Fiber-optic Intubation: Advanced Combinations For More Success and Less Morbidity

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Expected, and particularly unanticipated, difficulty in airway management can be an unpleasant clinical challenge. However, a crucial life preserver is available: the flexible fiber-optic or endoscopic bronchoscope (FOB). The FOB has a universally well-deserved reputation for rescuing failed intubations and accomplishing its mission in extreme circumstances under the skilled guidance of clinicians—anesthesiologists, intensivists, and emergency department specialists (Figure 1).
The National Emergency Airway Registry created a prospective observational study of 7,712 patients in the emergency department requiring intubation at 30 hospitals in the United States, Canada, and Singapore. Of the total, 2.7% experienced failed attempts at rapid-sequence or non–rapid-sequence intubation (RSI or non-RSI) during rigid laryngoscopy. However, despite the superiority of fiber-optic intubation (FOI), with 120% to 180% greater success rates for airway rescue compared with other techniques, clinicians chose FOI in just 5% of cases (Table).

Why the hesitation to use FOI? Does it ever fail? The most common cause of FOI failure is associated with inadequate training. But this technique can be thwarted by lack of patient cooperation, equipment difficulties (including a scope tip exiting through the Murphy eye), and various anatomic scenarios: endotracheal tube (ETT) impingement on the arytenoids, soiled upper airway, severe periglottic abnormalities, subglottic stenosis, and other problems.

Anticipated difficulty in securing a patient’s airway or the sudden appearance of difficulty with any choice of airway device (even an FOB) should steer clinicians toward lateral thinking. Clinicians must avoid Karl Duncker’s trap of “functional fixedness,” that results in the inability to put items to new uses, secondary to a rigid mentality formed by previous experiences with the items. Lateral thinking advances the possibility of using an FOB for more than one purpose, including to assist another device.

Clinicians gradually are emerging from their 1-dimensional viewpoints to follow a similar modus operandi that has been successfully promoted in multiple areas of practice: the combination of devices or techniques to improve success rates and decrease morbidity. Think of providers employing ultrasound combinations during regional anesthetic techniques and invasive line placements, or neurosurgeons who use 3-dimensional neuronavigational systems during image-guided brain surgery. An additional benefit of pairing an airway device with an FOB is the “compound interest” that accrues to clinicians’ banks of experience.

Most, but not all, tools for airway management can be paired with an FOB. The purpose of this review is to illuminate the range of FOB combinations with a host of airway devices. The reader should assume that patients have received psychological preparation, antisialagogues, sedation, full pre-oxygenation, or supplemental oxygen (O₂), as needed. It also should be assumed that either general anesthesia (GA) or local anesthesia (LA) of the airway for awake intubation is optimally applied.

All combinations that follow can be used with both anesthetic techniques. Some will have notations whenever they are more likely to provoke adverse hemodynamic changes or reflexes. An assistant often is mandatory and duties should be fully explained prior to the technique. For simple assistance, ongoing reinforcement of instruction is often sufficient. In other

<table>
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<td>Trachlight</td>
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ETT, endotracheal tube; Non-RSI, non–rapid-sequence induction; RSI, rapid-sequence induction Adapted from reference 1.
cases, the assistant must be very capable of helping with the technique itself, patient monitoring, and/or ensuring adequate ventilation and anesthetic depth, with or without muscle relaxants. Patient positioning for FOI is usually supine, at the lowest bed level possible (a step stool may be necessary). In cases of significant dyspnea, morbid obesity, or other abnormality, a semi- or completely sitting position may be preferable.

Rigid Laryngoscope–FOB

If intubation using a rigid laryngoscope (RL) on a patient receiving LA fails, a combination RL–FOB rescue technique frequently succeeds. This joint approach typically confers the luxury of more time when performed under LA as opposed to GA.

