Question III.1: All of the following are potential causes of confusion and seizures in an elderly man undergoing bronchoscopic biopsies of a large right upper lobe mass **except**.

A. Silent brain metastases from bronchogenic carcinoma
B. Hydration and paraneoplastic inappropriate SIADH-like syndrome
C. Lidocaine toxicity
D. Midazolam toxicity
E. Methemoglobinemia

Answer III.1: D

Midazolam (Versed) is currently the most widely used agent for conscious sedation. It is a water -soluble benzodiazepine with rapid onset of action. It is four times more potent on a mg per mg basis than diazepam for sedation and amnesia. When 5 mg are administered intravenously, sedation and anxiolysis usually occurs within 2 minutes. Complete recovery of motor performance and consciousness occurs within one hour in most individuals.

Sedative responses are increased in patients who have received opioides or other benzodiazepines. In addition, level of sedation and risk for respiratory depression are increased in the elderly and in patients with pre-existing respiratory dysfunction.

Combining Midazolam and opioides increases the incidence of apnea. Large doses can produce prolonged drowsiness and cardio respiratory arrest.

Midazolam does not cause seizures. Central nervous system dysfunction, including confusion and seizures can be seen in patients with brain metastases and in patients with paraneoplastic syndromes.

Seizures can also occur from Lidocaine toxicity (especially if hepatic dysfunction results in increased plasma levels) and Benzocaine-induced methemoglobinemia.

Question III.2: During intubation over the flexible bronchoscope the endotracheal tube can become caught on laryngeal structures and not enter into the trachea. All of the following maneuvers are warranted **except**.

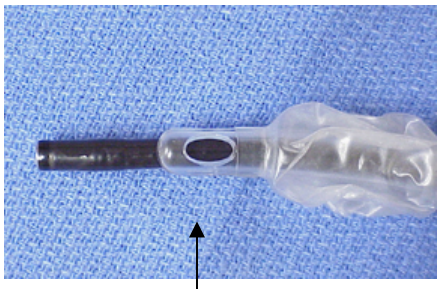
A. Partially withdrawing the endotracheal tube over the bronchoscope, rotating it 90 degrees clockwise and readvancing the tube.
B. Partially withdrawing the endotracheal tube over the bronchoscope, rotating it 90 degrees counter-clockwise and readvancing the tube.
C. Changing from a small 4.8mm diameter bronchoscope to a larger 6 mm diameter bronchoscope
D. Withdrawing the endotracheal tube over the bronchoscope and repeating multiple attempts at intubation

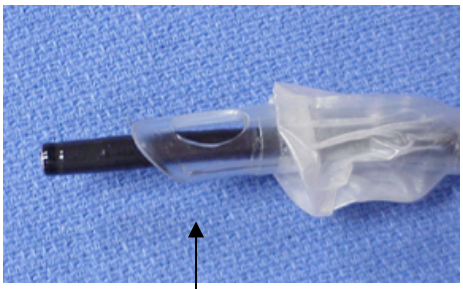
Answer III.2: D

Although one might withdraw the scope and endotracheal tube once and try again as described in response D, such repeated attempts at intubation are often unsuccessful and traumatic. Precious time is wasted and the risks for hypoxemia are increased. Repeated trauma to the larynx can also prompt reflex laryngospasm, reflex arrhythmias and vomiting. Inadvertent esophageal intubation is a possibility, and tracheal esophageal fistulas have been known to occur.

If resistance is met during intubation, remember that the epiglottis or the arytenoids are a frequent encountered obstruction after passing an endotracheal tube over a bronchoscope through the nares or through the mouth. Endotracheal tubes can also inadvertently enter aryepiglottic folds. Sometimes it helps to grasp the patient's tongue with a gauze pad, and to ask an assistant to pull the tongue out of the mouth slightly. This creates more space to maneuver in the oropharynx.

If intubation is still unsuccessful, it is best to change techniques in order to facilitate passage of the endotracheal tube between the vocal cords. All the techniques described in responses A, B, and C should be considered. A larger diameter bronchoscope allows for better manipulation and control of the endotracheal tube than a small diameter bronchoscope. By filling up more of the space within the endotracheal tube, the larger-sized scope and endotracheal tube ensemble is more readily maneuverable. Although it is recommended to intubate with the largest size endotracheal tube possible, most experts agree that a 7,5 endotracheal tube is the largest diameter tube that should be inserted through the nares. Rotating the scope 90 degrees clockwise or counterclockwise will change the angles of the curved tip of the endotracheal tube and might facilitate laryngeal intubation.





Question III.3: Fentanyl is a short acting opioid 100 times more potent then morphine. Its onset of action is within 2 minutes of intravenous injection. In addition, its maximum respiratory depression effect occurs

A. Immediately upon injection
B. Within 2-4 minutes after injection
C. 5-10 minutes after injection
D. 11-15 minutes after injection
E. More than 15 minutes after injection

Answer III.3: C

Fentanyl is a synthetic opiate analog that is structurally different from morphine or meperidine. The usual adult dose is 50-100 micrograms. Given intravenously, its onset of action and maximum respiratory depression effect occurs about 5-10 minutes after administration, and lasts anywhere from 30-60 minutes. Given intramuscularly, the onset of action is within 7-15 minutes with duration of action lasting up to two hours. Fentanyl should never be used in patients receiving MAO inhibitors because of increased risk of respiratory depression and coma.

Question III.4: All of the following statements about Naloxan (Narcan) are true **except**

A. It reverses all effects and side effects of narcotics including sedation, respiratory depression, apnea, and pain control.
B. Standard practice is to dilute 1 ampoule (0.4 mg or 1 ml) in 10 ml volume to make 0.04 mg/ml.
C. In order to reverse respiratory depression and apnea, 1 ml of dilute solution (0.4 mg) is injected intravenously every 2-4 minutes until consciousness is regained.
D. In the intensive care unit or on the ward, it is best to immediately administer the entire ampoule (0.4 mg) if the patient is severely respiratory depressed and if expert airway management is not available.
E. No more than 5 ml total should be administered because of risk of narcotic withdrawal.

Answer III.4: E

Naloxone is a pure opiate antagonist that reverses all effects and side effects of opiates. Actually, no more than 10 mg should be administered because this might lead to increased activity of the sympathetic nervous system from acute termination of analgesia. Consequently, patients may develop hypertension, dysrhythmias, and pulmonary edema.

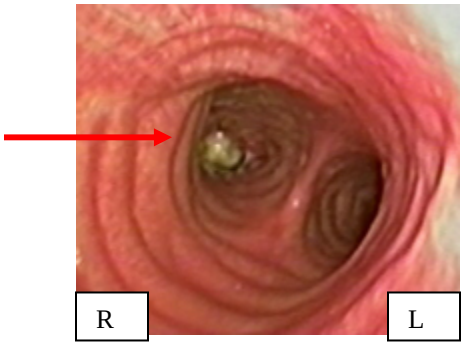
In case of over sedation with benzodiazepines, the benzodiazepine antagonist Flumazenil should be administered (0.2 mg iv over 15 seconds then repeated every minute up to a maximum of 1 mg). Low doses of Flumazenil will reliably reverse sedation within 2 minutes, but higher doses are needed to reverse benzodiazepine-related anxiolysis. Side effects include nausea, vomiting, tremors, seizures, tears and dizziness. Contrary to naloxone, it does not cause hemodynamic instability.

