Current Concepts in the Management of The Difficult Airway

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Dr. Hagberg has disclosed that she has received education grants from Foundation for Anesthesia Education and Research; is a member of the speakers' bureaus for Ambu A/S, Cook Medical, Covidien, and LMA North America; and has received equipment support from Ambu A/S, Cook Medical, Intersurgical Inc, Karl Storz Endoscopy, LMA North America, and Verathon Medical.

The practice of airway management has become more advanced in recent years. This advancement is demonstrated by the introduction of many new airway devices, several of which have been included in the American Society of Anesthesiologists (ASA) Difficult Airway Algorithm (Figure).[1]

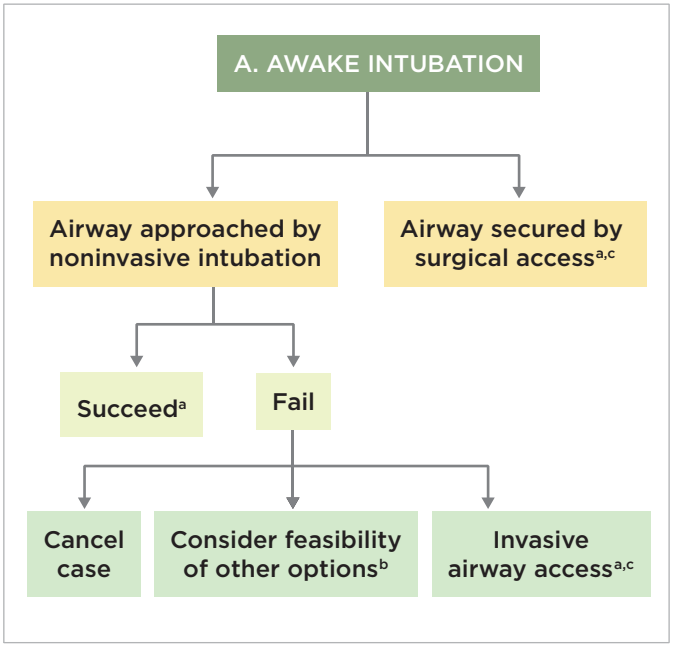
Management of the difficult airway remains one of the most relevant and challenging tasks for anesthesia care providers. Claims involving airway management continue to comprise an important aspect of the ASA Closed Claims Project database, which tracks all anesthesia-related insurance claims.[2]

This review focuses on several of the alternative airway management devices/techniques and their clinical applications, with particular emphasis on the difficult or failed airway.

Alternative Airway Devices

A common factor preventing successful tracheal intubation is the inability to visualize the vocal cords during the performance of direct laryngoscopy. Many devices and techniques are now available to circumvent the problems typically encountered with a difficult airway using conventional direct laryngoscopy.

1. **Assess the likelihood and clinical impact of basic management problems:**
   a. Difficult ventilation
   b. Difficult intubation
   c. Difficulty with patient cooperation or consent
   d. Difficult tracheostomy
2. **Actively pursue opportunities to deliver supplemental oxygen throughout the process of difficult airway management.**
3. **Consider the relative merits and feasibility of basic management choices:**
   a. Awake intubation vs intubation attempts after induction of general anesthesia
   b. Noninvasive technique for initial approach to intubation vs invasive technique for initial approach to intubation
   c. Preservation of spontaneous ventilation vs ablation of spontaneous ventilation
4. **Develop primary and alternative strategies.** (Refer to diagram.)



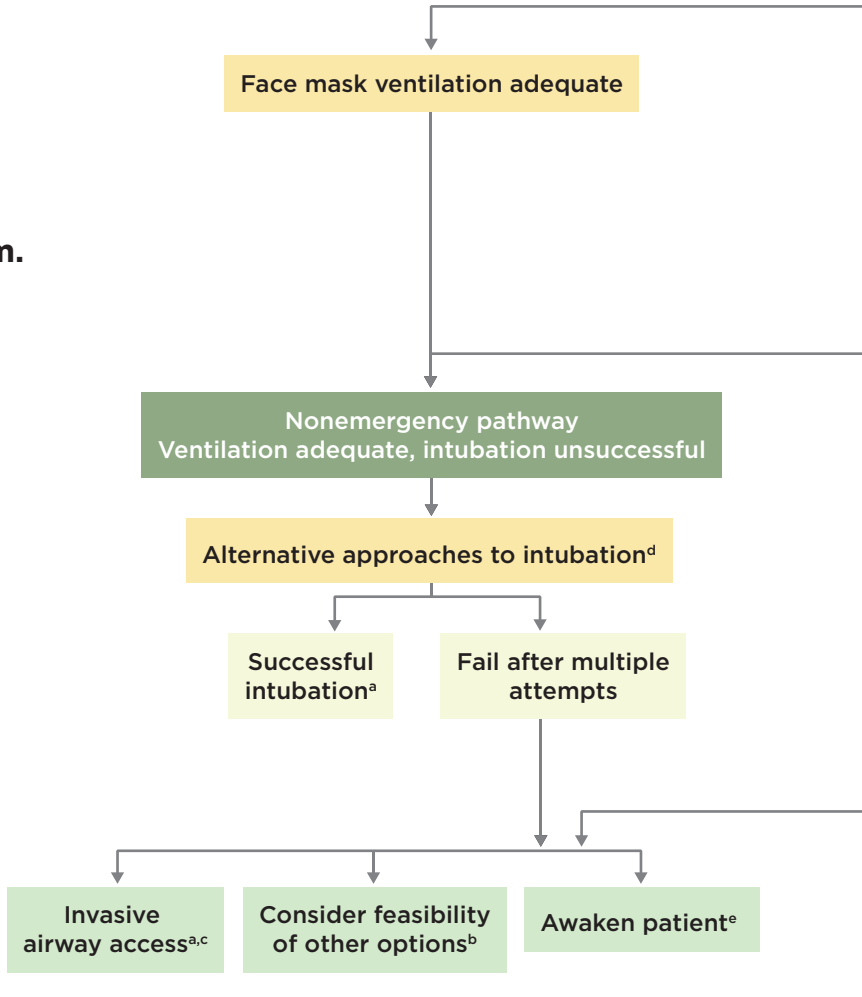


Figure. ASA Difficult Airway Algorithm.

Footnotes

[a] Confirm ventilation, tracheal intubation, or LMA placement with exhaled CO_2.

[b] Other options include (but are not limited to): surgery utilizing face mask or LMA anesthesia, local anesthesia infiltration, or regional nerve blockade. Pursuit of these options usually implies that mask ventilation will not be problematic. Therefore, these options may be of limited value if this step in the algorithm has been reached via the emergency pathway.

[c] Invasive airway access includes surgical or percutaneous tracheostomy or cricothyrotomy.

[d] Alternative noninvasive approaches to difficult intubation include (but are not limited to): use of different laryngoscope blades, LMA as an intubation conduit (with or without fiber-optic guidance), fiber-optic intubation, intubating stylet or tube changer, light wand, retrograde intubation, and blind oral or nasal intubation.

[e] Consider repreparation of the patient for awake intubation or cancellation of surgery.

[f] Options for emergency noninvasive airway ventilation include (but are not limited to): rigid bronchoscope, esophageal-tracheal Combitube ventilation, or transtracheal jet ventilation.

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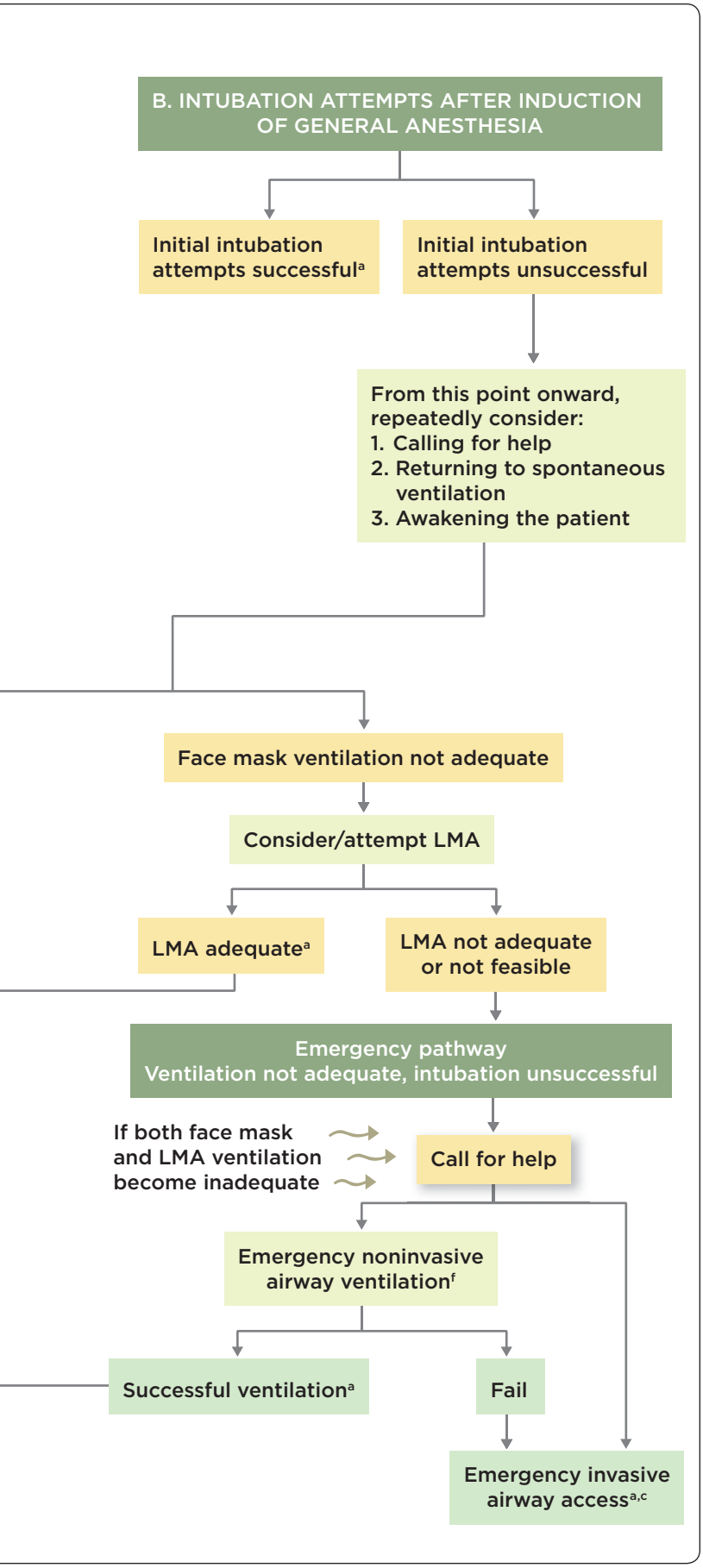

