The transmission of a recognizable image through a flexible fiber-optic bundle was first reported by Hopkins and Kapany in 1954.¹ Three years later, the flexible fiber-optic gastroscope was introduced. In 1967, Murphy reported the first tracheal intubation assisted by fiber optics, using a choledochoscope.² The practice of “flexible fiber-optic bronchoscopy” was introduced by pulmonologists the following year.
With few anesthesiologists having the skill to use or teach the technique, the specialty was slow to introduce the device into clinical practice. Ovassapian and Roberts, pioneers in the teaching of modern airway management techniques, developed methods for teaching fiber-optic-assisted tracheal intubation that could be introduced to all anesthesiology residents. However, even those teaching programs did not immediately gain widespread application because of a shortage of faculty with significant experience using fiber-optic devices.

Nevertheless, by the early 21st century, the specialty of anesthesiology had fully embraced fiber optics and anesthesia residents should be thoroughly trained in use of flexible airway fibroscopy. Residents completing their training should be skilled with video laryngoscopes and flexible fiberscopes, as well as with traditional airway devices such as pharyngeal airways, supraglottic airways, and rigid, direct laryngoscopes.

The current format of a standardized training program in fiber optics is presented each year at the annual meeting of the American Society of Anesthesiologists (ASA) and has been reviewed by Gil in Anesthesiology News. The ASA Workshop is an excellent opportunity for practicing anesthesiologists who did not receive fiber-optic training during their residency to learn the required skills to introduce fiber optics into their practice.

Technology of Flexible Fiberscopes

Significant advances in the technology of airway devices over the past 15 years have provided anesthesiologists with many new tools for airway management. Some devices, most notably video laryngoscopes, have reduced the need for tracheal intubation with a flexible fiberscope. However, many clinical situations still exist for which fibroscopy is indicated. As a result, every anesthesiologist should be skilled in the use of the technology.

Two types of flexible fiberscopes now are available for clinical use: optical and video (or “chip”) scopes. An optical fiberscope has an imaging bundle composed of several thousand individual fibers. The size and resolution of the image is directly dependent on the number of fibers in the imaging bundle. The smaller the fiber bundle, the smaller the image.

Video fiberscopes contain a charge-coupled device chip but lack an imaging bundle. The image is generated electronically and displayed on a color monitor. Video fiberscopes produce a wide-angle, high-resolution image of the airway and are much more useful than optical scopes for patients with airway trauma or airway tumors. Although a camera can be placed on the head of an optical scope, the limitations of the optical imaging bundle—narrow field of view and reduced resolution—remain. The flexible video laryngoscope is especially useful for teaching, as the trainee and teacher can see the image simultaneously. As manufacturers develop smaller and better video fiberscopes, optical fiberscopes undoubtedly will become obsolete.

The important physical feature of the flexible fiberscope is its ability to conform to the patient’s airway rather than the patient’s anatomy having to conform to the instrument. All direct laryngoscopes require some deformation of the patient’s tissue to obtain line-of-sight visualization of the larynx. The line of sight is achieved in most patients by depressing the tongue and sublingual tissue into the submandibular space. The greater the force required for line of sight, the greater the likelihood of injury to the upper airway. Fragile dentition, dental malocclusion, micrognathia, lingual tonsillar hyperplasia, and reduced mandibular mobility are some of the abnormalities that may make rigid, direct laryngoscopy difficult and require the use of a flexible fiberscope.

The other application of flexible airway fibroscopy is for awake tracheal intubation. If rendering the patient unconscious prior to intubation may result in life-threatening airway obstruction that is not amenable to standard airway techniques, or cervical trauma requires immobilization of the neck, awake tracheal intubation may be the safest method of managing the airway. Video laryngoscopes may reduce the indications for awake tracheal intubation, but do not eliminate them. The flexible fiberscope also is a useful tool for diagnosis when the precise cause of the airway abnormality is unknown or the site of obstruction is undetermined. The flexible fiberscope is the only airway device that allows the anesthesiologist to examine the inside of the tracheobronchial tree or the inside of another airway device, such as a supraglottic airway or tracheal tube. Video laryngoscopes cannot be used to visualize the inside over tracheal tubes or supraglottic airways, and cannot visualize the airway beyond the glottic inlet.

The main disadvantage of the flexible fiberscope with respect to emergent airway management is that it is not a ventilation device. If the patient requires ventilation prior to tracheal intubation, it must be provided with another device, such as a laryngeal mask airway.

