Question I.1: The first flexible bronchoscope was introduced to the world in

A. Freiberg, Germany
B. Copenhagen, Denmark
C. Philadelphia, PA

Answer I.1: B

Shigeto Ikeda, of Tokyo Japan introduced the first flexible fiberoptic bronchoscope at the Ninth International Congress on Diseases of the Chest held in Copenhagen in 1966. Frieberg is an important city for the history of bronchoscopy because it is the mother city of Gustav Killian (1860-1921), often called the father of bronchoscopy. Chevalier Jackson, the famous North American Otorhinolaryngologist, was from Philadelphia, where he produced a rigid bronchoscope with a distal illuminating tip in 1904.

Question I.2: Flexible fiberoptic bronchoscopy resides on the principle that light can be transmitted through glass fibers. This discovery is credited to

A. Baird and Hansell
B. Heel and O'Brien.
C. Hopkins and Kapany

Answer I.2: A

In 1927-1930, Baird (an Englishman) and Hansell (a North American) proposed that optical properties of glass fibers could be utilized. Heel (from Holland) and O'Brien (from the United States) developed cladding glass; the technique used to insulate and coat each light-transmitting optical glass fiber so that light could be transmitted through the fiber even if it were twisted and bent. Hopkins and Kapany (both from Great Britain) developed the optically arranged fiber bundle and are thus credited with the introduction of the word "fiberscope".

Question I.3: Which of the following should be addressed during a consultation for bronchoscopy

A. Analyze the request for bronchoscopy and justify the indication
B. Review history and physical and pertinent radiographic images
C. Formulate a prebronchoscopy plan with consideration to all bronchoscopic and nonbronchoscopic procedures needed to maximize diagnostic yield or therapeutic success
D. Discuss patient safety issues, comfort, and informed consent
E. All of the above

Answer I.3: E

Bronchoscopy is a minimally invasive procedure, but an invasive procedure nevertheless. Every indication for bronchoscopy must be justified, and alternatives means (invasive and noninvasive) for diagnosis or treatment should always be considered. Bronchoscopy can also be a very costly procedure. Use of accessory instruments, specimen processing, and time in the hospital, and consequences of potential procedure-related complications further increase the cost. If possible, everything should be done so that diagnostic yield is maximized and diagnosis is obtained from a single (and not repeated) procedure.

For example, if bronchoscopic inspection reveals no airway abnormalities, the bronchoscopist should be ready to perform transbronchoscopic sampling. In this case, yield might be increased if radiographic guidance is used, and is definitely increased if cytopathologic analysis is performed on-site. Informed consent is ethically justified because patients “have a right to know”, and has become mandatory in an increasing number of countries.

Question I.4: All of the following should be routinely obtained prior to performing flexible bronchoscopy **except**

A. Chest radiograph
B. Platelet count
C. Physical examination with special attention to heart and lung examination
D. Allergy history and history and procedure-related adverse events
E. Review of potential risk factors

Answer I.4: B

Surveys performed by the American College of Chest Physicians and the American Association for Bronchology show that the number of laboratory tests routinely obtained prior to performing bronchoscopy are decreasing. Flexible bronchoscopy is very safe. In the absence of risk factors, complications such as bleeding are rare. Not all patients need to have platelet counts. In fact, in severely thrombocytopenic patients, flexible bronchoscopy with bronchoalveolar lavage has proven safety even when the scope is inserted nasally. Increasingly, experts advocate that platelet counts be obtained only in patients with a history and physical suggestive of a bleeding or coagulation disorder and undergoing endobronchial or bronchoscopic lung biopsies.

Question I.5: According to American Thoracic Society guidelines, which of the following is an absolute contraindication to flexible bronchoscopy:

A. Patient with unstable asthma or status asthmaticus.
B. Patient with refractory hypoxemia or inadequate oxygenation during the procedure.
C. Recent or unstable angina or recent myocardial infarction.
D. Severe hypercarbia and significantly reduced forced expiratory volume in one second.
E. Superior vena cava obstruction.

Answer I.5: B

It is wiser to postpone or defer a procedure if patients are severely hypoxemic. Bronchoscopy itself causes a fall in oxygen saturation. In addition, every procedure-related complication causes hypoxemia. It is true that sometimes, "a bronchoscopist must be lucky", but what if it is not your or the patient's lucky day. The risks of the procedure, including potential need for intubation and mechanical ventilation should be carefully explained to critical patients and to their families. One good question to always ask is "will the results of this procedure alter medical management"? If the answer is "no", it is wiser to postpone the procedure.

Bronchoscopy has repeatedly been shown to be an extremely safe procedure. The patient trusts your judgment. Your "contract" is with the patient. Curiosity about the disease, outcome, or a macho attitude that 'I can do this" are nice, but in the grand scheme of medical ethics and morality, have no place here. Now, after that short editorial comment, back to the question…The American Thoracic Society has listed only four contraindications to bronchoscopy. These are absence of informed consent, operator inexperience, inadequate facilities, and inability to assure adequate oxygenation during the procedure. Prolonged hypoxemia during the procedure can lead to cardiac arrhythmias, myocardial infarction, mental status changes, and respiratory failure. In fact, some experts suggest that uncorrectable hypoxemia, hypertension, or elevated intracranial pressures are relative contraindications to bronchoscopy. Any procedure-related event such as bleeding or post-lavage related hypoxemia can increase or prolong a hypoxemic episode. Textbooks state that bronchoscopy is less safe in patients with recent or unstable angina, hypercarbia, superior vena cava obstruction, and unstable asthma, as well as in patients with uremia, pulmonary hypertension, and advanced age. Specific data regarding this "increased risk" are controversial.