Question III.5 Bronchoscopy is performed in a patient with cough and partial unilateral atelectasis. Based on the findings shown below, bronchoscopic examination should proceed with

A. Examination of the left bronchial tree, then inspection and biopsy of the lesion on the right.
B. Inspection and biopsy of the lesion on the right, then examination of the left bronchial tree.
C. Examination of the right bronchial tree, then inspection and biopsy of the lesion on the left.
D. Inspection and biopsy of the lesion on the left, then examination of the right bronchial tree.

Answer III.5 A

The lesion is noted in the right main bronchus. The anterior cartilaginous rings and posterior membrane of the trachea are well visualized. It is prudent to proceed with an examination of the left bronchial tree before intervening in any way on the right side. This way, the presumed normal airway is examined and secretions are cleared. Should bleeding occur after biopsy of the lesion on the right, the bronchoscopist will know that the left airway is normal, able to assure respiration, and that there are no contra lateral abnormalities that might effect patient management.



Question III.6: While intubating a patient over the flexible bronchoscope, it suddenly becomes difficult to advance the bronchoscope. Although you are able to see the vocal cords, it is impossible to advance the endotracheal tube over the bronchoscope. What happened and what should you do next?

A. The bending tip of the bronchoscope broke. You remove the bronchoscope from the endotracheal tube.
B. The tip of the bronchoscope has accidentally passed through the Murphy eye of the endotracheal tube. You remove the scope and the tube together as an ensemble.
C. The polyurethane covering of the bronchoscope has slipped and intussuscepted over itself, occluding the endotracheal tube lumen. You remove the bronchoscope from the endotracheal tube.
D. The tip of the bronchoscope is flexed too much and the endotracheal tube is caught in the aryepiglottic fold. You partially withdraw the endotracheal tube over the bronchoscope.

Answer III.6: B

Each of the above problems can be encountered during intubation over a flexible bronchoscope. It is probably wisest to remove the bronchoscope and endotracheal tube together as a unit. If one withdraws one without the other, one risks damaging the bronchoscope. In addition, the problem may not be fixed.

Before intubating over a bronchoscope, one should fully load the endotracheal tube onto the bronchoscope under direct vision, taking care to identify the radio-opaque markers on the tube, as well as the Murphy eye and direction of the distal opening of the endotracheal tube. Some experts believe that the endotracheal tube should remain fully loaded onto the bronchoscope until the scope is passed beyond the vocal cords. The endotracheal tube is then fed into the trachea using the Seldinger technique.

Other experts recognize that on some occasions, such as when there is subglottic stenosis, laryngeal edema, tumor, blood or secretions, it might be preferable to keep the tip of the bronchoscope inside the endotracheal tube. The bronchoscope-endotracheal tube ensemble is then passed simultaneously past the cords. In case of severe tracheal stenosis, this technique avoids blind forceful dilation of the stricture as the bronchoscopist can see and feel the tube enter the stenotic area.

Each of the above techniques should be practiced on inanimate models. The bronchoscopist should use the technique with which he or she is most experienced, and always choose the safest technique based on the patient's underlying illness and ventilatory status.

Question III.7: Glutaraldehyde is frequently used for bronchoscope disinfection. All of the following side effects can be noted in persons exposed to this chemical **except**

A. Headache
B. Conjunctivitis
C. Dermatitis
D. Asthma-like symptoms
E. Diarrhea

Answer III.7 : E

Exposure to Glutaraldehyde may cause nasal irritation and all the other symptoms listed above except diarrhea. It is important that cleaning areas be well ventilated. Automated cleaning and disinfecting machines relieve personnel from the time-consuming manual disinfection process. They do not replace manual cleaning that is necessary before and often after machine disinfection. Specific infectious outbreaks have been reported with a variety of organisms, and cross infection has occurred between bronchoscopes and among patients.

For example, organisms have been found in the rinse water of automated machines. Fundamental errors in disinfection and cleaning regularly occur in many institutions. There is substantial intrahospital and interhospital variability regarding policies and procedures for bronchoscope decontamination, cleaning, disinfection, and maintenance.

Close collaboration between infectious disease specialists (hospital epidemiologists), bronchoscopists, nursing personel is advantageous. Learning sterilization and cleaning procedures and policies can help future bronchoscopists institute appropriate rules and regulations in their own hospitals later on.

Question III.8: All of the following statements pertaining to bronchoscope cleaning and disinfection are correct **except**.

A. High-level disinfection with 2% Glutaraldehyde for 45 minutes inactivates all fungi, viruses, and vegetative organisms.
B. High-level disinfection with 2% Glutaraldehyde for 45 minutes will not inactivate all bacterial spores.
C. Video bronchoscopes with a distal CCD chip are more likely to be damaged by Glutaraldehyde disinfection than fiberoptic bronchoscopes.
D. A positive leak test can indicate damage to the proximal polyurethane or distal rubber sheath of the insertion tube, or rupture of the integrity of the working channel of a flexible bronchoscope.

Answer III.8: C

Video bronchoscopes are as likely to be damaged by Glutaraldehyde as fiberoptic scopes. The CCD (charge coupled device) is a solid-state imaging sensor that is able to produce higher resolution images than a purely fiberoptic system. Fiberoptic bundles are still used in the light guide and universal cord. High-level disinfection requires a 45 minutes immersion to inactivate all fungi, viruses, and vegetative organisms, as well as about 95% of bacterial spores. To eradicate all mycobacteria, a 45 minutes immersion is necessary.

In fact, the 10 minutes immersion time used in many institutions to accelerate bronchoscope turn around time eradicates 99.8 % of Mycobacteria. Glutaraldehyde-based chemicals such as Cidex or Sporicidin corrode the steel components of any bronchoscope after 24 hours of contact time. These chemical solutions can be toxic to exposed persons.

Question III.9: During fluoroscopy, x-rays that pass though the patient and strike the image detector or fluoroscopic screens is called

A. Scattered radiation
B. Remnant radiation
C. Primary radiation

Answer III.9: B

Primary x-rays are those photons emitted by the x-ray tube, whereas scattered x-rays are those photons produced when primary photons collide with electrons in matter. Did you think this information is irrelevant? In the United States, many states or institutions require certification (by studying for and passing a special examination) in order to personally control a fluoroscopy machine!

Question III.10: While using fluoroscopy, scatter of radiation is increased when

A. Allied voltage (kVp) is decreased
B. Wavelength is decreased
C. Tissue density is decreased
D. Tissue thickness is increased

Answer III.10: D

Scatter, also known as Compton scatter, is non-useful ionization of patient tissue caused by x-ray bombardment. Scatter occurs when an x-ray photon with increased energy strikes an electron and is deviated from its original path. This is potentially caused by increased voltage or decreased wavelength, and also when tissues thickness is increased and tissue density is increased. The x-ray photon thus travels in a different direction, but with less energy.

An increase in scatter diminishes the quality of the fluoroscopic image, and decreases the contrast of the image seen on the monitor by increasing what is referred to as quantum mottle. Quantum mottle looks like “crawling ants” on the screen. It results from an insufficient number of photons and can be reduced by increasing the milliamperage i.e. anode tube current.

