Continuing Medical Education

Fibreoptic intubation

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Although not widely utilized, fibreoptic techniques represent a dramatic advance in the management of the difficult intubation. Particularly suited to the awake patient in the elective setting, fibreoptic intubation can also be useful in selected emergency situations, and can be done under general anaesthesia. In the awake patient fibreoptic intubation maintains a wide margin of safety while producing minimal patient discomfort, but requires adequate local anaesthesia of the airway. Intimate familiarity with the bronchoscope and the anatomy of the upper airway is essential as is careful attention to various aspects of technique. Intubation mannequins can be readily utilized to develop dexterity in bronchoscopic manipulation and intubation workshops are also effective in improving skills. This CME article provides the clinician with a detailed approach to the technique of fibreoptic intubation based on the author's personal experience supplemented by a limited literature review. Fibreoptic intubation is not a difficult skill to master and should be in the armamentarium of all practising anaesthetists.

Sans être universellement utilisée, la fibroscopie constitue un progrès intéressant pour la prise en charge des voies aériennes difficiles. Particulièrement adaptée au malade éveillé pour des interventions programmées, l'intubation fibroscopique est aussi utile en urgence et réalisable sous anesthésie générale. Chez le patient éveillé, l'intubation fibroscopique parmet une grande marge de sécurité avec désagrément minime, mais nécessite une anesthésie locale adéquate des voies respiratoires. Il faut bien connaître le bronchoscope, l'anatomie des voies respiratoires supérieures et les particularités de la technique. Des mannequins peuvent être utilisés pour développer la dextérité nécessaire à la manipulation du bronchoscope et les ateliers d'enseignement sont efficaces. Cet article d'enseignement médical continu fournit au clinicien un accès détaillé à la technique d'intubation fibroscopique basée sur l'expérience personnelle de l'auteur avec une brève revue de la littérature. L'intubation fibroscopique n'est pas difficile à maîtriser et devrait faire partie de l'arsenal de tous les anesthésistes en exercice.

Key words
AIRWAY: anaesthesia;
EQUIPMENT: bronchoscopes, fibreoptic;
INTUBATION: fibreoptic, technique.

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Airway management is fundamental to the practice of anaesthesia and tracheal intubation is frequently required to ensure adequate airway control, while providing optimal operating conditions. Intubation by direct laryngoscopy is usually satisfactory. However, in the presence of certain anatomical variants or airway pathology, visualization of the glottis by direct laryngoscopy can be difficult or impossible. Furthermore, in the presence of cervical spine injury, neck movement must be minimized if neurological injury is to be avoided; although optimal airway management in this circumstance remains controversial, and no intubation technique has been shown to be clearly superior to any other.[1-3] Difficulty laryngoscopy can usually be predicted on physical examination, but unexpected difficult laryngoscopy can occur. If intubation fails and ventilation is inadequate, then a surgical airway (percutaneous transtracheal ventilation or cricothyrotomy) is immediately necessary. If difficult laryngoscopy is anticipated, or occurs unexpectedly following induction of general anaesthesia and mask or spontaneous ventilation is adequate, then alternative techniques include blind nasal, digital, retrograde, lightwand assisted, and fibreoptic intubation. Intubation over a fibreoptic scope can be an invaluable option. Despite extensive attention in the literature since its initial description in 1967[4] fibreoptic intubation has not achieved widespread utilization and continues to be approached with trepidation by many physicians who regularly manage the airway.

Awake versus asleep

Although fibreoptic intubation can be done in the unconscious individual, it is particularly suited to the awake patient and, with proper technique, produces minimal discomfort while maintaining a wide margin of safety.[5-9]

However, meticulous attention must be paid to local anaesthesia of the airway.

Loss of consciousness is associated with a loss of tone in the submandibular muscles that directly support the tongue and indirectly support the epiglottis.[10] Posterior movement of the tongue and epiglottis can then obstruct the airway at the level of the pharynx and larynx respectively, the degree of obstruction being influenced by variations in airway anatomy, body habitus, and depth of coma.[10,11] Induction of general anaesthesia in the presence of a suspected difficult intubation may be followed by airway compromise and difficult mask ventilation. If intubation is difficult, then patient safety may be jeopardized.[12] Furthermore, in the unconscious individual reduction of the calibre of the pharyngeal lumen makes fibreoptic visualization more difficult.[5,13-15] Contact of the lens with the mucosa results in complete loss of the visual field and thus one's ability to manoeuvre past an epiglottis in contact with the posterior pharyngeal wall is limited,[13,16] although various airway intubators can be used to facilitate fibreoptic intubation in this circumstance.[17,18]

Where possible, fibreoptic intubation should be performed with the patient awake.

Equipment

An adequate fibrescope is necessary. Standard adult bronchoscopes work well, having excellent optics, a suction channel which is useful for injection of local anaesthetic and administration of oxygen,[5,19,20] and sufficient length (about 60 cm) to accommodate the endotracheal tube proximally while leaving an adequate distal segment for manoeuvrability.[15] Shorter scopes limit manoeuvrability and make intubation more difficult. Silicone or soap solution applied to the tip of the scope prevents fogging of the room temperature lens on exposure to warm humidified gas in the airway.[4,15] Alternatively, the tip of the scope can be briefly held against the buccal mucosa to warm the lens and prevent condensation. The endotracheal tube should be precut if possible to the appropriate length, and the lumen lubricated (lidocaine spray works well). Lubricating the scope is unnecessary and makes it difficult to hold and manoeuvre. The tube is then threaded over the distal tip of the scope, fed proximally, and fixed in position adjacent to the control handle using adhesive tape. Bronchoscopes such as the Olympus model B3R with an outside diameter of 5.9 mm will accommodate a 6.5 mm or larger endotracheal tube.[20] A 3.2 mm bronchoscope such as the Olympus BF 3C2 will accommodate tubes as small as 4.5 mm internal diameter (ID) for paediatric intubation.[14] The "ultra-thin" flexible bronchoscope with an outside diameter of 2.7 mm at its distal tip has allowed application of the technique to infants requiring tubes as small as 3.0 mm ID[21] (Table I). Use of the paediatric bronchoscope for fibreoptic intubation in the adult makes the procedure more difficult. The more flexible paediatric scope forms a floppy stylette, is easily buckled away from the glottis as the ensleeved endotracheal tube is advanced, and may be pulled back out of the trachea by an endotracheal tube directed away from the glottic opening.[19,22]