Question I.6 Originally, the flexible bronchoscope was designed to be held as shown in the Figure below. A reason for this is

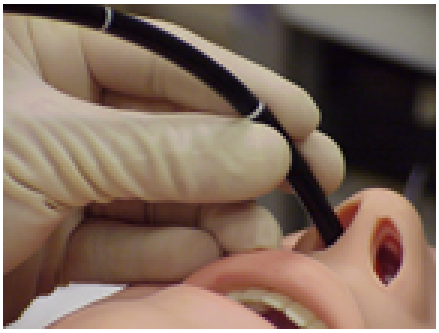
A. The operator must always stand behind the patient; therefore it is best for the control section to be held in the left hand.
B. Dr. Ikeda, original designer of the flexible bronchoscope, was left-handed.
C. The operator must always stand to the right of the patient; therefore, it is best for the control section to be held in the left hand so that the bronchoscopist's right hand can be closest to the patient.
D. The operator must always stand to the left of the patient; therefore, it is best for the control section to be held in the left hand so that the bronchoscopist's right hand can be closest to the patient.

Answer I. 6 B

The originator of the scope was left-handed! It really does not matter where one stands while performing flexible bronchoscopy. The scope can be held in either the left or the right hand, depending on personal comfort, teacher biases, and where one places one's assistants.

If held in the right hand (as shown in the Figure and standing at the supine patient's right, the free left hand is closest to the patient's head, and comfortably holds the scope at the insertion site.

Similarly, if the bronchoscopist were standing to the patient's left, a scope held in the left hand would allow the free right hand to be closest to the patient's head.



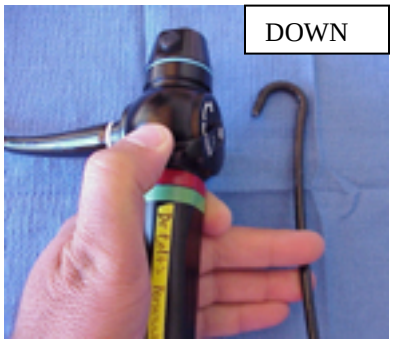
Question I.7 Maximum flexion of the distal bending tip of the flexible bronchoscope is obtained by which of the following

A. Moving the thumb upwards
B. Moving the thumb downwards

Answer I.7 B

Moving the thumb downwards will flex the bending tip maximally. Forceps or other instruments should never be advanced forcefully through a maximally flexed bronchoscope because this risks tearing the working channel. Maximum flexion may be necessary to enter the apical segments of the upper lobes, but is otherwise rarely needed because simple turning of the wrist will satisfactorily guide most movements of the bronchoscope.

The flexion-extension movement is particularly useful in order to examine first the middle lobe bronchus (slight flexion), then the superior segmental bronchus of the right lower lobe (slight extension), without moving the bronchoscope.



Question I.8: Each of the following is considered "poor technique" when handling a flexible bronchoscope **except**

A. Twisting the insertion tube rather than rotating the entire instrument along its entire longitudinal axis.
B. Advancing the bronchoscope by pushing down from the handle.
C. Exerting excessive pressure with one's fingers on the patient's nostril or cheek.
D. Attempting to pass an instrument through a fully flexed distal extremity of the bronchoscope
E. Keeping the bronchoscope "in the midline" of the airway lumen throughout as much of the procedure as possible.

Answer I.8: E

"Stay in the middle" is a favorite phrase of several teachers of bronchoscopy. This provides the bronchoscopist greater visibility inside the airway and avoids unnecessary mucosal trauma, minimizes gagging, deglutition, and cough, and maximizes flexion and extension capabilities. Twisting the insertion cord is inelegant and can damage the fragile fibers of either a fiberoptic or videobronchoscope.

Exerting excessive pressure onto the patient's nostril with the hand holding the distal extremity of insertion cord causes patient discomfort. One might cause nasal trauma and bleeding, insert one's gloved finger into the patient's eye, lacerate the former of the patient's lip, or dislodge a loose tooth. Attempting to forcefully pass an instrument such as a forceps through the fully flexed distal extremity of the bronchoscope is a big "no no", because of the great risk of damaging the working channel of the bronchoscope.

Advancing the bronchoscope by pushing down on the handle causes excessive bending of the instrument proximally. This prompts the bronchoscopist to bend over at the shoulders, which is very poor posture, and over time and hundreds of bronchoscopies can cause backache. In addition, it will be more difficult and potentially harmful to the bronchoscope to insert instruments through the working channel. This is especially the case for transbronchial needles! It is more elegant to lean back slightly, straightening the shoulders, and to straighten the insertion cord of the bronchoscope by stepping a bit away from the patient. The bronchoscope is advanced by moving the entire ensemble (insertion cord and control section).

Ideally, the bronchoscope can be advanced as the patient inhales, and, if necessary, pulled back when the patient exhales. Thus, the bronchoscopist, the bronchoscope, and the patient remain "in harmony" throughout the procedure.

Question I.9: Sensory anesthesia from the epiglottis to the vocal cords is obtained by numbing which of the following.

A. The Sphenopalatine nerve fibers
B. The Glossopharyngeal nerve
C. The Recurrent laryngeal nerve
D. The Superior laryngeal nerve
E. The second (maxillary) division of the trigeminal nerve

Answer I.9: D

Anesthesia of the superior laryngeal nerve results in blocking sensory innervation to the base of the tongue, epiglottis, periform fossa, and valleculae. This is usually satisfactory after administration of nebulized topical anesthetic. The Glossopharyngeal nerve innervates the posterior third of the tongue, the tonsillar region and the oropharynx. A bilateral glossopharyngeal nerve block (performed by injection behind each posterior tonsillar pillar) can be used to completely abolish the gag reflex in selected patients. This can result in sudden respiratory compromise from rapid paralysis of the pharyngeal muscles and the base of the tongue.

Bilateral nasal administration of anesthetic provides partial posterior pharyngeal anesthesia by affecting the Sphenopalatine nerve fibers. The recurrent laryngeal nerve supplies sensory and motor innervation of the intrinsic muscles of the larynx. The second division of the trigeminal nerve supplies much of the sensory innervation to the nasal mucosa.

Question I.10: All of the following are responsible for a difficult or painful insertion of the flexible bronchoscope through the nasopharynx and oropharynx **except.**

A. Swelling of nasal mucosal membranes
B. Septum deviation
C. Nasal polyps
D. Hypertrophy of the nasal turbinates
E. Enlarged adenoids

Answer I.10: E

Swelling of the mucosal membranes can often be reduced through application of cocaine (using small cotton pledgets) and other vasoconstrictors (Lidocaine with epinephrine), which help to increase the diameter of the nasal passage and decrease the incidence of bleeding. If swollen membranes are noted, patients should be warned that they might experience discomfort during passage of the bronchoscope. Sufficient amounts of lubrication and topical anesthetic should be applied.

