Use of the Fiberoptic Bronchoscope in Airway Management.

The fiberoptic bronchoscope (FOB) is a ubiquitous instrument in anesthesia, being available to 99% of surveyed active ASA members. The technique of fiberoptic-aided intubation was first performed using a choledochoscope in a patient with Still’s disease (idiopathic, adult onset arthritis). By the late 1980s it was recognized that the use of the flexible FOB represented such a significant advancement in the management of the patient with a difficult airway that experts stated that no anesthesiologist could afford not to be facile with this technique. It is now generally accepted that for a variety of clinical situations, the FOB is a critical tool in the armamentarium of the anesthesiologist dealing with the awake or unconscious patient who is, or appears to be, difficult to intubate. The FOB has proven to be the most versatile tool available in this regard.

There is no true or firm indication for FOB-aided intubation, as there might be with direct laryngoscopy (e.g., rapid-sequence induction for the full-stomach patient). There are, however, many clinical situations where the FOB can be of unparalleled aid in securing the airway, especially if the clinician has made an effort to master the necessary skills by using it in routine intubations. These include anticipated difficult intubation due to historical or physical exam findings, unanticipated difficult intubation (where other techniques have failed), lower and upper airway obstruction, unstable or fixed cervical spine disease, mass effect in the upper or lower airways, dental risk or damage, and awake intubation. Unlike the other devices used to intubate the trachea, the FOB can also serve to visualize structures below the level of the vocal folds. For example, it can identify the placement of the tracheal tube or aid in placement of a double lumen tracheal tube. It may be helpful in diagnosis within the trachea and bronchial tree, or in pulmonary toilet.

Contraindications to FOB-aided intubation are relative, and revolve about the limitations of the device. (Table 1).

Because the optical elements are small (the objective lens is typically 2 mm in diameter or smaller), minute amounts of airway secretions, blood, or traumatic debris can hinder visualization. Care must be taken to remove these obstacles from the airway beforehand: application of intramuscular or intravenous antisialagogues (e.g., glycopyrrolate, 0.2–0.4 mg; atropine, 0.5–1 mg) will produce a drying effect within 15 minutes, but caution should be taken in patients who may not be able to tolerate an increase in heart rate. Vasoconstriction of the nose using topical oxymetazoline, phenylephrine, or cocaine reduces the chances of bleeding should this route be chosen. If an awake intubation is planned using the FOB, the patient must be able to cooperate—a “quiet” airway, with little motion of the head, neck, tongue, and larynx, is vital to success. Finally, because FOB-aided intubation of the trachea can require significant time, especially if the clinician is not facile with the device, hypoxia or impending hypoxia is a contraindication, and a more rapid method of securing an airway (e.g., LMA or surgical airway) should be considered.

**Elements of the Fiberoptic Bronchoscope.** The FOB is a fragile device with optical and non-optical elements. The fundamental element consists of a glass-fiber bundle. Each
fiber is 8 to 12 microns in diameter, and is coated with a secondary glass layer termed the cladding. The cladding aids in maintaining the image within each fiber as the light is reflected off the sidewall at a rate of 10,000 times per meter as it moves from the objective lens to the eyepiece lens in the operator’s handle. The typical intubating FOB has 10,000–30,000 such fibers encased in a 60-cm, water-impermeable insertion cord, with gradation marks every 10 cm. Though the fibers are allowed to rotate over each other throughout the length of the cord, they are fused together at the two ends in a coherent pattern; that is, the arrangement of the fibers at the eyepiece end is identical to the arrangement at the objective lens, where a diopter ring allows focusing. Therefore, one might envision that the image before the objective lens (i.e., the objective) is divided into 10,000 individual and unique pictures, which independently travel down an unwieldy cord, to be reassembled in front of the eyepiece lens. Broken fibers, which may occur because of bending of the insertion cord, entrapping the cord in other equipment, and dropping the FOB, are readily apparent and are generally no more than a nuisance until the number of broken fibers interferes with the visual field.