TABLE I

Bronchoscope (OD)	*Endotracheal (ID)*
5.9 mm (Olympus Model B3R)	≥6.5 mm
3.5 mm (Olympus BF-3C4)	≥4.5 mm
2.7 mm (Olympus PF-27L)	≥3.0 mm

The size of the ensleeved endotracheal tube relative to the scope can also affect the passage of the tube into the trachea over the scope. A snug fit between the scope and the endotracheal tube minimizes the concentric gap between the two and therefore the risk of the tube catching on the laryngeal cartilages as it is advanced over the scope.[16,23,24] However, if the bronchoscope must remain inside the tube in the trachea for relatively prolonged periods, as during diagnostic or therapeutic bronchoscopy, then the concentric airway remaining must be adequate to permit ventilation.[24,25] A 5 mm bronchoscope passed through an 8–8.5 mm ID tube leaves a concentric airway that approximates a 7 mm ID endotracheal tube in cross-sectional area.[24] Similarly when oxygen is administered through the suction channel of the scope, an adequate concentric gap between the scope and the tube must exist if barotrauma is to be avoided.[19] Flexible armoured tubes may more easily follow the curves of the fibreoptic bronchoscope as it passes through the glottis and trachea.[25,26] Stiffer preformed endotracheal tubes can be softened by immersion in warm water.[12]

Manual dexterity with the bronchoscope is essential to ensure successful fibreoptic intubation. It must be appreciated that the tip of the scope can be flexed in one plane only and maximally in only one direction using the control lever located at the handle.[16] Movement of the tip of the scope in any other plane requires rotation of the entire instrument.[16] On occasion it may be necessary to orient the scope such that the maximum flexion occurs anteriorly.[14] The flexible tip of the scope must also be unlocked and the optics prefocused on printed material. Generally the proximal control section of the scope is held in one hand with the index finger on the suction port and the thumb on the lever which regulates angulation of the distal tip.[27] The other hand holds the shaft of the scope distally and guides its advance. The light source and suction are most conveniently located to the operator's left. Manipulation of the instrument should be second nature before intubation of a patient is attempted.

Airway anaesthesia

If adequate local anaesthesia can be obtained, subsequent fibreoptic intubation is usually easy. A variety of techniques exists, the choice often being a matter of personal preference.[28,29]

Lidocaine is probably the local anaesthetic most frequently used for topical anaesthesia of the airway, although tetracaine is also popular and cocaine is still used by some for nasal anaesthesia.[3] Lidocaine 2–4% applied to mucous membranes produces superficial anaesthesia in about one minute.[28,30] The peak effect occurs within two to five minutes and the duration of action is 30–45 min.[31] The maximum safe dosage has generally been considered to be 3–4 $mg \cdot kg^{-1}$, although some recommend up to 6 $mg \cdot kg^{-1}$.[30,32–34] In a recent study of lidocaine absorption in awake fibreoptic intubation, dosages up to 11 $mg \cdot kg^{-1}$ were used[23] and, despite the high dose (mean ± S.D., 5.3 ± 2.1 $mg \cdot kg^{-1}$; range 2.5–11 $mg \cdot kg^{-1}$), mean peak plasma concentration was low (0.6 ± 0.3 $\mu g \cdot ml^{-1}$) and the highest plasma concentration was 1.6 $\mu g \cdot ml^{-1}$. The normal therapeutic plasma concentration for control of ventricular arrhythmias is 2–5 $\mu g \cdot ml^{-1}$.[23] Lidocaine concentrations also showed no correlation with either the total dose or $mg \cdot kg^{-1}$ dose administered.[23] Topically administered tetracaine produces a peak anaesthetic effect in three to eight minutes and has a duration of action of 30–60 min.[3,30,35] Concentrations of 0.45–2% are effective,[22,30,31,34] and the maximal safe dosage is 50–80 mg.[30,34] Cocaine is the only local anaesthetic that inhibits reuptake of norepinephrine and thereby produces vasoconstriction, hence its popularity for nasal procedures.[3,28] Following topical application, surface anaesthesia is essentially immediate whereas vasoconstriction occurs after a latent period of five to ten minutes.[33,34] The anaesthetic effect persists for 30–90 min.[33,34] Concentrations of 4–10% are effective.[31,34] The maximum safe dosage is generally considered to be 1–3 $mg \cdot kg^{-1}$,[31,33–35] although toxic reactions have been reported after nasal administration of as little as 20–30 mg[3,35,36] (see Table II).

Sensation to the nasal and oral cavities is supplied by the trigeminal nerve, which also innervates the roof of the nasopharynx and contributes to the sensory supply of the soft palate and palatine tonsils.[28] The posterior edge of the soft palate, the posterior third of the tongue, the superior aspect of the epiglottis, and the remainder of the oropharynx and nasopharynx are innervated by the glossopharyngeal nerve.[28] Stimulation of these latter structures during intubation typically provokes gagging and vomiting. The vagus through the internal laryngeal branch of the superior laryngeal nerve supplies sensation to the laryngopharynx including the piriform sinuses, and to the larynx above the level of the false vocal cords.[28,37] The recurrent laryngeal nerve supplies sensation to the larynx below the false cords and to the adjacent trachea.[28,37]

TABLE II Airway topical anaesthesia

Anaesthetics
1 Lidocaine 2–4% Maximum: 3–4 $mg \cdot kg^{-1}$
2 Tetracaine 0.45–2% Maximum: 50–80 mg (adult)
3 Cocaine 4–10% Maximum: 1–3 $mg \cdot kg^{-1}$

For awake oral fibreoptic intubation topical anaesthesia of the posterior tongue, palate, uvula, tonsillar pillars and the posterior pharyngeal wall can be achieved sequentially, using commercially available lidocaine spray (10 mg per spray), simply by directing the spray onto the relevant structures.[28] Alternatively, cooperative patients can gargle 30 ml of lidocaine 2–4% liquid in two to three stages to achieve anaesthesia of the posterior aspects of the oral cavity and the oropharynx.[28] At least one minute should be allowed for the anaesthetic effect to occur.[28] Anaesthesia of the anterior aspect of the oral cavity innervated by the trigeminal nerve is not necessary. Nebulized anaesthetic can then be used to produce dense anaesthesia of the remaining unblocked areas of the pharynx, the larynx, and the trachea. A DeVilbiss atomizer containing 10 ml lidocaine 2% or tetracaine 0.45% can be connected to a high pressure oxygen source by means of suitable tubing with a lateral hole cut in it.[28] Using an oxygen flow of about 8 $L \cdot min^{-1}$, a spray of local anaesthetic is produced from the atomizer nozzle by intermittently occluding the hole with a fingertip.[28,38] Held at the nostril, the nozzle can deliver anaesthetic throughout inspiration, and when coordinated with respiration can produce intense anaesthesia of the airway from the nose to the trachea in less than five minutes[28,38] (Figure 1). Alternatively, the atomized anaesthetic can be administered via the mouth, although superior gas flow characteristics through the nose may deliver the anaesthetic more efficiently to the pharynx, larynx, and trachea. Aerosolized anaesthetic (4 ml lidocaine 4%) can also be administered through the mouth using a standard nebulizer fitted with a mouthpiece.[40] An airway intubator can be attached to the nebulizer to deliver the aerosol into the more distal airway.[28,39] Anaesthesia of the nasal airway can be achieved using a standard oxygen face mask attached to the nebulizer and having the patient

