**Paparella: Volume III: Head and Neck**

**Section 2: Disorders of the Head and Neck**

**Part 5: The Larynx, Trachea, and Esophagus**

# Chapter 36: Endoscopy and Foreign Body Removal

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Adequate examination of the head and neck, esophagus, stomach, and tracheobronchial tree requires the use of rigid and flexible endoscopes. Diagnosis, biopsy, brushing, photography, laser therapy, and foreign body removal may require use of both instruments. The use of one is not mutually exclusive of the other. Flexible instruments can be used through rigid ones, and flexible foreign body instrumentation can be used through rigid endoscopes, thus expanding the capabilities of each method.

As the rigid endoscope once revolutionized endoscopy in its diagnostic and therapeutic capabilities, the flexible fiberscope has opened many new doors.

A specialist in the examination through the orifices above the clavicles should become a master of both rigid and flexible techniques. In general, the flexible endoscopes are much easier to use than are the rigid ones, so their use is an easy extension of one's knowledge.

The following is an endoscopic guide for the complete examination, diagnosis, and treatment of selected disorders of the head and neck, esophagus, and tracheobronchial tree using both flexible and rigid instrumentation.

## The Complete Office Examination

The office examination is limited only by the equipment. A complete examination of the ears, nose, oral cavity, oropharynx, nasopharynx, larynx, and hypopharynx may require the use of multiple instruments. Topical anesthesia in the oral cavity, pharynx, and hypopharynx with Cetacaine (14 per cent benzocaine, 2 per cent butyl aminobenzoate, 2 per cent tetracaine hydrochloride) or Hurricaine (20 per cent benzocaine) makes the examination more comfortable for the patient and the examiner. Four per cent Xylocaine (lidocaine) on a cotton-tipped applicator in the floor of the nose after nasal decongestion also helps. A complete examination of the nose requires nasal decongestion material in both sides of the nose. Benzocaine tends to burn the nose - 4 per cent lidocaine does not. On many occasions, a complete examination of the larynx includes passage through the vocal cords; in this situation, 4 per cent lidocaine can be sprayed directly on the surface of vocal cords with a mirror and a curved applicator. The patient then phonates and 2 per cent lidocaine can be applied to the vocal cords and subsequently injected into the trachea. This type of topical anesthesia will allow one to examine the tracheobronchial tree to the bifurcation, and most patients can also swallow a small fiberscope, allowing examination of the upper esophagus.

In a patient with a severely obstructed airway, however, this examination should be postponed and performed with an anesthesiologist and all of one's equipment available in the

operating room, including a tracheotomy set, rigid bronchoscopes, and so on.

Flexible fiberoptic nasopharyngolaryngoscopes are available in pediatric and adult sizes without suction. The smaller the fiberscope, the poorer the image and the lighting. The larger the fiberscope the more likely a suction channel can be added without impairing optics. When suction is required, we use our office broncho-fiberscope, which is approximately 5.1 mm in diameter with a 2-mm suction-working channel. This instrument comes with brushes and biopsy instrumentation. Almost all of these fiberscopes have a tip range of motion that is more than adequate in an up and down direction (120 degrees). Distortions (usually miniaturization) are present with their use. Knowledge of the diameter of the fiberscope used is extremely important. When it is passed through a narrowing, simple multiples of the size of the instrument can be used to gauge airway or esophageal size.

Rigid nasopharyngoscopy, sinus endoscopes, and laryngoscopes are also available. Some rigid laryngoscopes have a high and low magnification, whereas others have a fixed viewing image. Most of these instruments give a magnificent view in a cooperative patient and give the best view for photography. These instruments are harder to use and harder for patients to tolerate. Flexible fiberscopes may have to be used through the nose to avoid gagging difficulties even in a patient who has received topical anesthesia.

A complete head and neck examination uses both visualization and palpation of accessible areas. I prefer the flexible instruments for the nose and nasopharynx. The best view is gained after topical decongestants and topical anesthesia are administered. Both sides of the nose must be examined. A brief sojourn in the nasopharynx must view the roof; anterior, posterior, and lateral walls; eustachian tube orifices; the fossae of Rosenmüller; and palatal movement (phrases such as "I like Coca-Cola but I don't like cheesecake, we three geese, Popeye plays baseball, and Susy sings in the sun" plus "e" and "ka" should be phonated to evaluate palatal closure), before passing into the oropharynx and hypopharynx. At this point, the patient should be asked to say "E" and "A" and to perform a modified Valsalva maneuver (blowing against pursed lips balloons out the pyriform sinuses and postcricoid area and frequently allows an unparalleled view down almost to the level of the cricopharyngeus muscle). If a view through the vocal cords is required, topical anesthesia application in the larynx and hypopharynx would allow one to safely pass the flexible fiberoptic instrument through the vocal cords to examine the subglottic area down to the level of the tracheal bifurcation. Tracheal and subglottic problems can be easily delineated. Unless the flexible instrument is used through the mouth, a view of the base of the tongue is very limited. This area is best examined with a mirror or one of the rigid instruments, or both, plus of course palpation. Palpation is also included in the examination of the oral cavity, oropharynx, submandibular triangles, base of the tongue, and neck from the front and from behind including palpation of the parotid-facial area.

In the postsurgical head and neck cancer patient without a larynx, the flexible fiberoptic instrument can be passed through the nose and swallowed, which allows a beautiful view of the esophagus, sometimes all the way to the gastroesophageal junction. With swallowing and a deep breath, the esophagus opens and one has quite a view of all the suture lines, and if a voice prosthesis is in place, its position can be easily checked. If air insufflation is needed, the flexible fiberscope with suction channel can be used. The air-blowing device on most office examination machines can be carefully used and air insufflated

to open an area that requires better visualization. If bleeding or suspicious areas are seen, additional examinations will most likely be required with sedation or a general anesthesia, or both.

An examination of the larynx with the patient awake is, of course, the only way to observe motion abnormalities. The use of these instruments in children is more difficult, but possible. Many very small children require no anesthesia. Older children may require sedation or restraints, or both, and a very controlled situation in the operating room, progressing from an awake to an asleep state.

The flexible instruments and sometimes the rigid instruments and the semirigid instruments that are available today can be used through a tracheostomy. In the office, topical anesthesia can be administered through the tracheotomy site and then the tracheotomy tube can be removed and the flexible instrument passed downward to view the trachea and both main bronchi and upward, giving a view of the subglottic and interarytenoid area that is not possible from above. Scar bands between the vocal processes and interarytenoid scars can be easily visualized using this retrograde technique in the office, and the patient can be scheduled for definitive management instead of endoscopy in the operating room. The examination from above, however, should be performed, as the supraglottic structures are difficult to examine this way. Office removal of a tracheotomy tube is safe as long as a replacement is readily available.

All patients who receive topical anesthesia should be instructed that they should have nothing to ear, drink, or smoke for at least a half-hour, if benzocaine is used and for at least 1.5 hours if topical lidocaine is used. All administration of the topical anesthetics should be kept within recommended dosages. Occasionally a patient will require sedation prior to coming to the office for an examination such as this. Adults may require diazepam 1 hour before their arrival. Children might receive chloral hydrate rectally.

Small foreign bodies lodged in the tonsil, base of the tongue, pyriform sinuses, laryngeal surface of the epiglottis, and postcricoid area can frequently be removed in the office using topical anesthesia and a straight or curved hemostat or a straight or curved foreign body forceps, with or without a laryngeal mirror or with a flexible fiberscope with working channel. If this method is unsuccessful, sedation or general anesthesia, or both, may be required in an operating room setting. Most commonly, these foreign bodies are small bones (chicken or fish) and, on occasion, toothbrush bristles.

Most children will require sedation or general anesthesia for removal of small foreign bodies in this area.

Safety is the prime concern and if the physician does not have the facilities in the office and is fearful, he or she must proceed to a more controlled situation for the removal of these foreign bodies. Each hospital, each office, and each physician has patient factors, physician factors, and equipment factors that may dictate an alternate approach that would be equally effective.

Video stroboscopes can be used with flexible and rigid instrumentation. This type of view of the larynx can give information on subtle motion abnormalities of the vocal cords or

parts of the vocal cord that are not perceived with other methods. Color or black and white photographic units, or both, can be attached to these videos and the physician and the patients and students can then have an immediate visual record and a permanent printed record of the examination. Efficient use of this type of equipment requires the patience of both the examiner and the examinee. This type of examination should be reserved for evaluation of the professional voice user or in situations in which subtle diagnoses are entertained.

If there is a fully equipped operatory in the office, one could proceed to a complete bronchoscopy or esophagoscopy, or both. These examinations in the office would require sedation, usually with a narcotic plus atropine; benzodiazepine plus atropine would be an acceptable sedation alternative. Topical anesthesia would be applied as previously described and the examination performed. A nurse assistant would be required. For esophagoscopy, a small amount of viscous lidocaine is added to the preparation to be swallowed.

The best examination of the larynx in the office is done with the patient properly positioned in a chair with the buttocks back as far as possible. The back should be straight, and the patient should be flexed forward at the waist 15 to 20 degrees with the chin up slightly. This is the "sniff" position. This type of office examination leaves little to the imagination.

## Examination and Treatment of Conditions of the Esophagus Outside an Endoscopy Suite

Knowing what you are dealing with is mandatory prior to the instrumentation of the esophagus. Death lurks here. History has proved it. There is no need to recapitulate history.

A posteroanterior and lateral x-ray film of the neck, lung, and abdomen will identify the location and character of most foreign bodies in the esophagus. *Esophageal foreign bodies align parallel to the spine and laryngeal ones align perpendicular to it.* Properly taken x-ray films will identify even partially radiopaque objects. In a symptomatic patient, even when this type of simple x-ray film is normal, one should proceed to the administration of barium. Complete obstructions will be easily delineated, as will partial ones, and small foreign bodies will divert the barium stream. Cotton-soaked barium will hang up on a foreign body. On occasion, a computed tomography (CT) scan may be required to delineate the endoesophageal or exoesophageal presence of a foreign object.

A video barium swallowing function with upper gastrointestinal series gives quite a detailed view of the nasopharynx, hypopharynx, esophagus, stomach, and duodenum. Very few conditions would escape this examination. Small lesions in the hypopharynx and cervical esophagus can, however, be missed. Examination with a flexible esophagoscope usually leaves this same blind area.