Failed RL intubation under GA is a more serious problem, but by no means insurmountable. The clinician should follow the difficult airway algorithm; if continued oxygenation by mask is safe and possible, a combined RL–FOB approach is an excellent option—as long as the assistant is instructed and capable. In this technique, the RL acts as an airway opener to push obstructing anatomy away from the FOB (Figure 2).

The technique can be applied electively in a relatively young, healthy patient with no urgency to intubate, after informing personnel in the operating room regarding the objective to gain experience with FOI. An assistant should be available to monitor time—no more than 2 to 3 minutes are necessary—and switch to RL intubation if needed.

Nasopharyngeal Airway–FOB

The nasopharyngeal airway (NPA)–FOB assist technique can be performed in patients under any level of sedation, after obtaining prior knowledge of limiting nasal factors and instillation of mucosal vasoconstrictors (Figure 3). Lu et al described using an ordinary, soft NPA in the creation of a “breakaway” guide for FOI that virtually leads the FOB tip to the perilaryngeal area. A second technique combining NPA with bronchoscopy involves administration of oxygen, and even general anesthetics, through the nasal airway during intubation (Figure 4). This technique is more common in pediatric patients. In this case, FOI may be carried out in an unhurried manner under GA, while maintaining good oxygenation (recent studies have shown that atmospheric contamination with GA gases may occur). Holm-Knudsen et al reported on their use of this method in 19 children. FOI was performed within mean times of 55 or 120 seconds depending on whether the clinician was experienced in the technique or not, respectively. In one patient, spraying a local anesthetic during light GA resulted in a brief period of laryngospasm and desaturation with no sequelae.

Endoscopy Mask–FOB

Endoscopy masks are available in pediatric and adult sizes, and have a single port for administration of oxygen and anesthetic gases. They also have a port with an insertion diaphragm wide enough to accommodate both an ETT and an FOB (Figure 5). The “ETT-occluded” diaphragm permits spontaneous or controlled GA ventilation, while an assistant maintains airway and anesthetic vigilance. This mask can assist awake FOI in

Figure 2. Tips for performing the combined rigid laryngoscopy–fiber-optic bronchoscope technique.

- Ensure that end-tidal O₂ levels are close to 96%.
- Have the FOB assessed and loaded with a smaller-than-usual ETT.
- Lift the mask.
- Attempt laryngoscopy with the RL to obtain the optimal view as quickly as possible.
- Carefully position the assistant’s hands to maintain the RL position to perform FOI.
- Insert the FOB into the oropharynx until the larynx is visible.
- Advance to 2 to 3 rings above the carina.
- “Railroad” the ETT with the Murphy eye anterior, into the trachea.
- Secure the ETT when seen just above the carina; inflate the cuff; remove the RL and FOB.
- Check the ETT for correct positioning (end-tidal carbon dioxide, bilateral breath sounds, etc. Note: Under LA, laryngoscopy and intubation with an RL is more stimulating than with an FOB).
- Success is more likely with an ETT having a centrally curved tip (eg, Parker or Endotrol). If both team members are experienced using an RL and FOB, switching positions is unnecessary.
- An intubating oral airway may be inserted, but only if there is room in the oropharynx.
patients requiring continuous positive airway pressure or higher levels of oxygen.

The endoscopy mask–FOB technique can be used to perform nasotracheal FOI, but the alignment of the diaphragm port with the patient’s nasal passage may pose problems (Figure 6). If the ETT and the FOB are inserted simultaneously, decreased maneuverability of the scope may impede nasal passage entry because of a misleading tube direction and/or the short distance from the port to the nostril.

During surgery with general anesthetics, the oral approach with this combination can be used in young, healthier patients to examine the oropharynx, larynx, or trachea to gain knowledge of the anatomy or for FOI. However, patients must be sedated sufficiently to avoid response to stimulation of sensitive structures.

