarding the potential for post-obstructive pus, the bronchoscopy should be performed with an attempt to reduce the potential of decanting the drainage. This can be accomplished with use of the safety position or with rotation of the OR bed into an oblique angle with the involved lung down.

Laser use can cause significant damage if higher wattage is utilized. This deeper damage may not be initially visible, and postoperative reevaluation may be warranted.

One potential complication of therapy is the potential for retained foreign bodies. This may develop because of loss of some primary material, iatrogenic loss of instruments (balloon pieces), or failure to diagnose a second foreign body. This may be the most troublesome because the initial high index of suspicion is now significantly reduced. Ensuring a clear airway by methodical evaluation of all visualizable airways is crucial.

Conclusion

While the majority of aspirated foreign bodies involve children, a significant number of adults experience inhalation of foreign material. A high index of suspicion must be maintained. When clinical suspicion suggests a potential foreign body in the tracheal bronchial tree, negative imaging must never exclude the diagnosis. Chevalier Jackson stated "Do not fail to search endoscopically for a foreign body in all cases of doubt." Furthermore, once airway foreign bodies are diagnosed, exhaustive efforts should be undertaken to remove the object to mitigate long-term complications.

Flexible bronchoscopy can be safely and successfully utilized in the majority of cases. However, if there is any doubt as to the ability to remove the foreign body with a flexible scope or the risk of intraoperative complications, the bronchoscopist must be prepared and facile with a rigid bronchoscope. Rigid bronchoscopy is the fail safe backup for the vast majority of difficult extractions. Surgery, including bronchotomy and lobectomy, should be rarely required.

Suggested Reading

1. Niwa T, Nakamura A, Kato T, et al. Bronchoscopic intralesional injection of triamcinolone acetonide treated against bronchial obstruction caused by peanut aspiration. Respir Med. 2005; 99:645–7.
2. Bergthorsdottir R, Benediktsdottir KR, Thorsteinsson SB, Baldursson O. Endobronchial actinomycosis secondary to a tooth aspiration. Scand J Infect Dis. 2004;36:384–6.
3. Chouabe S, Perdu D, Deslee G, Milosevic D, Marque E, Lebargy F. Endobronchial actinomycosis associated with foreign body: four cases and a review of the literature. Chest. 2002;121(6):2069–72.
4. Qureshi RA, Soorae AS. Foreign body in tracheal bronchus simulating bronchogenic cancer. Eur J Cardiothorac Surg. 2001;20:639–41.
5. Athanassiadi K. Management of foreign bodies in the tracheobronchial tree in adults: a 10-year experience. Eur J Surg. 2000; 166(12):920–3.
6. Tuggey JM, Hosker HSR, DaCosta P. Primary pulmonary botryomycosis: a late complication of a foreign body aspiration. Thorax. 2000;55:1068–9.
7. Ho JCM, Ooi GC, Lam WK, Lam B, Cheung TF, Tsang KWT. Endobronchial actinomycosis associated with a foreign body. Respirology. 2000;5:293–6.
8. Ragab A, Ebied OM, Zalat S. Scarf pins sharp metallic tracheobronchial foreign bodies: presentation and management. Int J Pediatr Otorhinolaryngol. 2007;71:769–73.
9. Muller-Quernheim J, Vollmer E, Galle J. Secondary bronchial botryomycosis due to foreign body aspiration. Monaldi Arch Chest Dis. 2007;67(2):119–21.
10. Hsu W-C, Sheen T-S, Lin C-T, Yeh T-H, Lee S-Y. Clinical experiences of removing foreign bodies in the airway and esophagus with a rigid endoscope: a series of 3217 cases from 1970 to 1996. Otolaryngol Head Neck Surg. 2000;122(3):450–4.
11. Rafanan AL, Mehta AC. Adult airway foreign body removal whats new? Clin Chest Med. 2001;22(2):319–30.
12. Zaytoun GM, Rouadi PW, Baki DHA. Endoscopic management of foreign bodies in the tracheobronchial tree: predictive factors for complications. Otolaryngol Head Neck Surg. 2000;123:311–6.
13. Depriest K, Wahla AS, Blair R, Fein B, Chin Jr R. Capsule endoscopy removal through flexible bronchoscopy. Respiration. 2010;79:421–4.
14. Coldron J. Management of a respiratory emergency in the antarctic winter: a case of foreign body aspiration. Wilderness Environ Med. 2007;18:120–6.