Should every foreign body be investigated with a barium test prior to its removal? The less the physician's experience with endoscopy, the more likely this is to be true. Knowing whether or not there is an abnormality of the esophagus before instrumentation is helpful. Diverticulae, stenoses, hiatal hernia, reflux erosions, and extravasations are important things to be aware of prior to endoscopic manipulation. Barium does, in some ways, obscure one's view of a foreign body, cancer, or burns; however, with the rigid or flexible endoscope,

irrigation usually relieves the situation. The suction and irrigation capabilities of a rigid endoscope, in general, are more powerful than those of the flexible ones. A water jet can be attached to a flexible endoscope and an area irrigated quite effectively.

In adults, there are some common calcifications in the larynx and surrounding head and neck area that can be confused with foreign bodies (cricoid, hyoid, triticeous, and stylohyoid calcifications and osteophytes). If the x-ray examination is done with a Valsalva maneuver or a modified Valsalva maneuver, some of these confusions can be eliminated. A barium stream or CT scan may also help delineate the exact relation of these calcifications.

A large dose of barium in the face of complete obstruction is not wise, as aspiration into the tracheobronchial tree is a definitive possibility.

Patients with achalasia have a large saccular esophagus filled with an incredible amount of debris. Barium in this situation is more difficult to clear, but it is important to know what the condition is because the situation should be approached with intubation with the patient awake followed by general anesthesia and, most likely, a combination of rigid and flexible endoscopy in order to rapidly clear the achalasia sac of debris prior to careful examination of the cavity.

## Foreign Body Removal: Esophagus

Current practice is that esophageal foreign bodies of the smooth variety are frequently manipulated by the radiologist, pediatrician, emergency room physician, or family practitioner, or all of these professionals, with a variety of techniques.

### Noninvasive Methods

For adults, an upright position is used with smooth foreign bodies (usually food), and gas-forming agents are given in the x-ray examination room under fluoroscopic guidance. One method is 15 mL of tartaric acid (18.7 gm/100 mL) followed immediately by 15 mL of sodium bicarbonate (10 gm/100 mL). This is followed immediately by the administration of 60 mL of high-density barium. Eight patients were given this concoction by Rice and colleagues. One patient required a second dose. All esophageal obstructions were relieved with this method. It is interesting that the procedure was done without complication, as the authors observed retching in all of their patients. Every one of the patients had an underlying esophageal disease, including a benign stricture, Barrett's esophagus, Schatzki's ring or hiatal hernia, or a postoperative stricture, all of which required later direct visualization.

Substances that form less gas can be used with a lower percentage of success. Mohammed and Hegedus described using 100 mL of a carbonated beverage in adults in an upright position followed by a mouthful of barium and they recorded an 80 per cent success rate but did not limit themselves to totally smooth food situations. There was a coin and meat with bone. They did not record retching. Twenty per cent of the foreign bodies had to be removed with esophagoscopy. In neither of these reports were the foreign body delivered from an anterograde direction. They all apparently passed into the stomach.

Also, in the X-ray Department with the patient upright (once again in adults), glucagon has been administered, 0.5 to 2 mg, followed by the ingestion of water. In these doses, glucagon appears to decrease lower esophageal sphincter pressure. All the foreign bodies for which this material was used were smooth and considered to be food or meat. There was one pork bone in the group. Obstructions in the middle or upper portion of the esophagus were excluded from their evaluation. All the patients with distal esophageal obstructions had abnormalities below the impaction, including, once again, hiatal hernia, diverticuli, esophagitis or stricture, and Schatzki's ring. The barium test delineated this. One foreign body passed spontaneously. Two patients vomited up their foreign bodies after the administration of glucagon. Another few foreign bodies passed into the stomach, successfully relieving the obstruction. There was a 37 per cent success rate, including the vomited foreign objects. The disadvantage of glucagon is the nausea and vomiting associated with its administration. The authors felt this side effect could be avoided if the glucagon was administered slowly. They noted that a history of pheochromocytoma or insulinoma would be the only known contraindication to the use of glucagon.

The key to both of these approaches is the use of fluoroscopy so that the manipulator is aware of the nature of the foreign body and the pathologic characteristics with its enlodgement.

## Invasive Methods

Fluoroscopically guided manipulation of foreign bodies is reasonably direct and safe. In a patient well known to the physician, with a smooth stable distal stricture, passage of a tapered mercury-filled Maloney bougie (in the X-ray Department after barium under fluoroscopic guidance) can be a safe way to advance a foreign body into the stomach.

In a known case of stricture with fluoroscopic aid, passage of a balloon dilator into the stomach can be easily performed. The balloon is drawn back into the stricture and inflated. The foreign body may then spontaneously pass. In the face of esophagitis or an unknown condition that has not previously undergone endoscopy by the manipulator, the procedure should be deferred to direct endoscopic visualization with a flexible or a rigid endoscope, and the foreign body should be removed under direct vision and the pathologic area examined, evaluated, brushed, and biopsied, if appropriate. If, at the time of endoscopic removal of the foreign body, a large amount of inflammation is found that might create inflammatory confusion with regard to the biopsy, the biopsy should be deferred until the inflammation subsides to reduce the risk of perforation.

Patients who fail these two methods could theoretically be taken immediately to an endoscopy suite for definitive management.

## Foley Catheter Extraction of Smooth Esophageal Foreign Bodies

Foley catheter extraction is being advocated by pediatricians, radiologists, emergency room physicians, and family practitioners for performance when endoscopy suites are unavailable or distant. It is purported to be an extremely safe method. No significant airway problems have been reported as the result of this technique. McGuirt evaluated this technique and gives guidelines for the performance of the procedure. His prerequisites include a

cooperative patient, a smooth, inert radiopaque foreign body, duration of lodgement less than 48 to 72 hours, and barium esophagogram revealing negative results for total obstruction, multiple foreign bodies, or underlying esophageal disease. Fluoroscopy must be available and an endoscopist standing by who can manage the airway. Physicians using this method for the removal of foreign bodies report a 15 per cent rate of failure. Children can be made to cooperate for this procedure with a restraint jacket. The patient should be placed in a head-down (table in extreme Trendelenburg) position. Some physicians do this in a prone position with the head in a lateral position. The position is assumed to minimize aspiration. A 12 to 16 French Foley catheter balloon should be checked for even inflation prior to use. A small amount of barium can be placed in the Foley balloon for easier visualization. The Foley balloon, once inflated, can then be slowly withdrawn (without force), expelling the foreign body into the oropharynx and out the corner of the mouth. After the procedure has been performed, a check for a second foreign body should be made under fluoroscopy with a little barium.

Some physicians perform the Foley catheter extraction procedure after the administration of topical anesthesia in the nose and pass the Foley catheter through the nose. Nosebleeds have been induced in this situation, and coins have been dislodged into the nose or nasopharynx. There was one reported case of hyperpyrexia and one case of transient laryngospasm with the nasal route. The use of the Foley catheter through the mouth obviates the need to lower the balloon upon extraction, thus theoretically reducing the risk of aspiration of the foreign body into the laryngeal inlet. Obviously, if the balloon is left inflated when pulled out through the nose, a significant injury to the nose could occur.

### Extraction With Other Balloons

Arterial embolectomy and foreign body balloons of a variety of types are available for use through endoscopes and can also be used without endoscopes under fluoroscopy. The guidelines for their use would parallel those described for the Foley catheter. Direct visualization of pathologic features beyond the foreign body should be available prior to the performance of the procedure. Fluoroscopy with barium qualifies as a reasonably direct technique for visualization of the area. Any suspicion of underlying disease that would include severe inflammation from trauma from the foreign body or underlying disease should preclude the consideration of the use of any nonvisualization technique. As more physicians use this method, more complications will undoubtedly become evident. The balloon techniques should not be used unless the airway can be secured.

The balloon methods, however, must be included in the armamentarium of foreign body and laser experts, whether the foreign body be in the esophagus or lung, as these techniques provide helpful guidance and may facilitate removal of tissue as well as foreign bodies. With fluoroscopic guidance, a foreign body can be held in position with a foreign body balloon or a Foley catheter balloon blown up beyond the foreign body preventing it from passing further into the periphery. Passing the balloon may further impact the foreign body. This method must be carefully applied. A balloon or part of it can become a foreign body.

## Proteolytic Enzymes

Food impaction in adults is one of the most common foreign bodies. Use of proteolytic enzymes has been advocated. This, of course, is not a good idea when inflammation is present in the area of the foreign body. The proteolytic enzymes will dissolve the esophagus along with the foreign body. The use of these substances should be relegated to history.

## Special Situations

Interventional radiologists have a variety of foreign body forceps for flexible situations. These foreign body instruments were developed to remove errant catheters in the heart and other areas of the arteriovenous system. It would be worthwhile for the reader to pass through a radiologist's interventional area and view the equipment available, as it might be needed in a difficult endoscopic situation.

## Examination and Treatment of Some Esophageal Disorders

## in an Endoscopy Suite

The endoscopy suite should have both rigid and flexible instruments and equipment and personnel available for topical, local standby, and general anesthesia. Anesthesia should be chosen so that patient and operator comfort and airway safety can be maintained. Sharp foreign bodies and difficult rigid esophagoscopies require general anesthesia with paralysis. A standard apneic induction with cricoid pressure is *probably* safe even with sharp foreign objects.

## Anesthesia

### Local Anesthesia with Sedation

Sedation plus atropine is helpful. We prefer a combination of Versed (midazolam hydrochloride) and Sublimaze (fentanyl citrate) injection plus atropine. Midazolam is a shorter acting benzodiazepine used parenterally that has diminished respiratory depression side effects and has greater amnesia effects than does Valium (diazepam). Midazolam is more potent and is given in 0.07 to 0.08 mg/kg divided dosages. Intravenously, just 1 to 2 mg of midazolam provides superb sedation, with onset in 15 minutes and peaking at 30 to 60 minutes, thus lasting just the right amount of time. Combining midazolam with fentanyl can improve the sedation and relieve the discomfort of the procedure. Using fentanyl concomitantly with midazolam requires a reduction by one half to one third of the usual dose of fentanyl. Fentanyl 0.5 mL or 0.025 mg, might be enough. The respiratory depressant effect of fentanyl must be carefully monitored. We administer 0.4 to 0.6 mg of atropine in addition to sedation. Atropine reduces secretions and allows for an easier, less complicated procedure. It blocks laryngeal reflexes. It is contraindicated in patients who have peptic ulcer disease, glaucoma, obstructive uropathy, achalasia, pyloric or duodenal stenosis, paralytic ileus, or intestinal atony of the elderly or the debilitated patient, or in patients with an unstable cardiovascular status, severe ulcerative colitis, toxic megacolon, or myasthenia gravis.