Question III.11: Which of the following might prompt you to carefully reexamine the indications for bronchoscopy in the intensive care unit of your institution

A. Bronchoscopy is frequently performed in critically ill patients with copious secretions and elevated airway pressures while on mechanical ventilation
B. Bronchoscopy is frequently performed in critically ill patients without radiographic evidence of atelectasis, and has not prompted significant changes in medical management
C. Bronchoscopy is frequently performed in critically ill patients with new onset of hemoptysis
D. Bronchoscopy is frequently performed in critically ill patients with new or persistent radiographic pulmonary infiltrates despite use of empiric antibiotics

Answer III.11: B

Bronchoscopy is frequently indicated and performed in critically ill patients. For example, accepted indications include copious secretions that cannot be cleared by routine suctioning, persistent or acute unexplained hypoxemia, unexplained failure to wean from mechanical ventilation, new onset of hemoptysis, pulmonary infiltrates with suspicion for infection when the bronchoscopic procedure is likely to alter therapy, and persistent or hemodynamically significant radiographic atelectasis that is unresponsive to chest physical therapy or suctioning.

If it appears that numerous procedures are being performed without good evidence of radiographic abnormalities, impaired oxygenation or ventilation status, or difficulties with secretion management, indications for bronchoscopy should probably be closely examined to be certain that procedures are being performed in the appropriate circumstances.

Of course, the decision to perform bronchoscopy can often be based on a subjective assessment of the situation rather than on hard objective data. This can easily lead to bronchoscopy in the intensive care unit being easily be performed in excess. Practices can also vary according to available resources, staffing, and referring physician preferences.

Question III.12: Which of the following intubation-oral airways will most likely allow adequate visualization of the larynx and vocal cords, even if the airway is inserted too far?

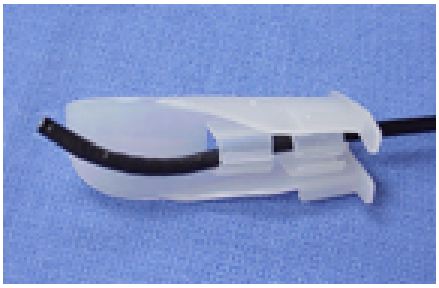
A. Berman pharyngeal airway.
B. Williams airway intubator.
C. Ovassapian airway

Answer III.12: C

Oral intubating airways help the bronchoscopist keep the flexible bronchoscope in the midline, expose laryngeal structures, and maintain an open pharynx. The Ovassapian fiberoptic intubating airway provides an open space in the oropharynx and protects the bronchoscope from being bitten by the patient. The airway can be removed without disconnecting the endotracheal tube adaptor. The wider distal half of the airway prevents the tongue and soft tissues of the anterior pharyngeal wall from falling back and obstructing the view of the glottis. The proximal half has a pair of guide walls that provide a space for the bronchoscope and endotracheal tube. This airway accommodates endotracheal tubes up to 9 mm inner diameter.

The Berman airway is also recommended for bronchoscopic intubation, but its length and tubular shape hinder maneuverability of the flexible bronchoscope once it is inserted. If the distal end of this airway is not perfectly in line with the glottic aperture, the airway must be partially withdrawn in order to expose the vocal cords.

The Williams airway intubator was designed for blind orotracheal intubation. Its distal half has an open lingual surface, which makes lateral and anteroposterior maneuverability of the bronchoscope difficult. In order to remove the Williams airway after intubation, the endotracheal tube adaptor must be removed prior to intubation.



Question III.13: You are about to describe a tracheal abnormality to a surgeon. In which of the following might she be most interested

A. Distance of the abnormality from the carina
B. Whether the abnormality has a wide or narrow base
C. Location of the abnormality in relation to the bronchial wall
D. Size of the abnormality (length, diameter, degree of airway obstruction)
E. Distance of the abnormality from the inferior margin of the vocal cords

Answer III.13: E

Well, you probably had to think about this one. In fact, when considering a tracheal lesion for surgical repair, all of the above should be well described. The reason the noted response is E, is because the distance from the inferior margin of the vocal cords, may, in many instances, be the deciding factor regarding evaluation of complexity of surgical resection.

Of course, other components of tracheal disease that should be described are length of the stricture in centimeters and number of cartilage rings involved, consistency (firm, rubbery, soft), appearance (glistening, vascular), fragility (oozing, actively bleeding, pus-filled), color (white, red, dark, yellow), shape (regular, round, irregular, elongated, bulging), dynamics (mobile with respiration or cough, ball-valving, immobile), degree of airway wall involvement, associated airway wall abnormalities (malacia, cartilaginous destruction, foreign body). Having a videotape of the examination available for review by surgical colleagues is always appreciated.

Question III.14: A 76-year-old patient with chronic cough, difficulty swallowing and new onset hoarseness is referred for bronchoscopic evaluation. 1 mg of Midazolam is injected intravenously and abundant topical anesthetic is applied to the oropharynx and larynx. The vocal cords move normally, but a firm lesion resembling adenoid cystic carcinoma obstructing 20 percent of the subglottis is seen. Because of the lesion's proximity to the vocal cords, no biopsies are obtained. About one hour after the procedure the patient develops a bluish discoloration of the lips. Arterial oxygen saturation decreases from 98 percent to 88 percent despite administration of supplemental oxygen. The patient has become anxious and combative in the recovery area. Resting heart rate increases to from 110 to 150. The most likely cause for this patient's symptoms is.

A. Cetacaine spray induced methemoglobinemia
B. Procedure-induced laryngospasm
C. Tetracaine toxicity
D. Myocardial infarction from prolonged hypoxemia
E. Lidocaine toxicity

Answer III.14: A

Methemoglobinemia can result from exposure to Benzocaine, the Esther family local anesthetic contained in Cetacaine and Hurricane, two aerosol sprays frequently used for topical anesthesia of the oropharynx. Risk is greatest in the elderly and in infants. Diagnosis should be suspected in patients who develop cyanosis with bluish discoloration of the skin, lips and mucous membranes. It is confirmed by Co-oximetry. Up to a methemoglobin level of 20 percent, oxygen saturation drops by about half the methemoglobin percentage. Patients develop a functional anemia because the ferrous hemes of hemoglobin are unable to bind oxygen. Treatment is by intravenous injection of 1-2 mg/kg Methylene blue.