Patients with a deviated nasal septum, nasal polyps, and turbinate hypertrophy may also experience discomfort during nasal insertion of the flexible bronchoscope. Satisfactory anesthesia should be administered topically, and the bronchoscopist should not hesitate to attempt insertion in the contra lateral side. Repeated unsuccessful attempts should be avoided because of increased patient discomfort, risk for bleeding, and patient loss of confidence (bronchoscopy assistants don't like watching this either). It is preferable to change to a transoral approach.

Enlarged adenoid tissue (also known as the nasopharyngeal tonsils) in the mucous membrane of the posterior wall of the nasopharynx can cause partial airway obstruction that prevents nasopharyngeal insertion of an endotracheal tube, but usually does not prevent insertion of the flexible bronchoscope.

Question I.11: Which of the following topical anesthetics should be used in a patient who has just informed you of a severe allergic reaction to Novocaine during a recent visit to the dentist.

A. Lidocaine
B. Benzocaine
C. Tetracaine
D. Cocaine
E. All of the above

Answer I.11: A

There are two families of topical anesthetics; these are the Amides: Bupivicaine (Marcaine), Lidocaine (Xylocaine), Mepivicaine (Carbocaine), Ropivicaine (Naropin), and the Esters: Procaine (Novocaine), Cocaine, and Benzocaine, and Tetracaine (Pontocaine), One way to remember which drugs belong to which family, is to remember that drugs spelled with one "i" are Esters, whereas those spelled with two (ii) are Amides.

Allergic reactions (usually rash, urticaria, laryngeal edema, or bronchospasm) as well as anaphylaxis are common within a same family, but much less frequent between families. If a patient reports allergy to a drug belonging to one family, anesthesia using a drug from another family is usually safe. However, preservatives used in the manufacture of these drugs can have cross reactivities. Allergy can therefore occur when using different drugs, especially within the Ester class.

Because some preservatives are structurally similar to the allergen para-aminobenzoic acid (PABA), many allergic reactions are caused by antibody response to the preservative and not to the local anesthetic agent. Local anesthetics of the Ester class have metabolites related to PABA, and are therefore most likely to cause allergic reactions. If a patient has had an allergic reaction to a drug of the Ester class of local anesthetics, it is almost always safe to administer a drug from the Amide class. Some pharmacies carry "preservative free" drug preparations. True lidocaine allergies are extremely rare, and often the "allergic" reaction is actually an adverse response to epinephrine or phenylnephrine contained in the preparation. Allergic reactions and drug-related complications can be prevented by (1) always asking patients about medication allergies before performing the procedure, (2) using the least amount of anesthetic possible, especially in elderly patients or in those with significant comorbidities, (3) watching for drug reactions and adverse effects.

Question I.12: What is the official and commonly accepted name for the epiglottis shown.

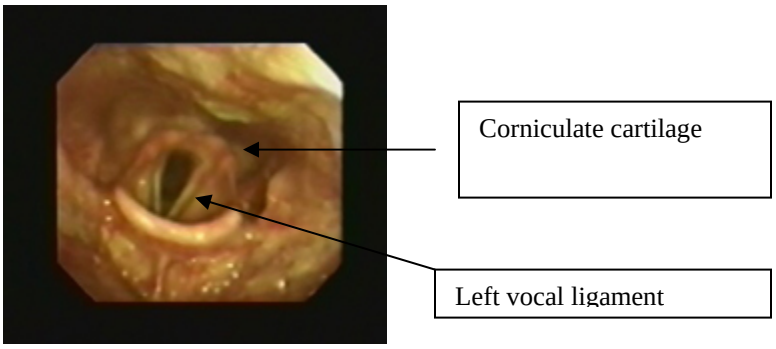
A. Omega or infantile epiglottis
B. Horseshoe epiglottis
C. U-shaped epiglottis
D. Normal appearing epiglottis

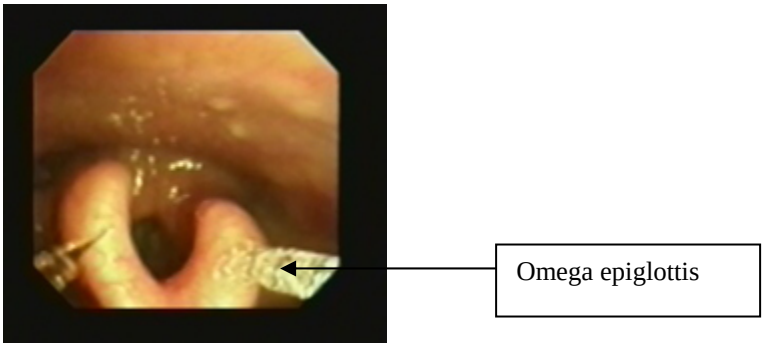
Answer I.12: D

This is a normal appearing epiglottis. In the adult male, the larynx is 5-7 cm in length and lies opposite the 4th, 5th, and 6th cervical vertebrae. It is usually shorter and smaller in women. The inferior margin of the cricoid cartilage is the most inferior portion of the larynx. The cricoid is the narrowest portion of the airway in children (whereas the glottic opening, or rima glottidis, is the most narrow portion of the upper airway in adults).

Two arytenoid cartilages are pyramid-shaped and articulate with the superior margin of the cricoid cartilage. On their superior aspects are the corniculate cartilages. True vocal cords, also called vocal ligaments, are attached posterior to the base of the arytenoids cartilages, whereas the false vocal cords, also known as vestibular ligaments, are attached higher on the vertical walls of the arytenoids.

The epiglottic cartilage is a single cartilage lying behind the base of the tongue. The epiglottic cartilage is attached to the tongue by a median and two lateral glossoepiglottic folds. The depressions between the lateral and median folds are called the valleculae. In children and in some adults, the epiglottis is elongated and curved. This is called an infantile, elongated, or omega epiglottis.