Clinical Indications for Flexible Airway Fibroscopy

Flexible fiberscopes offer distinct advantages over other airway devices in several clinical situations involving management of the airway (Table 1).

Table 1. Indications for Flexible Airway Fibroscopy

<table>
<thead>
<tr>
<th>Indication</th>
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<tbody>
<tr>
<td>Awake tracheal intubation</td>
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<tr>
<td>Changing an endotracheal tube</td>
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<tr>
<td>Confirmation of tracheal tube position</td>
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<tr>
<td>Diagnosis of upper airway pathology</td>
</tr>
<tr>
<td>Difficult direct laryngoscopy</td>
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<tr>
<td>Position confirmation of supraglottic airways</td>
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</table>
**Awake Tracheal Intubation**

The flexible fiberscope is small and much better tolerated by the patient than a rigid laryngoscope blade. The working channel in the fiberscope permits the administration of topical anesthetic directly to the larynx, trachea, and bronchi. The fiberscope can be used for orotracheal or nasotracheal intubation. The key to success with any awake intubation is a comfortable patient. Good topical anesthesia with light sedation renders a patient comfortable but cooperative. Some patients may want to follow the progress of the intubation on the monitor.

**Difficult Tracheal Intubation**

The scenario from the ASA Practice Guidelines for Management of the Difficult Airway that best fits this situation is the *can ventilate, cannot intubate* situation. When conventional direct laryngoscopy fails, fiberoptic-assisted intubation has been shown to be an effective first-choice technique. Direct, rigid laryngoscopy may be difficult for many reasons, some of which are congenital and others acquired (Table 2).

**Diagnosis of Airway Pathology**

In many cases, the precise cause of airway difficulty is unknown. Flexible fibroscopy can be used to diagnose the problem and provide important information for airway management.

**Positioning of Supraglottic Airways**

Supraglottic airways are designed for blind insertion and placement. However, malpositions do occur and may endanger the patient. Examination with a flexible fiberscope through the airway provides a rapid assessment of the accuracy of positioning.

**Confirmation of Tracheal Tube Position**

Chest radiography has been the standard for confirming the position of a tracheal tube. Yet obtaining a chest radiograph is time-consuming and exposes the patient to potentially harmful radiation. Fiberscopic confirmation of tracheal tube position is quick and eliminates the risks associated with radiation.

**Changing of a Tracheal Tube**

Tracheal tubes can be changed using several techniques. The selection of a particular method depends on the likelihood that the patient will lose his or her airway in a given situation; no method is foolproof, but some are safer than others. A tracheal tube in a patient with a normal anatomic airway can be changed with little risk using conventional direct laryngoscopy. A change in a patient with upper airway pathology that precludes direct laryngoscopy carries a substantially greater risk for a lost airway. Tube changers can be used, but this is a blind technique and is associated with both lost airway and bronchial perforation. The flexible fiberscope with the new tracheal tube loaded onto the scope can be navigated alongside an existing tracheal tube past the tube cuff and into the trachea. After visual confirmation that the fiberscope is in the trachea, the old tube can be withdrawn and the new tube passed into the trachea.

**Clinical Cases**

The following cases illustrate important uses of the flexible airway fiberscope.

**Case 1**

A 64-year-old man with somnolence and labored breathing arrived at the emergency room. The precise cause of his airway obstruction was not known. He was immediately taken to the operating room for airway management. The upper airway was anesthetized with topical local anesthetic and a fiber-optic airway examination was performed. A large, bilobed posterior pharyngeal mass was seen (Figure 1). The fiberscope was advanced through the glottis and an endotracheal tube was passed over the fiberscope and into the trachea. A tracheostomy was performed.

**Case 2**

A 72-year-old man with stridor was brought to the operating room for a diagnostic laryngoscopy. An awake fiber-optic examination was performed that revealed

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**Table 2. Conditions That May Cause Difficult Direct Laryngoscopy**

<table>
<thead>
<tr>
<th>Condition</th>
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<tbody>
<tr>
<td><strong>Congenital</strong></td>
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<tr>
<td>Glycogen storage disease</td>
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<td>Goldenhar syndrome</td>
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<tr>
<td>Klippel-Feil sequence</td>
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<tr>
<td>Mucopolysaccharidosis (Hunter and Hurler syndromes)</td>
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<td>Pierre Robin syndrome</td>
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<td>Treacher Collins syndrome</td>
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<tr>
<td><strong>Acquired</strong></td>
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<tr>
<td>Burn scar contractures</td>
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<tr>
<td>Decreased cervical mobility</td>
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<tr>
<td>Fragile dentition</td>
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<tr>
<td>Intralaryngeal tumors</td>
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<tr>
<td>Lingual tonsil hyperplasia</td>
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<tr>
<td>Mandibular ankylosis</td>
</tr>
<tr>
<td>Morbid obesity</td>
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<tr>
<td>Supraglottic tumors</td>
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Figure 1. A large bilobed posterior pharyngeal tumor. The epiglottis is at the top of the picture.