15. Koulaouzidis A, Pendlebury J, Douglas S, Plevris JN. Aspiration of video capsule: rare but potentially life-threatening complication to include in your consent form. Am J Gastroenterol. 2009; 104:1602–3.
16. Mise K, Savicevic AJ, Pavlov N, Jankovic S. Removal of tracheobronchial foreign bodies in adults using flexible bronchoscopy: experience 1995–2006. Surg Endosc. 2009;23:1360–4.
17. Xing Y, Zhao J, Chen X, Song J. Elevated FDG uptake in right middle segmental bronchus impacted with foreign body. Clin Nucl Med. 2009;34(4):241–2.
18. Yoruk Y, Hatipoglu O. Synchronous foreign body and non-small cell carcinoma of the main bronchi. Eur J Cardiothorac Surg. 2004;26:648.
19. Gencer M, Ceylan E, Koksal N. Extraction of pins from the airway with flexible bronchoscopy. Respiration. 2007;74:674–9.
20. Seo JB, Lee JW, Ha SY, Park JW, Jeong SH, Park GY. Primary endobronchial actinomycosis associated with broncholithiasis. Respiration. 2003;70:110–3.
21. Tang LF, Du LZ, Chen ZM, Zou CC. Extracellular matrix remodeling in children with airway foreign-body aspiration. Pediatr Pulmonol. 2004;38(2):140–5.
22. Karakoc F, Karadag B, Akbenlioglu C, et al. Foreign body aspiration: what is the outcome? Pediatr Pulmonol. 2002;34(1):30–6.
23. Yildizeli B, Zonuzi F, Yuksel M, Kodalli N, Cakalagaoglu F, Kullu S. Effects of intrabronchial foreign body retention. Pediatr Pulmonol. 2002;33(5):362–7.
24. Langer D, Petermann C, Lubbers H, Lankisch PG. Relapsing pneumonia due to a migrating intrathoracic foreign body in a World War II veteran shot 53 years ago. J Intern Med. 1999;245(4):405–7.
25. Clancy MJ. Bronchoscopic removal of an inhaled, sharp, foreign body: an unusual complication. J Laryngol Otol. 1999;113(9): 849–50.
26. Debeljak A, Sorli J, Music E, Kecelj P. Bronchoscopic removal of foreign bodies in adults: experience with 62 patients from 1974–1998. Eur Respir J. 1999;14(4):792–5.
27. Olson EJ, Utz JP, Prakash UBS. Therapeutic bronchoscopy in broncholithiasis. Am J Respir Crit Care Med. 1999;160(3):766–70.
28. McCaughan JS, Heinzmann HG, McMahon D. Impacted broncholiths removed with the holmium:YAG laser. Lasers Surg Med. 1996;19(2):230–2.
29. Miks VM, Kvale PA, Riddle JM, Lewis Jr JW. Broncholith removal using the YAG laser. Chest. 1986;90(2):295–7.
30. Reddy AJ, Covert JA, Sporn TA, Wahidi MM. Broncholith removal using cryotherapy during flexible bronchoscopy. Chest. 2007;132(5):1661–3.
31. Hilman BC, Kurzweg FT, McCook WW, Liles AE. Foreign body aspiration of grass inflorescences as a cause of hemoptysis. Chest. 1980;78(2):306–9.
32. Overdahl MC, Wewers MD. Acute occlusion of a mainstem bronchus by a rapidly expanding foreign body. Chest. 1994;105(5): 1600–2.
33. Divisi D, DiTommaso S, Garramone M, et al. Foreign bodies aspirated in Children: role of bronchoscopy. Thorac Cardiovasc Surg. 2007;55(4):249–52.
34. Mahafza T, Khader Y. Aspirated tracheobronchial foreign bodies: a Jordanian experience. Ear Nose Throat J. 2007;86(2):107–10.
35. Adaletli I, Kurugoglu S, Ulus S, et al. Utilization of low-dose multidetector CT and virtual bronchoscopy in children with suspectyed foreign body aspiration. Pediatr Radiol. 2007;37(1):33–40.