Question I.13: You have been asked to develop a bronchoscopy service in your hospital. You recognize that your success, income, and future hospital funding depends on clinical activity. You also recognize that declining to perform a procedure may not be conducive to your ambitions. You have spoken with several colleagues who have been in similar situations. One way to build and maintain a busy service and perform bronchoscopy in virtually every patient referred to you is to say that

A. Bronchoscopy is justified "in anyone who has an airway"
B. Bronchoscopy is justified in anyone with an abnormal chest radiograph.
C. Bronchoscopy is justified because you are working in a training program
D. Bronchoscopy is justified in order to avoid litigation
E. Bronchoscopy is justified in order to keep the referring physician happy

Answer I.13: E

None of the above responses are ethically, morally, or medically justified. Were you uncertain, and, in doubt, answered the "lesser evil" E? To say that bronchoscopy is performed to keep the referring physician happy, even if the indication is unclear, is perhaps the most tenable position for one's conscience, although not necessarily morally appropriate. Sometimes, a person might additionally justify this action on the grounds that bronchoscopy is safe and provides minimal or no discomfort for the patient. However, no person would want a surgeon to operate if it were not medically indicated and justifiable. The same holds true for minimally invasive procedures.

Although there are no scientific studies of this question, all of the above responses have been heard either jokingly or seriously in bronchoscopy circles. It is the bronchoscopist's moral and ethical responsibility to provide a service when it is medically indicated and to help educate other health professionals about the indications for bronchoscopy, potential dangers, and about alternative procedures even if it means referral to other physicians.

In a training program, computer simulation, case studies, didactic teaching, guided reading, and video rounds can help trainees learn appropriate and justifiable indications for each procedure they perform or might perform in the future. If bronchoscopy is being performed for other reasons, such as to avoid possible litigation, or "because the patient wants to be certain that a diagnosis of cancer has been excluded", trainees should be allowed to witness the conversation between the bronchoscopist and the patient so that misperceptions and misunderstandings about the medical justifications for the procedure are avoided.

Question I.14: All the following statements regarding the effects of flexible bronchoscopy on cardiovascular hemodynamics are correct **except**

A. Flexible bronchoscopy increases oxygen consumption ($V0_2$), decreases mixed venous oxygen (SvO_2), and oxygen delivery ($D0_{2)}$ remains unchanged.
B. Flexible bronchoscopy increases cardiac index (CI) by at least 10-15 percent.
C. Flexible bronchoscopy increases heart rate, and correlations have been noted between presence of arrhythmias and depth of oxygen desaturation, but not with presence of cardiovascular disease of chronic obstructive pulmonary disease.
D. Known coronary artery disease does not appear to increase the frequency of bronchoscopy-related cardiac ischemic events as long as precautions are taken (use of supplemental oxygen, judicious use of sedation, rapid procedure performance).
E. Impact of flexible bronchoscopy on cardiovascular function and oxygen saturation ends when the bronchoscope is removed from the airways.

Answer I.14: E

The impact of flexible bronchoscopy on cardiovascular function and oxygen saturation persists for several minutes, and, as in the case of oxygen desaturation, for several hours after the bronchoscope is removed from the airways. Most studies of the hemodynamic effects of bronchoscopy have been performed in critically ill, mechanically ventilated patients, and very little has actually been done in the awake nonintubated patient.

The effects of procedure duration and patient position have not been thoroughly examined. Potential concomitant factors that can potentially alter hemodynamic effects are underlying disease status, medication use, and conscious sedation.

Question I.15: When referring to digital photography, video imaging, television, or fluoroscopic image intensifiers, the term “resolution” is defined as

A. Number of pixels per square centimeter
B. Number of lines per inch or line pairs per millimeter
C. Brightness of an image on screen
D. Sharpness of an image on screen

Answer I.15: B

Resolution is defined as the number of lines per inch or line pairs per millimeter. In general, picture resolution is often referred to when describing the quality of an image. For fluoroscopic image intensifiers resolution is usually best in the center of the screen, where the image is also brighter and has less geometric distortion. For television and video, resolution can depend on the type of equipment used and design refinements. For example, a television receiver can generally reproduce 320 vertical black and white stripes, whereas more advanced designs can resolve over 560 lines.

A typical VHS (Video Home System) video recorder resolves about 250 lines, and an S-VHS (Separate, or Super VHS) recorder about 400 lines. In digital photography, resolution refers to the number of pixels per *linear* inch (ppi) in an image. A resolution of 72 ppi therefore, means there are 72 pixels horizontally and 72 pixels vertically, or 5,184 pixels for each square inch of image. With fewer pixels, more detail will be lost.

Question I.16: When using a fluoroscopy C-arm, radiation exposure rates to the patient are higher when

A. The x-ray tube is closer to the table top
B. The x-ray tube is farther from the table top
C. X-ray tube to table distance is irrelevant

Answer I.16: A

Radiation exposure rates are measured at the tabletop. They are excessively large if the x-ray tube, which is a standard rotating anode tube operated at currents that are much lower than those used in radiography, is closer than 12 inches (approximately 30 cm) to the table top. Shutters in the x-ray tube allow the operator to regulate the size and shape of the x-ray beam.

Question I.17: Which of the following statements pertaining to bronchoscopy-related complications is least likely to be justified by anecdotal experience or clinical studies.