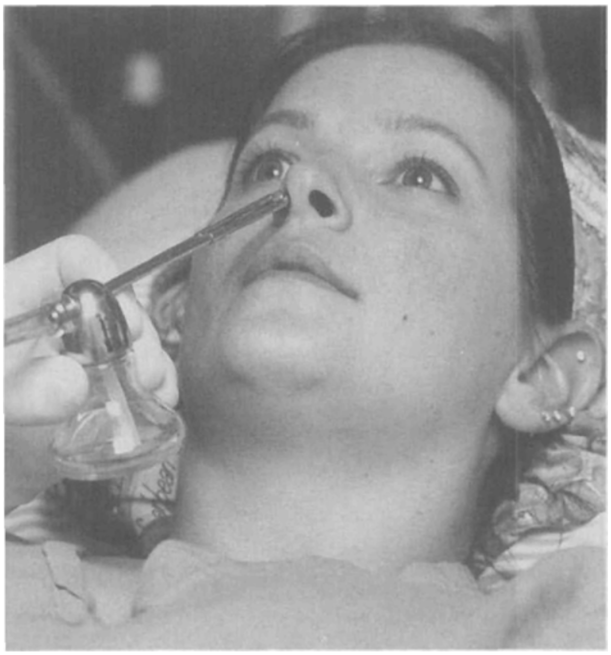

FIGURE 1 The DeVilbiss atomizer positioned at the naris. The operator's right hand intermittently occludes the lateral hole cut in the oxygen tubing to produce a spray of local anaesthetic from the atomizer nozzle during the inspiratory phase of respiration.

breathe through the nose.[40] Cotton tipped applicators or cotton plegets can also be used to administer topical anaesthesia to the nasal mucosa.[5,6,9,41]

The superior laryngeal nerve can be blocked in the piriform fossa where it runs just deep to the mucosa by using Kraus or Jackson forceps to hold a cotton pledget soaked in lidocaine 2–4% against the mucosa for about 60 sec[9,28,34,38,42] (Figure 2). Alternatively, this block can be performed using an external approach to the nerve as it penetrates the thyrohyoid membrane near the greater cornu of the hyoid bone.[9,43,44] A 21 to 22 gauge needle is passed in a posteromedial direction to make contact with the hyoid at or near the greater cornu and then walked caudally until it slips off the bone. A loss of resistance may be appreciated as the thyrohyoid membrane is perforated. Following aspiration to rule out entry into a vessel or the pharyngeal lumen, 3 ml lidocaine 2% can be injected.[43] If the hyoid cannot be palpated or if palpation produces undue patient discomfort, the thyroid cartilage can be used as a landmark,[9,29] the needle being inserted just above the thyroid cartilage at a point $^1/_3$ of the distance from the midline to the greater cornu and advanced upward and medially until a definite give is felt as the thyrohyoid membrane is perforated.[45]

Laryngeal anaesthesia can also be produced by cricothyroid puncture.[42,43,45-49] A 21–22 gauge needle is

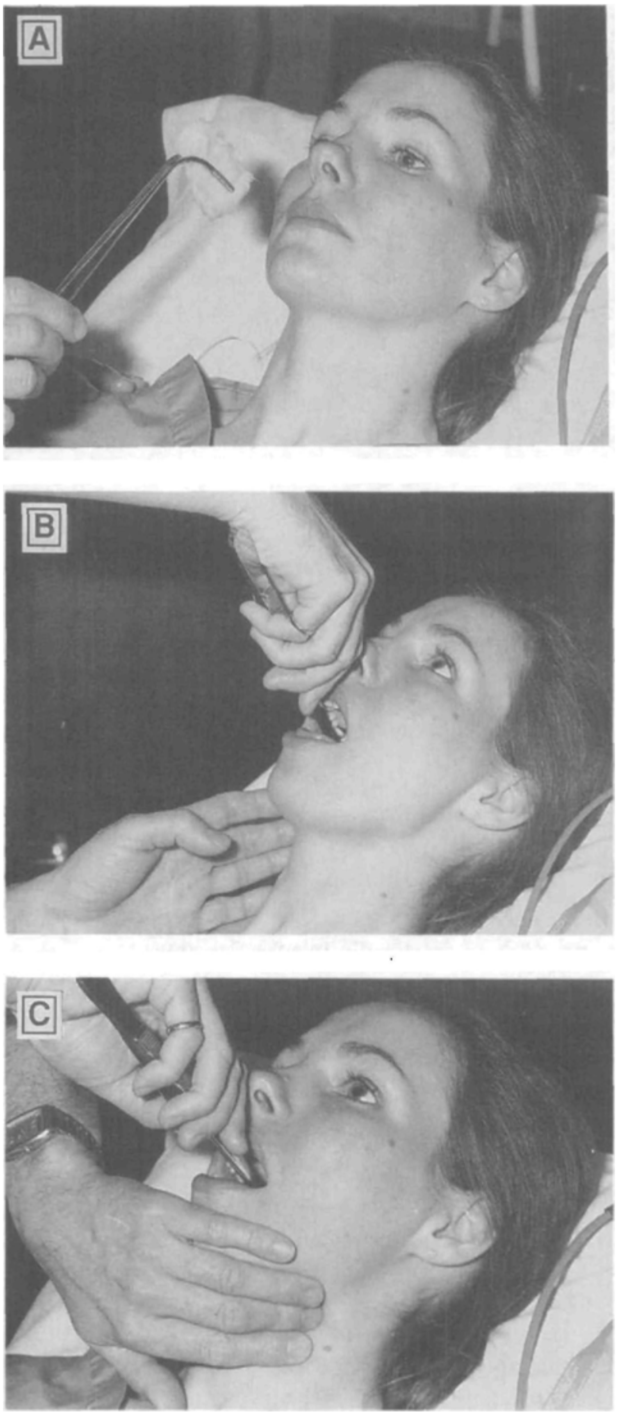

FIGURE 2 Superior laryngeal nerve block (internal approach). A cotton pledget soaked in 4% lidocaine is held securely by Jackson forceps and introduced into the oral cavity near the midline, advanced posteriorly over the dorsum of the tongue, until at about the level of the vallecuca it is moved laterally and caudad to enter the piriform sinus. Correct positioning in the piriform sinus is confirmed by palpation of the neck lateral and superior to the thyroid cartilage. The block is then repeated on the contralateral side.