Glycopyrrolate injection has been advocated as an alternative to atropine because it has fewer cardiac effects and retains its drying capabilities. I have not found this to be the case. I still prefer atropine.

Topical anesthesia for the oral cavity using benzocaine and viscous lidocaine can be administered. When sedation is used, topical anesthesia in the larynx is usually not necessary with the passage of the flexible or rigid esophagoscope.

## General Anesthesia

Aspiration is prevented with endotracheal intubation. A flexible or nasal intubation with the patient awake and sitting up or an oral intubation under laryngeal mirror guidance with an introducing device should entirely eliminate the possibility of aspiration or mucosal damage.

In adults we use either Forane (isoflorane) or Ethrane (enflurane) along with Tracrium (atracurium besylate) injection. In children we use halothane alone or in combination with atracurium. Atracurium is a nondepolarizing skeletal muscle relaxant. Recovery from the neuromuscular blockade under balanced anesthesia can be expected to begin approximately 20 to 35 minutes after injection. The agent's effects are reversible with the anticholinergic agents. I prefer atracurium over succinylcholine because succinylcholine increases the amount of secretions and may make removal of any foreign body more difficult. Atropine doses for children and adults are given on an age and weight basis and its use is obligatory to reduce laryngeal reflexes and secretions.

Regardless of the instruments or the type of anesthesia used, monitoring - including blood pressure, electrocardiogram (ECG), and oxygen saturation - should be performed. All of the equipment one intends to use should be functional prior to administration of sedation and topical or general anesthesia.

When performing esophagoscopy in the pediatric age group, the anesthesia dosages, as already described, have to be adjusted according to age. The inhalational agent used for children is halothane.

## Equipment

A flexible esophagoscope should always be available with the appropriate light source, air, water, and suction. One size of a flexible esophagoscope is not enough. The minimum that should be available is a 7.8-mm esophagogastroduodenoscope. This small endoscope can also pass through some of the standard, larger rigid esophagoscopes. This extends the use of a rigid endoscope and may allow for easier removal of some foreign bodies that have passed beyond the reach of the rigid instrument. Our "workhorse" flexible fiberoptic esophagogastroduodenoscope is 11.5 mm in diameter and has a large working channel. All flexible fiberscopes used in the esophagus have up and down motion and left and right motion that allows for a complete examination in most every fold and pocket of the esophagus, stomach, and duodenum.

A variety of rigid endoscopes are available, including a Jackson style (round) and a Jesberg style (oval). For most foreign body situations, the short and wide esophagoscopes are the first choice, as foreign bodies are frequently lodged in the postcricoid-cervical esophageal-upper thoracic area. Esophagoscopes that are 29 to 30 cm long are perfect for this situation. The shorter the esophagoscope is, the easier the visual accommodation and the better the view. Esophageal speculums - shorter than esophagoscopes but longer than laryngoscopes - are also helpful. The longer rigid esophagoscopes come in a variety of sizes from 4- to 13-mm widths and can vary in length from 30 to 55 cm. Some rigid esophagoscopes have occlusive devices for the proximal end that will allow air insufflation (a disadvantage of some of the other rigid esophagoscopes). Telescopes are available for use through the rigid esophagoscopes. These telescopes are the same quality as those used with the bronchoscopes and provide a superb view of esophageal pathologic areas and the best view for photography.

The barium esophagogram or pertinent x-ray films should be posted in the endoscopy suite for instant referral. Fluoroscopy, either biplane or C-arm, should be immediately available for evaluating a difficult stricture, foreign body, or laser case.

## Technique

### Flexible Esophagoscopy

The technique of flexible esophagogastroduodenoscopy after topical anesthesia in the oral cavity, oropharynx, and esophagus varies. The patient can be sitting with the instrument passed through a plastic mouth prop that prevents biting of the instrument. The fiberscope is introduced through the oral cavity, and the larynx and hypopharynx can be visualized, and under direct vision the endoscope can be passed into the esophagus. Once the endoscope enters a pyriform sinus or the postcricoid area, air insufflation is begun. This opens the esophagus in front of the endoscope, allowing safe passage of the endoscope into the esophagus and down into the stomach with a great deal of ease. The endoscope should be lubricated prior to the passage with some type of water-soluble jelly. An alternative to this introduction method is with the patient on the left side, but once again using a plastic mouth prop and passing the endoscope through the mouth and into the postcricoid hypopharyngeal area, then beginning insufflation before continued passage of the endoscope. Regardless of the technique of introducing the flexible esophagoscope, the postcricoid-pyriform sinus area and cricopharyngeal and cervical esophageal area are not well visualized. They are sometimes better visualized when the endoscope is removed maintaining air insufflation. This area is best examined with a rigid laryngoscope, a Forbes esophageal speculum, or one of the shorter Jesberg esophagoscopes, or a combination. The typical endoscopic constrictions that also coincide with the areas of lodgement of foreign bodies are shown. The flexible esophagoscopes are especially easy to read in term of centimeters from the upper incisor. There are markings every 10 cm, with an intermediate mark at 5 cm. The flexible fiberscope can perforate at natural constrictions or at unnatural ones, just as a rigid esophagoscope.

With the introduction of any esophagoscope, care must be taken not to go into a blind pouch with force. Once in the stomach, air insufflation will usually open all of the rugal folds, allowing for complete examination of the stomach and then easy passage into the pylorus and duodenum. It is important to monitor the amount of air insufflation. Overdistension of the stomach can occur, as can perforation of the stomach or small bowel. This type of accident

is more likely to occur when using the laser, since one is concentrating on the laser rather than on air accumulation in the distal viscera. Removal of the air in the stomach prior to withdrawal is important, followed by limited careful air insufflation to examine the esophagus on the way out, especially in the cervicoesophageal area. Visualized abnormalities consistent with ectopic gastric mucosa, ulceration secondary to reflux, or areas suspicious for tumor, can be easily biopsied through the flexible fiberscope. It is recommended that at least four biopsy specimens be taken from marginal areas as well as from more abnormal-appearing areas to be certain that a positive diagnosis can be obtained. Multiple brushings are also important, as cytologic examination is extremely accurate in evaluating most esophageal lesions. If a lesion is accessible to the rigid esophagoscope and biopsies with the flexible endoscope have been unsuccessful, the rigid esophagoscope does allow for larger biopsies and easier control of bleeding.

## Rigid Esophagoscopy

The rigid esophagoscope cannot be used in the face of severe spinal arthritis or large osteophytes. A laryngoscope (17.5 cm) or short esophagoscope (30 cm), however, can usually be introduced to visualize difficult-to-examine areas in almost all of these patients. On occasion, one cannot pass a rigid esophagoscope through the cricopharyngeus muscle in a severely kyphotic patient, especially in someone who has a full complement of teeth or a small lower jaw. Rigid endoscopes are extremely easy to use in children. Problems, however, with a small jaw, trismus, and congenital cervical deformities would preclude its use. Positioning for the rigid endoscopy in a child is not very difficult; however, the positioning as described is mandatory with the advancement of the endoscope down the esophagus of an adult. The head would have to be flexed, then flattened and angled to the right.

At times, the passage of the rigid or flexible esophagoscope under general anesthesia can be impaired by a collapsed lower jaw, the tongue, or the larynx. A forward lift on the jaw by grasping inside the lower alveolar ridge with the thumb and an index finger under the chin frequently allows the esophagoscope to pass easily. On occasion, the balloon on the endotracheal tube is inflated too much for passage of the esophagoscope and must be lowered. If these two areas of unnatural obstruction are not recognized, struggling occurs and there is an increased risk of perforation.

## Instrumentation for Foreign Body Removal

A variety of foreign body removal instruments are available for the flexible and rigid endoscopes. Suction devices and water jets can be used with either form of instrumentation. The water jet may be helpful in breaking up trichobezoars or large meat impactions inside an achalasia sac. The largest suction devices are available with rigid endoscopes with a suction trap for collecting a specimen. All of the foreign body instruments available for the flexible fiberscope can be used with the rigid endoscope, and the flexible fiberscope can be passed through some of the rigid ones. There is a variety of foreign body instrumentation available for flexible fiberscopes. These instruments are certainly worth having and using, for example, foreign body baskets. forceps, and balloons. There is also a foreign body hood available. This is a rubber umbrella hood that fits over the end of the fiberscope or the rigid endoscope that can be advanced with the hood flattened against the endoscope. The hood can be everted by passing it into the stomach and coming back through the distal esophageal sphincter or it can

be everted at one of the other constrictions. Once the foreign body hood is everted, a sharp foreign object can be shielded during removal. Sharp foreign objects can be removed from the stomach or esophagus, or both, using this hood. Everting the hood without passing a sharp foreign object would seem most prudent. Such an eversion is possible with the addition of a suture along the distal margin of the hood. This suture can be held loosely with a forceps through the instrument channel, and once eversion is needed the foreign body forceps can be advanced out of the end of the endoscope, thus everting the hood. Flexible overtubes for fiberscopes are also available, which increase the ability of the flexible fiberscope to manage a sharp foreign body in the esophagus or stomach. These flexible overtubes are available in a variety of sizes. Their introduction, I believe, would be easier under general anesthesia. However, they can be introduced quite easily under local anesthesia with sedation and do provide a conduit into which a sharp object can be withdrawn. The flexible endoscope can then be introduced and removed multiple times with minimal trauma to the patient in the case in which a flexible instrument is used for a large impaction. The flexible overtube is an excellent device as long as one realizes that mucosa can be trapped in the passage of the overtube. The safest way to pass the overtube is with the advancing flexible fiberscope. This means that one can see everywhere the overtube goes. This would be especially appropriate in a situation in which one did not want to accidentally dislodge or disrupt or move a sharp foreign body. Biplane or C-arm fluoroscopy can help to determine a three-dimensional relationship of the instrumentation and the foreign body.