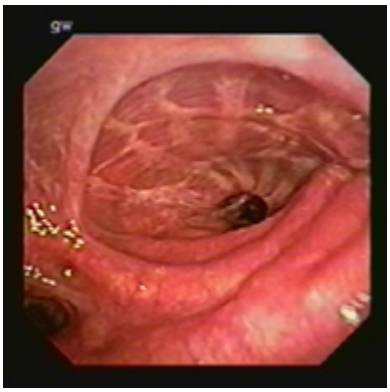
Acute onset laryngospasm would cause stridor and respiratory distress. Tetracaine, a long-acting and potent topical anesthetic, is also a component of Cetacaine aerosol spray (2% Tetracaine, 14% Benzocaine, 2% butyl ester of *para*aminobenzoic acid). Tetracaine is a derivative of *para*aminobenzoic acid, and can thus cause allergic reactions. Its rapid rate of absorption and prolonged duration of action compared to Lidocaine are in part responsible for its narrow margin of safety when used for bronchoscopy. Systemic effects include convulsions and sudden death. Other symptoms include restlessness, numbness around the lips and mouth, tonic-clonic seizures, hypotension, and apnea. Lidocaine is an amide local anesthetic that is less potent and has a shorter duration of action than Tetracaine. It comes in various solutions ranging from 0.5% to 4%. The 4% solution provides about 15 minutes of reliable topical anesthesia. A 10% solution is available for spraying the oral and nasopharynx. Each spray delivers 0.1 ml (10 mg) of Lidocaine. A 2.5% and 5% gel is also available, and usually preferred by patients for anesthesia of the nasal passages. Peak concentration is usually reached within 30 minutes of airway application.

The maximum dose of Lidocaine recommended is 300 mg in adults. Blood concentration is directly related to total dose used regardless of the concentration of solution employed. When Lidocaine is administered by aerosol spray, it is absorbed less rapidly than if it is administered by ultrasonic nebulizer. In addition, when swallowed, less Lidocaine is absorbed into the bloodstream than when it is deposited onto the mucous membranes of the upper and lower respiratory tract.

Because Lidocaine is metabolized in the liver, patients with hepatic dysfunction or low cardiac output will have high Lidocaine plasma levels. Side effects include hyperactivity, restlessness, tingling of the lips, slurred speech and tremors. At higher blood levels, seizures and cardiorespiratory depression occur, including bradycardia, hypotension, and cardiac arrest.

Question III.15: Tracheomalacia is defined as a loss of longitudinal elastic fibers of the posterior tracheal membrane with or without destruction or damage to tracheal cartilage leading to loss of rigidity and tracheal collapse. During an airway examination, which of the following is seen.

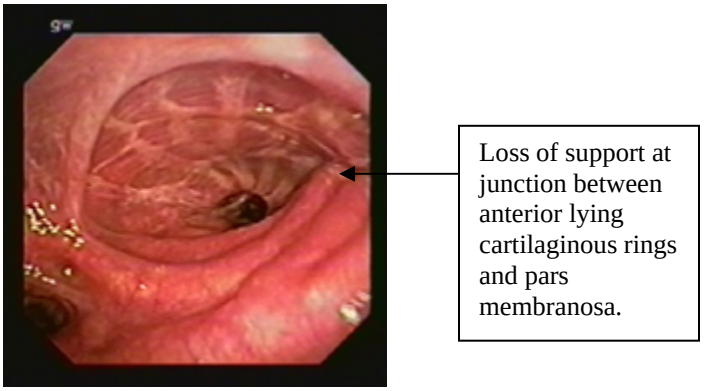
A. Collapse of the malacic intrathoracic segment during expiration and/or collapse of the malacic cervical segment during inspiration
B. Collapse of the malacic intrathoracic segment during inspiration and/or collapse of the malacic cervical segment during expiration
C. Collapse of the malacic intrathoracic segment during expiration and/or collapse of the malacic cervical segment also during expiration
D. Collapse of the malacic segment during expiration or inspiration with substantial inward movement of the pars membranosa



Answer III.15: A

Inspiratory collapse should be noted in a malacic cervical trachea when the malacic tracheal wall is sucked inwards by negative intratracheal pressure. During expiration, collapse of the intrathoracic malacic segment occurs when intrathoracic pressure exceeds intratracheal pressure. Tracheomalacia can be noted during bronchoscopic examination and electron beam computed tomography scanning. It should be suspected in patients after longstanding intubation, in patients with history of pneumonectomy and herniation of the remaining lung into the vacant hemithorax, and in patients with dyspnea, difficulty raising secretions, and chronic cough.

Usually, malacia is diagnosed when cartilaginous collapse is noted during airway inspection. Some experts believe that it should be differentiated from dynamic airway collapse where significant obstruction is due to inward movement of the pars membranosa, but without evidence of cartilaginous destruction or loss of rigidity and shape of cartilaginous rings. To avoid confusion or misunderstandings, one should be explicit in describing the extent, severity, location, and nature of all anomalies noted.



Question III.16: All of the following reasons for immediate intubation of the inhalation injury victim are correct **except**

A. Intubation before the development of significant airway edema and respiratory compromise avoids an emergency procedure, the outcome of which may be disastrous.
B. Burn-related chest restriction and circumferential neck burn related airway obstruction further reduces ventilatory flow.
C. Noted airway abnormalities such as soot, charring, mucosal necrosis, edema, and inflammation below the level of the carina antedate blood gas and radiographic changes suggestive of parenchymal injury.
D. Parenchymal damage is frequently delayed.
E. Maximum upper airway edema occurs within the first 24 hours after injury

Answer III.16: E

Actually, maximum upper airway edema peaks as late as 36-48 hours after injury! If a patient is intubated, extubation is frequently delayed until all edema has resolved. The absence of edema, stricture, or subglottic swelling during bronchoscopically-guided extubation, or a leak around the endotracheal tube are two indicators that are used to help determine the time for extubation.

When patients present with inhalation injury, chest radiographs and arterial blood gases are notoriously unhelpful in predicting whether parenchymal injury has occurred. In addition, findings may be delayed hours and even days. For these reasons, in many burn centers, all smoke exposed victims are bronchoscoped routinely. Presence of dyspnea, wheezing, laryngeal abnormalities, tracheobronchitis, and abnormal arterial blood gases or chest radiographs almost always warrants intubation. Delayed problems include tracheobronchial tissue sloughing, decreased mucociliary clearance, mucous plugging, atelectasis, impaired clearance of secretions, pneumonia, pulmonary edema and acute respiratory distress syndrome.

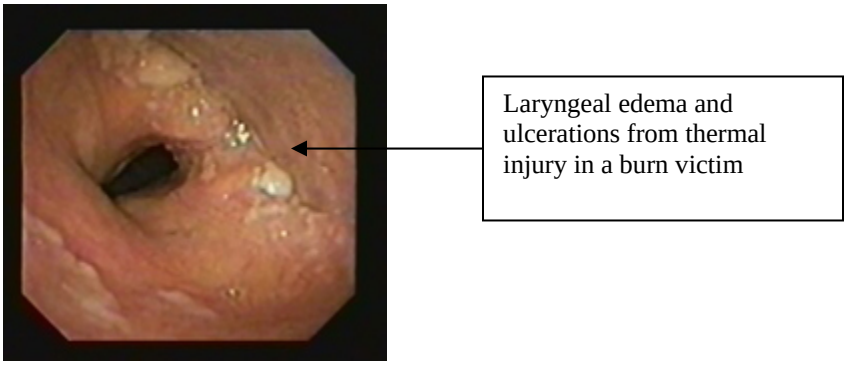
Question III.17: All of the following statements about inhalation injury in burn victims are correct **except**

A. The use of bronchoscopy for diagnosis has resulted in a recognized increase of the incidence of inhalation injury from a 2-15 percent incidence (based on history, carbonaceous sputum, and facial burns) to as high as 30 percent incidence.
B. When inhalation injury is present, mortality is greater than when cutaneous burns alone are noted.
C. Bronchoscopic findings consistent with inhalation injury in burn victims are usually airway edema, inflammation, or carbonaceous secretions (presence of soot).
D. Erythema, hemorrhage and ulceration rarely occur within the tracheobronchial tree.
E. Gaseous and particulate products of incomplete combustion are associated with the tracheobronchial injury of smoke inhalation.