passed posteriorly in the midline immediately cephalad to the cricoid cartilage to enter the larynx.[47] Correct positioning within the lumen is confirmed by aspiration of air, and then 1.5–2.0 ml lidocaine 4% injected, optimally at end exhalation.[45,47] The subsequent inspiration and cough then facilitates spread of anaesthetic, which has been reported to reach the superior aspect of the cords in 95% of cases.[50]

Almost always, when elective fibreoptic intubation is required, excellent local anaesthesia can rapidly and reliably be obtained by lidocaine gargle or spray followed by an aerosol technique. The DeVilbiss atomizer works especially well. A lidocaine-soaked cotton pledget held in Jackson forceps can then be used to assess the intensity of the pharyngeal anaesthesia and complete the superior laryngeal nerve block as necessary. In selected circumstances other techniques may be particularly useful. Ideally, fibreoptic intubation should not be attempted until satisfactory anaesthesia has been obtained. However, in more urgent situations or when local airway anaesthesia cannot be achieved before introduction of the bronchoscope, local anaesthetics can be administered through the suction channel of the scope and directed onto the relevant structures, although some cough or gagging may be precipitated.

Theoretically, in high-risk situations, administration of local anaesthesia to the larynx and trachea may predispose to aspiration by obtunding protective airway reflexes.[42–45,48,50] However, these techniques have been used in these circumstances without associated aspiration,[7,45,46,48,49,51,52] and the relative risk must be weighed against those associated with other airway management modalities. A common sense approach using good clinical judgement is mandatory.

If lidocaine or tetracaine is used for nasal intubation, a vasoconstrictor is helpful to reduce mucosal bleeding. Phenylephrine 0.005–1%[31,36,46] administered by spray is suitable. Oxymetazoline 0.05% or xylometazoline 0.05–0.1% (otrivin) can also be used[21,53,54] (see Table III[54,55]). Despite local vasoconstriction, some bleeding occurs in up to 69% of nasal intubations.[36]

Secretions dilute local anaesthetics topically applied to the airway and interpose a mechanical barrier between the anaesthetic and the mucosa.[3,28,56] Antisialogogues are invaluable adjunts but must be given (usually *im*) at least 30 min before airway manipulation to permit adequate drying of the mucous membranes to occur.[2,38] Both atropine and glycopyrrolate are effective.[3,28] In the adult the appropriate dosage of glycopyrrolate is 0.2–0.4 mg *im* (children, 0.01 $mg \cdot kg^{-1}$)[57] and of atropine 0.4–0.6 mg *im* (children, 0.01–0.03 $mg \cdot kg^{-1}$, maximum 0.6 mg).[54,57,58]

The use of carefully titrated sedation to facilitate local anaesthesia of the airway and fibreoptic intubation can lessen patient discomfort and attenuate recall. The antitussive effect of narcotic is also useful.[5,59] The use of sedation, however, introduces additional risks. If airway compromise or respiratory distress exists, any further impairment of consciousness can worsen hypoxia and hypercarbia.[3,28] Furthermore, as the sedated patient understands or follows commands less well or becomes more distressed, control of the situation may be lost.[3,28] As airway reflexes are further obtunded the risk of aspiration also increases. In the elective setting, useful sedation can be achieved in the adult using increments of fentanyl (50 μg), diazepam (1–2 mg), or midazolam (0.5–1.0 mg) *iv*, either alone or in some combination. In children diazepam 2–5 mg *iv* has been used successfully to permit fibreoptic intubation;[14] alternatives include meperidine 1–2 $mg \cdot kg^{-1}$ *iv*, and a lytic cocktail of meperidine 2 $mg \cdot kg^{-1}$, promethazine 1 $mg \cdot kg^{-1}$, and thorazine 1 $mg \cdot kg^{-1}$ *im* one hour before the procedure.[60] In the infant and small child chloral hydrate 75 $mg \cdot kg^{-1}$ *po* 30–45 min before the procdedure has been used supplemented with meperidine *iv*.[60] Again, choice of sedation is largely personal preference. In the adult, small doses of droperidol (1–2 mg *iv*) added to fentanyl, classic neuroleptanalgesia, is very effective. Titration of diazepam or midazolam to a suitable level of sedation without producing respiratory depression or impaired patient cooperation can, however, be problematic.[3,61] In the emergency situation haloperidol (2–10 mg *iv*) can be immensely helpful when judicious chemical restraint is required to permit appropriate airway management of combative and often intoxicated patients.[3,62] The goal of sedation should be a calm and comfortable patient responsive to command.[6] As time and circumstances permit, patient anxiety can be reduced and cooperation enhanced by a preceding explanation of the procedure including a frank discussion of the indications including the increased margin of safety.[9,60] Communication with the patient throughout the procedure also enhances cooperation and lessens anxiety.

TABLE III Topical nasal vasoconstrictors

1 Neosynephrine
– Adults (≥12 yr): 0.25–0.5%, 2–3 sprays in each nostril
– Children (6–12 yr): 0.25%, 2–3 sprays in each nostril
– Infants (<6 mo): 0.16%, 1–2 drops in each nostril
2 Xylometazoline
– Adults: 0.1%, 1–2 sprays or 1 metered dose spray or 2–3 drops in each nostril
– Children (>6 yr): 0.05%, 1–2 sprays or 2–3 drops in each nostril
– Children (<6 yr): 0.05%, 1 spray or 1 drop in each nostril
3 Oxymetazoline
– Adults and children ≥6 yr: 0.05%, 2–3 sprays or drops in each nostril
– Children (2–5 yr): 0.025%, 2–3 drops in each nostril

Skillfully done, patients tolerate awake fibreoptic intubation surprisingly well. Of those who recalled the procedure in two studies only three of 37 and eight of 183 considered it unpleasant or somewhat unpleasant.[6,7] During the procedure oxygen can be administered by nasal prongs, a modified mask, or via the suction channel of the bronchoscope.