## Special Uses

Flexible and rigid endoscope equipment and treatment potential is quite diverse. There are electrocautery devices, laser fibers, sclerotherapy needles, and so on. If one is interested in the "nuts and bolts" of endoesophageal lasing, I suggest reading the article by Fleischer and Kessler and the viewing of the recommended video. If one is interested in stenting esophageal cancer or stenoses I would suggest reading about a variety of techniques.

Flexible and rigid esophagoscopes can be used through gastrostomy openings. Retrograde esophagoscopy with the flexible endoscope is easiest. When a string cannot be swallowed from above to allow for retrograde dilatation in severe stenosis, the retrograde passage of a polytetrafluoroethylene (Teflon)-coated wire and the threading of a string, will usually be possible, precluding the need for an open procedure. A flexible or a rigid endoscope, or both, can be used through the gastrostomy site to retrieve a swallowed string. The need for using this technique has diminished. Fortunately, with the control of caustic substances, the incidence of severe caustic ingestion in children has been reduced. The incidence of suicide attempts for adolescents, adults, prisoners, and the mentally impaired, however, has not diminished. It is this latter group that has the most severe injury, which may necessitate retrograde dilatation (severe strictures are usually conical on the bottom and flat on the top; thus they are easier to dilate from below).

The videos suggested in the references should be viewed.

## Types of Foreign Bodies Removed in the Endoscopy Suite

Whether a foreign body is removed under general or local anesthesia depends on the patient and the foreign body. Intubations with the patient awake and advances in anesthesia

technique make the use of general anesthesia the physician's or patient's choice. There are come situations in which general anesthesia with good muscle relaxation is obligatory. Sharp foreign object removal is facilitated by this method. Edges of sharp foreign objects frequently can be rotated safely or advanced into the end of the rigid endoscope and withdrawn. Sharp foreign bodies that cannot be withdrawn because of potential for perforation can be advanced into the stomach, air insufflated, and the object rotated and brought out with the point trailing. A trailing point will not cause perforation, especially if the foreign body is not held so securely that it cannot freely move during extraction. Once a sharp foreign body has its edge trailing, it can be safely withdrawn. If the flexible endoscope is used, the sharp foreign object, regardless of what it is, could be withdrawn within a foreign body hood or in an overtube. The foreign body hood provides a larger protective area than do most rigid endoscopes or overtubes. Version of a sharp object in the stomach is facilitated by the administration of air. Air should be insufflated into the stomach, distending it beyond the size of the sharp foreign body. Endoscopic version in the stomach in a child is extremely easy with a rigid endoscope. In an adult, it is not so easy and if version is required, it would be simpler with a flexible endoscope. The best visualization of any foreign object allows for an analysis of the object and the formulation of a plan for removal. Ideally, a matching object would be practiced upon prior to the administration of general anesthesia. In most situations, a comparable foreign body can be created. This practice session will allow the choice of the proper foreign body instrument. The expertise of the endoscopist or the equipment available should never be the limiting factor in foreign body removal. Large, sharp foreign bodies are not a good first case and would best be left to an experienced endoscopist. It is possible that an experienced endoscopist would look, make one attempt, and recommend surgical removal if an obvious risk of perforation or additional perforation would be created by endoscopic removal of the object. It would be helpful to read Jackson and Jackson's description of the removal of sharp foreign objects in the 1950 edition of *Bronchoesophagology*. Their technique hints are exhaustive and invaluable, in particular their suggestions on the removal of a jack. A jack lodged in the esophagus can also be an airway emergency. The jack should be grasped with an instrument that allows free movement. The instrument should be applied to one of the balls, not the points, and then with the jack freely floating with the child under complete relaxation, the jack usually is safely removed without rents.

## Razor Blades

Razor blades are either single- or double-edged. Their ingestion frequently is a suicide attempt. If they lodge in the esophagus and if they hold up in the stomach, they should be removed. If a razor blade cannot be withdrawn inside a rigid endoscope or inside a foreign body hood, on occasion, they can be gently advanced into the stomach from which they may pass (general anesthesia with relaxation is mandatory). Most razor blades are too large to fit inside a rigid endoscope. Endoscopic scissors and bending devices are extremely awkward. If fractured or cut, razor blades provide two sharp foreign bodies instead of one. I prefer flexible endoscopic removal under general anesthesia with air insufflation and a foreign body hood or a flexible overtube that will protect the esophagus during withdrawal. If this cannot be done, the razor blade is advanced into the stomach with a magnet or a soft red catheter (no force). It is not unreasonable to have to remove a sharp object from the stomach with a simple gastrostomy. If removing the foreign body with the endoscope is going to create a laceration, this would be the best approach.

Once a foreign body is removed, the esophagus should be examined in its entirety to be certain that a second foreign body is not retained. Pathologic areas that are not secondary to foreign body irritation should be brushed or biopsied, or both. Endoscopic dilatation of a stricture could also be performed safely if there was no evidence of severe esophagitis. Endoscopic dilatation, of course, would be done with fluoroscopy for balloon positioning or for determining the trajectory of other types of dilators.

Underlying pathologic conditions should be no surprise. Prior esophagography should alert one to endoscopic abnormalities.

## Button Batteries

Litovitz's article on button batteries as potentially dangerous foreign bodies should be read carefully. Button batteries are readily available too children in calculators, clocks, hearing aids, and cameras. They vary in size from approximately 11 to 23 mm. The largest diameter batteries are about the size of a quarter and are the most worrisome. Radiographically, the disc batteries are relatively easily identified. On the anteroposterior or lateral view, a double image is projected. The history should alert one to the possibility of a button battery ingestion. Most button batteries can produce solutions with a pH greater than 12. They contain up to a 45 per cent solution of alkaline electrolyte. Injuries occur from pressure and liquefaction necrosis. Disc batteries can contain mercury. Systematic toxicity can theoretically occur from mercury. One low mercury level has been observed in an ingestion of a mercury-containing button battery. So far, mercuric oxide cells have been associated with more severe injuries. The suspicion of a button battery ingestion or any ingestion should be evaluated by x-ray studies. If the foreign body is lodged in the esophagus, it should be removed. Button batteries, in particular, should be removed expeditiously from the esophagus at the earliest convenience and should not be allowed to sit. Once the button battery has passed into the stomach, periodic x-ray monitoring may be used until passage occurs. Cathartics may help speed the passage of the battery. One battery has lodged in a Meckel's diverticulum and caused a perforation. Lodgement in the gastrointestinal tract with the development of symptoms such as pain, tenderness, or guarding would warrant surgical intervention.

Ingested button batteries that have lodged in the esophagus have a high incidence of complications. In most situations in which severe complications have occurred, the history of ingestion and symptoms of dysphagia, fever, lassitude, and vomiting were ignored. Seven cases of severe burns as a result of battery ingestion have been reported. Two of the children died of massive exsanguination secondary to aortic rupture associated with perforation at the site of foreign body lodgement (one child died within 3 hours of the ingestion). Two patients required colon interposition and one required a partial esophagectomy. It is apparent that it would behoove us to have battery manufacturers improve the integrity of the battery system so that leakage is less likely. It would also be important to alert button battery users to the possibility of this as a new, potentially lethal, foreign body. Button batteries can easily be removed with the rigid endoscope with standard instrumentation or with a flexible endoscope with a basket. Most batteries are also magnetic. Remember, the double shadow could be a button battery and then again, maybe it could be two coins. If there is any doubt, it would seem appropriate to look directly and remove it. A blind extraction with a balloon technique in the face of the suspicion of a button battery injury would be a mistake, as there is a need to know if a burn exists.

## Caustic Agent Ingestion

The same "need to know" exists in almost all caustic agent ingestions. Symptoms of drooling, pooling, dysphagia, and odynophagia require laryngoscopy, esophagoscopy, and possible bronchoscopy to determine the extent and severity of injuries. Evaluation of injuries in children are usually amenable to rigid endoscopy. The rigid endoscope gives a better view of the hypopharyngeal-cricopharyngeal area. In adults, a combination of rigid and flexible esophagoscopy is appropriate. Regardless of the instrument, caution should be used at a circumferential burn. If a significant burn is present, the patient requires treatment with steroids and antibiotics. In this situation, one may want to pass a nasogastric tube or a string, or both. Passage through a circumferential burn to examine the entire esophagus and stomach is *probably* safe with a pediatric flexible esophagoscope. This is controversial and should be performed by an experienced endoscopist. Air insufflation can cause perforation.

The lack of oral cavity or oropharyngeal burns does not preclude esophageal burns. If a significantly caustic or acidic substance - in particular, a Clinitest tablet - has been ingested as shown by the history, esophagogastroscopy should be performed to delineate the severity of injury and to remove the residual.

If significant hypopharyngeal burns are noted circumferentially with a flexible fiberoptic nasopharyngolaryngoscope, significant injury beyond might be assumed, and in this case antibiotics and steroids would most likely benefit the patient.

Caustic ingestion in adults is usually a suicide attempt, and there is a greater level of injury than in children.

Fortunately, labeling and public education have reduced the number and severity of caustic injuries. Placing potent cleaning solutions in wine bottles and soda bottles is still commonplace enough to be of note. Recently nine adults drank from a wine bottle containing a cleaning solution in sequence during a wine "chugging" activity and suffered severe caustic injuries.

Bleach ingestion is associated with a minimal risk of esophageal injury, and in most cases of bleach ingestion esophagoscopy is not indicated.

## Complications

Complications from careful endoscopy should be extremely rare. Laryngeal edema or esophageal edema, or both, secondary to manipulation in the postcricoid area or esophagus should be transient and should resolve within 48 hours. Airway complications from esophagoscopy should also be rare. They can occur if a foreign body is missed and passed over in a mucosal fold and pushed against the soft common tracheoesophageal wall. If such an incident occurs, removal of the esophagoscope will usually relieve the airway obstruction. Most patients should have the trachea intubated and the esophageal foreign body removed in order to prevent airway compromise. This type of situation can be predicted by the severity of the symptoms prior to the attempted foreign body removal and presence of the foreign body in the upper portion of the esophagus. A rigid endoscope is usually best for these foreign bodies. We use a Forbes esophageal speculum or a 13 x 30 cm Jesberg style of

esophagoscope. The dreaded complication of an esophageal perforation can occur as a result of a foreign body, the manipulation of a foreign body, or as a result of instrumentation without any pathologic condition.