Bronchoscopy Adapter–FOB

A bronchoscopy swivel adapter is a connection that can be used for FOI. It is placed between the ventilation system and either the patient’s mask or a supraglottic airway (SGA). For intubation purposes, its flip-cap diaphragm port permits entry of a pediatric FOB having a loaded Aintree catheter (4.7 mm internal diameter, 6.3 mm external; Figures 7 and 8). Spontaneous or controlled ventilation is possible after entry, while the FOB is advanced to the larynx. Only under rare circumstances—using a pediatric scope and small ETT—would passage of the ETT and the FOB through a swivel adapter be anything but a struggle.

If the glottic opening or tracheal diameter is too small to accommodate the ETT over the catheter, the patient can be ventilated with the Aintree once its 15-mm adapter is attached (if exhalation is observed) until a definitive airway is placed. Alternatively, a wire approximately 100 cm long, threaded through the working channel of the scope, could be advanced in a manner similar to that of the Aintree–FOB unit. The remainder of the technique would be similar except
For patients receiving GA, use mask straps, induce, and establish adequate ventilation and anesthetic depth under 100% oxygen.

For patients receiving LA, use mask straps and apply oxygen and/or continuous positive airway pressure as required.

Insert an intubating oral airway and replace the mask.

Be prepared to use LA liberally to reduce stimulation if only GA was used.

Insert the lubricated ETT-loaded FOB simultaneously through the diaphragm.

Perform FOI as described previously.

Assistant Duties
- May need to hold the mask steady for the clinician.

**Figure 5. Oral approach to intubation combining an endoscopy mask with fiber-optic bronchoscopy.**

ETT, endotracheal tube; FOB, fiber-optic bronchoscope; FOI, fiber-optic intubation; GA, general anesthesia; LA, local anesthetic

Steps are similar to the oral approach, except:
- Insert the lubricated ETT-loaded FOB alone through the port to enter the nasal passage.
- Advance the scope until the larynx is visible.
- Continue advancing and at some point insert the ETT past the diaphragm.
- Once through the glottis until just above the carina, continue FOI.

**Figure 6. Nasal approach to intubation combining an endoscopy mask with fiber-optic bronchoscopy.**

ETT, endotracheal tube; FOB, fiber-optic bronchoscope; FOI, fiber-optic intubation

For GA, use mask straps, induce, and establish adequate ventilation and maintain depth under 100% oxygen.

For LA, use mask straps and administer oxygen and/or continuous positive airway pressure as needed.

An intubating oral airway can be inserted and the mask replaced.

Be prepared to use local anesthetic liberally to reduce stimulation, if only GA is used.

Insert lubricated Aintree and pediatric FOB unit through the swivel adapter.

Advance the FOB to the larynx and down the trachea until immediately above the carina. Advance the Aintree until immediately above the carina and hold in place securely.

Remove the scope, mask, swivel adapter, and ventilation system.

Insert an ETT-loaded FOB through the Aintree until immediately above the carina, then slide the ETT into the trachea until visible; hold securely.

Remove FOB and Aintree.

Assistant Duties
- May need to hold the mask steady for the clinician.

**Figure 7. Common face mask approach with swivel adapter–fiber-optic bronchoscope.**

ETT, endotracheal tube; GA, general anesthesia; FOB, fiber-optic bronchoscope; LA, local anesthetic
• Steps are similar to the face mask approach (Figure 5), except:
  - For GA, induce, insert the SGA, and establish adequate ventilation and anesthetic depth under 100% oxygen.
  - For LA, insert the SGA and administer oxygen and/or continuous positive airway pressure, as needed.
  - Continue similar steps until the Aintree is immediately above the carina.
  - Hold the Aintree securely and remove the FOB, leaving the Aintree protruding from the SGA by way of the swivel adapter.
  - Disconnect the SGA from the ventilation system.
  - Maintain pressure on the Aintree to prevent it from being dislodged.
  - Slowly withdraw the SGA sufficiently to firmly grasp the Aintree in the patient’s mouth.
  - Remove the SGA, leaving the Aintree in place.
  - Insert an ETT-loaded FOB through the Aintree and follow intubation steps similar to the face mask approach (Figure 6).
  - If ventilation must be continuous, after disconnecting a “large enough” SGA, perform FOI with an ETT-loaded FOB down the Aintree, in the SGA.
  - Remove the FOB and Aintree; maintain pressure on the ETT with a pusher rod or slightly smaller tube to prevent the ETT from coming out; slowly remove the SGA until the ETT is grasped in the mouth.