Endotracheal Tube Guides

A number of endotracheal tube (ET) guides (Table 1) have been used to aid in intubation, including the Portex Venn Tracheal Tube Introducer (Smiths Medical) and, more recently, the Single-Use Bougie (Smiths Medical), the Frova Intubating Introducer (Cook Medical), the Aintree Intubation Catheter (Cook Medical), the Arndt Airway Exchange Catheter Set (Cook Medical), the Cook Airway Exchange Catheter EF (Cook Medical), the Cook Airway Exchange Catheter EF Soft Tip (Cook Medical), the RadLyn Stylet (RadLyn LLC), the GlideRite Rigid Stylet (Verathon Medical), and the OptiShape Stylet (Truphatek International Ltd). Recently, a new range of introducers, stylets, and tube exchangers has been introduced by VBM Medizintechnik GmbH. These include the METTS (Muallem ET Tube Stylet) and METTI (Muallem ET Tube Introducer), which are solid in design, and several ventilating catheters.

Lighted Stylets

In the past several years, several lighted stylets have been developed, including light wands such as the Trachlight (Laerdal Medical Corp) and the AincA Lighted Stylet (Anesthesia Associates, Inc.), and visual scopes, such as the Shikani Optical Stylet (SOS, Clarus Medical), Flexible Airway Scope Tool (Pocket/FAST Scope, Clarus Medical), Levitan GLS (Clarus Medical), Clarus Video System (Clarus Medical), Bonfils Retromolar Intubation Fiberscope (Karl Storz Endoscopy), Brambrink Intubation Endoscope (Karl Storz Endoscopy), and the SensaScope (Acutronic Medical Systems AG). Light wands rely on transillumination of the tissues of the anterior neck to demonstrate the location of the tip of the ET—a blind technique, unless combined with direct laryngoscopy (Table 2).[3,4] The visual scopes, on the other hand, utilize fiber-optic imagery and allow indirect visualization of the airway. They also can be used alone or in conjunction with direct laryngoscopy.

Rigid/Video Laryngoscopes

Video-assisted techniques have become pervasive in various surgical disciplines, as well as in anesthesiology. As more video laryngoscopes are introduced into clinical practice, and as airway managers become more skillful with the technique of video-assisted laryngoscopy, it could well become the standard procedure for patients with known or suspected difficult airways. It may be longer before video laryngoscopy becomes the standard for all routine intubations, but as the equipment and users' skills improve, video laryngoscopy may become routine with the potential for important savings in time and decreased morbidity in patients.

It is beyond the scope of this review to discuss all of the laryngoscopes that have been manufactured; thus, only some of the most recently developed blades will be described. Modifications of traditional laryngoscope blades are primarily designed to overcome certain problems associated with difficult airway management, such as limited mouth opening, anterior larynx, sternal space

Table 1. Endotracheal Tube Guides

Name (Manufacturer)	Description	Length, cm	Clinical Applications
Aintree Intubation Catheter (Cook Medical)	Polyethylene 19 Fr AEC allows passage of an FOB through its lumen. Has 2 distal side holes and is packaged with Rapi-Fit adapters. Color: light blue.	56	Exchange of SGAs for ETs ≥7.0 mm using an FOB. Its hollow lumen allows insertion of an FOB directly through the catheter so that the airway can be indirectly visualized.
Arndt Airway Exchange Catheter Set (Cook Medical)	Polyethylene 8 and 14 Fr AEC with a tapered end, multiple side ports, packaged with a stiff wire guide, bronchoscope port, and Rapi-Fit adapters. Color: yellow.	50, 65, 78	Exchange of LMAs and ETs using an FOB.
Cook Airway Exchange Catheter EF (Cook Medical)	Polyethylene 11 and 14 Fr EF AEC that facilitates exchange of DLT of 4.0 mm or larger ID. Also comes in a soft-tipped version. Color: EF green; Soft-Tipped green with purple tip.	100	Exchange of DLTs.
Frova Intubating Introducer (Cook Medical)	Polyethylene 8 and 14 Fr AEC with angled distal tip with 2 side ports. Has hollow lumen and is packaged with a stiffening cannula and removable Rapi-Fit adapters. 14 Fr also packaged in box of 10. Colors: 8 Fr yellow; 14 Fr blue.	35, 65	Facilitates endotracheal intubation and allows simple ET exchange. Can also be used by placing it first in the ET, with its tip protruding, or placing it directly into the glottis and then placing the ET over it.
GlideRite Auto Stylet (Verathon Medical)	Reusable, sterilizable, semirigid stylet that conforms to GlideScope blade angulation; adjustable for ETs of various lengths.	Accommodates ETs 6.0 mm and larger ID.	Designed to work with GlideScope Cobalt AVL, GVL, Cobalt, and Ranger models to facilitate intubations in OR, ED, and emergency settings.
GlideRite Rigid Stylet (Verathon Medical)	Reusable, sterilizable, semirigid stylet that conforms to GlideScope 60-degree blade angulation; provides improved maneuverability in ET placement.	Accommodates ETs 6.0-10.0 mm ID. Overall length is 32.34 cm (12.73 in).	Designed to work with GlideScope GVL, Cobalt, and Ranger models to facilitate intubations in OR, ED, and emergency settings.
OptiShape Stylet (Truphatek International Ltd)	Reusable, sterilizable, semirigid stylet with optimal shape for indirect intubation procedures.	Two sizes. Accommodates ETs 5.0-6.5 and 7.0-9.0 mm ID.	Facilitates smooth passage of ET in both routine and difficult intubations. Especially useful in combination with the variety of video laryngoscopes that employ >42-degree angles. Designed with the ideal curve to closely follow the blade shape and ensure successful passage of ET through vocal cords.
Portex Venn Tracheal Tube Introducer (Smiths Medical)	15 Fr ET introducer made from a woven polyester base, with a coude tip (angled 35 degrees at its distal end). Also known as the *gum elastic bougie*. Color: golden brown.	60	Proven useful in patients with an anterior larynx (grades 2b, 3, and 4) and those with limited mouth opening. Can be used by slightly protruding through the ET, or placing it directly into the glottis and then placing an ET over it.
RadLyn Stylet R-100 (RadLyn LLC)	Single-use, semirigid dilating stylet employing malleable guide tip and soft, dilating balloon.	Single size only. Accommodates ETs 7.0-10.0 mm ID.	Combines the functionality of a coude tip bougie with a traditional wire stylet into a single, easy-to-use device. Facilitates smooth passage of ET in routine intubations; when the laryngeal inlet is distorted, edematous, or narrowed; when vocal cords are reactive (ie, nonparalyzed); or when Cormack-Lehane grade III/IV view is encountered.
Single-Use Bougie (Smiths Medical)	New 15 Fr PVC ET introducer with coude tip. Has a hollow lumen that discourages reuse and is provided sterile. Color: ivory.	70	Single-use product reduces the risk for cross-contamination. Otherwise, same as Portex Venn Tracheal Tube Introducer.

Abbreviation key for all tables is on page 71.

	Special Features
	Large lumen (4.7 mm) allows passage of FOB. Rapi-Fit adapters allow both jet ventilation and ventilation with 15-mm adapter (anesthesia circuit or Ambu bag). Single use.
	Tapered end and multiple side ports. Rapi-Fit adapters allow both jet ventilation and ventilation with 15-mm adapter (anesthesia circuit or Ambu bag). Single use.
	EF with 2 distal side holes. The soft-tip version offers a more flexible tip to help minimize tracheal trauma. Rapi-Fit adapters as above, but should be used primarily for jet ventilation because of length. Single use.
	Can be used in pediatric population for ETs as small as 3.0 mm. Hollow lumen allows oxygenation/ventilation in all sizes. Single use.
	Reusable, durable stainless steel; easy to clean; adjustable for ETs of various lengths (including cut tubes).
	Reusable, durable stainless steel; easy to clean and sterilize in an autoclave.
	Easily adjustable to a variety of ET sizes. Suitable for use in combination with a variety of video laryngoscopes that employ >42-degree angle of vision.
	Nondisposable and reusable. Size 5 Fr is single use. Has memory properties. Coude tip effectively detects "tracheal clicks" to confirm correct placement. Part of a range of introducers, stylets, and guides for adults and pediatrics. Can be reused after cold water disinfection.
	Tapered, dilating balloon facilitates mechanical dilation of the laryngeal anatomy for less traumatic passage of the ET.
	Similar to Portex Venn Tracheal Tube Introducer, but hollow lumen allows oxygenation/ventilation. Single use.

restriction, small intraoral cavity, and immobile or unstable cervical spine (Tables 3 and 4).[5-7]

Indirect Rigid Fiber-Optic Laryngoscopes

These laryngoscopes were designed to facilitate tracheal intubation in the same population that would be considered for flexible fiber-optic bronchoscopy, such as patients with limited mouth opening or neck movement. Relative to the flexible fiber-optic bronchoscopes (FOBs), they are more rugged in design, control soft tissue better, allow for better management of secretions, are more portable (with the exception of the new portable FOBs), and are not as costly. Intubation can be performed via the nasal or oral route and can be accomplished in awake or anesthetized patients (Table 5).[8-10]

Supraglottic Ventilatory Devices

The Laryngeal Mask Airway (LMA, LMA North America, Inc.) is the single most important development in airway devices in the past 25 years. Since its introduction into clinical practice, it has been used in more than 200 million patients worldwide with no reported deaths.[11] Several new variants of the LMA Classic, or standard LMA, are available, including the LMA Flexible (wire-reinforced flexible), LMA Unique (disposable), LMA Fastrach (intubating, reusable, and disposable), the LMA ProSeal (50% higher seal pressure, with gastric drain tube), the LMA CTrach (a Fastrach with integrated fiber optics), and, most recently, the LMA Supreme (single-use LMA with a built-in gastric drain tube).