Foreign bodies cause perforation in approximately 1 of 100 cases. Perforation from instrumentation should occur more commonly. Reports of perforations with a flexible fiberscope are lower than those with the rigid esophagoscope. With the advent of laser use and more invasive flexible fiberendoscopic procedures, this rate is going up. In the past, the rigid instrument was used for the worst-case scenario. This is the predominant explanation why more perforations have been associated with its use. In the combined statistics of the Jackson Clinic, the incidence is less than 1 in 3000 esophagoscopies. Rigid endoscopy was used predominantly. Now a combination of rigid and flexible endoscopy is performed. From 5 to 10 per cent of perforations can occur with high-pressure pneumatic dilatation for achalasia. National statistics show approximately 0.9 per cent.

Instrument perforation most commonly occurs in the cervicopostcricoid area behind the cricopharyngeus muscle or in one of the pyriform sinuses. It is imperative that direct visualization of the cricopharyngeus muscle be positively made before advancing the esophagoscope. If visualization cannot be achieved, a lumen finder may be helpful (with or without fluoroscopy). Positioning is of utmost importance with the rigid endoscope. The presence of osteophytes, dentition, or a small jaw may make it impossible to perform rigid esophagoscopy. Introducing the flexible esophagoscope can also be difficult in some situations. Flexible esophagoscopes can be passed over a radiopaque guidewire passed into the stomach under fluoroscopy. Rigid esophagoscopes can sometimes be passed over nasogastric tubes confirmed, as in the stomach, by auscultation or fluoroscopic guidance, or both. I perform most rigid esophagoscopies under general anesthesia. In this situation, relaxation with atracurium facilitates easy passage of the rigid instrument. Instrument injuries with the rigid esophagoscope, I believe, are less common in a fully relaxed state. Struggling, the need for force, or failure to visualize a distal lumen should alert one not to proceed. With the advancement of the rigid esophagoscope, the head must be dropped in order to advance into the thoracic esophagus and eventually into the stomach. The head must be low in relation to the torso and the head must be angled to the right in most situations to enter the stomach. Regardless of the instrument used, perforations can occur in areas of natural constriction or abnormality. Cervical osteophytes make it more risky for perforation, as would a diverticulum, reflux esophagitis, ulceration, a postsurgical anastomosis that is fresh (8 weeks or less), and tumors or strictures that cannot be seen through. If a distal lumen cannot be identified with fluoroscopy or a radiopaque guide, instrumentation through the site of abnormality should be discontinued until the situation can be corrected or a safer approach outlined.

The most common sites of perforation in order of frequency are (1) cervical, (2) thoracic, and (3) hiatal. Purely cervical or abdominal perforations have a lower morbidity rate than do thoracic perforations. The mortality rate for cervical and abdominal perforations in most series is 23 to 25 per cent. Thoracic perforations are associated with a 40 to 45 per cent mortality rate. If the perforation is recognized within 24 hours of its occurrence, the mortality rate drops from 45 to 24 per cent.

When it is believed that perforation has occurred, it is my belief that the morbidity and mortality can be reduced even further by aggressive and expectant management. A dye

contrast study, usually barium, should be administered immediately to rule perforation in or out. Within minutes, or at least within several hours of the time of the perforation, broad-spectrum antibiotics can be administered. I prefer clindamycin and tobramycin. The administration of the antibiotic does not in any way alter the development of fever or discomfort in the area of the perforation. The administration of steroids, however, might alter the appearance of fever and the white cell count but not the pain. Once an area of leakage has been identified, it should probably be drained regardless of the suspected minimal nature of some perforations. With this early management - drainage and patching - if possible, perhaps the mortality and morbidity statistics will improve. There is no question that thoracic perforations are fraught with greater morbidity and mortality. Every thoracic perforation should probably be drained or patched, or both, in an attempt to prevent catastrophic complications.

Cervical perforations can be drained through the neck. The incision is made anterior to the sternocleidomastoid muscle, a tunnel is made into the area of perforation, and fascial planes are opened as low or as high as needed. Multiple drains should be used. If there is not too much inflammation and the opening can be patched, it should be. Drainage alone, however, allows for closure in most of these situations. Patients should be monitored with periodic x-ray films to look for progression. On occasion, mediastinitis will develop, and chest tubes will have to be inserted in addition to cervical drainage. For some distal thoracic perforations, chest tubes, thoracotomy, and an abdominal procedure to patch a large rent are needed. Cervical and abdominal esophageal perforations are relatively easily managed because of easier access. The cervical and abdominal perforations have a lesser incidence of morbidity and mortality as long as they are recognized early.

An uncomplicated esophagoscopy, for whatever reason, should be done as an outpatient procedure. Feedings should commence whenever the patient is no longer under the influence of the topical anesthetics, sedation, or general anesthesia. Any patient in whom perforation is suspected should be admitted and monitored in the fashion previously described. If a perforation is missed, usually within 6 to 8 hours of the time of the procedure, the patient will experience of odynophagia, chest pain, abdominal pain, neck pain, fever, and neck crepitation, evidence of mediastinal air, or evidence of peritoneal irritation. If one suspects a perforation, the house officer on call should be instructed to proceed with a chest x-ray study or dye study of the esophagus, or both, to be certain that this most dreaded complication is not missed.

Suppurative complications of perforation are less severe because of modern antibiotics. However, there is no substitute for early recognition. Most patients with perforations still die of suppurative complications or vascular erosions, or both.

Other ways of treating esophageal perforations have been recorded, and transoral irrigation along with drainage is one of them. There is no harm in administering transoral irrigation in the face of a drain. This is done frequently for fistulas occurring after major head and neck surgery - some of them are rather low and it indeed helps. This should not be the sole means of treatment, however. The irrigant used by Santos and colleagues consisted of continuous normal saline, 50 to 75 mL/hour. They used it in cervical and thoracic esophageal perforations with good results. Proper active drainage is required at the site.

Antibiotic therapy alone with careful monitoring is risky but may suffice in highly selected cases.

Penetrating foreign bodies were reviewed by Remsen and colleagues. They described all 321 reported cases, and their conclusions are worthy of careful review. All of the foreign bodies that caused perforation also caused symptomatology. The symptoms included voice change, dysphagia, odynophagia, wheezing, coughing, increased salivation, and tracheal aspiration. Most of the perforations were intraluminal, that is, the foreign body remained predominantly within the lumen. Forty-one of the 321 cases were extraluminal, that is, they had migrated outside the esophagus. Most of the perforations occurred in the 0- to 10-year age group. The most common objects causing perforation were bones, pins, coins, dental appliances, wooden sticks, and jackstones (six-pronged metal pieces). The site of penetration for both the intraluminal and extraluminal foreign bodies was highest in the cervical esophagus followed by the upper thoracic esophagus and then the oropharynx. The overall mortality rate was 45 per cent. Intraluminal penetration of foreign bodies carried a mortality rate of 56 per cent, whereas those that migrated extraluminally carried a mortality rate of 14 per cent. Sharp, pointed objects were associated with the greatest mortality and, in order of decreasing frequency, included meat bones, jackstones, safety pins, wooden sticks, coins (only non-sharp ones), fishbones, straight pins, and chicken bones. Mortality was greater when perforation was in the thoracic area. Vascular accidents were the most common cause of mortality, followed by diffuse suppurative processes.

It is apparent that the occurrence of a penetrating foreign body in the upper aerodigestive tract places a patient at significant risk for a life-threatening complication. All patients with a history of a suspected foreign body should have direct endoscopic examination, and if a breach of mucosa is detected, the patient should be placed on prophylactic systemic antibiotics. If the intraluminal penetrating foreign body is removed, close observation for several days is appropriate. If a foreign body is not detected through routine radiographic examination, a CT scan may be needed to detect a possible extraluminal object that may require surgical removal. Patients with a history of a foreign body that was not found and in whom hemoptysis develops, should have an arteriogram to exclude a vascular injury.

Most ingested foreign bodies are passed. All those that lodge in the esophagus should be removed with the proper technique. The longer a foreign body is left, the more likely perforation is to occur. A sharp foreign body object is more likely to penetrate than a smooth one; however, smooth ones are not exempt if they are left long enough. Every person suspected of a foreign body ingestion should have x-ray studies performed, including a posteroanterior and lateral soft tissue x-ray film of the neck, chest, and abdomen. Missing a lodged foreign body can be a disaster. The longer the foreign body is lodged, the harder it is to remove. Barium may be required.

Esophageal perforations occur at a reasonable frequency in patients who have pneumatic dilatations for achalasia (5 to 10 per cent). The tears can be mucosal or transmural, with or without bleeding. Not all esophageal perforations occur as a result of ingested foreign bodies or instrumentation. A more realistic view of esophageal perforations is given by Goldstein and Thompson in their evaluation of 44 patients with a total of 50 esophageal perforations constituting a 15-year experience. Fifty per cent of the perforations were a result

of instrumentation - nine resulted from bougienage, five resulted from endoscopy alone, six resulted from Mosher balloon dilatation, one resulted from endotracheal intubation, and one resulted from a Sengstaken-Blakemore tube. Iatrogenic perforation intraoperatively added five more cases, and the remainder were the result of spontaneous perforation from trauma - two cases were penetrating trauma, three cases were blunt trauma, two cases occurred from caustic agent ingestion, one case resulted from foreign body ingestion, and one case was a Zollinger-Ellison patient with an incarcerated parahiatal hernia. The patterns of these perforations were 27 per cent cervical, 54 per cent intrathoracic, and 19 per cent intra-abdominal - a distribution very similar to those from instrument perforation only.

Of all foreign bodies ingested, it is estimated that 80 per cent pass without any manipulation. Large foreign bodies, in addition to those lodged in the esophagus, should be removed endoscopically as long as their removal can be safe. Endoscopic removal of large foreign bodies can sometimes be extremely difficult. Large, sharp foreign objects are probably best removed surgically. A foreign body greater than 2.5 cm in diameter and 5 cm in length will probably not pass through the gastrointestinal tract and should be removed endoscopically if it is not extremely sharp.