Figure 2. Laryngeal cancer.

Figure 3. Blood clot overlying an endobronchial tumor in the right mainstem bronchus.

Figure 4. Malignant right endobronchial tumor.

Figure 5. Left vocal cord polyp.

Figure 6. Hypertrophied lingual tonsils depressing the epiglottis.
A diffuse laryngeal carcinoma (Figure 2). Because the glottic inlet was of normal size, a 7-mm tracheal tube was inserted, the patient was anesthetized, and multiple laryngeal biopsies were taken.

Case 3

A 62-year-old man with known bronchial carcinoma—but who had refused all treatment for the tumor—developed an ischemic leg and was brought to the operating room for a femoral embolectomy. Because the patient was taking blood thinners, regional anesthesia was contraindicated. The preoperative chest radiograph revealed a completely opacified right chest cavity. After an IV induction and tracheal intubation, a fiber-optic examination of the trachea was performed. A large clot overlying the endobronchial tumor was observed (Figure 3). Because the patient was anticoagulated and a bronchial carcinoma was underneath the clot, suctioning of the airway was not performed.

Case 4

A 65-year-old man with a chronic dry cough was scheduled for laryngoscopy and bronchoscopy under general anesthesia. Fiber-optic examination of the airway demonstrated a right endobronchial carcinoma (Figure 4).

Case 5

A 45-year-old woman was undergoing an abdominal hysterectomy with general anesthesia. During a routine fiber-optic-assisted tracheal intubation, an incidental vocal cord polyp on the left vocal cord was discovered (Figure 5). After surgery she stated she did have intermittent episodes of mild hoarseness. Consequently, she was referred to an otolaryngologist for further evaluation.

Case 6

A 54-year-old man scheduled for laparoscopic cholecystectomy had a normal preoperative airway examination. After an IV induction, direct laryngoscopy proved difficult and a fiber-optic-assisted tracheal intubation was performed. The fiber-optic examination revealed pronounced lingual tonsil hyperplasia (Figure 6), which has been shown to be a frequent cause of difficult direct laryngoscopy.9

Case 7

A 72-year-old man was scheduled for a femoral-popliteal bypass graft under general anesthesia. The induction was uneventful and controlled ventilation by face mask was easy. The glottic inlet was easily exposed with a 3.5 MAC laryngoscope and a 7.5-mm internal diameter tracheal tube passed through the vocal cords, but could only be advanced 3 cm. Diagnostic flexible fibroscopy revealed a tracheal web (Figure 7). A laryngeal mask airway (LMA; LMA North America) was inserted and anesthesia progressed without difficulty. Seven days later, the web was resected with a CO2 laser.

Case 8

An 8-year-old boy was scheduled for esophagoscopy. The medical history of the child, who was a recent adoptee, was unknown, other than that he had undergone a gastrostomy as a toddler because of ingestion of a caustic substance. An inhalation induction with sevoflurane and oxygen was performed without difficulty. After induction, an IV catheter was inserted. The initial laryngoscopic view is shown in Figure 8A.
a flexible fiberscope was passed through the opening (Figure 8B), the glottic inlet was visualized (Figure 8C). Figure 8D shows the hypopharynx after laser excision of scar tissue. In this case, the hypopharynx was severely scarred but the glottis was spared caustic damage.

CASE 9

A 70-year-old man had been intubated for respiratory failure. After 10 days with no substantial progress in ventilatory weaning, a percutaneous tracheostomy was scheduled to be performed in the intensive care unit. The first step for insertion of a percutaneous tracheostomy is tracheal puncture with a catheter and passage of a guide wire for dilation and tracheostomy tube passage. This can be visualized with a flexible fiberscope to assure midline positioning (Figure 9).

Conclusion

Although many new airway devices have been introduced into clinical practice, the flexible airway fiberscope is still the device of choice for many situations. Technological advances in flexible fiberoptic design have given anesthesiologists a powerful diagnostic and airway management tool. These cases illustrate the exceptional versatility of the modern flexible fiberscope. Every anesthesiologist should be skilled with its use for tracheal intubation and diagnosis of airway abnormalities.

References