Awake fibreoptic intubation – technique

Standing at the head of the bed (as for laryngoscopic intubation) may best preserve conventional spatial orientation as the airway is viewed through the scope. However, positioning oneself at the patient's side facing cephalad facilitates negotiating the curved pathway to the trachea, and as eye contact with the patient can be maintained, this position may be less intimidating. The patient monitors can also be readily observed. The patient may be supine or seated, although the sitting position may also be less intimidating, and better maintains the patency of the pharyngeal lumen, thereby improving fibreoptic visualization. Head tilt without neck flexion maximally opens the pharyngeal airway and use of the sniffing position as for direct laryngoscopy may be counterproductive.[10,29,63] Where possible, the patient should be sitting or semisitting with the neck in neutral position. Appropriate monitors include ECG, pulse oximetry, and noninvasive blood pressure.

If the oral route is chosen, the most important aspect of the technique is to stay in the midline. Introducing the scope through or alongside a suitable bite-block avoids potential damage to the scope; however, the block tends to push the tongue posteriorly and cephalad into the oropharyngeal isthmus and makes visualization more difficult. Furthermore, its use is unnecessary if adequate local anaesthesia has been achieved and patient cooperation is satisfactory. Visualization is markedly improved by having an assistant stand on the opposite side of the patient gently retracting the tongue using gauze-covered gloved fingers (Figure 3).[15,64] Then the endoscopist holding the control handle of the bronchoscope in one hand places the other hand on the flexible shaft of the instrument near its distal tip and inserts the scope into the mouth in the midline (Figure 4), and advances it posteriorly over the dorsal surface of the tongue either under direct vision or fibreoptic control until the uvula is identified in the superior aspect of the visual field (Figure 5). Gently resting the hand guiding the shaft of the scope on the subject's chin may help preserve a midline orientation.[16] If the uvula is in contact with the dosum of the tongue, the patient can be instructed to take a deep breath to elevate it and create an adequate airspace for visualization. If the tip of the bronchoscope is allowed to contact the mucosa, visualization is lost. The scope is then advanced just past the uvula and flexed caudally

FIGURE 3 Gentle tongue retraction.

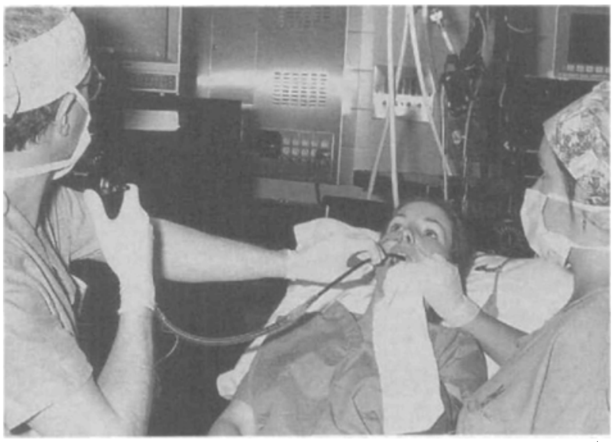

FIGURE 4 Insertion of the bronchoscope into the oral cavity.

to visualize the epiglottis, seen inferiorly in the scope's field of vision (Figure 6). If the epiglottis is tilted posteriorly or in contact with the posterior pharyngeal wall, the patient can again be instructed to take a deep breath and thereby lift the epiglottis anteriorly. The scope can then be passed behind the epiglottis to visualize the vocal cords (Figures 7 and 8), advanced into the larynx, and passed through the glottic opening into the trachea (Figure 9) during inspiration. The tip of the scope is then positioned just proximal to the carina (Figure 10). If at any time visualization or orientation is lost, the scope should be withdrawn until an appropriate midline landmark (usually the uvula or epiglottis) is identified and then advanced again. The lubricated ensleeved endotracheal tube is then advanced under direct vision over the scope which functions as a stylette, aiming for the midline and following the natural curve of the airway (Figure 11). The bevel of the tube should be oriented in an antero-posterior direction parallel to the vocal cords

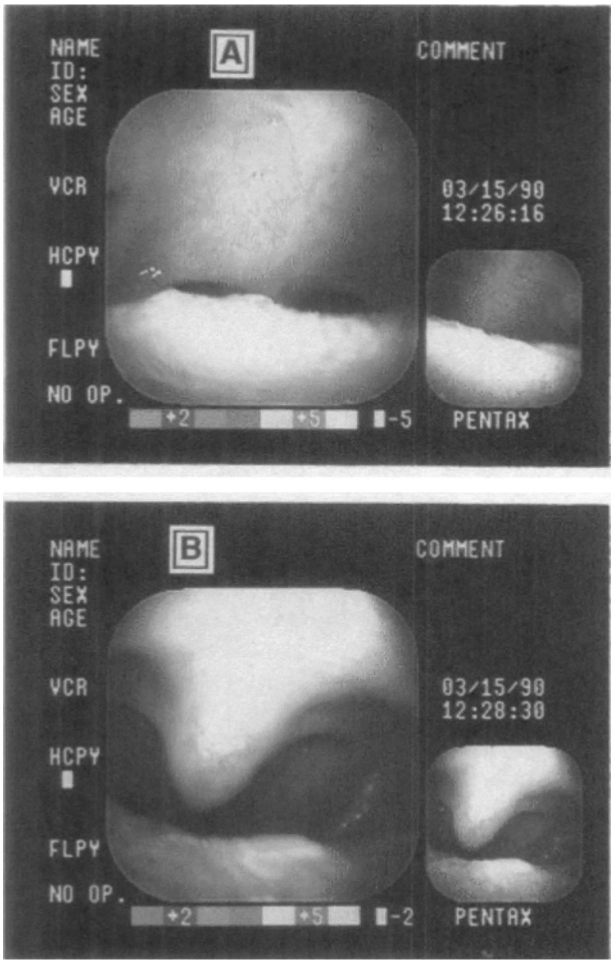

FIGURE 5 The uvula (superiorly) and the dorsum of the tongue (inferiorly) as seen through the brnchoscope.

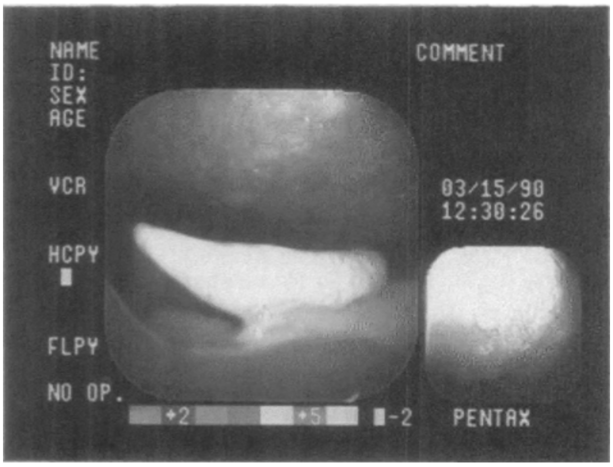

FIGURE 6 The bronchoscopic view of the epiglottis seen as a pale leaf-like transverse structure.