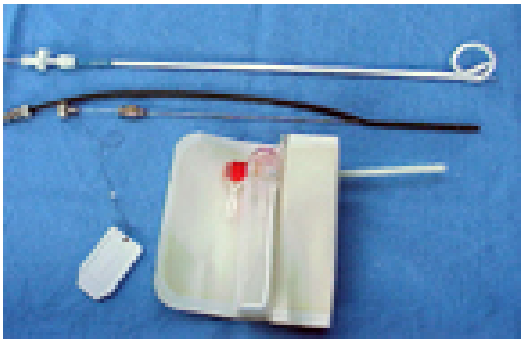
A. Fever and chills may occur as late as 6-8 hours after bronchoscopy.
B. Transient pulmonary infiltrates secondary to saline retention after bronchoalveolar lavage should be in the differential diagnosis of any patient with new or increased pulmonary infiltrates.
C. Continuous suction during bronchoscopy can reduce tidal volume and exacerbate preexisting hypoxemia.
D. Most bronchoscopy-related pneumothoraces occur several hours after the procedure.
E. The addition of conscious sedation can increase the likelihood of post-procedure hypoxemia or respiratory insufficiency

Answer I.17: D

Most experts agree that the true incidence of bronchoscopy-related pneumothorax may not be known, although pneumothorax usually occurs during or immediately after bronchoscopy and bronchoscopic lung biopsy. This justifies chest radiographs or fluoroscopic examination within two hours after biopsies are taken, especially if patients are symptomatic. Late pneumothorax has been reported, but is very rare. Regardless, patients should be instructed to call their health care provider or go to the nearest emergency room for a chest radiograph in case of new-onset or increased shortness of breath or pain during the first 24 hours after a bronchoscopic lung biopsy.

When bronchoscopy-related pneumothorax occurs, it is often small. If the patient has symptoms, or if the pneumothorax increases on subsequent chest radiographs, drainage using a small-bore chest tube or simple aspiration is warranted. Many patients can be sent home with an indwelling chest tube and one-way valve if clinically stable. Indications for hospitalization should be individualized. Chest tubes should be available in every bronchoscopy procedure cart because in very rare instances, emergency chest tube insertion may be necessary and therefore life-saving.

The other possible responses have been documented by various investigators. The possible occurrence of fever or chills prompts many bronchoscopists to suggest use of acetaminophen as needed post procedure. Transient pulmonary infiltrates can be seen on chest radiograph or computed tomography scans, and should not be misinterpreted as new infection. Continuous suction has been shown to reduce tidal volumes, and obviously excessive sedation increases the risk for respiratory insufficiency, and in some cases, might even prompt bronchoscopists to electively intubate patients prior to procedure performance.



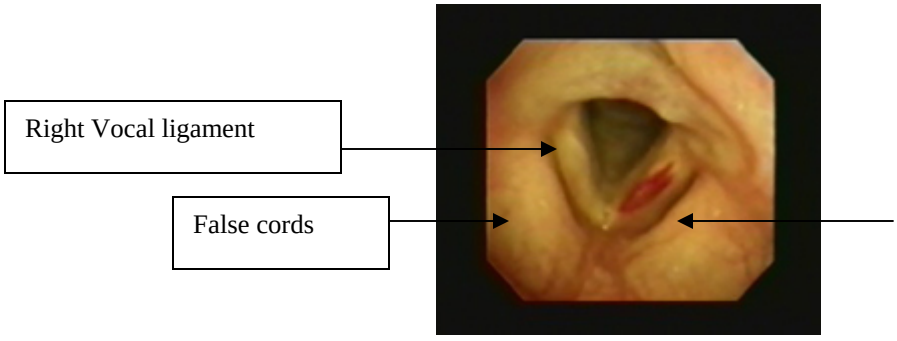
Van Sonnenberg, Cook, and TruClose chest tubes for small iatrogenic pneumothoraces

Question I.18 The abnormality shown in the Figure below is on the

A. Left vocal cord
B. Right vocal cord
C. Epiglottis
D. Arytenoids

Answer I.18 A

This ecchymosis of the left vocal cord is the result of an unsuccessful attempt to pass the flexible bronchoscope past the vocal cords into the trachea. The Epiglottis is not visible in the photograph. Both cords are well seen, and both the anterior (point of the V), and posterior (wide commissures of the larynx are visualized. The arytenoid cartilages (which are not visible in the photograph) are at either end of the wide base of the V.



Question I.19 The larynx seen in the Figure below is from an adult

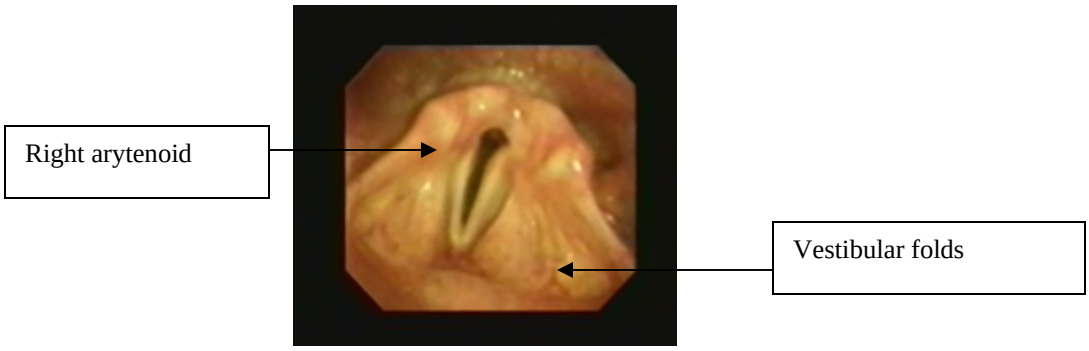
A. Man
B. Woman
C. Horse

Answer I.19 B

The larynx shown belongs to a woman. The triangular-shaped anterior aspect of the "rima glottidis (the middle space between the vocal cords)" is well visualized. A man's vocal folds are usually thicker than a woman's, and in full abduction noticed if the patient is asked to inhale deeply; the man's glottic opening is larger (on average about 19 mm). An adult woman's glottis is usually smaller than that of a man (on average a woman's rima glottidis is 12 mm in diameter with maximum abduction of the white vocal folds).

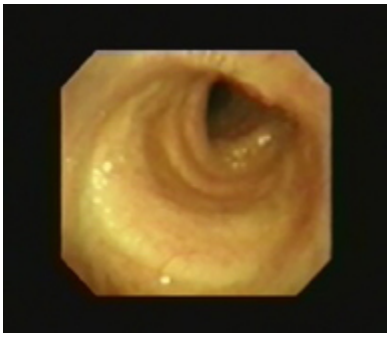
Vocal folds move with respiration, whereas the vestibular folds just above should not. In horses, a huge decrease in air pressures during inhalation would cause the larynx to collapse if it were not for the abductor cricoarytenoid muscle. During exercise, quasi-permanent contraction of this muscle dilates the larynx by pulling the arytenoid cartilage and vocal cord out of the airstream.