Other supraglottic ventilatory devices (Table 6)[12-15] include the Soft-Seal Laryngeal Mask (Smiths Medical), the CobraPLA[16] (Engineered Medical Systems), the King Laryngeal Tube (King Systems/VBM Medizintechnik GmbH), and the Esophageal Tracheal Combitube (Covidien).

Special Airway Techniques

Awake Intubation

For managing patients in whom a difficult airway is suspected or anticipated, securing the airway before induction of general anesthesia adds to the safety of anesthesia and helps minimize the possibility of major complications, including hypoxic brain damage and death. To perform awake intubation, the patient must be adequately prepared for the procedure. Good topical anesthesia is essential to obtund airway reflexes and can be provided by various topical agents and administrative devices (Table 7).

Atomizing devices currently available for delivering topical anesthesia to nasal, oral, pharyngeal, laryngeal, and tracheal tissues include the DeVilbiss Model 15 Medical Atomizer (DeVilbiss Healthcare), the Enk Fiberoptic Atomizer Set (Cook Medical), and the MADgic Laryngo-Tracheal Atomizer (Wolfe Tory Medical Inc). Although any technique of tracheal intubation can be performed under topical anesthesia, flexible fiber-optic intubation is most commonly used.

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Table 2. Lighted Stylets

Name (Manufacturer)	Description	Size
AincA Lighted Stylet (Anesthesia Associates, Inc.)	Completely reusable device consisting of removable handle with xenon bulb, easily malleable copper stylet with light-guide and adjustable ET holder/stop.	Adult and children (ETs ≥5 mm). Infant (ETs ≥3.5 mm).
air-Vu Plus Fiber-optic Stylet (distributed by Mercury Medical)	High-resolution, stainless steel, rigid stylet. Incorporates an adjustable tube stop and optional oxygen port for oxygen insufflation.	Adult (ETs ≥5.5 mm).
Ambu aScope; Ambu aScope Monitor (Ambu Inc.)	Fully portable, lightweight, and flexible optical intubation scope with an ergonomic handle design and enhanced camera technology. Connects to the Ambu aScope color monitor, which provides a buffered video output and composite video NTSC signal.	One size only. Minimum ET (ID) size, 6.0 mm.
Bonfils Retromolar Intubation Fiberscope (Karl Storz Endoscopy)	High-resolution rigid fiber-optic stylet with a fixed 40-degree curved shape at the distal end. Available without a working channel for ease of cleaning. Available with a standard eyepiece or with a DCI for video.	3.5- and 5.0-mm OD. ET must be ≥0.5 mm larger to fit.
Brambrink Intubation Endoscope (Karl Storz Endoscopy)	High-resolution semiflexible fiber-optic stylet with a 40-degree curved shape at the distal end, 40× magnification, a fixed eye-piece, a movable ET holder, and an insufflation port.	2.0-mm OD. ET must be ≥0.5 mm larger to fit.
Flexible Airway Scope Tool (Pocket Scope/FAST; Clarus Medical)	Flexible stylet with a nondirectable tip.	Adult (ETs ≥4.0 mm).
Levitan GLS (Clarus Medical)	Similar to the Shikani Optical Stylet (SOS), but does not have a movable tube stop.	Adult (ETs ≥5.5 mm).
SensaScope (Acutronic Medical Systems AG)	Hybrid S-shaped, semirigid fiber-optic intubation video stylet. Has a 3-cm steerable tip that can be flexed in sagittal plane for 75 degrees in both directions with lever at proximal end of device. Quality of optics is similar to flexible fiber-optic and rigid endoscopes, but has no working channel.	6.0-mm OD. ET must be >0.5 mm larger to fit.
Shikani Optical Stylet (SOS; Clarus Medical)	High-resolution, stainless steel, malleable fiber-optic stylet that comes in a preformed hockey stick shape. Has an adjustable tube stop and integral oxygen port for oxygen insufflation.	Adult (ETs ≥5.5-mm ID). Pediatric (ETs 2.5- to 5.0-mm ID).
Trachlight Stylet (Laerdal Medical AS)	Consists of 3 parts: a reusable handle, a flexible wand, and a stiff, retractable stylet.	Available in 3 sizes: adult, child, and infant. Accommodates ETs 3.0- to 10.0-mm ID.[3]

Clinical Applications	Special Features
Although usable for routine blind intubations or additional illumination during laryngoscopy, it is especially useful when the FOB is unavailable (eg, outside locations or ambulances), or when bronchoscopy is difficult to perform (eg, obscured airway or limited head motion allowed).	Can be used alone or in conjunction with other techniques. Handle-mounted xenon light source is always on and keeps stylet tip cold. Uses 2 AA batteries. System is completely reusable and sterilizable.
Allows for visualization during intubation through an air-Q laryngeal mask.	A portable, durable rigid stylet that allows for a fiber-optic view during intubation through the air-Q. Light source options include GreenLine laryngoscope handle or fiber-optic light source (4 AA batteries).
Can be used orally or nasally in awake or anesthetized patients for clinical indications, eg, upper and lower airway problems, anterior airways, in patients with limited mouth opening or neck movement, and in obese patients; also used for teaching purposes.	Single use and sterile. The distal end is bendable and can be manipulated 120 degrees (upward and downward). Total operation time is 30 minutes in an 8-hour period. Equipped with power indicator display. Has a working channel for instillation of local anesthetics. Not currently available in the United States.
Able to elevate a large, floppy epiglottis and navigate through the oropharynx of patients with excessive pharyngeal soft tissue, midline obstruction, limited mouth opening, or fragile veneers on incisors.	Fixed-shape shaft with an adjustable eyepiece that allows ergonomic movement during intubation, in addition to an adapter for fixation of ETs and oxygen insufflation. Portable, rugged, and better maneuverability than the flexible FOB. Used with a battery-powered or fiber-optic light source.
Similar to Bonfils Retromolar Intubation Fiberscope.	Available with a standard eyepiece or a DCI for video cameras.
Allows for visualization during intubation through ILMA or quick confirmation of SGA or ET placement/positioning. Also used for extubation.	This device has been modified with a tip that allows it to be used for nasal intubation (FAST Plus; Clarus Medical).
Designed as an adjunct to direct laryngoscopy. Can also be used as a stand-alone device similar to the SOS.	Very similar to the SOS, but requires the user to cut the ET because it does not have a movable tube stop. Use either a GreenLine laryngoscope handle or an LED light source.
Similar to Brambrink Intubation Endoscope.	Offers an improved view of glottis, simultaneous direct and endoscopic views, full visual control over passage of ET, and confirmation of final position. No need for extreme head extension or forced traction of laryngoscope. Can be rapidly assembled to use immediately. Not currently available in the United States.
Similar to flexible FOB. Can be used alone or as an adjunct to laryngoscopy and is especially useful for those unable to maintain skills with a bronchoscope.[4]	Has the simple form of a standard stylet, plus the advantage of a fiber-optic view and maneuverability of its tip. Portable, rugged, and better maneuverability than the flexible FOB. Light source options are light cable, Turbo LED or GreenLine laryngoscope handle with adapter.
Although it can be used for routine intubations, it is especially useful in situations in which the FOB is unavailable (eg, in ambulances or outside locations) or in which bronchoscopy is difficult to perform (eg, when an airway is obscured by blood or secretions or when a patient's head cannot be flexed or extended).	Blind technique that can be used alone or in conjunction with other techniques.

Table 3. Video Laryngoscopes

Name (Manufacturer)	Description	Size
Berci-Kaplan DCI Video Laryngoscope System (Karl Storz Endoscopy)	Video laryngoscope system with interchangeable laryngoscope blades. Handles allow a DCI camera head to snap onto any standard eyepiece fiberscopes (flexible or semirigid). Required components include a camera control unit, xenon light source, and monitor. MediPack portable combination video/light source/monitor unit is also available for use with this system.	MAC 3 and 4, Dörges, and all Miller blade sizes.
C-MAC Video Laryngoscope (Karl Storz Endoscopy)	Instant on, battery-powered video laryngoscope. Standard shaped, interchangeable Macintosh blades. Blades house high-resolution CMOS distal chip and LED technology. Real-time viewing on 7-in LCD monitor. With the Dörges D-Blade (Difficult Airway Blade, Karl Storz Endoscopy), angle of view is approximately 80 degrees; acute curvature design.	MAC 2, 3, 4, and D-Blade. D-Blade is 1 size for adults only (ideal for obese patients).
Clarus Video System 30000-V (Clarus Medical)	Removable and articulating monitor, video-malleable stylet, USB for charging rechargeable battery and connecting to wireless notebook or monitor; red LED for transillumination. Optional detachable flexible scope and laryngoscope blades available.	5-mm OD. ETs ≥5.5 mm.
GlideScope Cobalt Advanced Video Laryngoscope (AVL) (Verathon Medical)	Airway views in digital video clarity enable swift intubation. Integrated real-time recording, onboard video tutorial, and multiple configurations for a wide range of patients.	Offered with 5 disposable Stats ranging in size from GVL 0 through GVL 4.
GlideScope Video Laryngoscope (GVL) and GlideScope Cobalt Single Use System (Verathon Medical)	Offers improved real-time view of airway and tube placement enabling quick intubation. Easy to use, learn and teach. Operational in seconds. Includes high-resolution camera, antifogging mechanism to resist lens contamination, non-glare color monitor, and unique blade angulation. Video output for remote display or recording option available.	GVL reusable offers GVL 2 through GVL 5 blade sizes. GlideScope Cobalt (single use system) is offered with 5 disposable Stats ranging in size from GVL 0 through GVL 4.
GlideScope Ranger and Ranger Single Use Video Laryngoscopes (Verathon Medical)	Designed for EMS and military paramedics; it provides a clear view of the airway and tube placement. Portable, compact, and rugged. Operational in seconds. Offers same benefits as the GVL and Cobalt systems.	Reusable Ranger offers 2 blade sizes, GVL 3 and GVL 4 (patient sizes, 22 lb to morbidly obese). Ranger Single Use is offered with 5 disposable Stats ranging in size from GVL 0 through GVL 4.
McGrath Video Laryngoscope (Aircraft Medical Ltd; distributed by LMA North America, Inc.)	Fully portable wireless laryngoscope with single-use disposable blades. Flatscreen monitor is mounted on the handle.	Adjusts to fit many adult and pediatric sizes.
Pentax Airway Scope (Pentax Medical; distributed by Ambu Inc.)	Wireless video laryngoscope with disposable transparent blade (Pblade) that has a suction port. Has a 12-cm cable with CCD camera and 2.4-in LCD color monitor.	One size only.
Truview EVO Optical Laryngoscope and TruVision LCD screen with PCD camera (Truphatek International Ltd)	Fully portable, lightweight and compact system with interchangeable laryngoscope blades. New 5-in LCD color monitor with picture capture device. Video output for remote display and recording. Rechargeable battery pack.	Four blade sizes: neonatal, pediatric, small, and adult (patient sizes, premature to morbidly obese).