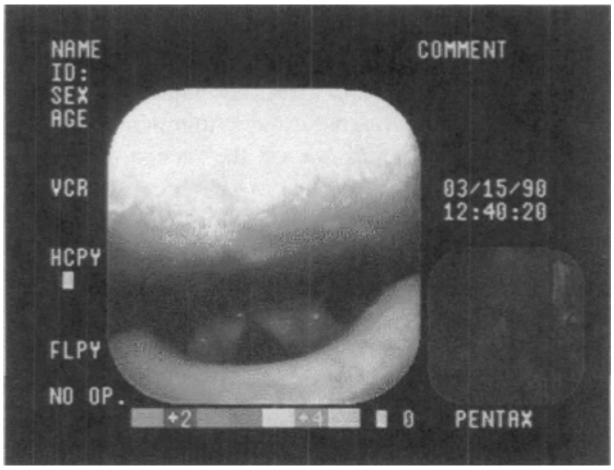

FIGURE 7 The vocal cords coming into view as the scope is advanced past the epiglottis which is seen inferiorly.

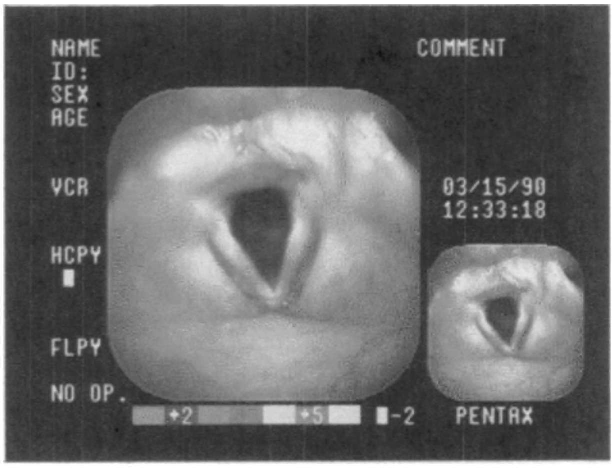

FIGURE 8 The view of the glottis with the bronchoscope positioned just above the cords. The posterior commissure is seen to be oriented superiorly in the visual field with the operator facing cephalad.

and advanced through the glottis during a deep inspiration to maximize cord abduction.[13] During oral fibreoptic intubation the acute angle of insertion into the larynx may cause the ensleeved endotracheal tube to move posteriorly relative to the scope and impact on the arytenoids.[65] Orienting the bevel to face posteriorly may facilitate laryngeal entry,[65] as can rotation of the tube.[22,24] Use of a tube with a tapered tip without a bevel may also facilitate laryngeal cannulation.[66] The intratracheal position of the endotracheal tube can then be confirmed endoscopically before the scope is removed. Correct placement of the tube can be further confirmed by capnography and physical signs in the usual fashion.

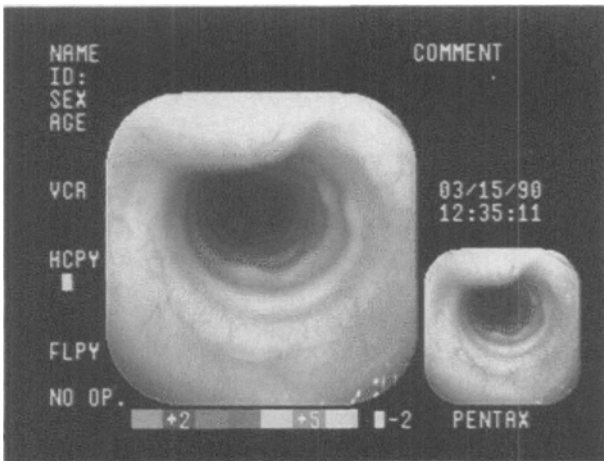

FIGURE 9 The bronchoscopic view of the trachea.

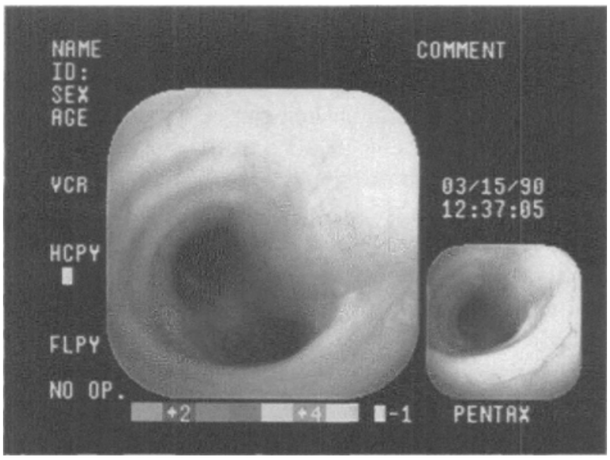

FIGURE 10 The carina as seen through the bronchoscope with the operator facing cephalad. The posterior aspect of the trachea is oriented superiorly and to the right. The right mainstem bronchus is seen to the left and superiorly.

If the nasal route is chosen, the endotracheal tube can be introduced first until it exits the choana to enter the nasopharynx.[5-7,9,14,19,24,51] The scope is then advanced through the lubricated tube. The glottis is usually in view straight ahead, or at least the epiglottis is visible as the scope exits the endotracheal tube. The scope is advanced toward the glottis taking care to avoid touching the walls of the pharynx. If the epiglottis is lying against the posterior pharyngeal wall, the patient can again be asked to take a deep breath to elevate the epiglottis anteriorly and create an adequate airspace for the scope to be passed behind it without touching the mucosa with the lens and thereby losing the visual field. The scope is then advanced into the trachea as during oral fibreoptic intubation and