Answer III.17: D

Erythema, hemorrhage and ulcerations are frequently noted as a direct effect of thermal injury to the upper or lower airways. This occurs most frequently from hot smoke or steam inhalation, but can also result from direct heat injury during therapeutic bronchoscopic electrocautery and laser resection. Although the upper airway protects the lower airway and parenchyma, any exposures to hot air may cause reflex laryngospasm. Laryngeal complications can occur acutely, but also many hours after injury. They are frequently life threatening. Edema and inflammation are proof of upper airway injury and are often immediately visible to the bronchoscopist.

The presence of carbonaceous secretions in the oropharynx also suggests airway damage. Lower airway injury, however, is typically delayed. Many experts say that “if in doubt” about upper or lower airway injury, immediate intubation should be preferred to a ‘watch and wait” approach. The presence and extent of lower airway injury can be ascertained on follow-up flexible bronchoscopy. Extubation should be done carefully because of the risk of persistent laryngeal and subglottic edema as well as laryngeal swelling due directly to the endotracheal tube or prolonged intubation.



Question III.18 A 63-year-old man comes to your office because of a three-year history of dyspnea. He is short of breath with minimal exertion. Asthma was diagnosed one year ago. He is using inhaled bronchodilators and oral corticosteroids occasionally. Physical examination reveals mild stridor. Laboratory tests are normal. Chest radiograph and computed tomography scan of the chest reveal a 3 cm intraluminal mass narrowing the midportion of the trachea to 5 mm. There is no evidence of extraluminal tumor or enlarged mediastinal adenopathy. Flexible bronchoscopy confirms the presence of the 3 cm intraluminal mass in the midtrachea. Airway lumen is narrowed but adequate. Biopsy reveals adenoid cystic carcinoma. Which of the following would you recommend next

A. Referral to radiation oncology for external beam irradiation
B. Referral to medical oncology for systemic chemotherapy
C. Referral to interventional Pulmonology for Nd:YAG laser resection
D. Referral to thoracic surgery for sleeve resection of the trachea

Answer III.18: D

The major question here is whether this patient should be referred for laser resection or immediate surgery. Adenoid cystic carcinoma (previously known as cylindroma) accounts for about 0.1% of all primary lung tumors and 10% of bronchial adenomas (which also include carcinoid tumors and mucoepidermoid tumors). If the patient is clinically and hemodynamically stable, has no contraindications for surgery, and is willing to undergoing tracheal resection, referral for sleeve resection with removal of at least 6 tracheal rings (there are about two tracheal cartilages per centimeter) and reanastomosis is warranted.

Often, surgical margins reveal microscopic tumor. Many patients are subsequently referred for external beam radiation therapy. Despite resection, recurrence occurs in more than 50% of patients, and metastases are known to occur to the lung, brain, liver, bones and skin. Tumors usually grow very slowly. Even in case of tumor recurrence, survival can be 10 –15 years.

Question III.19: It is most likely that the patient with this abnormal airway seen in the Figure has which one of the following disorders

A. Sarcoidosis
B. Relapsing polychondritis
C. Teratoma with extrinsic tracheal compression
D. Underlying chronic obstructive pulmonary disease
E. Pulmonary amyloidosis

Answer III.19: D

The figure is that of a saber-sheath or scabbard trachea. Saber-sheath trachea is defined as a trachea with excessive transverse narrowing and widened sagittal diameter of the intrathoracic portion of the trachea. This is very different from the C-shaped trachea seen in about 49% of normal adults. The saber has been described in up to 5 % of elderly men. In these instances, ossification of tracheal rings may also be found. Usually, the abnormality spares the cervical portion.

The majority of patients with saber-shaped trachea have chronic obstructive pulmonary disease, and it is believed that the narrowing is related to air-trapping in emphysematous upper lobes, chronic cough, and cartilaginous degeneration. When discovered, additional study by computed tomography scanning may be warranted. The differential diagnosis includes extrinsic compression by extratracheal mediastinal mass, tracheobronchopathica osteochondroplastica, amyloidosis, relapsing polychondritis, and saber-sheath trachea in patients with excessive kyphosis.

Saber-sheath trachea

C-shaped trachea

Horseshoe-shaped trachea

Question III.20: You are asked to emergently bronchoscope a 33-year-old male in the intensive care unit. The patient has been intubated and mechanically ventilated for the past week. He was the victim of a motorcycle accident causing closed-head trauma and loss of consciousness. Respiratory therapy just noted fresh blood tinged secretions on suctioning. Some watery secretions and blood are in the endotracheal tube. The patient is hemodynamically stable, but hypertensive. Which of the following bronchoscopic appearances is most likely to account for this patient's problem?

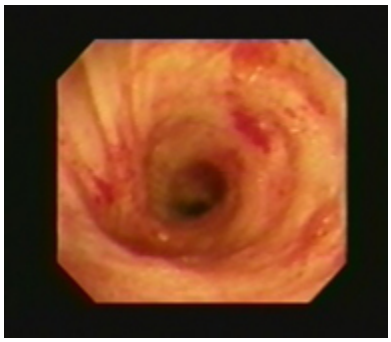
A. Diffuse tracheobronchial erythema, purulent secretions, and tissue sloughing.
B. Diffuse swelling and erythema of bilateral airways.
C. Raised whitish plaques with surrounding erythema in the distal lower lobe bronchi.
D. Edema, erythema, and petechia in the right main bronchus and on the main carina.
E. Swollen airway mocosa and pink frothy secretions.

Answer III.20. D

A frequent cause of hemoptysis during mechanical ventilation is suction trauma due to stiff suction catheters. The figures below shows petechia and erythematous swelling from aggressive suctioning with a stiff-tipped catheter. Underlying tracheal and bronchial mucosa is often erythematous, swollen and easily bruised.

Other causes of hemoptysis that must be excluded are necrotizing pneumonia (response A), severe tracheobronchitis (response B), tracheobronchial herpes (response C), pulmonary edema (response E), mycobacterial infection, pulmonary thromboembolism, pulmonary artery dissection from a pulmonary artery catheter, erosions from the endotracheal tube cuff, and innominate artery-tracheal fistula.

Of course, bleeding can also be due to underlying diseases such as Wegener's granulomatosis, Goodpasture's syndrome and other vasculitities, neoplasms, and disseminated intravascular coagulopathy.