Clinical Applications	Special Features
Useful for anterior airways, obese patients, and patients with limited mouth opening or neck extension. Additionally useful for teaching purposes, verification of ET position, aiding application of external laryngeal manipulation, or passage of an intubating introducer. Recommend styletted or special ET. May also be used for nasal intubation and ET exchange.	The wide-angle camera allows improved visualization and video documentation of laryngoscopy and intubation. Extreme positioning of the head is unnecessary. MAC 3 and 4 blades provide 45- and 60-degree angles of view, respectively.
Same as DCI. D-Blade is designed for intubations of anterior airways that cannot be intubated with a standard Macintosh blade.	Built-in still and video image capture on memory card. Familiar blade design and 80-degree field of view. Angled distal lens provides 45- to 60-degree angle of view. Inherent antifog design. Unit can be pole-mounted, inserted into waterproof field bag, or freestanding on easel-back clamp. No special ETs or stylets needed. Can be used concurrently with battery charging. On-screen toggle brightness control facilitates use in low and bright ambient light conditions.
ET intubation, confirmation, extubation (with video); LMA placement, positioning, and intubation with certain LMAs. Provides access with limited mouth opening; malleable stylet provides shaping to reduce cervical movement.	Red LED provides more than 5 times the transillumination of white LED lights in cases when use of the scope is contraindicated due to blood or vomit. Video laryngoscope blades available.
Same as GVL.	Real-time recording, onboard video tutorial, antifog mechanism to resist lens contamination, advanced resolution output to an external monitor, intuitive user controls and status icons, lightweight and easily transportable, impact-resistant, durable polycarbonate-coated video screen.
Useful for adult and pediatric airways, including preterm/neonatal and obese patients, bloody or anterior airways, and patients with limited neck mobility. Can be used for teaching purposes. GVL and Cobalt systems are optimized for demanding applications in the OR, ED, ICU, and NICU.	GVL reusable and single-use (Cobalt) offers improved visualization and allows video documentation of laryngoscopy and intubation. Disposable blades allow quick turnaround and help limit the possibility of cross-contamination. The GlideRite Rigid Stylet is designed to complement the angle of the GlideScope GVL to help facilitate placement of an ET.
Ideal for EMS (ground and air), military, ED, ICU, and crash cart settings.	Ranger models are compact, rugged, portable, and built to military and EMS specifications (received US Army Airworthiness Certification). Powered by rechargeable lithium polymer battery; 1.5 lb.
Useful in patients with limited mouth opening or head and neck movement, and anterior airways; in obese patients; in patients in whom an increased hemodynamic response is a concern; and for teaching purposes.	Highly portable and lightweight. Does not require an electrical outlet and thus is ideal for settings outside the OR. Uses disposable blades for quick turnaround between uses and for limiting cross-contamination. An adjustable blade allows use of different blade lengths on the spot. Low-profile blade and disarticulating handle can accommodate patients with very limited mouth opening and severely limited movement of the head and neck. The monitor is located on the handle to remain in a more natural line of sight with the patient.
Similar to McGrath Video Laryngoscope. Useful for patients with limited neck mobility. Does not require alignment of the oral, pharyngeal, and laryngeal axis. Ideal for prehospital use. Monitor permits viewing from various positions to facilitate all methods of intubation. Additionally useful for teaching purposes.	Green target symbol on monitor display indicates direction of the tracheal tube tip. The Pblade comes with 2 channels: one allows safe placement and insertion of ET, and the other has a suction port through which a suction catheter can be passed. ET is attached to right side of the blade. The device, powered by 2 AA alkaline batteries, is portable with a 1-hour run time and 5-minute low-battery warning.
With a 42- to 47-degree blade angle, used in difficult adult and pediatric intubations of all grades, including patients with limited neck extension or mouth opening. Provides improved visualization of airway and tube placement for quick intubation. Easy to use. Addition of oxygen prevents fogging and secretion buildup in bloody airways and provides insufflation. May be used as a teaching tool.	Preformed stylets with ideal shape for indirect intubation technique provided in each set. Reusable and affordable. Versatile and rugged system can be used with unaided vision through eyepiece, or with customized camera attachment and monitor.

Table 4. Rigid Laryngoscope Blades

Name (Manufacturer)	Description	Size	Clinical Applications	Special Features
Dörges Emergency Laryngoscope Blade (Karl Storz Endoscopy)	Developed in Europe as a universal blade that combines features of both the MAC and Miller laryngoscope blades.	One size only for patients >10 kg.	Blade is inserted into the oropharynx to the appropriate depth, which correlates with the patient's size.	Has 10-kg and 20-kg markings on the blade.
Modified MAC Blades				
AincA Flex-Tip Fiber-Optic Laryngoscope Blade (Anesthesia Associates, Inc.)	Flexible tip or levering fiber-optic MAC laryngoscope blades are designed with a hinged tip controlled by a lever at the proximal end. Designed to fit standard handles.	Adult sizes only.	Useful in patients with a recessed mandible and decreased mouth opening.	A lever controls the tip angle through 70 degrees during intubation to lift the epiglottis, if necessary, to improve laryngeal visualization.[5]
Flipper (Rüsch Inc./Teleflex)				
Heine Flex Tip Fiber-Optic Laryngoscope Blade (Heine USA, Ltd.)				
Rüsch Truview EVO (Truphatek International Ltd; distributed by Rüsch Inc./Teleflex)	Indirect rigid laryngoscope with specially designed 42-degree blade curvature; fits onto all standard endoscopic camera heads. Provides clear, unmagnified view of the glottis. Oxygen channel for demisting, clearing secretions, and insufflation.	Adult, pediatric, and neonatal sizes.	Useful for difficult adult and pediatric airways, including patients with an anterior airway and limited neck extension.	Rugged, portable, easy to maintain. Depth lines on the blade to guide insertion. Can be used with all fiber-optic laryngoscope handles. Designed to provide indirect laryngoscopy with continuous oxygen insufflation.

Flexible Fiber-Optic Intubation

Flexible fiber-optic intubation is a very reliable approach to difficult airway management and assessment. It has a more universal application than any other technique. It can be used orally or nasally for both upper and lower airway problems and when access to the airway is limited, as well as in patients of any age and in any position. Technological advances—including improved optics, battery-powered light sources, better aspiration capabilities, increased angulation capabilities, and improved reprocessing procedures have been developed. Rescue techniques, such as direct laryngoscopy and placing a retrograde guidewire through the suction channel, may be used if the glottic opening cannot be located with the scope, or if blood or secretions are present.[17] Insufflation of oxygen or jet ventilation through the suction channel may provide oxygen throughout the procedure, and allow additional time when difficulty arises in passing the ET into the trachea.[18]

Retrograde Intubation

Retrograde intubation (Table 7) is an excellent technique for securing a difficult airway either alone or in conjunction with other airway techniques.[19] Every anesthesia care provider should be skilled in employing this simple, straightforward technique. It is especially useful in patients with limited neck mobility (that is associated with cervical spine pathology, or in those who have suffered airway trauma). Cook Medical has 2 retrograde intubation sets: a 6.0 Fr for placing tubes of 2.5 mm or greater ID, and a 14.0 Fr for placing tubes of 5.0 mm or greater ID.

Transtracheal Jet Ventilation

Transtracheal jet ventilation (TTJV) is a well-accepted method for securing ventilation in rigid and interventional bronchoscopy (Table 7).[20] There are a number of commercial manual jet ventilation devices currently available, including the Manujet III Jet Ventilator (VBM Medizintechnik GmbH), the Manual Jet Ventilator (Instrumentation Industries), and the AincA Jet Ventilator (Anesthesia Associates, Inc.). The Enk Oxygen Flow Modulator (Cook Medical) is a new device recommended for use when jet ventilation is appropriate but a jet ventilator is not available.[21] The Wadhwa Emergency Airway Device (Cook Medical), which also can be used for TTJV, is several devices in one (Table 7).[22,23] It has an emergency nasopharyngeal airway catheter; a large-diameter transtracheal needle for a cricothyrotomy procedure with the option for TTJV; and the main body of the device acts as a blow tube or 15-mm adapter.

Table 5. Indirect Rigid Fiber-Optic Laryngoscopes

Name (Manufacturer)	Description	Size	Clinical Applications	Special Features
Airtraq (Prodol Meditec SA, LLC; distributed by King Systems)	Disposable optical laryngoscope that provides magnified angular view of glottis without alignment of oral, pharyngeal, and tracheal axis. Includes guiding channel to hold ET and direct it toward vocal cords. Optional reusable camera can be attached for viewing on external monitor. Sizes are color-coded: regular adult (blue); small adult (green).	Seven versions available: regular adult for ET 7.0-8.5 mm; small adult for ET 6.0-7.5 mm; pediatric for ET 4.0-5.5 mm; infant for ET 2.5-3.5 mm; nasotracheal (adult and infant); and double-lumen endobronchial tubes.	Intended to facilitate intubation in routine and difficult airway situations. Useful in emergency settings, cervical spine immobilization, fiberscope guidance, tube exchange, and foreign body removal.	Totally self-contained disposable advanced airway device with built-in antifog system, and low-temperature light source. Can be used with standard ETs. Integral tracking channel allows ET to be directed without a stylet or bougie.
Bullard Elite Laryngoscope (Gyrus ACMI)	Most recent version of the Bullard laryngoscope and the only indirect fiber-optic laryngoscope that incorporates attachable metal stylets.	Adult and pediatric sizes (newborn/infant and child).	Six methods of intubation have been described.[8,9] Useful for anterior airways and patients with limited neck extension.	Has a working channel for oxygen insufflation, suction, and instillation of local anesthetics. Can be used with a conventional laryngoscope handle or fiber-optic light source.