The insertion cord also contains a working channel: a lumen, up to 2 mm in diameter, which travels from the distal tip to the handle. It can be used for applying suction, or oxygen, and instilling lavaging fluids or drugs (e.g., local anesthetics). There is one report of gastric rupture attributed to the insufflation of oxygen through the working channel when the FOB was within the esophagus. In general, FOBS <2 mm in external diameter (e.g., pediatric) do not have a working channel.

Two wires traveling from a lever in the handle down the length of the insertion cord control movement of the distal tip in the sagittal plane. The entire insertion cord is protected by a metal “wrap” until the level of the distal tip, which is hinged for movement. Coronal plane movement is accomplished by a combined use of the control lever and rotation of the entire FOB from handle to distal end. Because the fibers are able to move over one another, except for where they are fused at the extreme ends of the optic cord, rotational control is maximized by reducing any curves in the FOB shaft.

The final element of the FOB is the light source. Illumination of the objective is provided by one or two noncoherent bundles of glass fibers which transmit light from the handle to the distal tip. The light is provided either by a “universal” cord which emerges from the handle and is inserted into a medical-grade endoscopic light source, or may be provided by a battery-operated light source on the handle.

**Preparation of the Fiberoptic Bronchoscope.** When approaching the FOB-aided intubation, one must ensure that the device is in working order. A series of inspections are made, as listed in Table 2.

**Use of the Fiberoptic Bronchoscope.** The FOB is held in the nondominant hand, the thumb over the control lever and the index finger poised over the working channel valve. The dominant hand will be used to steady and hold the insertion cord as it is manipulated in the patient. Many operators are tempted to “switch” hands, but the thumb of the nondominant hand should be capable of controlling the gross movement of the control lever. Any experienced endoscopist will recognize that the fine control required to hold the shaft of the endoscope steady, advance the objective end into the airway and make directional adjustments is where the art of endoscopy lies.

The insertion shaft is lubricated with a water-soluble lubricant, and it is threaded through the lumen of an ETT, the objective end emerging from the main ETT orifice.
clinically appropriate ETT should be chosen, but the larger the ratio between the internal diameter of the ETT and the external diameter of the insertion shaft, the greater the risk of “hangup” on airway structures, as occurs in 20–30% of attempts.

Hangup occurs when a cleft exists between these two devices because of the differential sizes. Hangup may involve entrapment of the epiglottis, corniculate/arytenoid cartilages, the aryepiglottic folds, or the vocal folds, and can occur with any number of stylet-guided techniques (e.g., fiberoptic, retrograde wire, lighted stylet, etc.) though it is most thoroughly described with fiberoptic aided intubation. The orientation of the tracheal tube bevel is important in this regard. In orotracheal intubation, the bevel is likely to entrap the right arytenoid cartilage when the ETT is in its typical concavity anterior position. Rotation of the ETT counterclockwise 90° places the bevel facing positively and improves passage. During nasotracheal intubation, the epiglottis may be entrapped, and a bevel up position (rotation of the ETT 90° clockwise) may facilitate passage.

The type of tracheal tube may also affect passage. It has been suggested that the Parker Flex-tip (Parker Medical, Cincinatti) may pass the airway structures more easily than a standard ETT bevel. The use of soft-tipped ETTs, asking the patient to inspire deeply during the ETT advancement, and the “double setup” ETT, which uses a small ETT (e.g., 5.0 id) within a clinically adequate ETT (e.g., 7.5 id) to overcome the clefts caused by size differentials have been described.

The clinician chooses the route of intubation, either oral or nasal, based on clinical requirements, surgical needs, operator experience, and other intubation techniques available should FOB-aided intubation fail. This last factor is important because should an attempt at nasal intubation fail, there may be significant bleeding hindering other indirect visualization techniques. The nasal route is considered easier by many clinicians. The differences between oral and nasal FOB-aided intubation are discussed in Table 3.