Some horses develop what is known as left recurrent laryngeal hemiplegia. In this case, paralysis of the dorsal cricoarytenoid muscle causes the arytenoid cartilage and vocal cord on the affected side to collapse into the larynx during inhalation and obstruct the airways. By the way, similar findings occur in humans! Unlike in horses though, where the cause is often hereditary, it is often from tumor, infection, or trauma.



Question I.20 The anatomic structure shown in the Figure below is

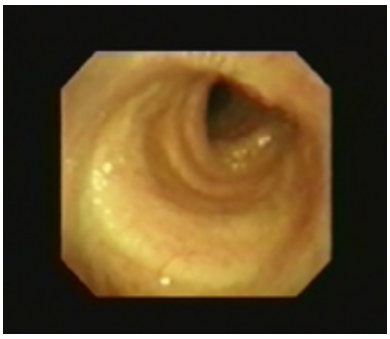
A. The most narrow part of the adult airway
B. The most narrow part of the pediatric airway
C. The most narrow part of the adult female airway
D. The most narrow part of the adult male airway



Answer I.20 **B**

The cricoid is the narrowest part of the pediatric airway. The glottis is the narrowest part of the adult airway. If one is called to perform a bronchoscopy in a child, it is important to recall that the epiglottis and larynx are usually more anterior, that the trachea is more pliable and easily collapsible, and that tissues and mucous membranes are floppy in the mouth and pharynx.

If intubation is necessary, uncuffed endotracheal tubes should be used in children under age 8. The external diameter of the endotracheal tube should approximate the size of the size of the child's nares. Better still to use Broeslow tape measure available in most emergency rooms.



Question I.21: The average cross-sectional area of the trachea in a 30-year-old male is

A. 1.5 cm^2
B. 2.8 cm^2
C. 3.2 cm^2
D. 5.0 cm^2

Answer I.21: B

The average cross-sectional area of the male adult trachea is approximately 2.8 cm^2. The average cross sectional area, as well as tracheal length, diameter and volume correlate with body height. In adults, the average cross-sectional area at age 30 is about 2.8 cm^2, increasing to an average of approximately 3.2 cm^2 by age 60. The cross-sectional area of a female is about 40 percent less than that of a male.

The tracheal index (TI) is characterized by the ratio of transverse and sagittal diameters. Normally, the tracheal index is about 1 (the transverse diameter is usually a couple of millimeters less than the sagittal diameter). Saber sheath tracheas, for example, have a reduced tracheal index (TI is 0.6 or less), because the sagittal diameter is large and the transverse diameter is small.

Question I.22: How would you describe the trachea shown in the Figure below.

A. Normal C-shaped
B. Normal U-shaped
C. Normal horseshoe-shaped
D. Abnormal saber-shaped
E. Abnormal Lunate shaped

Answer I.22: B

This is a normal U-shaped trachea (although some might actually call it a triangular shape) in an elderly male with increased ossification of prominent cartilaginous rings and The adult tracheal diameter is usually reached by the age of 20.The trachea consists of a cervical extrathoracic segment (encompassing the first 6 tracheal rings and ending at the manubrium), and an intrathoracic segment that accounts for about 2/3 of tracheal length ending at the carina.

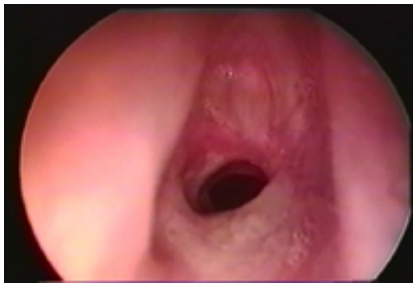
Length, diameter, volume, and cross-sectional area correlate with body height. Cross-sectional area increases with age, probably as a result of age-related loss in elastic recoil. The cross-sectional area of a male's trachea is about 40 % larger than that of a female. A transverse diameter of 25 mm and sagittal diameter of 27 mm are the upper limits of normal usually cited for males. The lower limit of normal for both transverse and sagittal diameters being about 13 mm in men and 10 mm in women.

The C-shaped trachea is the most common cross-sectional tracheal shape described in adults (49 %). The second most common shape is the U-shape (27%). Saber and Lunate shaped trachea may reflect chronic obstructive airways disease, and are also found in patients with other respiratory disorders.

U-shaped trachea

Question I.23 A 29-year-old woman with Wegener's granulomatosis and increasing shortness of breath undergoes flexible bronchoscopy. Based on the finding shown you should.

A. Attempt to pass the bronchoscope beyond the subglottic stricture in order to measure its length.
B. Request an angioplasty balloon in order to dilate the stricture immediately.
C. Request and endotracheal tube at the bedside, then attempt to push the bronchoscope beyond the stricture in order to determine whether it is simple or complex
D. Stop the examination, remove the bronchoscope. Keep the patent under observation, and notify otolaryngology, thoracic surgery and an interventional bronchoscopist of the finding.



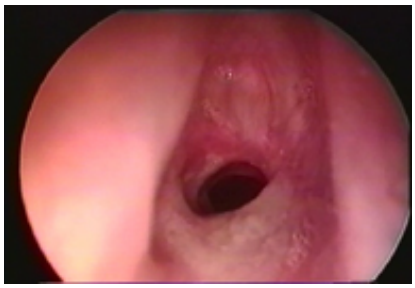
Answer I.23 D

Continuing the examination or attempting to dilate the stricture is potentially dangerous. Subglottic edema or reflex laryngospasm are potentially life threatening. Remember, "Never take away something you cannot give back". Before preceding any further, one should be ready to perform an emergency tracheostomy. It might also be necessary to proceed with rigid bronchoscopy in case stenoses are at multiple levels inside the airway. Although limited Wegener's may initially involve only the subglottis, usually causing firm subglottic narrowing, it may also involve the upper and even the entire trachea as well as lobar and segmental bronchi.

Thus, it is wiser to continue the evaluation in the hands of an experienced interventional bronchoscopist able to organize a multidisciplinary approach to this patient's airway problem and systemic vasculitic disease. Less than 10 percent of patients with Wegener's are believed to have tracheobronchial involvement. Response to cytotoxic agents and corticosteroids is variable. In patients with systemic Wegener's combined therapy increases survival and decreases relapse compared to corticosteroids alone.