Cricothyrotomy

Cricothyrotomy (Table 8), a lifesaving procedure, is the final option for "cannot-intubate, cannot-ventilate" patients according to all airway algorithms, whether they concern prehospital, emergency department, intensive care unit, or operating room patients.

In adults, needle cricothyrotomy should be performed with catheters at least 4 cm and up to 14 cm in length. A 6 Fr reinforced fluorinated ethylene propylene Emergency Transtracheal Airway Catheter (Cook Medical) has been designed as a kink-resistant catheter for this purpose.

Percutaneous cricothyrotomy involves using the Seldinger technique to gain access to the cricothyroid membrane. Subsequent dilation of the tract permits passage of the emergency airway catheter. The Melker Emergency Cricothyrotomy catheters are available in 3.5 mm, 4.0 mm, and 6.0 mm uncuffed tubes, and 5.0 mm cuffed tubes (Cook Medical). A Portex (Smiths Medical) emergency cricothyrotomy kit (U.S. availability is anticipated in October 2010) uses a Veress needle and integral dilator to insert a 6.0 mm cuffed ET. The Quicktrach (VBM Medizintechnik GmbH) is available for children and adults in 2.0 mm and 4.0 mm ID, respectively.

Surgical cricothyrotomy is performed by making incisions through the cricothyroid membrane using a scalpel, followed by the insertion of an ET. This is the most rapid technique and should be used when equipment for the less invasive techniques is unavailable and speed is particularly important.

Tracheostomy

Tracheostomy (Table 9) establishes transcutaneous access to the trachea below the level of the cricoid cartilage.[24] Emergency tracheostomy may be necessary when acute airway loss occurs in children under 10 years of age or children whose cricothyroid space is considered too small for cannulation, as well as in individuals whose laryngeal anatomy has been distorted by the presence of pathologic lesions or infection.[25]

Percutaneous dilatational tracheostomy is the most commonly performed tracheostomy technique, yet it is still considered invasive and can cause trauma to the tracheal wall. The Portex Ultraperc Percutaneous Dilatational Tracheostomy Kit (Smiths Medical) incorporates a unique introducer to aid smooth insertion of the tracheostomy tube over a Seldinger wire. In addition, the Ciaglia Blue Rhino Percutaneous Introducer Set (Cook Medical) has a flexible tip dilator for less traumatic insertion. The slippery hydrophilic coating and tapered profile eliminate the need for multiple passes with increasingly larger dilators. The Ciaglia Blue Dolphin Balloon Percutaneous Tracheostomy Introducer has a unique balloon-tipped design that combines balloon dilatation and tracheal tube insertion into one step (Cook Medical).

Translaryngeal tracheostomy, a newer tracheostomy technique, is considered to be safe and cost-effective, and it can be performed at the bedside.[26] It may be beneficial in patients who are coagulopathic.

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Table 6. Selected Supraglottic Ventilatory Devices

Name (Manufacturer)	Description	Size
AES Ultra (AES, Inc)	All-silicone laryngeal mask with standard cuff valve.	Adult sizes 3, 4, 5, 6.
AES Ultra Clear (AES, Inc)	Silicone cuff and PVC tube, laryngeal mask with standard cuff valve.	Adult sizes 3, 4, 5, 6.
AES Ultra Clear CPV (AES, Inc)	Silicone cuff and PVC tube, laryngeal mask with cuff pilot valve (CPV) which constantly monitors cuff pressures.	Pediatric to adult sizes 1, 1½, 2, 2½, 3, 4, 5, 6.
AES Ultra CPV (AES, Inc)	All-silicone laryngeal mask with CPV that constantly monitors cuff pressures.	Pediatric to adult sizes 1, 1½, 2, 2½, 3, 4, 5, 6.
AES Ultra EX (AES, Inc)	All-silicone, multiple-use laryngeal mask (40 uses).	Pediatric to adult sizes 1, 1½, 2, 2½, 3, 4, 5, 6.
AES Ultra Flex CPV (AES, Inc)	Wire-reinforced, silicone cuff and tube. Single use with CPV which constantly monitors pressure changes in the cuff.	Pediatric to adult sizes 1, 1½, 2, 2½, 3, 4, 5, 6.
AES Ultra Flex EX (AES, Inc)	All-silicone, wire-reinforced, multiple-use laryngeal mask (40 uses).	Pediatric to adult sizes 1, 1½, 2, 2½, 3, 4, 5, 6.
air-Q Reusable Laryngeal Mask (Cookgas LLC; distributed by Mercury Medical)	Hypercurved intubating laryngeal airway that resists kinking, and removable airway connector. Anterior portion of mask is recessed; a larger mask cavity allows intubation using standard ETs. Air-Q removal after intubation is accomplished by using air-Q reusable removal stylet.	Sizes (2.0, 2.5, 3.5, and 4.5) that can accommodate standard ETs 5.5–8.5 mm.
air-Q Disposable Laryngeal Mask (Cookgas LLC; distributed by Mercury Medical)	Same features as air-Q Reusable Laryngeal Mask, except disposable.	Sizes (1.5, 2.5, 3.5, and 4.5) that can accommodate standard ETs up to 8.5 mm. Introducing new infant, child and toddler sizes in 2009.
Ambu AuraFlex (Ambu Inc.)	The Ambu AuraFlex is a disposable wire-reinforced flexible laryngeal airway.	Adult and pediatric sizes 2-6.
Ambu AuraOnce (Ambu Inc.)	A laryngeal mask with a special built-in curve that replicates natural human anatomy. It is molded in 1 piece with an integrated inflation line and no epiglottic bars on the anterior surface of the cuff.	Adult and pediatric sizes 1-6.
Ambu AuraStraight (Ambu Inc.)	Similar to the LMA Unique but without epiglottic bars on the anterior surface of the cuff.	Adult and pediatric sizes 1-6.
Ambu Aura40 (Ambu Inc.)	Same design as the Ambu AuraOnce, but reusable.	Adult and pediatric sizes 1-6.
Ambu Aura40 Straight (Ambu Inc.)	Similar to the LMA Classic. No epiglottic bars on the anterior surface of the cuff.	Adult and pediatric sizes 1-6.

Clinical Applications	Special Features
This is a standard all-silicone SGA.	All silicone. Single use.
Combines all-silicone cuff with PVC tube for cost savings.	All-silicone cuff with PVC tube. Single use.
Similar to AES Ultra CPV.	Similar to AES Ultra CPV.
Similar to LMA Classic, but with built-in CPV to minimize post-operative sore throat. Color-indicator bands provide instant feedback regarding pressure changes.	The CPV detects changes caused by temperature, nitrous oxide levels, and movement within the airway, enabling clinician to maintain a recommended cuff pressure of 60 cm H_2O. Single use.
Reusable, standard SGA.	40 uses.
Wire-reinforced SGA that accommodates repositioning of the head and neck. Color-indicator bands provide instant feedback regarding pressure changes.	Single use. The cuff pressure indicator detects changes caused by temperature, nitrous oxide levels, and movement within the airway. The CPV enables the clinician to maintain a recommended cuff pressure of 60 cm H_2O.
Reusable, wire-reinforced SGA, designed to accommodate repositioning of the head and neck during surgery.	40 uses.
Similar to both LMA Classic and LMA Fastrach. Allows easy access for flexible fiber-optic devices. Use as routine masked laryngeal airway. Removable connector allows intubation with standard ETs up to 8.5 mm.	Designed to minimize folding of the cuff tip on insertion. Same use and benefits as LMA Classic and LMA Fastrach. Integrated bite block reinforces the tube while diminishing the need for a separate bite block. Color-coded removable connectors are tethered to the airway tube avoiding episodes of misplaced connectors.
Same as air-Q Reusable Laryngeal Mask.	Same as air-Q Reusable Laryngeal Mask, but disposable.
Designed for use in ENT, ophthalmic, dental and torso surgeries.	Integrated pilot tube, and high flexibility enables positioning away from the surgical field, without a loss of seal. Single use. EasyGlide texture and extra-soft cuff ease insertion and removal. Convenient depth marks for monitoring correct position of the mask.
Allows easy access for flexible fiber-optic devices. For use in both anesthesia and emergency medicine.	Anatomically correct curve facilitates placement. One-piece mold. EasyGlide texture for ease of insertion. Convenient depth marks for monitoring correct position of the mask. MRI safe. Extra-soft cuff. If intubation becomes necessary or desired, recommend intubation over Aintree AEC. Single use.
For use in both anesthesia and emergency medicine.	Single-use, one-piece mold. EasyGlide texture for ease of insertion. Convenient depth marks for monitoring correct position of the mask. MRI safe. Extra-soft cuff.
Same as the LMA Classic.	Same as the LMA Classic, but reusable.
Same as the LMA Classic.	Reusable. Available only in the United States.