A variety of intubating oral airways (IOA) are commercially available. Their chief function is to provide a clear visual path from the oral aperture to the pharynx, keep the bronchoscope in the midline, prevent the patient from biting the insertion cord, and provide a clear airway for the spontaneously or mask-ventilated patient. The common characteristic of all IOAs is a channel along the length of the airway large enough to allow the passage of the endotracheal tube. The Ovassapian airway provides two sets of semicircular, incomplete flexible flanges which stabilize the ETT (up to size 9.0 id) in the midline but allow its removal from the airway after intubation has been accomplished so that the IOA can be removed from the mouth. The flat lingual surface of the airway gives it good lateral and rotational stability. The Patil-Syracuse endoscopic airway and the Luomanen oral airway were also designed for fiberoptic-aided intubation. Each has a central groove, open at the lingual (Patil-Syracuse) or palatal (Luomanen) aspect, which allows easy removal of the ETT. The flat lingual surface provides good stability. Though this style of IOA provides superb access to the pharynx, it is larger than other airways and is often uncomfortable for the patient. The Williams airway and the Berman airway were both designed for blind oral intubation. It is often difficult to manipulate the tip of the fiberscope when it is within these narrow airways. Both are molded plastic with a complete circular internal lumen which guides the ETT toward the larynx. These airways have a small profile and are often better tolerated by the awake patient, but tend to be less stable on the tongue. Because the internal lumen is a complete circle, the Williams airway
must be retreated off the ETT if it is going to be removed after intubation. This may pose difficulty if the ETT in use has a fused circuit adapter. The Berman airway solves this problem by being split along the length of one side. The plastic of the opposite side is thin and malleable. If the interincisor gap is adequate, the airway can be opened laterally to allow removal from the ETT.

After successful navigation through the supraglottic airway, the endoscopist visualizes the vocal folds. If glottic closure, gag, or coughing occur as the FOB distal tip stimulates the structures of the larynx, the operator can choose to apply local anesthetic through the working channel, administer more sedation, or withdraw the scope and reinforce preparatory procedures. The clinician might also decide to advance the FOB into the larynx without further preparation. The actions taken must be dictated by the individual clinical situation; in the elective scenario, for example, there may be time for reinforced airway analgesia, whereas in the face of impending respiratory arrest patient discomfort may need to be tolerated. Once the larynx is entered, the operator may choose a structure, such as the tracheal carina, to serve as an identifying landmark as the ETT is advanced. Simply because the FOB has entered the trachea, there is no guarantee that the intubation will be successful. As noted above, 20–30% of ETT advancements are accompanied by hangup. Therefore, a patient with a critical airway should not be induced with a general anesthetic with the assumption that the ETT will be easy to pass.

Once the ETT enters the trachea, the clinician may choose to view the ETT and a chosen anatomic landmark simultaneously (e.g., the tracheal carina) to assure correct ETT placement before the FOB is withdrawn.

There have been a number of variations and adjuncts to FOB-aided intubation. The reader is referred to the primary literature listed in Table 4, which is not meant to be exhaustive.

Although FOB-aided intubation is a versatile and vital technique, there are several pitfalls, most of which have been discussed. Table 5 lists the most common reasons for failure of FOB-aided intubation.

Flexible fiberoptic aided intubation is a technology intense technique. Apart from the delicate fiberoptic device, there are cameras, recorders, light sources and a variety of disposable adjuncts which are typically required. Dedicated wheeled carts, designed carry required as well as optional equipment in a functional arrangement, are available. The clinician called to manage the patient outside the operating theater may benefit from portable arrangements.
Table 1. CONTRAINDICATIONS TO FIBEROPTIC BRONCHOSCOPY

Hypoxia
Heavy airway secretions not relieved with suction or antisialagogues
Bleeding from the upper or lower airway not relieved with suction
Local anesthetic allergy (for awake attempts)
Inability to cooperate (for awake attempts)