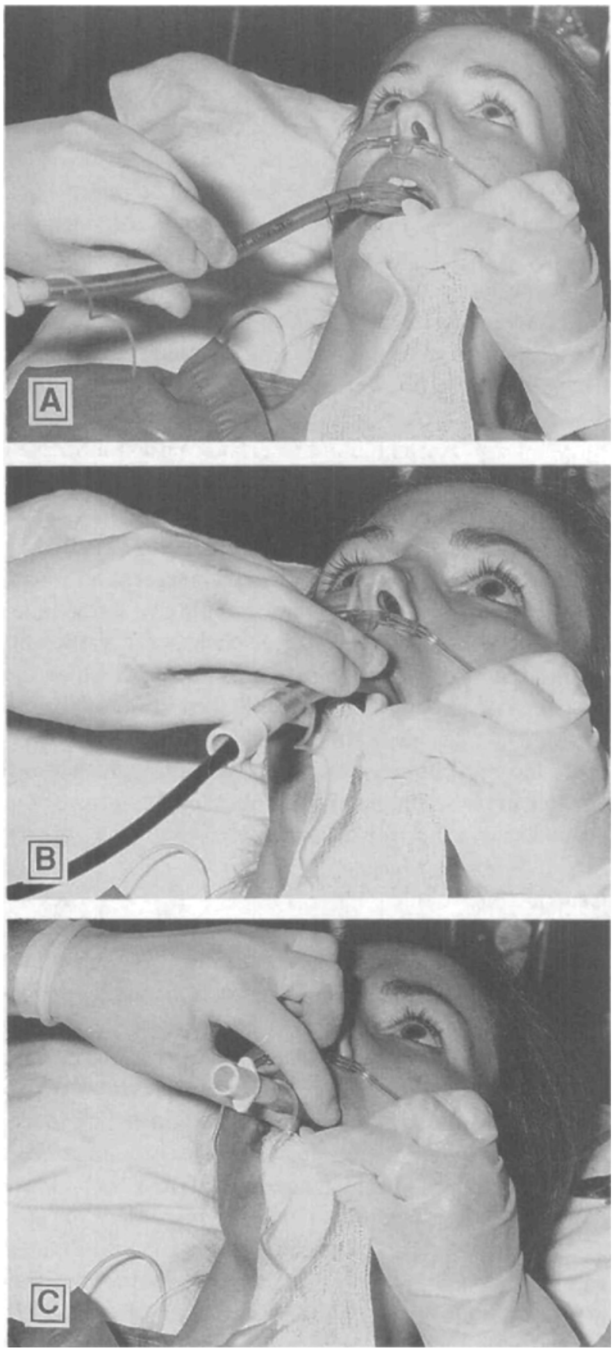

FIGURE 11 The ensleeved tube being advanced over the bronchoscope.

the endotracheal tube advanced over the scope. Nasal fibreoptic intubation may be easier to perform because less patient cooperation is required and the angle of insertion into the glottis is less acute; after the nasopharynx is entered, the scope makes an almost straight approach to the target.[15,24] A midline orientation may also be more easily maintained.[29] If, on passing the bronchoscope through an endotracheal tube previously positioned in the pharynx, no view of the vocal cords or epiglottis is obtained, the lens may be covered with blood or secretions or the tube may have been advanced too far and directed toward a piriform sinus. The lens of the scope should be checked and if necessary the tube pulled back into the nasopharynx or choana to facilitate adequate visualization. On advancing the endotracheal tube over the scope the leading edge may impact on the epiglottis because with the nasal approach the tube tends to move anteriorly relative to the scope.[65] Orienting the tube such that the bevel faces anteriorly or advancing the tube with a rotating or twisting motion may facilitate laryngeal entry.[22,24,26,65] The temporary insertion of a soft lubricated nasopharyngeal airway into the nose before subsequent insertion of the endotracheal tube permits exploration of the nasal cavity such than an approximately sized tube can be chosen,[15] produces further decompression of the nasal mucosa,[67] and may reduce trauma due to the more rigid endotracheal tube.[29] A nasopharyngeal airway slit longitudinally can be used as a guide through which the bronchoscope can be passed, and then removed before subsequent passage of the endotracheal tube.[68] Alternatively the bronchoscope can be passed through the nose and on into the trachea under fibreoptic control before the endotracheal tube is inserted.[13,20,27,60,69]

General anaesthesia

Fibreoptic intubation under general anaesthesia requires two skilled individuals and ideally two anaesthetists.[12,13,22,70] If only one anaesthetist is available, the assistant must monitor the patient and observe the apnoea time as well as help to maintain the pharynx in an open position.[12] When two anaesthetists are present, one assumes the responsibility of airway maintenance, mask fit, ventilation, and monitoring while the second performs the intubation.[22] The first anaesthetist may also be required to perform additional manoeuvres to open the pharyngeal airway. The modified anaesthesia mask fitted with a diaphragm permits endoscopy during positive-pressure ventilation.[71] Following induction of satisfactory general anaesthesia an oral airway intubator such as those described by Williams and Ovassapian can be placed.[17,18] This device displaces the tongue anteriorly away from the posterior pharyngeal wall and permits the concentric insertion of the fibreoptic bronchoscope and endotracheal tube.[22] When properly positioned the end of the airway is in close proximity to the laryngeal entrance.[22] The bronchoscope is then passed through the diaphragm in the mask, into and along the airway intubator and then manipulated into the larynx and trachea under fibreoptic visual control. If the epiglottis is in contact with the posterior pharyngeal wall or oriented posteriorly such that manipulation of the scope around it is difficult or impossible, additional manoeuvres by an assistant such as increased head tilt, jaw thrust, lifting of the larynx anteriorly by grasping it externally between the thumb and fingers, and tongue retraction may be required to open the pharyngeal airway.[12,13,16,72] Anterior displacement of the base of the tongue using the MacIntosh laryngoscope may also improve bronchoscopic visualization.[8,15] The nasotracheal route can also be used.[12,13] Should the tube impact on the laryngeal cartilages as it is advanced over the bronchoscope despite correct orientation and rotation, digital manipulation may facilitate glottis entry.[16] Fibreoptic intubation under general anaesthesia can be difficult, and arterial oxygen desaturation can occur.[73] Fortunately one of the advantages of fibreoptic intubation is that general anaesthesia is rarely required.[60]

Emergency airway management

Immediate airway control in the emergency setting can be difficult with fibreoptic techniques due to blood, vomit, or secretions in the airway and poor patient cooperation. However, fibreoptic intubation can be a valuable option in selected patients.[19,20,27,51,52] Success rates of 83–87% have been reported using a nasotracheal fibreoptic technique in the emergency department, including successful fibreoptic intubation of both agitated and actively seizing patients.[19,51] Intermittent administration of high-flow oxygen via the suction channel of the scope resulted in dispersal of secretions or vomitus that obscured the visual field.[19] Additional oropharyngeal or nasopharyngeal suctioning was also effective in improving visualization.[19]

Contraindications

Patients with massive facial injury, complete upper airway obstruction, apnoea, severe hypoventilation, or profuse upper airway bleeding are almost never appropriate candidates for fibreoptic intubation.[19] Lack of patient cooperation makes the technique more difficult and in this circumstance the nasal route may be preferable.[19,70] Relative contraindications to nasal intubation include nasal fractures, and haemostatic disorders.[46] Nasal obstruction may preclude nasal intubation and basilar skull fractures raise the possibility of inadvertent intracranial penetration.[14,46] Transient bacteraemia has also been reported with nasal intubation.[74] True allergy to local anaesthetics precludes topical airway anaesthesia.