Response A is of course possible if one uses a small 3mm diameter bronchoscopy. In this case, however, secretions beyond the stricture may easily occlude the working channel of the scope. It could be used, however, to document patent distal airways and to measure the length of the stricture. Dilating the stricture immediately can be dangerous unless all materials necessary for balloon dilatation (and other interventional techniques) are readily available. These strictures can be very firm, making accidental tracheal or bronchial rupture a possibility. In regards to passing an endotracheal tube through this stricture…such a maneuver is likely to be unsuccessful, even when using a #6 or #5

uncuffed tube. Regardless, introduction of the tube will not allow one to determine whether the stricture is complex or simple, which requires a careful assessment of cartilage involvement, inspection of airway mucosa, presence of absence of additional strictures, and presence or absence of malacia.



Question I.24: Bleeding-related morbidity and mortality after flexible bronchoscopy is most frequently caused by

A. Massive pulmonary hemorrhage
B. Hypoxemia and respiratory insufficiency resulting from filling of ventilatory dead space
C. Dysrhythmias from hypovolemia
D. Hypotension and myocardial infarction

Answer I.24: B

A patient's left main bronchus, right main bronchus, and trachea make up ventilatory dead space. This structure can completely fill with only 150 ml of blood or fluid, causing hypoxemia and respiratory arrest. For this reason, patency of the contralateral airway must be maintained while the bronchoscopist attempts to stop the bleeding. Massive hemorrhage is rare, usually occurring only when large vessels or bronchial arteries are perforated during laser resection or bronchoscopic debulking. Tradition has it that bleeding is also feared in patients with uremia, thrombocytopenia, renal cell carcinoma, and carcinoid tumors.

Question I.25: A patient with breast cancer and venous thromboembolism is on Warfarin (Coumadin). Her INR is 2.1. Flexible bronchoscopy is scheduled for tomorrow. Bronchoalveolar lavage and biopsy are planned. You are concerned about procedure-related bleeding. You might choose to do which of the following.

A. Refer the patient to someone else
B. Proceed with bronchoscopy. There is no need to hold Warfarin
C. Hold Warfarin the day of the procedure only
D. Hold Warfarin today and tomorrow, administer vitamin K 2.5 mg orally today, and repeat INR measurement the day of the procedure.
E. Administer vitamin K, 10 mg intravenously now. Fresh frozen plasma should be available for the procedure in case it is needed.

Answer I.25: C

Well, this is not a trick question, but this issue certainly comes up quite often. Although you might choose any of the possible responses, in this case it is probably safe to proceed with bronchoscopy after holding Warfarin the day of the procedure. If the INR were 4 or greater, 1-2.5 mg of Vitamin K orally should decrease the INR to 1.8-3.2 in at least 50% of patients. In general, intravenous administration of vitamin K is usually reserved for patients with INR >20 or active bleeding. Additional vitamin K and fresh frozen plasma transfusion can be repeated every ten hours as needed.

There is no "cookbook" approach to dealing with patients on Warfarin. Some bronchoscopists routinely hold medications and administer vitamin K. Others "ignore" the INR and proceed with bronchoscopic inspection (with washings or bronchoalveolar lavage). When in doubt, it is always safe to AVOID doing biopsies or brushings. If an abnormality is seen that requires biopsy, the patient can always be rescheduled after the coagulation abnormality is corrected, and normal coagulation profiles are noted on subsequent laboratory reports.

Question I.26: A 43-year-old woman with a history of healed tracheostomy presents to the emergency department with dyspnea and stridor. The first thing you do while preparing for flexible bronchoscopy is

A. Administer intravenous sedation and heliox
B. Place the patient's head and neck in the "sniff" position.
C. Administer oxygen and mist humidification.
D. Prepare for immediate tracheal dilatation using rigid bronchoscopy tubes of increasing diameter.

Answer I.26: B

The sniff position is frequently the first step required to improve passage through the upper airways, glottis, and subglottis. The sniff position is reached by simply placing a small pad under the patient's head for adults. This allows proper opening of the mouth, and extends the cervical vertebrae at the atlantoaxial joint, as well as flexes the lower cervical vertebral joints. Additional jaw elevation results in extension of the head and forward projection of the base of the tongue. Placing a pad that is too large will hinder maximal mouth opening.

Question I.27: Laryngoscopy and flexible bronchoscopy are frequently used to evaluate and monitor patients with potential or known inhalation injury. They are least helpful in patients with

A. Supraglottic edema from direct heat-induced mucosal injury
B. Glottic edema from smoke-induced mucosal injury
C. Soft tissue swelling that accompanies general body edema from fluid resuscitation
D. Bronchospasm

Answer I.27: D

Upper airway evaluation is crucial in patients with known or suspected inhalation or burn injury. Inhalation injury should always be suspected in burn victims, especially if the face, neck or chest are burned, or if there is presence of burned nasal hairs, or if soot is found in the nostrils, mouth or throat.

In burn and trauma victims the upper airway and tracheobronchial tree are frequently examined while other diagnostic and therapeutic measures are being instituted, central lines are being placed, and radiographs are being obtained. Oxygenation using nasal prongs or a facemask is always warranted. Special attention is necessary to avoid additional facial trauma in patients with burns to the face. Soot may additionally obstruct an already swollen and inflamed nasal passage. Examinations should be done gently in order to avoid hurting the patient, and to decrease the potential for bronchoscopically-induced laryngospasm and bronchospasm.

Conscious sedation should be used sparingly in the acute burn victim because the burn surgical team is interviewing the patient in order to discover additional symptoms, sites of injury, and mode of injury (enclosed environment, smoke exposure, heat exposure, chemical exposure, exposure to asphyxiant gases). After providing the patient gentle, confident reassurance, the bronchoscopist should be able to perform a thorough examination of the nasal passages, oral pharynx, larynx, and tracheobronchial tree.