Table 2. PREPARATION OF THE FIBEROPTIC BRONCHOSCOPE

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Finding</th>
<th>Significance and Action</th>
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<tbody>
<tr>
<td>Inspect passive angulation: Allow FOB to hang from the hand.</td>
<td>Observer deviations from “plum”</td>
<td>Angulation may signify damage to the insertion shaft. If lever controls are operative, the FOB may be usable. Excessive angulation or curvature may make manipulation difficult, disorienting the operator, so the scope should not be used.</td>
</tr>
<tr>
<td>Active angulation: The control lever is used to manipulate the distal tip</td>
<td>Does the lever control move the tip in the sagittal plane smoothly and to the extent stated by the manufacturer?</td>
<td>There may be a damaged or entrapped control wire. The device should be repaired by the manufacturer.</td>
</tr>
<tr>
<td>Apply suction to the working channel</td>
<td>No or minimal suction at distal aperture</td>
<td>Caking of secretions within channel may require cleaning by the manufacturer. Crimping of insertion cord requires repair.</td>
</tr>
<tr>
<td>Picture clarity: Observe printed writing a few millimeters in front of the objective lens</td>
<td>Foggy or dirty picture</td>
<td>The objective lens and eyepiece lens can be cleaned with a lint-free cloth. -Use a commercial defogger. -Prior to placing in the patient, warm water may prevent further fogging by equalizing the lens and patient temperatures. -Suction or oxygen insufflation -If these are unsuccessful, the FOB may need cleaning by the manufacturer.</td>
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Table 3. TECHNIQUES OF NASAL AND ORAL FOB-AIDED INTUBATION

<table>
<thead>
<tr>
<th>Nasal</th>
<th>Oral</th>
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<tbody>
<tr>
<td>Preparation</td>
<td>Antisialagogues, topical decongestant, serial dilations with soft and lubricated nasal trumpets*</td>
</tr>
<tr>
<td>ETT</td>
<td>Softened by placing in warm water. May be kept either on proximal insertion cord (near handle) or inserted† into the nose so that it is felt to turn the bend from the nasal cavity into the nasopharynx.</td>
</tr>
<tr>
<td>Structures seen</td>
<td>-Floor of nose, nasal turbinates, superior aspect of the soft palate, nasopharyngeal posterior wall, base of tongue, epiglottis (distal tip),‡</td>
</tr>
</tbody>
</table>
arytenoid cartilages, vocal folds, tracheal rings, carina

*Although phenylephrine and cocaine have been used to decongest the nose, evidence suggests that oxymetazoline may be the best agent.
†The bevel of the ETT should follow along the nasal septum, away from the turbinates. If the ETT will not turn into the nasopharynx, it may be rotated 90° in a clockwise or counterclockwise direction and readvanced.
‡An obstructing base of tongue or epiglottis can be moved by extension at the atlanto-occipital joint, jaw thrust, chin lift, or assistant pulling tongue forward.

Table 4. AIDS TO FIBEROPTIC AIDED INTUBATION

<table>
<thead>
<tr>
<th>Technique</th>
<th>Advantage</th>
</tr>
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<tbody>
<tr>
<td>Endoscopy mask</td>
<td>Control ventilation maintained during or between attempts at FOB-aided intubation</td>
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<tr>
<td>Laryngeal mask</td>
<td>Excellent view of the larynx and ability to ventilate during or between attempts at FOB-aided intubation</td>
</tr>
<tr>
<td>Fiberoptic-aided retrograde intubation</td>
<td>Guiding of the FOB with a wire known to be entering the trachea</td>
</tr>
<tr>
<td>Retrograde fiberoptic intubation</td>
<td>Changing a tracheostomy to an oral or nasal tracheal tube when antegrade intubation is difficult or impossible</td>
</tr>
<tr>
<td>FOB-aided intubation with the aid of a rigid laryngoscope</td>
<td>Helpful with an obstructing mass or large epiglottis</td>
</tr>
</tbody>
</table>

Table 5. COMMON REASONS FOR FAILURE DURING FIBEROPTIC-AIDED INTUBATION
Lack of experience: Not practicing on routine intubations
Failure to adequately dry the airway: Underdose or rushed technique
Failure to adequately anesthetize the airway of the awake patient: Secretions not dried; rushed technique
Nasal cavity bleeding: Inadequate vasoconstriction; rushed technique; forcible ETT insertion
Obstructing base of tongue or epiglottis: Poor choice of intubating airway; require chin lift/jaw thrust
Inadequate sedation of the awake patient
Hangup: ETT too large
Fogging of the FOB: Suction or oxygen not attached to working channel; cold bronchoscope