36. Latifi X, Mustafa A, Hysenaj Q. Rigid tracheobronchoscopy in the management of airway foreign bodies: 10 years experience in Kosove. Int J Pediatr Otorhinolaryngol. 2006;70(12):2055–9.
37. Heyer CM, Bollmeier ME, Rossler L, et al. Evaluation of clinical, radiologic, and laboratory prebronchoscopy findings in children with suspected foreign body aspiration. J Pediatr Surg. 2006;41(11): 1882–8.
38. Kocaoglu M, Bulakbasi N, Soylu K, Demirbag S, Tayfun C, Somuncu I. Thin-section axial multidetector computed tomography and multiplanar reformatted imaging of children with suspected foreign-body aspiration: is virtual bronchoscopy overemphasized? Acta Radiol. 2006;47(7):746–51.
39. Hasdiraz L, Ogizkaya F, Bilgin M, Bicer C. Complications of bronchoscopy for foreign body removal: experience in 1,035 cases. Ann Saudi Med. 2006;26(4):283–7.
40. Moura e Sa J, Oliviera A, Caiado A, et al. Tracheobronchial foreign bodies in adults – experience of the bronchology unit of centro hospitalar de Vila Nova de Gaia. Rev Port Pneumol. 2006;12(1):31–43.
41. Tariq SM, George J, Srinivasan S. Inhaled foreign bodies in adolescents and adults. Monaldi Arch Chest Dis. 2005;63(4):193–5.
42. Zissin R, Shapiro-Feinberg M, Rozenman J, Apter S, Smorjik J, Hertz M. CT Findings of the chest in adults with aspirated foreign bodies. Eur Radiol. 2001;11(4):606–11.
43. Eroglu A, Kurkcuoglu IC, Karaoglanoglu N, Yekeler E, Aslan S, Basoglu A. Tracheobronchial foreign bodies: a 10-year experience. Turk J Trauma Emerg Surg. 2003;9(4):262–6.
44. Nalaboff KM, Solis JL, Simon D. Endobronchial foreign body extraction: a new interventional approach. Chest. 2001;120(4):1402–5.
45. Stjernquist-Desatnik A, Cwikiel W. Foreign body in the peripheral bronchus: extraction using an interventional radiologic method. Acta Otolaryngol. 2002;122:311–3.
46. Oka M, Fukuda M, Takatani H, Nakano R, Kohno S, Soda H. Chronic bronchial foreign body mimicking peripheral lung tumor. Intern Med. 1996;35(3):219–21.
47. Kim ST, Kaisar OM, Clarke BE, et al. Iron lung: distinctive bronchoscopic features of acute iron tablet aspiration. Respirology. 2003;8:541–3.
48. Sundar KM, Elliott CG, Thomsen GE. Tetracycline aspiration. Respiration. 2001;68(4):416–9.
49. Srppnath J, Mahendrakar V. Management of tracheobronchial foreign bodies- a retrospective analysis. Indian J Otolaryngol Head Neck Surg. 2002;54(2):127–31.
50. Cho HK, Cho KY, Cho SY, Sohn S. Bronchial foreign body aspiration diagnosed with MDCT. Korean J Pediatr. 2007;50(8):781–4.
51. Pinto A, Scaglione M, Pinto F, et al. Tracheobronchial aspiration of foreign bodies: current indications for emergency plain chest radiography. Radiol Med. 2006;111:497–506.
52. Sodhi KS, Aiyappan SK, Saxena AK, Singh M, Rao K, Khandelwal N. Utility of multidetector CT and virtual bronchoscopy in tracheobronchial obstruction in children. Acta Pediatr. 2010;99:1011–5.
53. Ramos MB, Fernadez-Villar A, Rivo JE, et al. Extraction of airway foreign bodies in adults: experience from 1987–2008. Interact Cardiovasc Thorac Surg. 2009;9:402–5.