An awake, bronchoscopically guided intubation avoids the dangers associated with muscle relaxation or paralysis. If injury is noted and intubation is warranted, an endotracheal tube can be inserted using bronchoscopic guidance. The burn surgeon and the bronchoscopist should discuss the advantages and disadvantages of oral or nasal intubation. Indications for each should be individualized based on extent of inhalation injury, potential for delayed injury, need for prolonged intubation or tracheostomy, and presence of comorbid diseases. Once intubated the patient can be thoroughly sedated.

Question I.28: Flexible bronchoscopy has been shown to be of limited value in all of the following **except**.

A. Pulmonary atelectasis after thoracic surgery
B. Solitary pulmonary nodules less than 2 cm in diameter
C. Isolated, unexplained pleural effusion
D. Hemoptysis with a nonlocalizing chest radiograph
E. Persistent asthma-like symptoms and chronic cough

Answer I.28: E

Although flexible bronchoscopy is commonly performed for each of the above indications, it has been shown to be of limited value in all except individuals with persistent asthma-like symptoms and chronic cough. In these patients, bronchoscopy might reveal tracheal stenosis or benign airway tumors such as carcinoids. If the past medical history includes tuberculosis, inhalation injury, foreign body ingestion, childhood lung infections, intubation, or tracheostomy, flexible bronchoscopy should be performed early in the course of the diagnostic evaluation and prior to instituting empiric therapy for hyperreactive airways disease. Percutaneous needle aspiration is favored over bronchoscopic lung biopsy in most patients with lung nodules 2 cm or less.

In patients with hemoptysis and a nonlocalizing or normal chest radiograph, approximately 5 % are ultimately found to have a malignancy. Clinical data do not support the routine use of bronchoscopy to exclude lobar obstruction, and therefore a cause for trapped lung, in patients with unexplained pleural effusion. Bronchoscopy should be considered in patients with recurrent malignant effusions or poor lung reexpansion after thoracentesis. Flexible bronchoscopy is also of limited value in community-acquired pneumonia unless patients have failed antibiotics.

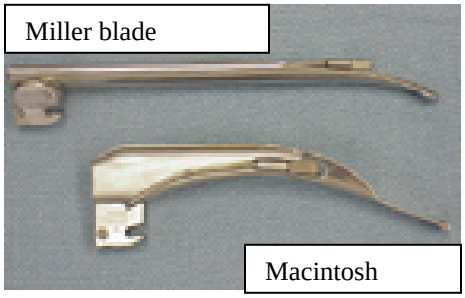
Question I.29: All of the following statements about endotracheal intubation are correct **except**

A. In obese patients in the supine position, elevating and supporting the shoulders in addition to elevating the head optimizes visualization by direct laryngoscopy
B. It is preferable to use a Miller Laryngoscope blade in patients with and anteriorly situated larynx
C. Rapid sequence induction (preoxygenation-sedation-muscle relaxation) facilitates bronchoscopic intubation
D. Cricoid pressure can be safely applied in patients who are at risk of aspiration
E. Patients with heart failure, myocardial ischemia or hypovolemia are at higher risk of peri-intubation mortality

Answer I.29: C

Elevating and supporting the shoulders in addition to elevating the head with pillows or towels places the head of the obese patient more readily into the "sniff" position (neck flexion, head extension). The sniff position improves access to an upper airway otherwise hindered by fat and redundant tissues. The Miller blade is a straight laryngoscopic blade that is inserted past the epiglottis. The epiglottis is then lifted out of the way in order to visualize the vocal cords. Many experts advocate using this blade in patients with a large epiglottis or anterior larynx. The wider, curved Macintosh blade, on the other hand, is also frequently shorter. It is inserted into the valleculae immediately anterior to the epiglottis. The Macintosh blade exposes the vocal cords after lifting the tongue anterior, which keeps the tongue from obscuring the visual field.

Cricoid pressure, also known as the Sellick maneuver, when performed correctly, is often warranted in patients at risk for aspiration. This includes patients who are obese, have recently eaten, and patients with known diabetic gastroparesis, pregnancy, or bowel obstruction. Rapid sequence intubation should only be performed in patients who are not believed to be difficult intubations. Muscle relaxation and sedation hinder visualization of the vocal cords, even with the flexible bronchoscope. Bronchoscopic intubation can be even more difficult when blood, mucus, secretions, or vomitus collect in the hypopharynx.



Question I.30 All the following findings are likely to make flexible bronchoscopic intubation of trauma victims more difficult **except**

A. Posterior displacement of the tongue and soft tissue edema
B. Vomitus, blood, and foreign bodies (teeth)
C. Agitation and anxiety
D. Using a larger caliber endotracheal tube over a larger caliber flexible bronchoscope
E. Rapid sequence anesthesia

Answer I.30 D

Using a larger caliber endotracheal tube and a larger diameter bronchoscope facilitates bronchoscopic intubation in most patients. Bronchoscopy can be performed via the nasal or oral passage. When using an oral approach, a bite block should always be used. Nasal intubation may be necessary in patients wearing high riding cervical collars. Posterior displacement of the tongue and soft tissue edema should be expected. It may be necessary to grasp the swollen tongue with a gauze pad and pull it partially out of the mouth to help expose the larynx. Vomitus, blood, and thick secretions should be aspirated using a Yankaur suction catheter rather than the flexible bronchoscope. The mouth should be carefully examined with the gloved hand, and accessible foreign bodies or broken teeth removed. Agitation and anxiety are common, and usually warrant conscious sedation.

An awake intubation, might be easier than attempting intubation of a fully sedated patient. Intubation should be performed prior to examination of the lower airways. Once the patient is intubated, additional sedation can be administered. Rapid sequence anesthesia should be avoided prior to bronchoscopic evaluation and intubation because muscle relaxation and paralysis will cause collapse of muscle tone of the upper airway, making it more difficult to visualize the larynx. In addition, muscle relaxation before obtaining an adequate and secured airway increases the risks of hypoxemia and cardiac disturbances.

Other elements that make flexible bronchoscopic intubation more difficult in the trauma victim include known or suspected cervical spine injury, frequent need to keep the patient in the prone or supine position, and abundant carbonaceous material, secretions, inflammation, and pain caused from burns and inhalation injury.