• Assistant Duties
  - May need to hold the SGA steady for the clinician.

Figure 8. Supraglottic airway approach with swivel adapter-fiber-optic bronchoscope.

ETT, endotracheal tube; FOB, fiber-optic bronchoscope; GA, general anesthesia, LA, local anesthetic; SGA, supraglottic airway

• Lubricated ETT should be tested for passage through all SGA prior to use.
• For patients receiving GA, induce, insert the SGA, and establish adequate ventilation and anesthesia under 100% oxygen.
• For patients receiving local anesthesia, insert the SGA and administer oxygen and/or continuous positive airway pressure as needed.

Be prepared to use local anesthetic spray liberally if none has been given.
• After obtaining a good respiratory waveform, disconnect the SGA from the ventilation system.
• Insert a lubricated ETT-loaded FOB through the SGA until the glottis is visible.
• Once in the trachea, advance the FOB until immediately above the carina and perform intubation.
• After the ETT is visible above the carina, hold it securely, remove the FOB, and confirm ventilation through the tube.
• Remove the ETT 15-mm connector.
• Maintain pressure on the ETT with a pusher rod or slightly smaller tube to prevent the ETT from coming out while removing the SGA.
• Slowly withdraw the SGA sufficiently to firmly grasp the ETT in the patient’s mouth, remove the pusher device and the SGA, leaving the ETT in place.
• Assistant Duties
  - May need to hold the SGA steady for the clinician.

Figure 9. Combining fiber-optic bronchoscopy with an intubating supraglottic airway.

ETT, endotracheal tube; FOB, fiber-optic bronchoscopy; GA, general anesthesia, LA, local anesthetia; SGA, supraglottic airway
that a much smaller ETT should be used in accordance with the size of the patient’s laryngeal and tracheal anatomy.

**SGA–FOB/Intubating SGA–FOB**

The laryngeal mask airway (LMA, LMA North America) is particularly useful when patients cannot be intubated with RLs but need to be ventilated for prolonged periods. When the LMA was initially released, clinicians realized that a correctly placed device could be a conduit to lead a bronchoscope to the larynx. This knowledge has resulted in countless intubation recoveries.

The LMA Fastrach is an intubating SGA with a single elevation bar instead of aperture bars. Once the position of the Fastrach is optimized, intubating blindly is advised by guiding the second component, a silicone ETT with a soft, centrally directed tip, through the SGA. The success rate of this method ranges from 90% to 96.2% with 3 attempts or adjusting maneuvers. Not surprisingly, the success rate of FOI through the SGA component is nearly 100% (Figure 9).

More recently, different manufacturers have designed many SGAs and intubating SGA devices, including the air-Q (Cook Gas; Figure 10), Ambu Aura-I, AuraOnce (Ambu), Cobra PLA (Pulmodyne, fpc), and i-gel (Intersurgical). All of these have the characteristic of facilitating the passage of increasingly larger ETTs up to 8 mm. However, multiple aperture bars of some of these devices may impede passage of an ETT. For SGAs with aperture bars, successful intubation is more likely with ETTs of smaller diameter, such as the Micro-laryngeal Tracheal Tube (Covidien), whose cuff size is equivalent to an 8.0-mm ETT.

To gain experience, clinicians should use the FOB to insert the SGA devices into the oropharynx under direct vision rather than placing them blindly, and should always use it with an intubating SGA (Figure 11).