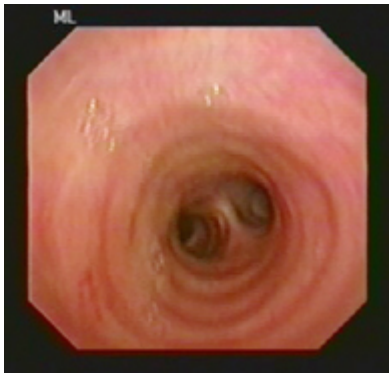
Question III.21: While performing a bronchoscopy in an adult patient with presumably normal airways, you ask the patient to inhale, exhale, and cough. Which of the following changes in airway anatomy would be abnormal

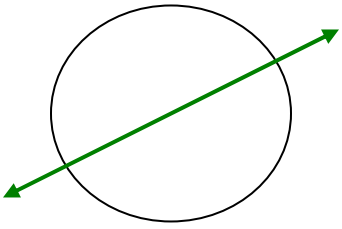
A. The tracheal length increased by 20 % (about) 1.5 cm) during normal inspiration
B. The tracheal transverse diameter decreased by 10% (about 2 mm) during normal expiration
C. The tracheal transverse diameter decreased by 30 % during cough
D. The tracheal sagittal diameter decreased to 0 during cough
E. The tracheal sagittal diameter decreased by 30 % during normal expiration

Answer III.21: E

The cross-sectional shape of the trachea is characterized by the ratio of transverse (separates trachea into front and back) and sagittal (separates trachea into left and right) diameters. Women tend to preserve a round configuration, while men tend to have some sagittal widening and transverse narrowing. The tracheal lumen changes dimensions depending on the phase of the respiratory cycle. For example, during coughing, intrathoracic pressure increases and becomes supra-atmospheric. This results in a narrowing of intrathoracic tracheal lumen as witnessed by decreased sagittal and transverse diameters.

The invagination of the posterior membrane can easily reduce the sagittal diameter to zero. Usually there should be no significant change in tracheal sagittal diameter during normal expiration because surrounding negative intrathoracic pressure supports airway patency. If there is intrathoracic tracheomalacia, expiratory collapse will occur, whereas extrathoracic tracheomalacia results in variable inspiratory obstruction, the major force opposing collapse being the upper attachment to the cricoid cartilage.





Transverse

Question III.22: All of the following "habits" can cause a bronchoscopist to miss a diagnosis or inadvertently harm a patient **except**.

A. Placing one hand under the chin while the other pushes downward on the top of the head while preparing to perform rigid laryngoscopic intubation.
B. Rapidly withdrawing the flexible bronchoscope without visualization and without careful attention to the subglottic larynx.
C. Repeatedly administering additional amounts of topical anesthetic to a coughing patient
D. Routinely performing the bronchoscopic airway inspection in the same sequence in all patients.

Answer III.22: D

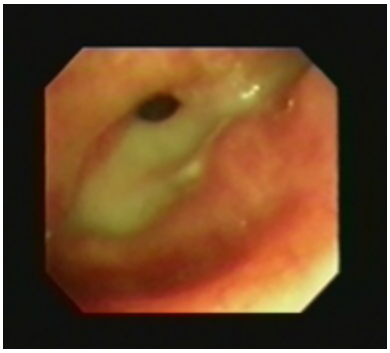
Routinely performing the bronchoscopic inspection in the same sequence in all patients is a good habit. The "normal" airways should be inspected first, leaving observations of abnormalities for last. By inspecting segmental bronchial anatomy in the same order, the bronchoscopist will never inadvertently overlook a segment. Many bronchoscopists leave the upper lobe bronchi for last because inspection of these segments can be more difficult, and because inspection of these segments often causes patients to cough. The habit of placing a hand on the chin while pushing down on the top of the head should be avoided because this maneuver can drive the odontoid process into the medulla oblongata. This is especially dangerous in patients with weakened C 1 vertebra such as that which occurs in trauma victims, in patients with bony erosion from metastases or primary tumor, and in patients with Paget's disease, severe osteoporosis, or platybasia (softening of skull bones).

Rapid removal of the bronchoscope from the airway without a repeat inspection of the airways and subglottis is unwarranted. For trainees, it is great practice to remain in the midline up to and above the larynx. Lessons learned would come in handy the day one faces a difficult intubation! In addition, careful inspection may detect abnormalities not seen during bronchoscope insertion. These include subglottic strictures, vocal cord polyps or contact ulcers, small endobronchial abnormalities, and tracheosophageal fistulas. Administering additional topical anesthetic or conscious sedation agents because a patient is coughing or is increasingly anxious or combative can abolish any existing airway reflexes remaining for the patient. In addition, it may delay recognition of other problems such as drug reaction or mental status changes from hypoxemia, and prompt adverse events caused by excess medication.

Many patients can be "talked down" or soothed by a confident and gentle bronchoscopist and assistant. In others, it might be best to temporarily stop the procedure until the patient calms down. Improper bronchoscopy technique such as repeatedly scraping the bronchoscope against the bronchial wall, frequent suctioning, and repeated unsuccessful attempts to enter an upper lobe bronchus is often responsible for patient discomfort.

Question III.23: The airway secretions seen in the Figure below should be described as

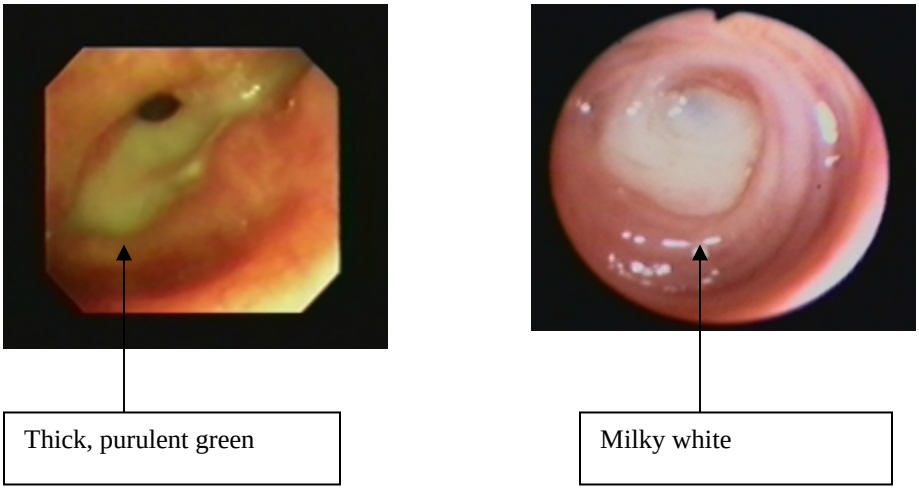
A. Clear
B. Viscous
C. Mucoid
D. Purulent



Answer III.23 D

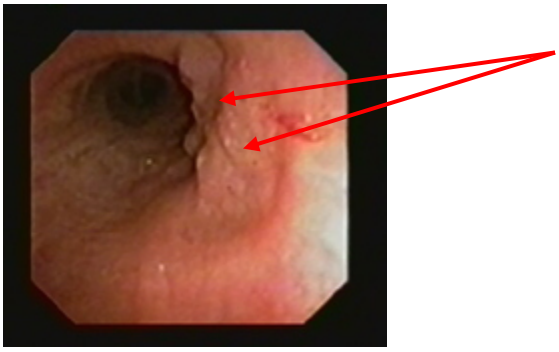
Purulent secretions can be yellow, green, white, or greenish-brown. Secretions can also be gray, blood-tinged, bloody, and black. As for all secretions, other descriptive terms include clear, milky, watery, thick, tenacious, scant, and abundant. Viscous means possessing viscosity, which is a property of a body by which flow occurs inside it. The term is inappropriately used in bronchoscopy reports.