The ingestion of coins and a variety of other objects is more common in children. Meat is the most common foreign body in adults. Safety pins used to be one of the most common foreign bodies in children, but the incidence has dropped. One should, however, read the Jackson and Jackson descriptions of removal of safety pins, as this object remains one of the more difficult to remove safely.

Other complications of peroral endoscopy can occur from introduction of the rigid esophagoscope or bronchoscope, or both. If the proper technique is not used, the lip can be inadvertently impaled against a tooth and lacerated (either the upper or lower lip). A tooth could be loosened, dislodged, or fractured, and if the eyes are not protected from the instruments, corneal abrasion can occur. Lacerations of oral cavity, oropharyngeal and hypopharyngeal mucosa can also occur from any endoscopic manipulation that is slightly rough, including laryngoscopy for intubation. Accidental esophageal intubation with endotracheal tubes or intentional esophageal intubation with esophageal airways can also cause pyriform sinus lacerations and cervical perforations.

When endoscopy is performed under general anesthesia, the eyes are taped shut and a cloth towel is carefully draped around the eyes and secured to prevent accidental injury. With the patient awake, the eyes are not taped shut, but a cloth towel is placed over the eyes and the patient is instructed to keep the eyes closed during the procedure to prevent instrument injury.

A rubber tooth protector for the upper dentition acts only as a reminder to avoid the teeth with the rigid instruments. It is best that it have a string attached so that it is not easily displaced into the oro- or hypopharynx. A plastic oval mouth prop must be placed between the teeth or gums for the introduction of fiberscopes. This mouth prop can traumatize dentition or the lip but is obligatory to protect the fiberscope.

If an obvious dental injury occurs, it is suggested that responsibility for the injury be readily and immediately conveyed to the patient and family. Financial responsibility for the

correction of the problem should be immediately assumed. In most instances, this precludes a major complaint, since on occasion dental injury can occur even in the most experienced hands.

Dental injuries frequently occur in areas of already abnormal dentition. It is important prior to the introduction of endoscopes to examine the dentition and place the endoscope appropriately to avoid teeth at risk. It is also important to suggest to the patient that teeth might be damaged because of their poor condition prior to the time of endoscopy.

If a patient is without dentition, the endoscopy is easier. However, injuries to the alveolar ridge can occur from undue pressure. When a patient is edentulous, we use wet gauze wrapped with Telfa to help protect the upper alveolar ridge and the upper lip. Lip injuries are best prevented by a continuous monitoring of the endoscope and frequent checks with the index finger to be certain that the lip is not becoming inverted.

When using suction in the esophagus, it is important that a velvet eye suction be used rather than open-ended suction. In the majority of cases, this will provide adequate suction power with less suction trauma to the mucosa. When greater suction power is required, for example, in removing large meat impactions or in clearing an achalasia sac, open-ended suction of a very large diameter with high suction power is a requisite for a rapid removal. Care must be taken to be certain that the suction is applied to the center of the food bolus.

Perforations of the esophagus do not necessarily always result from the esophagoscope but rather from brushes or biopsy forceps passed through these instruments. Too vigorous a biopsy, too large a biopsy forceps, or too much force in passing a brush can cause perforation, especially in the obviously abnormal situation.

If the airway is not protected prior to evacuation of large food boluses and salivary accumulation, aspiration of the contents of the esophagus is a risk. This should not occur in a general anesthesia situation if an intubation with the patient awake is used prior to the general anesthesia.

## Diagnostic and Therapeutic Considerations

## in the Larynx, Nasopharynx, and Tracheobronchial Tree

A complete examination of the larynx should be performed before entrance to the tracheobronchial tree. If there is no abnormality seen on the head and neck examination in the office, flexible fiberoptic bronchoscopy alone may be perfectly adequate for diagnosis and treatment of some tracheobronchial disorders.

### Types of Examination

*Laryngoscopy* for vocal cord motion is a procedure performed with the patient awake. Laryngoscopy for diagnosis and delineation of lesions is best performed under general anesthesia - intubation with a small endotracheal tube is safest and can be performed with the patient awake and sitting, by flexible fiberoptic bronchoscopy, or by routine methods, depending on the situation. The laryngoscopy should be systematic. One examines the oral

cavity, valleculae, pyriform sinuses, postcricoid area (the Holinger style anterior commissure scope is inserted to the level of the cricopharyngeus muscle and is withdrawn slowly), endolarynx, and subglottic areas. The laryngeal surface of the epiglottis is difficult to examine with all methods. The Holinger style laryngoscope is inserted to or through the vocal cords with slow withdrawal; anterior neck pressure helps (this maneuver is also necessary for biopsies of the laryngeal surface of the epiglottis). Viewing the cricopharyngeus muscle with the laryngoscope identifies the trajectory for the esophagoscope. Palpation of the nasopharynx, base of the tongue, pre-epiglottic space, oropharynx, and oral cavity should be performed at the completion of endoscopy and after biopsies to prevent bleeding; it may identify a submucosal lesion requiring biopsy. Palpation of the pre-epiglottic space is best done with one finger in the vallecula and another on the anterior portion of the neck.

*Nasopharyngoscopy* is performed with No. 16 French red catheters through the nose to retract the palate. A mirror defogged with soap film and reflected light from a head light gives good visualization for direct-view biopsies.

*Bronchoscope* using the peroral or pernasal flexible bronchoscopic technique is really quite simple. Topical anesthesia can be applied just as described for the office head and neck examination. When applied to the larynx it can be administered through the suction channel of the bronchoscope. Topical anesthesia can be instilled directly into the larynx with great accuracy. Additional topical anesthesia can be administered to the trachea and then to the left and right main bronchi. In the majority of situations, this amount of topical anesthesia is adequate for the entire procedure. Prefiberoptic sedation can be given with midazolam or fentanyl citrate and atropine, just as in esophagoscopy. On occasion, atropine may dry up the bronchial secretions, so saline may have to be instilled to obtain adequate bronchial washings.

With the flexible fiberoptic bronchoscope, the tracheobronchial tree to the fourth-, fifth-, and some sixth-order bronchi can be examined with a great deal of ease. The rigid endoscopes cannot provide this type of complete examination unless a flexible fiberscope is used through them. Fiberoptic bronchoscopy should be combined with rigid laryngoscopy and tracheoscopy and rigid and flexible esophagoscopy and nasopharyngoscopy when performing endoscopy for tumors of the head and neck, lung, and esophagus. The use of the rigid bronchoscope with the angled telescopes might approach some first-, second-, and third-order bronchi, but not fifth- or sixth-order bronchi. The flexible fiberscope allows needed peripheral access. It can be used for brushing of endobronchial lesions under fluoroscopy. A C-arm or biplane fluoroscope allows localization of a brush within a small peripheral mass, yielding the greatest number of abnormal results. Proximal masses usually have an endobronchial presentation that is readily brushed or biopsied. To perform endoscopy on a patient for a peripheral mass that is 2 cm or smaller is probably not of value, but one might expect an abnormal result from brushing in 40 per cent of these cases. If the mass is greater than 2 cm, the percentage of abnormal results from a brushing approaches 95 per cent.

Passing the flexible fiberoptic bronchoscope through an endotracheal tube (which can be slipped in with the bronchoscope) prevents multiple removals of the fiberscope through the mouth or nose during the procedure. This allows for better retention of the specimen. I like this method best when brushing and biopsying because I do not like to use a smaller sheathed type of brush that gives a smaller specimen. The sheathed brushes can be withdrawn through the endoscope channels and retain the specimen better than non-sheathed brushes.

Multiple manipulations through a rigid bronchoscope are much easier. If oxygen must be administered during flexible bronchoscopy, a double-swivel attachment can be applied to an endotracheal tube and the flexible fiberscope passed through a rubber dam. Nasal cannulas are also helpful. A patient with an unstable medical condition should always receive oxygen during bronchoscopy and should always have cardiac and oxygen saturation monitoring. Bronchoscopy may need to be done with anesthesia standby in the very ill patient.

The common endotracheal-endobronchial findings associated with bronchitis, tumors, and stenosis are well described in several excellent atlases. The bronchoscopy books by Stradling, Oho, and Ikela are superb atlases that will allow you to recognize almost any endobronchial disease. The techniques of flexible fiberoptic bronchoscopy are best learned by doing them after reviewing the anatomy of the tracheobronchial tree. A few examples of segmental and bronchial anatomy are included in this chapter for your perusal. The Jackson Huber classification is probably the simplest and is used by most.

Anything more than a flexible bronchoscopy, that is, panendoscopy (nasopharyngoscopy, rigid and flexible esophagoscopy, palpation flexible bronchoscopy, and rigid laryngoscopy) should be performed with general anesthesia for patient comfort.

Flexible bronchoscopy is performed using check-points. The first check-point, of course, is the carina, and each subsequent major branching is another. Endoscopic checkpoints, pathologic characteristics, and therapeutics can all be learned as part of a residency training program and can be supplemented with several excellent videos that are listed for your consideration in the references. Either the rigid bronchoscope or the flexible endoscope can be used for transtracheal biopsy. There is an excellent video by Dr. Bernard Marsh (Johns Hopkins) that uses the Millrose system of Wang needle type biopsies of the common areas of carinal and pericarinal adenopathy. The technique of transbronchial biopsy is also well described in this video. Following the guidelines of Dr. Marsh, transtracheal and transbronchial biopsies can be performed safely. Transbronchial biopsies should be done in the periphery to prevent excessive bleeding. The incidence of pneumothorax or bleeding from such invasive procedures is extremely low.

The advent of the sheathed culture devices has improved collections when performing endoscopy for uncommon alveolar diseases. In the immunocompromised transplant patients and in patients with acquired immunodeficiency syndrome (AIDS), an alveolar lavage with these devices may offer the best cytologic and culture results.

As with esophageal brushings and biopsies, the amount of tissue that can be removed with a flexible fiberscope is limited in most situations unless a laser is used. Bronchial brushings and cytologic examination are much more accurate in most situations than are bronchial biopsies. A bronchial biopsy in an abnormal-appearing area may, however, show submucosal infiltration of tumor, whereas a brushing would not. A brushing, in an area of bronchial biopsy, may yield an abnormal result.