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Table 6. Selected Supraglottic Ventilatory Devices (continued)

Name (Manufacturer)	Description	Size
CobraPLUS (Engineered Medical Systems)	Similar to the CobraPLA. Includes temperature monitor (all sizes) and distal gas sampling (pediatric sizes only: ½, 1, and 1½).	Adult and pediatric sizes ½-6.
Coracle Perilaryngeal Airway (Engineered Medical Systems)	Large ID laryngeal tube, which is soft and flexible with a tapered, striated tip. Now has an improved distal curve, softer tube, and softer head. It has a high-volume, low-pressure oropharyngeal cuff.	Adult and pediatric sizes ½-6.
Esophageal Tracheal Combitube (Covidien)	A disposable DLT that combines the features of a conventional ET with those of an esophageal obturator airway. Has a large proximal latex oropharyngeal balloon and a distal esophageal low-pressure cuff with 8 ventilatory holes in between.	Two adult sizes. 41 Fr: height >5 ft. 37 Fr: height 4-6 ft.
Intersurgical i-gel (Intersurgical Inc)	Noninflating supraglottic airway designed to match the perilaryngeal anatomy, with an integral bite block and gastric channel.	Adult sizes (3-5) and nasogastric tube sizes 12-14 Fr.
KING LAD (King Systems/VBM Medizintechnik GmbH)	Family of disposable silicone and flexible laryngeal masks.	Adult and pediatric sizes 1-5 in silicone and 2-5 in flexible.
KING LT (King Systems/VBM Medizintechnik GmbH)	Multiuse, latex-free, single-lumen silicone tube with oropharyngeal and esophageal low-pressure cuffs, 2 ventilation outlets, insertion marks, and a blind distal tip (almost like a single-lumen, shortened Combitube).[16] Color-coded connectors for each size.	Sizes 3-5 available worldwide; sizes 0-2 currently available only outside the United States and Canada.
KING LT-D (King Systems/VBM Medizintechnik GmbH)	Same design as the KING LT, except disposable.	Adult sizes 3-5 and pediatric sizes 2, 2.5.
KING LTS (King Systems/VBM Medizintechnik GmbH)	Double-lumen laryngeal tube that incorporates a second (esophageal) lumen posterior to the ventilation lumen.	Adult sizes (3-5) and pediatric sizes (0, 1, 2, 2.5) currently available only outside the United States and Canada.
KING LTS-D (King Systems/VBM Medizintechnik GmbH)	Same as KING LTS, except disposable.	Adult sizes (3-5).
LMA Classic (LMA North America, Inc.)	Supraglottic ventilatory device that consists of an oval inflatable silicone cuff in continuity with a wide-bore tube that can be connected to an Ambu bag or anesthesia circuit. Designed to fit the pharynx of patients of various weights.	Adult and pediatric sizes 1-6, accommodating ET 3.5-7.0 mm.
LMA Classic Excel (LMA North America, Inc.)	The Classic Excel has the benefits of LMA Classic and an improved design to facilitate intubation. Reusable up to 60 times.	Adult and pediatric sizes 3-5.

Clinical Applications	Special Features
Same as LMA Classic. An added benefit is the ability to measure core temperature. In addition, distal CO_2 can be monitored in pediatric patients.	Similar to CobraPLA, but CobraPLUS allows monitoring of the patient's core temperature. In neonatal and infant patients, CobraPLUS has the ability to increase the accuracy of end-tidal CO_2 and volatile gas analysis. Single use. If intubation becomes necessary or desired, will accommodate ET up to 8.0 mm.
Same as LMA Classic.	Disposable. If intubation becomes necessary or desired, will accommodate ET up to 8.0 mm. Single use.
Same as LMA Classic. Appropriate for prehospital, intraoperative, and emergency use. Especially useful for patients in whom direct visualization of the vocal cords is not possible, patients with massive airway bleeding or regurgitation, limited access to the airway, and patients in whom neck movement is contraindicated.	Ventilation is possible with either tracheal or esophageal intubation. Distal cuff seals off the esophagus to prevent aspiration of gastric contents. Allows passage of an orogastric tube when placed in the esophagus. Single use.
Similar to other supraglottic airways, except the gastric channel allows for evacuation of stomach contents through passive venting or by the use of a suction catheter.	Noninflating cuff allows easy and rapid insertion, minimizing the risk for tissue compression. Gastric channel allows passive venting or suctioning of stomach contents with a catheter. Buccal cavity stabilizer reduces the risk for malposition and aids in insertion. Integrated bite block prevents occlusion of the airway channel. Single use.
Similar to LMA Classic but disposable.	Standard device is silicone. Flexible has silicone cuff and wire-reinforced tube.
Same as LMA Classic, but with ventilatory seal characteristics like those of LMA ProSeal.	Easily inserted, possible aspiration protection, and allows both PPV and spontaneous breathing. Nondisposable and reusable (up to 50 times).
Same as KING LT.	Also available in an EMS kit.
Same as KING LT, except that it has a second lumen for gastric access, similar to LMA ProSeal.	Allows easy passage of a gastric tube to evacuate stomach contents. Distal tip reduced in size to facilitate insertion. Reusable.
Same as KING LTS.	Allows passage of 18 Fr gastric tube. Also available in an EMS kit.
Although originally developed for airway management of routine cases with spontaneous ventilation, it is now listed in the ASA Difficult Airway Algorithm as an airway ventilatory device or a conduit for endotracheal intubation.[1,13] Can be used in both pediatric and adult patients in whom ventilation with a face mask or intubation is difficult or impossible. Can also be used as a bridge to extubation[14] and with pressure support or PPV.[15]	Nondisposable and reusable.
Same as LMA Classic.	Removable connector and epiglottic elevating bar to facilitate intubation. Works with ET up to 7.5 mm.

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Table 6. Selected Supraglottic Ventilatory Devices (continued)

Name (Manufacturer)	Description	Size
LMA CTrach (LMA North America, Inc.)	The LMA CTrach is an LMA Fastrach with built-in fiber optics that allow for ventilation, visualization, and intubation of the trachea. It includes an airway (made of silicone) that is similar to the Fastrach, with an attachable lightweight viewer.	Adult sizes 3-5 for patients ≥30 kg. Comes with Fastrach ETs 6.0-8.0 mm.
LMA Fastrach (LMA North America, Inc.)	Consists of a mask attached to a rigid stainless steel tube curved to align the barrel aperture to the glottic vestibule. The set includes an LMA with a stainless steel shaft covered with silicone (reusable version) and a single movable epiglottic elevating bar, ET stabilizer, and silicone wire-reinforced ET. The single-use Fastrach is made from PVC and includes a disposable wire-reinforced ET.	Adult sizes 3-5 that can accommodate special ETs 6.0-8.0 mm.
LMA Flexible (LMA North America, Inc.)	Original LMA cuff design attached to smaller diameter, flexible armored tube that allows repositioning of the tube without cuff displacement. New single-use version is easier to insert.	Adult and pediatric sizes 2-6.
LMA ProSeal (LMA North America, Inc.)	Designed with a modified cuff and dual tubes to separate the respiratory and alimentary tracts. Has a built-in bite block.	Adult and pediatric sizes 1½-5.
LMA Supreme (LMA North America, Inc.)	Has a gastric drain tube designed to suction the stomach, channel gases and fluids away from the airway, and confirm placement of the tip of mask at upper esophageal sphincter. The airway tube has a gentle curve and oblong shape to allow easier insertion and more stable placement.	Adult sizes 3-5.
LMA Unique (LMA North America, Inc.)	Original, disposable LMA design. Sterile, latex-free, available with or without syringe and lubricant. Soft cuff and airway tube allow for conformity to patients' natural anatomy.	Adult and pediatric sizes 1-5.
SLIPA Streamlined Liner of the Pharynx Airway (SLIPA Medical Ltd)	Similar to the LMA Unique.	Six adult sizes that relate to the dimension across thyroid cartilage cornu: 47, 49, 51, 53, 55, and 57 mm.
Soft-Seal Laryngeal Mask (Smiths Medical)	Similar in shape to the LMA Unique, but differs in its 1-piece design, in which the cuff is softer and there is no "step" between the tube and the cuff, an integrated inflation line, no epiglottic bars on the anterior surface of the cuff, and a wider ventilation orifice.	Adult and pediatric sizes 1-5.

Table 7. Devices for Special Airway Techniques

Name (Manufacturer)	Description	Size
Awake Intubation		
DeVilbiss Model 15 Medical Atomizer (DeVilbiss Healthcare)	Metal atomizer; includes glass receptacle (for liquid), pair of metal outlet tubes extending from metal atomizing nozzle, and adjustable tip for directing spray to inaccessible areas of the throat. Can be used with or without RhinoGuard tip cover.	Length: 10.5 in
Enk Fiberoptic Atomizer Set (Cook Medical)	Atomizer set consists of a pressure-resistant oxygen tube and a connecting tube attached by a 3-way side-arm fitting with a small flow control opening. The set also contains an introducer catheter and 2 syringes (1-mL).	

Clinical Applications	Special Features
Useful in unanticipated and anticipated difficult airways. Allows for continuous ventilation during intubation attempts. Provides a direct view of the larynx and real-time visualization of the ET passing through the vocal cords.	Reusable only. Comes with 3 airways, a viewer, charger, 5 ETs, and stabilizer rods.
Useful for ventilation and intubation. Designed for blind orotracheal intubation but can be used in conjunction with lighted stylets, FOB, or Flexible Airway Scope Tool. FOB recommended when using PVC ET.	Both reusable and disposable versions now available. Can be utilized as a blind or visually guided technique. Benefits include ability to intubate with larger ET and remove the device easily over the ET.
Particularly useful in ENT/head and neck procedures.	Both reusable and disposable versions now available. Airway tube resists kinking and cuff dislodgment, and thus may be positioned away from the surgical field without loss of seal.
Same as LMA Classic except drain tube also allows for evacuation of stomach contents.	Second cuff allows tighter seal for PPV. Reusable.
Same as LMA ProSeal.	A single-use LMA with a redesigned mask that achieves a 50% higher seal pressure than the Classic or Unique. Similar to all LMAs, the Supreme is designed to protect the airway from epiglottic obstruction—in this model with molded fins in the bowl of the mask.
Same as LMA Classic. Included in AHA 2000 Guidelines for CPR and Emergency Medicine Cardiovascular Care.	Single use.
Same as LMA Classic.	Its hollow structure allows storage of regurgitant liquids, minimizing aspiration risk.[1] More confident placement by first-time users.[2] Single use. Distributed in the United States by ARC Medical Inc.
Same as LMA Classic. Allows easy access for flexible fiber-optic devices.	If intubation becomes necessary or desired, will accommodate ET up to 7.5 mm. Single use.