Alternative techniques

Oral fibreoptic intubation over a retrograde guidewire or via a laryngeal mask may be useful in certain situations.[75,76] When direct laryngoscopy is predicted to be difficult but mask ventilation easy, then lightwand assisted intubation under general anaesthesia can be a fast reliable alternative.

Skill acquisition

Fibreoptic intubation is not a difficult skill to master. Intubation mannequins can be readily utilized to develop dexterity in bronchoscopic manipulation and in threading the endotracheal tube over the scope. Chest physicians who regularly perform awake bronchoscopy can be an invaluable resource for anaesthesia residents or colleagues. Workshops can also be effective in improving skills.[77] The necessary psychomotor skills can not, however, be developed without practice, and lack of training and experience constitute the most common cause of failed fibreoptic intubation. A reasonable level of ability in manipulating the bronchoscope in a given direction quickly and reliably can be achieved within three to four hours of independent practice using an intubation model,[78] and this step is critical before intubation of a patient is attempted. An "acceptable level" of technical expertise may be achievable after ten fibreoptic intubations on anaesthetized patients and 15–20 such intubations on awake patient with normal anatomy.[78,79] However, it has also been suggested that 30 fibreoptic intubations be completed before any degree of competency can be assumed,[64,80] and the amount of experience required for safe and effective use of the fibrescope in patients with compromised airways is not known, although 100 or more uses may be necessary.[78]

Conclusion

Tracheal intubation remains an essential skill for the clinical anaesthetist and fibreoptic techniques represent a dramatic advance in the management of the difficult intubation. Skill in fibreoptic intubation increases the available options and permits a more flexible approach, as the optimal airway management technique is individualized to the given clinical situation. Ideally all practising anaesthetists should be able to use a fibreoptic bronchoscope for intubation as expertly as they use a laryngoscope,[81] and be skilled at regional anaesthesia of the upper airway such that awake intubation can be performed with minimal patient discomfort.

Acknowledgements

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Multiple Choice Questions

FOR EACH QUESTION, SELECT THE ONE CORRECT ANSWER

1 The optimal method of endotracheal intubation in the presence of cervical spine injury is:
A Fibreoptic intubation.
B Controversial.
C Blind nasal intubation.
D Laryngoscopy and oral intubation with in-line stabilization.

2 Fibreoptic intubation in the unconscious individual can be difficult due to:
A Loss of tone in the submandibular muscles.
B Posterior movement of the tongue and epiglottis.
C A decrease in the calibre of the pharyngeal airway.
D All of the above.

3 The paediatric bronchoscope tends to make fibreoptic intubation of the adult more difficult because:
A The more flexible shaft forms a sloppy stylette.
B It is easily buckled away from the glottis by the advancing ensleeved endotracheal tube.
C It may be pulled out of the trachea by a misdirected ensleeved endotracheal tube.
D All of the above.

4 The ease of passage of the ensleeved endotracheal tube into the trachea over the bronchoscope can be affected by:
A The size of the tube relative to the scope.
B The flexibility of the tube.
C The orientation of the tube bevel.
D Rotation of the tube.
E All of the above.

5 Local anaesthetics useful for topical anaesthesia include:
A Lidocaine, tetracaine, cocaine.
B Lidocaine, tetracaine, mepivacaine.
C Lidocaine, cocaine, bupivacaine.
D All of the above.

6 The maximum safe dosage of topical lidocaine has generally been considered to be:
A $1\ mg \cdot kg^{-1}$.
B $1\text{–}2\ mg \cdot kg^{-1}$.
C $3\text{–}4\ mg \cdot kg^{-1}$.
D $20\ mg \cdot kg^{-1}$.

7 The only local anaesthetic that inhibits reuptake of norepinephrine and therefore produces vasoconstriction is:
A Lidocaine.
B Tetracaine.
C Cocaine.
D Benzocaine.

8 Sensation to the posterior edge of the soft palate, the posterior $^1/_3$ of the tongue and the superior aspect of the epiglottis is supplied by:
A The trigeminal nerve.
B The glossopharyngeal nerve.
C The superior laryngeal nerve.
D The recurrent laryngeal nerve.

9 Sensation to the laryngopharynx and the larynx above the level of the false cords is supplied by:
A The trigeminal nerve.
B The glossopharyngeal nerve.
C The superior laryngeal nerve.
D The recurrent laryngeal nerve.

10 Awake fibreoptic intubation is not facilitated by:
A Topical vasoconstrictors if the nasal route is chosen.
B Antisialogogues.
C Carefully titrated sedation.
D Muscle relaxants.

11 The optimal patient position for awake fibreoptic intubation is:
A Supine.
B Lateral decubitus.
C The "sniffing" position (head tilt + neck flexion).
D Sitting + head tilt without neck flexion.

12 The important midline landmarks to be identified during oral awake fibreoptic intubation are:
A The uvula, the epiglottis, the vocal cords, the carina.
B The uvula, the vallecula, the vocal cords, the carina.
C The uvula, the piriform fossa, the vocal cords, the carina.
D None of the above.

13 Nasal fibreoptic intubation may be easier to perform than oral fibreoptic intubation because:
A Less patient cooperation is required.
B The angle of insertion into the glottis is less acute.
C A midline orientation may be more easily maintained.
D All of the above.

14 During fibreoptic intubation under general anaesthesia, if the epiglottis is in contact with the posterior pharyngeal wall, manoeuvres that may improve visualization include:
A Increased head tilt, jaw thrust, lifting the larynx anteriorly, tongue retraction.
B Neck flexion, jaw thrust, lifting the larynx anteriorly, tongue retraction.
C Increased head tilt, jaw thrust, lifting the larynx anteriorly, tongue retraction, cricoid pressure.
D All of the above.

ANSWERS

1 B	3 D	5 A	7 C	9 C	11 D	13 D
2 D	4 E	6 C	8 B	10 D	12 A	14 A