**Video Laryngoscope/Optical Laryngoscope–FOB**

Clinicians have begun to discover that video laryngoscopes such as the GlideScope (Verathon Medical); AWS (Pentax), McGrath (Aircraft Medical), and C-MAC (Karl Storz) or optical laryngoscopes such as the Airtraq (Prodol) are the elite of recently developed airway management devices. They can accomplish much easier laryngoscopies and intubations compared with RLs. The combined use of FOB and video or optical laryngoscopy is particularly conducive to achieving airway control in the most difficult cases of airway management (Figure 12).

The better views of airway anatomy offered by video or optical laryngoscopes facilitate observation of FOB use and verbal guidance. Another singular advantage of this combination is the instructors’ ability to gauge a trainee’s progress on correct use of an FOB and to verbally assist the trainee while observing the laryngoscope screen. To gain experience with this technique, clinicians can attempt it electively for 2 minutes.

**Retrograde Intubation–FOB**

Retrograde intubation is a technique performed when intubation fails or for patients with highly soiled airways. The procedure is rarely elective (Figure 13). Retrograde intubation involves positioning a percutaneous wire through the cricothyroid or thyrotracheal membrane in a cephalad direction until the wire may be retrieved from the oropharynx or nasal passage. The wire is pulled cephalad, leaving a short distal portion to be clamped at skin level in the neck. The next step involves keeping the wire under tension while blindly sliding a tetrafluoroethylene catheter in a caudad direction into the trachea. An ETT then is railroaded blindly over both.

A better approach is the retrograde–FOB combination, which offers the possibility of directly visualizing entry into the trachea. If the distal end of the wire seems to be kinking in the trachea and preventing advancement of the bronchoscope, the wire should be smoothly cut at the skin level and the cephalad end pulled slightly.
• For patients receiving general anesthesia, induce and establish adequate ventilation and depth of anesthesia under 100% oxygen.
• For patients receiving local anesthesia, administer supplemental oxygen as required.
• Insert video or optical laryngoscope to obtain the best possible view.
• For channeled laryngoscopes, insert the fiber-optic bronchoscope directly into the loaded endotracheal tube.
• For unchanneled laryngoscopes, insert the bronchoscope at the midline; intubating oral airways are possible if space allows.
• If excessive brightness impairs viewing through the bronchoscope, reduce the light intensity of the laryngoscope, if possible.
• After the larynx appears, proceed with intubation.
• Assistant Duties
  – May need to hold the laryngoscope steady for the clinician.

Figure 12. Fiber-optic bronchoscopy and video or optical laryngoscopy.

Conclusion
The majority of these combinations have been limited to 2 different types of assisting instruments for intubation. In fact, any number of combinations is possible—although trying to see how many devices a patient’s mouth can accommodate is discouraged.

As the array of airway management inventions expands, an interesting question has emerged: Is it likely that new and improved video devices might seriously reduce the frequency of FOI and clinicians’ expertise with fiber-optic technologies? After all, video laryngoscopes and related instruments do tend to take the “difficult” out of the majority of difficult airway patients. Eventually, video laryngoscopes likely will obviate RLs. But until something arrives that is as intricately adept as a flexible fiberscope at following each twist in the most tortuously complex airway, anesthesiologists and other airway managers will always have to maintain and improve their skills with these devices.

• Prepare a lubricated FOB loaded with an ETT and remove the suction control valve.
• Under aseptic conditions, insert a Cook Retrograde Intubation wire into the trachea as directed.
• After retrieving and pulling the cephalad end, clamp the distal end at skin level in the neck.
• Thread the cephalad end of the wire into the working channel of the bronchoscope tip until it exits near the handle area.
• Maintain the wire under tension by having an assistant hold the cephalad end.
• Observe the wire as the scope is advanced and the glottis is passed as caudal as possible.
• Release the distal end of the wire.
• Advance the scope and intubate as described previously.

Figure 13. Retrograde intubation combined with fiber-optic bronchoscopy.

ETT, endotracheal tube; FOB, fiber-optic bronchoscope

References
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