Clinical Applications	Special Features
Intended for the application of topical anesthetics to the nose, oropharynx, and upper airway of patients, at the direction/discretion of a clinician.	Includes glass receptacle for dispensing the liquid; adjustable swivel top and vented nasal guard attached to a hand bulb. Can be used with all types of oil or water solutions that are compatible with rhodium metal plating. The all-metal top can be autoclaved. Reusable.
To apply topical anesthetics to laryngotracheal area through the working channel of a bronchoscope using oxygen flow. Designed and intended to be used by those trained and experienced in techniques of flexible fiber-optic intubation.	Device is an accessory to a bronchoscope. Delivery form is a fine spray mist using oxygen flow through a bronchoscope. Sterile. Single use.

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Table 7. Devices for Special Airway Techniques (continued)

Name (Manufacturer)	Description	Size
EZ-Spray (Intertex Research, Inc.)	Disposable atomizer device which comprises a plastic receptacle, atomizer nozzle, and gas inlet tube. Tubing is connected from an air or oxygen flowmeter nipple to the gas inlet tube on the device.	
MADgic Laryngo-Tracheal Atomizer (Wolfe Tory Medical, Inc)	Mucosal atomization device that incorporates a small flexible, malleable tube with an internal stiffening stylet that connects to a 3-mL syringe.	2 overall lengths: 11.4 cm, 21.6 cm
MADgicWand Pharyngeal Tissue Retractor/Atomizer (Wolfe Tory Medical, Inc)	Disposable pharyngeal tissue retractor/atomizer that connects to a 5-mL syringe.	
Face Mask Ventilation		
AincA Patil-Syracuse Mask (Anesthesia Associates, Inc.)	Reusable, contoured, good sealing face mask with capped port containing flexible silicone diaphragm that allows for endoscopy without interruption of ventilation.	Child, small adult, and large adult.
ErgoMask (King Systems)	Face mask with contoured finger/thumb grip.	Medium adult size.
Retrograde Intubation		
Cook Retrograde Intubation Set (Cook Medical)	Available as a complete set in 6.0 Fr or 14.0 Fr and includes Arndt Airway Exchange Catheter with Rapi-Fit adapter.	6.0 Fr=50 cm; 14.0 Fr=60 cm.
Transtracheal Jet Ventilation		
AincA Manual Jet Ventilator (Anesthesia Associates, Inc.)	Customizable assembly includes 5 ft of high-pressure tubing, flow control knob, on/off thumb control, internal filter, back pressure gauge, and 2 ft of low-pressure hose with distal Luer fitting.	Jet ventilation catheters of malleable copper with Luer fittings accommodate adults, children, and infants. Adapters allow direct connection to bronchoscope or ET.
Enk Oxygen Flow Modulator Set (Cook Medical)	Complete set including 15-gauge needle with reinforced fluorinated ethylene propylene catheter, syringe (5 cc), connecting tubing, and Enk oxygen flow modulator with tracheal catheter connector.	7.5 cm (2.0 mm ID).
Manujet III (VBM Medizintechnik GmbH)	Complete set including 4-m pressure hose, Luer lock connecting tubing, bronchoscope adapter, Endojet adapter with Endojet catheter, and jet ventilation catheter.	Jet ventilation catheters can accommodate adults, children, and infants.
Manual Jet Ventilator (Instrumentation Industries)	Complete set includes an on/off valve, 6 ft of high-pressure tubing, and 4 ft of small-bore tubing.	Jet ventilation catheter size 13G can accommodate adults, and 14G children.

Clinical Applications	Special Features
Application of topical anesthetic to the nose, oropharynx, and upper airway of patients, at the direction/discretion of a clinician.	Trigger-valve system provides controlled release of compressed gas to an atomizing nozzle, creating a liquid spray. Gas flow is adjusted to the desired setting. Use with either oil- or water-based solutions. Nonsterile. Single use.
Application of topical anesthetics to oropharynx and upper airway region. Fits through vocal cords, down LMA, or into nasal cavity.	Malleable applicator retains memory to adapt to individual patient's anatomy. Delivery of a fine spray mist is generated by a piston syringe. Luer connection adapts to any luer lock syringe. Nonsterile. Single use.
Allows retraction of soft tissue while applying topical anesthesia in a fine, gentle mist. Used to apply topical anesthetic to the airway before awake intubation.	Device blade positioned along floor of the mouth can be directed immediately in front of laryngeal inlet to generate a fine mist by a piston syringe. Nonsterile. Single use.
Simple technique that allows leak-free endoscopy while maintaining minimal interference with mask ventilation. Useful for identifying anatomic landmarks, obstructions, conditions and growths. Often used in conjunction with an oral airway (Patil-Syracuse, Williams, or other) to aid endoscopy.	Choice of 3 durable materials (aluminum, latex, and silicone), available in various sizes and seal types. Silicone seal of the port is replaceable if damaged. When capped, functions like a normal mask. Reusable and sterilizable.
Intended to facilitate 1-handed mask ventilation. Encourages proper chin lift to open airway. Allows improved control of mask seal.	Ergonomically designed for better hand placement. Ventilation port off-center facilitates use with small hands and improves mask seal.
Technique used for securing a difficult airway, either alone or in conjunction with other alternative airway techniques. Especially useful in patients with limited neck mobility or patients who have suffered airway trauma. 6.0 Fr places tubes ≥2.5 mm ID; 14.0 Fr places tubes ≥5.0 mm ID.	Packaged as a complete kit with everything needed to perform a retrograde intubation. The recently added Arndt Airway Exchange Catheter allows for patient oxygenation and facilitates placement of an ET. Disposable.
Same as Manujet III and usable for emergency direct TTJV and for laser throat surgery (elimination of plastic ET in laser path).	Easy factory customization available for hose lengths and oxygen source connection type (DISS vs various quick-disconnect types) as well as optional pressure regulator (with gauge) and standard or custom regulator-to-source connection hoses. Adapters, fittings, and connectors available. Completely reusable and sterilizable.
Same as Manujet III. Recommended for use when jet ventilation is appropriate but a jet ventilator is unavailable.	Packaged as a complete set with everything needed to perform TTJV. Disposable.
Well-accepted method for securing ventilation in rigid and interventional bronchoscopy. Because airflow is generally unidirectional, it is important that air has a route to escape (unobstructed airway).	Packaged as a complete kit with everything needed to perform TTJV. The Endojet adapter allows jet ventilation on an ET, LMA, or face mask. The catheter can be pushed forward through the ET or LMA as far as required, and can be fastened with a screw. Includes a pressure regulator. Reusable.
Same as Manujet III. Can also be used in unobstructed difficult airway management.	Offered with and without an adjustable pressure regulator to accommodate use on various-sized patients. Reusable.

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Table 7. Devices for Special Airway Techniques (continued)

Name (Manufacturer)	Description	Size
All in One		
Wadhwa Emergency Airway Device (Cook Medical)	Single device that looks similar to a pen. At one end of the "pen" is a needle with a 9 Fr cricothyrotomy catheter; on the other end is a nasopharyngeal airway catheter.	Cricothyrotomy catheter: 6.0 cm. Nasopharyngeal catheter: 9.5 cm (7.0 mm ID).

Table 8. Cricothyrotomy Devices

Name (Manufacturer)	Description	Size
Needle Cricothyrotomy		
Emergency Transtracheal Airway Catheter (Cook Medical)	6 Fr reinforced fluorinated ethylene propylene catheter.	5.0 and 7.5 cm.
Percutaneous Cricothyrotomy		
Melker Cuffed Emergency Cricothyrotomy Catheter Set (Cook Medical)	Same as Melker Emergency Cricothyrotomy Catheter Set.	9.0 cm (5.0 mm ID).
Melker Emergency Cricothyrotomy Catheter Set (Cook Medical)	Complete set including syringe (10 cc), 2- to 18-gauge introducer needles with TFE catheter (short and long), 0.038-in diameter Amplatz extra-stiff guidewire with flexible tip, scalpel, curved dilator with radiopaque stripe, and PVC airway catheter. Also available in a Special Operations kit, which includes all of the above in a slip peel-pouch and 2 airway catheters.	Standard kit: 3.8 cm (3.5-mm ID), 4.2 cm (4.0-mm ID), and 7.5 cm (6.0-mm ID). Special kit: 4.2 and 7.5 cm.
Pertrach Emergency Cricothyrotomy Kit (Engineered Medical Systems)	Contents include 2 splitting needles, cuffed or uncuffed ET, dilator with flexible leader, twill tape, syringe, extension tube, and scalpel (optional).	Adult: 6.8 cm (5.6-mm ID). Child: 3.9 cm (3.0-mm ID), 4.0 cm (3.5-mm ID), 4.1 cm (4.0-mm ID), and 4.4 cm (5.0-mm ID).
Quicktrach Emergency Cricothyrotomy Device (VBM Medizintechnik GmbH)	Complete kit includes airway catheter, stopper, needle, and syringes that come preassembled.	Adult (4.0-mm ID) and child (2.0-mm ID).
Surgical Cricothyrotomy		
There is no special kit for a surgical cricothyrotomy. It is performed by making an incision through the cricothyroid membrane using a scalpel, followed by the caudad insertion of an ET. This is the most rapid technique and should be used when equipment for the less invasive techniques is unavailable and when speed is particularly important.		
Combination Percutaneous and Surgical Cricothyrotomy		
Melker Universal Emergency Cricothyrotomy Catheter Set (Cook Medical)	Same as Melker Cuffed Emergency Cricothyrotomy Catheter Set for percutaneous technique. Also includes for surgical technique: tracheal hook, safety scalpel, Trousseau dilator, and blunt curved dilator.	9.0 cm (5.0-mm ID).

Clinical Applications	Special Features
Can be used for a needle cricothyrotomy, for TTJV, or as a nasal catheter.	The components require some preassembly. Once assembled, it is easy to transport to offsite locations and is intended for use in emergencies. The main body of the device acts as a blow tube or 15-mm adapter. Disposable.