Mucoid refers to a group of glycoproteins resembling mucin, as in normal secretions present in the cornea and in cysts. This is a descriptive term that is frequently used in bronchoscopy reports. Most readers understand that it describes secretions that are slightly tenacious, thick, and yet clear.



Question III.24: The appearance of the bronchial mucosa along the lateral wall of the bronchus shown in the Figure below should be described as

A. Pale, raised, and granular
B. Thickened and erythematous
C. Erythematous, shiny and edematous
D. Thickened, red and swollen

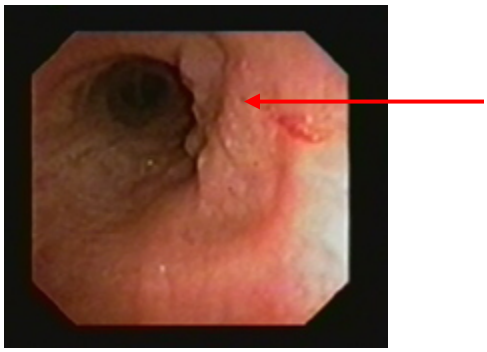


Answer III.24: A

The mucosa of the lateral wall of this bronchus is pale, raised and granular. It is difficult to assure a universal nomenclature for describing mucosal changes. The important thing is to develop a vocabulary for airway abnormalities that is constant, clear, and precise. As the operator, there should be a consistency in how you describe abnormalities. Misinterpretations should be avoided. Whenever possible, attach a photograph to the bronchoscopy report.

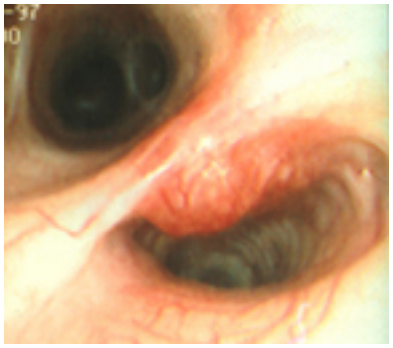
Use simple vocabulary. The location, size, and extent of each abnormality should be noted. Its impact on airway caliber and the degree of stenosis or airway narrowing should be estimated. Friability and texture (granular, waxy, shiny, thickened, swollen) should be noted, and concomitant findings (dynamic collapse, cartilaginous damage, focal, extensive or diffuse infiltration, or extrinsic compression) can be described. Lesions should be referred to as intraluminal (nodular, polypoid, or membranous) or extrinsic. Color might be important (pale, dark, brownish-black, white, yellow, greenish, red, purplish).

Airways might be inflamed, swollen or erythematous…but does not "inflamed," suggest swollen and erythematous? The bronchoscopy report should tell a story that everyone could read and understand the same way. Bronchial segments should be numbered and named. Lymph nodes sampled should be named and noted using the widely accepted ATS nodal station classification or the less widely accepted bronchoscopic classification system. In truth…it isn't easy.



Question III.25: The appearance of the airway abnormality shown in the Figure below should be described as

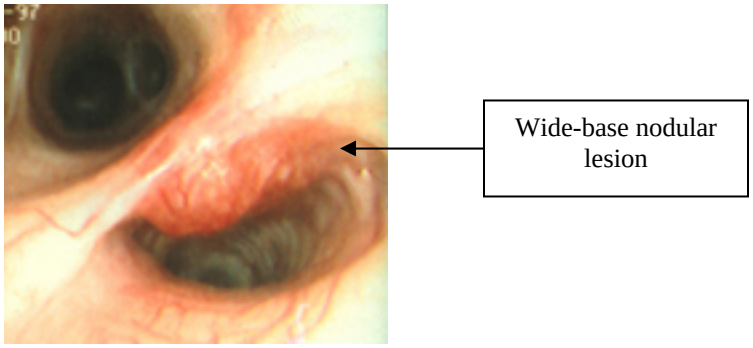
A. Polypoid
B. Nodular invasive
C. Superficial invasive
D. Intraepithelial neoplasia



Answer III.25: B

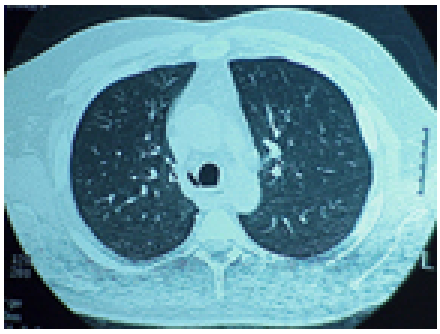
A generally accepted, but infrequently referred to classification of bronchoscopic findings is that of the Japan Lung Cancer Society. In this classification, bronchoscopic findings are described as mucosal or submucosal. Early stage cancer is a mucosal histopathologic change. Polypoid tumors are described as tumors attached to the bronchial wall at their base only: a typical lesion extends into the airway lumen and moves with respiration.

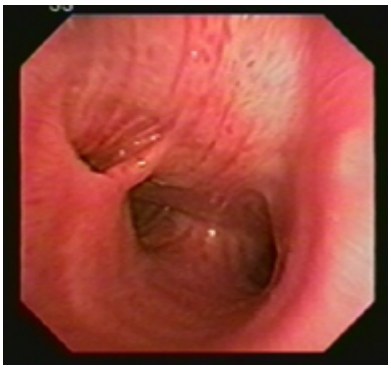
A nodular tumor has a mound-like shape and also extends into the bronchial lumen. The surface of both polypoid and nodular lesions may be granular, engorged with capillary vessels, or covered with necrotic material.



Question III.26: The bronchial anomaly seen in the figures below is.

A. A subapical segment of a right lower lobe bronchus
B. A tracheal bronchus, extending downwards and laterally from the right tracheal wall
C. An accessory right upper lobe bronchus





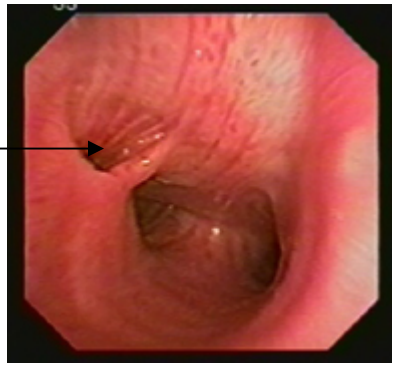
Answer III.26: B

The tracheal bronchus, also called “pig bronchus” because of its frequent presence in pigs, is usually a large developmental variation of the bronchial supply to an upper lobe, in this case, the right upper lobe bronchus. In humans, the tracheal bronchus is seven times more frequent on the right side of the trachea then the left. When it originates on the left, it is usually associated with other congenital abnormalities.

The tracheal bronchus can be seen in a many as 1% of individuals, although most authors cite a frequency of 0.25%. It is also seen in whales, giraffes, sheep, goats, and camels. In humans it is usually an incidental finding on bronchoscopy, chest radiograph, or computed tomography scan. When the orifice of the tracheal bronchus is relatively horizontal, recurrent episodes of aspiration, cough, bronchitis, and pneumonia may occur.