Lasers that can be transmitted through fibers easily pass through a flexible bronchoscope. We use a larger bronchoscope, that is, one with a 2.6-mm suction channel. It can be used transorally or transnasally for the administration of the neodymium-yttrium aluminum garner (Nd-YAG) or argon laser. I prefer to use the flexible fiberscope through a

clear PVC (polyvinylchloride) tube or through a rigid bronchoscope, or through both. It takes less time to administer laser therapy with a rigid bronchoscope.

Rigid endoscopes used for Nd-YAG or argon laser therapy have ventilation ports distally that allow for ventilation of the opposite lung when the bronchoscope is in one or the other main bronchus. Adequate ventilation can be given with this method even without a venturi-system, simply by packing the hypopharynx with moist vaginal gauze. A racine adapter is attached to the rigid endoscope and the patient is ventilated in a routine fashion. This negates the need for an endotracheal cuff attached to the rigid bronchoscope. Ventilation is easily maintained with the flexible fiberscope through the rubber dam on the rigid endoscope. In an adult, a 7.5- or 8.5-mm bronchoscope can be used without difficulty. When the laser is used, safety precautions must be instituted. Special anesthesia techniques are required to reduce the oxygen concentration to less than 50 per cent. Nitrous oxide should not be used, as it is also combustible. Controlling the oxygen in the inspired air makes it difficult to create a torch. Being certain that the laser fiber is out of the end of the endoscope when the laser is fired prevents accidental ignition of the fiberscope. Everyone in the room, including the patient, should be wearing frequency-specific eyewear protection. In the case of the Nd-YAG laser, this would be green glasses with an optical density of approximately 6. Orange-yellow glasses are required for the argon. If the flexible fiberscope is used through an endotracheal tube, the tube should have no markings and should be clear and the cuff should be inflated with saline. The Nd-YAG and the argon lasers will pass through a clear PVC tube. Continuous cardiac and oxygen saturation monitoring should be used throughout any laser procedure. The rigid bronchoscope should be used for the worst-case scenario. The rigid bronchoscope provides better access for large biopsies, bleeding control, and airway management. With the rigid endoscope inserted beyond a tumor obstruction, the airway can be cleared and maintained intermittently while the tumor is being removed with laser coagulation and forceps. The oxygen concentration must also be controlled in this situation to prevent the creation of a torch. Nitrous oxide, once again, should not be used, as it is combustible.

If the $CO_2$ and Nd-YAG laser combination is the preferred treatment for whatever endotracheal or endobronchial condition, the flexible fiberscope can be passed through the $CO_2$ rigid bronchoscope, which allows administration of the Nd-YAG laser. Rigid endoscopes specifically designed for Nd-YAG laser use have portholes that make it easier to ventilate the opposite lung. When operating in one or the other main bronchus, $CO_2$ bronchoscope systems, because of the optical systems required to transmit the laser, cannot have conventional ventilation ports. Older $CO_2$ bronchoscopes have no ports. Newer ones have ports angled at 45 degrees so that the beam cannot escape but air can.

## Intubation

The flexible fiberoptic bronchoscopes, that is, the small adult and large child sizes, can be passed through an endotracheal tube as small as a No. 6. Flexible fiberoptic intubation is a technique easily performed in the difficult intubation, preferably with the patient awake, under local anesthesia, and sitting up in a "sniff" position. The more prone the patient, the more difficult the intubation. For an elective fiberoptic intubation, we use cocaine or 4 per cent lidocaine mixed with 0.25 per cent neosynephrine or 1 per cent ephedrine in both sides of the nose for topical anesthesia and mucosal shrinkage. The oral cavity and oropharynx are

sprayed with benzocaine. A nasal airway trumpet of soft rubber is chosen, the same size as the endotracheal tube, and viscous lidocaine is applied to the outside of the nasal airway before introduction into the side of least resistance. The nasal airway is left in place for a few minutes and then the endotracheal tube that was chosen is inserted through the nose into the nasopharyngeal area. After application of a silicone emulsion spray, the flexible fiberscope is passed through the endotracheal tube with the endotracheal anesthesia adapter still attached. A nasal tube is longer than the oral tube. One must be certain that the nasal tube is, in an adult anyway, at least 28 cm in length. Once the fiberscope is inside the endotracheal tube, the fiberscope can be negotiated through the nasopharyngeal curve and topical anesthesia applied to the larynx and tracheobronchial tree. Once this has been completed, the endotracheal tube can be advanced toward the level of the larynx over the flexible bronchoscope (the endotracheal tube may not traverse the nasopharyngeal curve without the bronchoscope as a guide). The bronchoscope can then be passed through the vocal cords to the level of the carina, and the bronchoscope will then act as a guide for the passage of the endotracheal tube into the airway. As the bronchoscope is withdrawn, the position of the endotracheal tube above the carina can be confirmed.

An endotracheal tube can also be inserted, using a similar technique, through the oral cavity. The angulation, however, is more acute and not as direct. Positioning for both of these techniques plays an important role in the ease of the fiberoptic intubation.

Because of the "Murphy eye" (ventilation side port) on most endotracheal tubes, fiberscopes inadvertently passed through the port can be badly damaged because of extreme angulation.

In a patient who has severe obstruction with a bilateral vocal cord paralysis, arytenoid fixation, subglottic tumor of cartilage origin, or an obstructing carcinoma in which some force might be required to pass an airway, an oral intubation with a metal guidewire under mirror guidance might be safer or a rigid bronchoscopic intubation if the patient is not cooperative enough for a local tracheotomy in an awake state.

The flexible fiberscope, that is, the smallest adult one, can actually pass through a No. 5 endotracheal tube with a reasonable amount of lubrication. The smaller the fiberscope, the less likely that the suction channel will be powerful enough to provide a suction for a fiberoptic intubation. An alternative to using the fiberscope for suction is the passage of a flexible catheter through the opposite side of the nose or the use of tonsil suction in the oral cavity. Using these methods for removing unwanted secretions, even the smaller fiberscopes can be used for even smaller tubes, allowing for flexible fiberoptic intubation of children and possibly even neonates. The small flexible endoscopes available for examination in the pediatric situation can be passed down very small tubes and can be used instead of x-ray studies to confirm the position of endotracheal tubes and tracheostomy tubes, just as the fiberscopes can be used for these purposes in adults. It is interesting to note that a fiberscope, which is approximately 5 mm in diameter (smallest adult), will not pass through anything smaller than a No. 6 Shiley tracheotomy tube. If one tries to force it through anything smaller, the fiber bundles can be broken. It is possible in this situation to pass the fiberscope through the mouth or nose and lower the tracheotomy cuff if bronchoscopy is absolutely required.

## Other Bronchoscopic Techniques

The flexible fiberscope can be passed around most endotracheal tubes to examine the tracheobronchial tree. If one is performing panendoscopy, the flexible fiberscope can be passed through the endotracheal tube or around the endotracheal tube. The smallest endotracheal tube that we recommend so that the patient ventilates adequately during the performance of this procedure is a No. 7. A double-swivel adapter with a rubber dam allows for easy passage of the bronchoscope. If one is lasing with an endotracheal tube in place, a No. 8 or No. 8.5 is needed, as the fiberscope used is larger.

A rigid bronchoscope can also be passed around an endotracheal tube. In adults, the rigid endoscope can be passed easily beside a No. 7 endotracheal tube and the tracheobronchial tree examined, even though in a limited fashion.

If panendoscopy is performed with the flexible fiberscope through the endotracheal tube, a complete examination of the trachea can be performed when the patient is extubated with the fiberscope in place. An alternative to this method is examination of the subglottic area and the area above the endotracheal tube cuff with a telescope or fiberscope, or both.

There is no question that the flexible fiberscopes have revolutionized the visualization and diagnosis of conditions of the tracheobronchial tree. They certainly have not replaced the use of rigid bronchoscopy, however.

## Foreign Body Removal in Children

Foreign bodies of the lung in children must be removed for safety purposes with a rigid bronchoscopic system that allows for adequate ventilation during the removal of the foreign object. Telescopes with attached foreign body forceps, that is, optically guided foreign body forceps, make foreign body removal easier. A variety of foreign body instruments are available from Karl Storz Endoscopy - America. The variety available from Pilling Company is quite extensive and is the most complete of any rigid system; however, they are not optically guided.

It is important that the removal of foreign bodies in infants and children be performed with the least amount of endolaryngeal-endotracheal trauma. The cricoid area in the child is small and the bronchoscope chosen must easily pass through this area. The largest allowable endoscope actually makes the foreign body removal easier. Rigid telescopes of varying sizes can be used to gauge the actual cricoid size and may help in the choice of the rigid bronchoscope. Just the right size should be chosen to allow for easier foreign body removal and yet not cause trauma to the larynx, trachea, or bronchi.

The small flexible fiberoptic bronchoscopes with a suction channel can be used in children for diagnostic purposes; however, their use for removal of foreign bodies in young children is fraught with potential disaster. Some of the flexible foreign body instruments that are available for adult endobronchial foreign body removal can be used through the rigid endoscope and may facilitate the removal of some of the more difficult foreign bodies such as peanuts. A basket may work better on a peanut than a peanut forceps. The basket may surround the peanut without fragmenting it. An older child could have a foreign body

removed with the flexible fiberscope.

## Rigid Bronchoscopic Intubation

The rigid bronchoscope may be the only way too have successful resolution of the most difficult airway management problems. Obstructing lesions of the larynx or trachea require bronchoscopic intubation, as other means would be impossible. The rigid bronchoscope (without the laryngoscope) can be easily introduced with local or general anesthesia using the same positioning.

Once a rigid bronchoscope is introduced if there is a leak around the obstruction, the oropharynx-hypopharynx can be gently and effectively packed with moist vaginal gauze to create an adequate seal for ventilation. Once the bronchoscope has been introduced, an orderly tracheotomy can be performed as needed. If a tracheotomy was not the intent of the intubation but rather endobronchial or endotracheal debulking with the laser, the rigid bronchoscope can be intermittently passed beyond the tumor during the lasing to maintain a clear air passage and provide adequate ventilation. The use of the rigid bronchoscope with the flexible fiberscope through a rubber dam is a most effective and efficient system for the administration of the Nd-YAG laser.