Clinical Applications	Special Features
A lifesaving procedure that is the final option for "cannot-ventilate, cannot-intubate" patients in all airway algorithms.	Designed to be kink-resistant specifically for the purpose of needle cricothyrotomy.
Same as Melker Emergency Cricothyrotomy Catheter Set.	Same as Melker Emergency Cricothyrotomy Catheter Set.
Same as Emergency Transtracheal Airway Catheter. Intended to be used with the Seldinger technique via the cricothyroid membrane; however, it has the capability to be used as a surgical cricothyrotomy.	Packaged as a complete kit with everything needed to perform a percutaneous cricothyrotomy. The Special Operations kit comes in a slip peel-pouch for easy transport to offsite locations. Also can be used in the OR. It comes with 2 differently sized airway catheters to reduce the number of kits needed in the field. Disposable.
Use in failed orotracheal or nasotracheal intubation and/or fiber-optic bronchoscopy. Immediate airway control in patients with maxillofacial, cervical spine, head, neck, and multiple trauma. Also used when endotracheal intubation is impossible and/or contraindicated. Immediate relief of upper airway block.	Serves as an emergency cricothyrotomy or tracheostomy device that uses a patented splitting needle and dilator to perform a rapid and simple procedure.
Same as Melker Emergency Cricothyrotomy Catheter Set.	Packaged as a complete kit with everything needed to perform a percutaneous cricothyrotomy—even the neck tape and connecting tube. The removable stopper is used to prevent a "too-deep" insertion and avoid the possibility of perforating the rear tracheal wall. The conical needle tip allows for the smallest necessary stoma and reduces the risk for bleeding. Easily transported to offsite locations. Disposable.
Same as Melker Emergency Cricothyrotomy Catheter Set.	One-half of the tray is the same as Melker Cuffed Emergency Cricothyrotomy Catheter Set for the percutaneous technique. The other half of the tray includes all items necessary to perform a surgical emergency cricothyrotomy.

Table 9. Tracheostomy Devices

Name (Manufacturer)	Description	Size	Clinical Applications	Special Features
Percutaneous Dilatational Tracheostomy				
Ciaglia Blue Dolphin Balloon Percutaneous Tracheostomy Introducer (Cook Medical)	Complete kit with size-specific Blue Dolphin balloon dilator. Available with or without Shiley 6 or 8 PERC tracheostomy tubes. A tray version is available that includes lidocaine/epinephrine, 15-mm swivel connector, chlorhexidine skin prep, drape, and suture.	21, 24, 26, 27, 28, 30 Fr introducers.	One-step dilation and tracheal tube insertion. Establishes transcutaneous access to the trachea below the level of the cricoid cartilage by Seldinger technique.	Unique balloon-tipped design combines balloon dilatation and tracheal tube insertion into one step. Packaged as a complete kit with everything needed to perform a percutaneous dilatational tracheostomy.
Ciaglia Blue Rhino Percutaneous Introducer Set (Cook Medical)	Complete kit includes 24.0, 26.0, and 28.0 Fr loading dilators and Shiley 6 or 8 PERC disposable dual-cannula tracheostomy tube. A tray version is available that includes lidocaine/epinephrine, connector, chlorhexidine skin prep, drape, needle driver, and suture.	74 mm (6.4-mm ID); 79 mm (7.6-mm ID).	Same as Portex Ultraperc Percutaneous Dilatational Tracheostomy Kit.	Packaged as a complete kit with everything needed to perform a percutaneous dilatational tracheostomy. The single dilator with a hydrophilic coating and flexible tip results in a simpler, less traumatic insertion. The wire guide has a Safe-T-J tip to reduce trauma. Disposable.
Portex Ultraperc Percutaneous Dilatational Tracheostomy Kit (Smiths Medical)	Complete set with or without a tracheostomy tube.	70.0 mm (7.0-mm ID); 75.5 mm (8.0-mm ID); 81.0 mm (9.0-mm ID).	Establishes transcutaneous access to the trachea below the level of cricoid cartilage. Allows for smooth insertion of the tracheostomy tube over a Seldinger wire.	Packaged as a complete kit with everything needed to perform a percutaneous dilatational tracheostomy. The dilator is single-staged and prelubricated with an ergonomic handle to facilitate insertion. Disposable.
Shiley TracheoSoft XLT Extended-Length Tracheostomy Tubes (Covidien)	Available in 4 ISO sizes (5.0-, 6.0-, 7.0-, and 8.0-mm ID). Each size offers the choice of cuffed or uncuffed stylets, and proximal or distal extensions. Disposable inner cannula; replacements sold in packages of 10.	90 mm (5.0-mm ID); 95 mm (6.0-mm ID); 100 mm (7.0-mm ID); 105 mm (8.0-mm ID).	Flexible dual cannula tube for patients with unusual anatomy. Proximal length extension for thick necks; distal length extension for long necks, tracheal stenosis, or malacia.	The only fixed flange extended-length tube with disposable inner cannula. Flexible inner cannula conforms to the shape of the outer cannula. Sixteen configurations to fit a wide variety of patients. Disposable.
Surgical Tracheostomy				
Surgical tracheostomies are performed by making a curvilinear skin incision along relaxed skin tension lines between sternal notch and cricoid cartilage. A midline vertical incision is then made dividing strap muscles, and division of thyroid isthmus between ligatures is performed. Next, a cricoid hook is used to elevate the cricoid. An inferior-based flap or Bjork flap (through second and third tracheal rings) is commonly used. The flap is then sutured to the inferior skin margin. Alternatives include a vertical tracheal incision (pediatric) or excision of an ellipse of anterior tracheal wall. Finally, the tracheostomy tube is inserted, the cuff is inflated, and it is secured with tape around the neck or stay sutures.				

Surgical tracheostomy is more invasive, and should be performed on an elective basis and in a sterile environment.

Conclusion

Most airway problems can be solved with relatively simple devices and techniques, but clinical judgment born of experience is crucial to their application. As with any intubation technique, practice and routine use will improve performance and may reduce the likelihood of complications. Each airway device has unique properties that may be advantageous in certain situations, yet limiting in others. Specific airway management techniques are greatly influenced by individual disease and anatomy, and successful management may require combinations of devices and techniques.

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Abbreviation Key

AEC	airway exchange catheter
AHA	American Heart Association
ASA	American Society of Anesthesiologists
CCD	charge-coupled device
CMOS	complementary metal oxide semiconductor
CPR	cardiopulmonary resuscitation
DCI	direct coupled interface
DISS	diameter index safety system
DLT	double-lumen tube
ED	emergency department
EF	extra firm
EMS	emergency medical services
ENT	ear nose and throat
ET	endotracheal tube
FOB	fiber-optic bronchoscope
Fr	French
ICU	intensive care unit
ID	internal diameter
ILMA	intubating laryngeal mask airway
ISO	International Organization for Standardization
LCD	liquid crystal display
LED	light-emitting diode
LMA	laryngeal mask airway
MAC	Macintosh
NICU	neonatal intensive care unit
NTSC	National Television System Committee
OD	outer diameter
OR	operating room
PPV	positive pressure ventilation
PVC	polyvinyl chloride
PVP	polyvinylpyrrolidone
SGA	supraglottic airway
Stat	sterile single-use blade
TFE	tetrafluoroethylene
TTJV	transtracheal jet ventilation
USB	universal serial bus

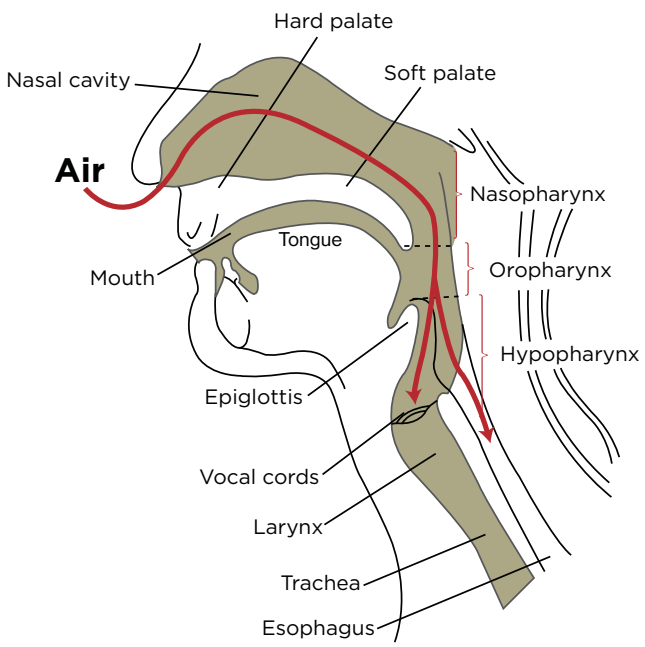
Patient Guide to THE AIRWAY

If you are undergoing surgery or a medical procedure, you most likely will receive drugs that put you to sleep (sedatives), cause you to lose consciousness (anesthetics), and relieve your pain (analgesics). While asleep, you may need help in continuing to breathe normally. This is called airway management and is the job of the anesthesiologist.

The anesthesiologist may use a face mask, tube, or other device to administer oxygen or drugs to you while you are unconscious. Such devices may be removed before or after you awaken. Once you are awake, be sure to let your doctor or nurse know if you experience any symptoms, such as hoarseness or other voice changes, coughing, throat irritation, or difficulty swallowing.

In most patients, management of the airway is straightforward. In some cases, however, it may be difficult. Therefore, the anesthesiologist may ask you for information ahead of time to determine whether the management of your airway might be difficult. This is especially important for patients who previously have experienced problems with anesthesia; who are obese; or who have sleep apnea, dentures, or jaw problems such as with the temporomandibular joint (commonly referred to as TMJ).

Anatomy of the Airway



Four Questions You May Want To Ask Before Undergoing Surgery And Anesthesia

1. Why do I need to fast the night before my operation?
2. Am I at a greater risk from anesthesia because I have sleep apnea?
3. If my anesthesiologist has difficulty in managing my airway, will I be informed?
4. If I am told that I had a difficult airway during anesthesia, what should I do with that information?

RESOURCES

American Society of Anesthesiologists
http://lifelinetomodernmedicine.com
www.asahq.org/PatientEducation

Society for Airway Management
http://samhq.com/patient-info/

Agency for Healthcare Research and Quality
www.ahrq.gov/consumer

From the office of _____

Directions/comments _____

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