There are several types of tracheal bronchus. The rudimentary type is a blind pouch. There is the “displaced” bronchus, the most common variant, which supplies the apical segment of the right upper lobe. In this case, the segmental bronchi to this segment are missing within a regularly placed right upper lobe bronchus. The supernumerary supplies the right upper lobe in addition to a normal right upper lobe bronchus. Finally, there is the right upper lobe tracheal bronchus, which has three normal segmental bronchi, all arising above the main carina, but without a right upper lobe bronchus below the tracheal bifurcation.

Tracheal Bronchus located 2 cm above the carina along right lateral wall of trachea



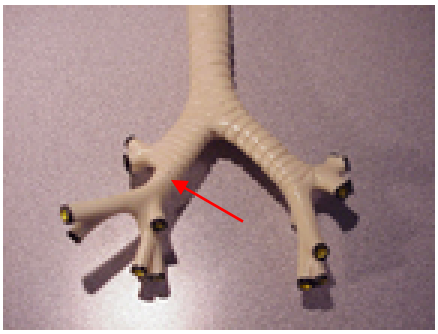
Question III.27: All of the following airway dimensions in the adult are correct **except**.

A. The left lower lobe bronchus beyond the origin of the superior segment is usually 1 cm in length before giving rise to the basal segmental bronchi.
B. The usual length of the trachea (distance from the cricoid cartilage to the main carina) ranges from 9-15 cm.
C. The usual internal caliber of the trachea ranges from 1.2 cm -2.4 cm.
D. The right upper lobe bronchus is usually located about 1.5-2.0 cm below the main carina.
E. The usual length of the bronchus intermedius ranges from 2-4 cm beyond the origin of the right upper lobe bronchus.

Answer III.27: E

The bronchus intermedius of the right bronchial tree is actually quite short, extending for 1.0-2.5 cm until its anterior wall extends into and becomes the middle lobe bronchus. Its posterior wall extends into and becomes the right lower lobe bronchus.

Volume loss caused by pleural effusion, radiation fibrosis, elevated right hemidiaphragm, as well as traction or torsion from a fibrotic or scarred right upper lobe often cause shortening of the bronchus intermedius.



Question III.28. All of the following may damage a flexible bronchoscope **except**:

A. Forceps biopsy in the apical segment of the right upper lobe.
B. Bronchoalveolar lavage in the lingula
C. Bronchoscopy through an endotracheal tube in a mechanically ventilated patient.
D. Transcarinal needle aspiration
E. Catheter brushing within the medial basal segment of the right lower lobe.

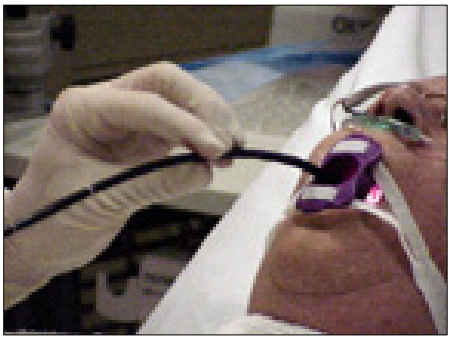
Answer III.28: B

Bronchoalveolar lavage should never damage a bronchoscope. Passing a forceps, needle, or even a catheter, however, through the working channel of a flexible bronchoscope can easily damage it. The risk for damage increases when the instrument is forced through an acute angle formed by the bronchoscope as it enters the apical segment of an upper lobe bronchus. In these cases it is safer and easier to keep the tip of the bronchoscope at the entrance of the upper lobe bronchus, and to pass the forceps into the apical segment, watching it pass beyond the tip of the bronchoscope. If the bronchoscope needs to be wedged into the apical segment, it can be advanced gently over the forceps.

A bronchoscope can be damaged anytime it is inserted through an endotracheal tube, even when one assumes that a patient is paralyzed. Paralysis may be incomplete. Other times, bite blockers slip and the endotracheal tube becomes wedged between the teeth. Lubrication with silicone, xylocaine gel, or normal saline solution should be routine before inserting the bronchoscope into the endotracheal tube. Acute angles between the scope and the endotracheal tube at the scope's insertion site should be avoided. An assistant can be asked to hold the scope and endotracheal tube upright.

A bite block should be used whenever a flexible bronchoscope is inserted into the mouth, regardless of the patient's level of consciousness. Short, longitudinal bite blocks used to protect endotracheal tubes from patient biting slip easily. The full sized mouth bite block is a safer tool that can be firmly held in place by an assistant, or tied into place using an around-the-head Velcro strap. The bite block can usually be placed in the middle of the mouth, displacing the endotracheal tube to the corner of the mouth, or the bit block can be placed in the corner of the mouth, displacing the endotracheal tube towards the midline. On rare occasions, it might be necessary to untape the endotracheal tube in order to place the bite block over it inside the mouth.

Note that purple bite block is attached using Velcro bands



Question III.29: All of the following statements pertaining to the safety of bronchoalveolar lavage are correct **except**

A. BAL can cause cough, bronchospasm, and dyspnea
B. BAL can cause a temporary decrease in Forced Expiratory Volume (FEV 1) of up to 20 %.
C. BAL can cause transient hypoxemia persisting for up to 6 hours.
D. BAL can cause radiographic lobar consolidation or peripheral opacities that might be suggestive of new onset procedure-related infection.
E. BAL can cause transient fever, chills, and myalgias.

Answer III.29: D

BAL has not been shown to cause pulmonary infections, although radiographic infiltrates may be visible for up to 24 hours after a procedure. For this reason, experts advocate obtaining radiographic studies prior to BAL rather than afterwards, when the presence of an infiltrate within a lobar segment that has been lavaged may erroneously be considered pathologic.

Most experts keep patients under observation for up to 2 hours after BAL. In the presence of dyspnea or bronchospasm, inhaled bronchodilators are usually administered. Supplemental oxygen is routine until arterial saturation has returned to baseline or is normal on room air. Patients should be warned about the possibility of delayed onset fever, chills, or myalgias. In this event, Patients should be instructed to take an antipyretic or other anti-inflammatory for symptomatic relief.

Question III.30: Each of the following airway findings adversely effect staging and prognosis in a patient with bronchogenic carcinoma **except**

A. Discovery of occult vocal cord paralysis
B. Discovery of contralateral endobronchial nodule
C. Discovery of main carinal involvement
D. Discovery of infiltrating mucosal involvement within 2 centimeters of the main carina
E. Discovery of a lesion obstructing the central airways

Answer III.30 E

Bronchoscopy plays a major role in lung cancer staging. One of the reasons for performing an "inspection" bronchoscopy in all patients with diagnosed bronchogenic carcinoma is because discovery of occult vocal cord paralysis, an ipsilateral or contralateral endobronchial metastasis, or involvement of and near the main carina alters therapeutic management and prognosis.

Discovering a lesion that obstructs the central airways might prompt endoscopic resection in order to decrease chances for post obstructive pneumonia, improve symptoms such as dyspnea and cough, and increase ventilatory function and exercise tolerance.

Often, a lesion that appears to obstruct a main bronchus and require pneumonectomy is actually originating from within a lobar bronchus and extending into the main bronchus without main bronchial wall involvement. In these cases, lobectomy or sleeve resections are possible instead of pneumonectomy. In addition, clinical Tumor stage is affected since patients might no longer have a tumor "within two centimeters of the main carina".