## Recognition of Foreign Bodies

Recognizing foreign bodies that have lodged in the air passages is sometimes difficult; however, when obstructive emphysema occurs on the side of the obstruction, recognition is relatively easy. Obstructive emphysema can also occur on a lobar or subsegmental basis. When the obstruction is incomplete during inspiration and expiration, no x-ray evidence of the foreign body may be visible unless the foreign body is opaque. If air passage is limited to inspiration, obstructive emphysema occurs. Air can go into the obstructed lung but not to come out. Sometimes edema around the foreign body prevents air from going in and coming out. In this situation, collapse can occur distal to the foreign body.

A foreign body in the airway should be suspected by the history. A history of choking and coughing should alert one to the possibility of such an ingestion. Peanuts, food, and just about anything else a child can get his or her hands on could be aspirated into the tracheobronchial tree. An x-ray film taken of the neck, chest, and abdomen will help in the isolation of the foreign body. Foreign bodies lodged in the esophagus usually align parallel to the spine, whereas foreign bodies in the airway lie perpendicular to it. This is especially important for the evaluation and localization of coins that are ingested or aspirated, or both. Sometimes a foreign body will be suspected when a decubitus film is taken in both directions. The dependent lung should have less aeration than the dependent one. If this aeration pattern is reversed, a foreign body can be suspected. If the foreign body is not radiopaque but suspected, a bronchoscopy should be performed. If the foreign body is not found but continues to be suspected, a CT scan may be necessary.

## Foreign Body Removal Technique

All foreign bodies in the tracheobronchial tree can be removed with the rigid endoscope. The rigid endoscope can be used with the patient under topical anesthesia with

sedation, with cardiac and oxygen monitoring, or with anesthesia standby. Many patients tolerate this well. Rigid endoscopy can also be safely performed under general anesthesia. The rigid bronchoscope can be introduced very easily after the anesthesiologist has induced the patient in a standard fashion. Once the anesthesiologist has prepared the patient, the bronchoscope is ready for introduction and is easily passed through the larynx into the trachea. The rigid bronchoscope may be introduced with or without a sliding laryngoscope. Once the bronchoscope is in position above the carina, the hypopharynx can be gently packed with moist vaginal gauze and an adequate seal achieved (spontaneous ventilation can also be used). With the glass occlusive cover on the end of the bronchoscope, ventilation can proceed while the C-arm is brought in for the difficult foreign body removal and while the foreign body forceps that have been previously chosen to extract the foreign body are handed to the endoscopist.

Most foreign bodies that have not been previously manipulated are visible and can easily be extracted. If the foreign body is beyond visibility, biplane fluoroscopy or a C-arm fluoroscope that can be rapidly rotated can isolate the foreign body in more than one plane so that one can be sure that the foreign body is properly grasped and further peripheral dislodgement will not occur.

There have been descriptions of foreign body balloons being passed beyond esophageal and bronchial foreign bodies, inflated, pulled back with the foreign body atop them into the end of the rigid endoscope, and extracted with the endoscope. This method may bring the foreign body into view for an easier grasp with the foreign body forceps, but this method cal also dislodge the foreign body into a less accessible area. It would seem that fluoroscopic extraction of a foreign body would be safer. Grasping the foreign body securely, with it at the tip of the endoscope or within the endoscope, is the best method of removal. Depending on the foreign body and its length of lodgement, baskets, balloons, and forceps available for the flexible fiberscope may not help. In this situation, foreign body forceps, available only for rigid endoscopes, must be employed. There are a variety of straight and angled magnets and angled forceps for upper lobe foreign bodies. There also are a variety of forceps that expand bronchi to grasp foreign body forceps that can be inserted inside a cylindric object and opened to remove the foreign body. Pilling Company will make a foreign body forceps for a particular foreign object. If a foreign body is identified and characterized and its position studied, the foreign body forceps constructed, and the simulated foreign body practiced upon, the real foreign body can be removed successfully.

It would be extremely rare that a foreign body could not be removed by using rigid endoscopic techniques. On occasion, I suppose, if the foreign body has embedded itself in a peripheral bronchus or had caused a perforation and the bronchial wall had sealed over, surgical intervention might be indicated. An extremely sharp object that cannot be removed without bronchial damage should be removed, of course, with the vessels under direct control. Most sharp foreign bodies can be removed as shown. The most common foreign bodies in children are nuts, and dental objects are most common in adults.

## Special Considerations

There are some special situations in the tracheobronchial tree that require mention. Good judgment is always indicated in managing tracheobronchial conditions. *Broncholiths* are

calcified concretions that may be a reaction to local chronic inflammation, but they are more likely related to extrabronchial calcified lymph nodes that have eroded through a bronchus and present endobronchially. When examining the tracheobronchial tree, such an endogenous foreign body can be confusing. It is not uncommon for it to be misconstrued as a piece of aspirated bone. When the source of this calcified material seems unlimited, a careful examination of the granulation tissue in the area of the calcified concretion may reveal a bronchial rent. Continued manipulation in the area could be fraught with a vascular disaster. In this situation, if a CT scan has not been obtained prior to the bronchoscopy, one should be obtained, or the previous one should be re-examined in terms of the relationship of the calcified lymphadenopathy to the blood vessels and the tracheobronchial tree. The treatment of this condition is open surgery.

"Panendoscopy" for trauma can be fraught with disaster. Direct laryngoscopy, nasopharyngoscopy, and bronchoscopy, regardless of trauma, are relatively safe once the airway is managed. Esophagoscopy, however, may not be. A dye contrast study is the best method of evaluating the esophagus in a trauma situation. Esophagoscopy in this situation may increase or create an additional rent.

When using the *laser* in the tracheobronchial tree, the lumen should always be visualized in the distance or at least imagined. Once again, the use of fluoroscopy and a radiopaque arterial embolectomy catheter can indicate the proper direction for lasing. Inflating the arterial embolectomy catheter in a bronchus can debulk the endobronchial presentation of the tumor, limiting the need for a long lasing procedure.

Bronchial and tracheal concretions, hemorrhage, tumor, clots, and thick secretions are best removed with a rigid bronchoscope. The suction power is much greater with this device than with the flexible fiberscope.

The larger flexible fiberscope used for the administration of Nd-YAG laser therapy has a 2.6-mm suction channel that is occasionally adequate for some of these conditions.

## Laryngeal Foreign Bodies

Foreign bodies in the larynx are usually coughed up our or removed with some other life-saving measure prior to arrival at the hospital. The current guidelines for management of foreign body obstruction of the airway are delineated for adults, children, and infants in the June 6, 1986 issue of the Journal of the American Medical Association. Foreign body obstruction of the airway accounted for approximately 3100 deaths in 1984. It is for this reason that foreign body airway obstruction should be considered in the differential diagnosis in any victim (especially if in the younger age group) who suddenly stops breathing, becomes cyanotic, and falls unconscious for no apparent reason. The presentation is exhaustive and its description should be part of one's library.

If an adult or child survives a foreign body in the larynx and comes to the emergency room, they may require endoscopy to check for residual damage or foreign body. If a laryngeal foreign body is partially obstructive or chronic in nature or acute with a partially obstructed airway, it can best be managed in an endoscopy suite in the operating room with an anesthesiologist and anesthesia appropriate for the age of the patient. A child can be

induced for a brief laryngoscopic examination with removal of the foreign body with spontaneous breathing of halothane and oxygen. An adult with a laryngeal foreign body that is nonobstructive may tolerate removal with only sedation or topical anesthesia, or both. Some small foreign bodies in the larynx can be removed in the adult patient with flexible fiberoptic instruments in the office.

Recurrent supraglottitis should be considered to be caused by a foreign body until proved otherwise. Subglottic foreign bodies should also be suspected in recurrent croup.

## Complications

Complications from foreign body removal occur mostly in children. A bronchial perforation is uncommon; if a perforation appears imminent as a result of the removal of the foreign body, open surgery should be the technique used, not endoscopy.

Subglottic edema and tracheobronchial edema are especially worrisome when they occur in a child, but they usually can be managed with humidification and, on occasion, steroid and antibiotic therapy.

The presence of a foreign body in a bronchus or in the trachea for a long period can cause scarring and stenosis requiring dilatation or surgical intervention, or both.

Most airway foreign bodies are recognized relatively soon after aspiration. However, chronic recurrent focal atelectasis, pneumonitis, or wheezing should make one suspect a foreign body in a child. Foreign body aspiration can also make asthma worse.

In an adult, one should suspect an obstructing cancer in the face of persistent pneumonitis, atelectasis, or wheezing. A foreign body would be a second choice as the cause. Adult-onset asthma is usually cancerous or cardiac in origin.

Once a foreign body is removed from the lung, a look on the opposite side is obligatory, just as a look at the esophagus after the removal of one foreign body is appropriate. Sometimes there are two or three foreign bodies instead of one.

Foreign bodies residing for long durations in the lung can erode through a bronchus and cause focal areas of bronchiectasis and hemorrhage that may, at some point, require a partial lung resection.

One special word here about iatrogenic foreign bodies. Portions of endoscopes, foreign body instruments, foreign body balloons, and laser fibers can become foreign bodies. It is best to prevent these iatrogenic foreign body occurrences. However, once they do occur, they can be interesting removal problems. Fluoroscopy may be needed. The flexible fiberscope can be used through an expanded thoracocentesis site to extract a lost piece of catheter.

Patients should have nothing by mouth for 6 to 8 hours if possible before bronchoscopy or esophagoscopy, or both.

## Discussion

Some foreign bodies of the lung are coughed up and swallowed. Most esophageal foreign bodies are passed through the gastrointestinal tract without complication. On occasion, a foreign body lodges in the distal bowel. Flexible fiberoptic instruments with overtubes and foreign body forceps are also available for extraction at these distal sites.

The only failures in foreign body removal should be the ones in which an experienced endoscopist retreats because the risks of removing the foreign body by endoscopy are greater than those associated with an open surgical approach.

General anesthesia is a safe way to manage the airway. If it is used judiciously, complications are extremely rare. Performing a difficult endoscopy in an endoscopy suite outside the operating room with sedation is potentially fraught with disaster. An endoscopy suite that will allow removal of esophageal and tracheobronchial foreign bodies should ideally be part of an operating room, with anesthesia, rigid and flexible endoscopes, and a variety of foreign body instruments and fluoroscopy easily at hand. At the Jackson-Norris Center in Philadelphia, we are fortunate to have one of the most complete endoscopy suites.

All medication and anesthesia references and dosages are taken directly from package inserts.