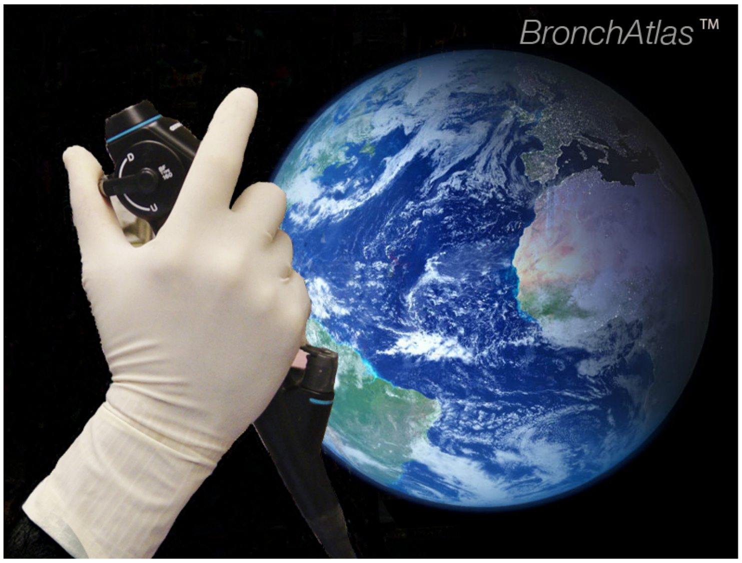
MODULE 1

BronchAtlas

Video Series



Henri Colt MD and Septimiu Murgu MD

THE BRONCHOSCOPY EDUCATION PROJECT

BronchAtlas Video Series:

Objectives:

- ✓ To provide a practical, concise overview of solutions to common problems.
- ✓ To provide short, easily accessible video-clips to enhance understanding.
- ✓ To provide easily accessible PDF files for viewing on PCs and mobile devices.

What is BronchAtlas?

The BronchAtlas™ Video Series is a collection of practice-oriented solutions to problems commonly encountered in bronchoscopy. Each lesson includes a lesson title, a one-sentence description of the problem, an overview of how and why this problem occurs, a bullet list of possible solutions, a video compiled from three different video sequences, and a short reference list. There are ten separate lessons in each BronchAtlas module. Lessons are in no particular order, and can be accessed individually or studied as part of this eBook.

Each video is compiled of three short (less than 1 minute) video sequences. These are accessed by clicking on the hyperlink inserted next to the video heading on the lesson page. All videos are hosted on the BronchOrg You Tube channel. Narrative voice-over is provided in many instances, and sequences easily recognized by their respective titles with the Bronchoscopy International logo.

Fundamentals of Bronchoscopy Lesson Series

BronchAtlas™ is part of the Fundamentals of Bronchoscopy© lesson series designed as part of the Bronchoscopy Education Project, which also includes a collection of training manuals and the Essential Bronchoscopist© series of books. BronchAtlas™ thus complements patient-centered practical approach exercises and didactic lectures that also make up the Fundamentals of Bronchoscopy lessons series. These lessons are used on-site during training seminars. Many lessons are also accessible online at www.Bronchoscopy.org. The Bronchoscopy Education Project is officially endorsed by numerous national and international professional societies.

BronchAtlas Video Series, Module 1

Authors Henri Colt MD and Septimiu Murgu MD

*Published by Bronchoscopy International, Laguna Beach, CA 92651

BronchAtlas™ Video Series[i]

BRONCHOSCOPY AND OBSTRUCTIVE SLEEP APNEA

Authors: Henri Colt MD, FCCP and Septimiu Murgu MD, FCCP

THE PROBLEM:

Patients with OSA undergoing flexible broncoscopy are at increased risk for procedure-related complications because:

- Redundant tissue prevents facile insertion of the bronchoscope[1] (Video sequence 1).
- Redundant tissue obstructs visualization of the glottis particularly in the supine positions.
- Upper airway collapsibility is worsened by analgesia and sedation. [2]
- Redundant tissue and increased airway collapsibility worsen the cough and gag reflexes.
- Reduced Functional Residual Capacity (FRC) in obese individuals is worsened by the supine position, sedation and analgesia.
- Risk for hypoxemia is increased due to reduction in FRC and subsequent ventilation-perfusion mismatch.
- Redundant pharyngeal tissue diminishes the effectiveness of anterior jaw thrust and chin lift maneuvers used to displace the mandible and the tongue forward to help visualize the larynx.
- Risks for hypoventilation are increased because of diminished expiratory flow secondary to breathing at low lung volumes in the presence of increased pleural pressure and early small airway closure. [4]

THE SOLUTIONS:

- Perform bronchoscopy in a semi-upright or upright position.
- Insert a large diameter nasal trumpet long enough to bypass redundant posterior pharyngeal tissues. [2]
- Administer either low dose sedation *or* analgesia because combination treatment has a synergistic adverse effect on respiratory drive.
- **Perform bronchoscopy on Continuous Positive Airway Pressure (CPAP)**

---

[i] Click on VIDEO hyperlink to view video (Videoclip includes sequences 1, 2 and 3)

- Connect a swivel adaptor to a resuscitation mask and secure it to the patient's face using elastic straps (Video sequence 2).
- Increase upper airway patency by counteracting negative inspiratory forces within the oropharynx.
- Compensate for abnormal hypotonicity of the upper airway muscles and splint redundant tissue. [3]
- The pneumatic splinting effect of CPAP facilitates passage of the flexible bronchoscope beyond otherwise collapsing oropharyngeal tissues[1, 3] (Video sequence 3).
- Reduce gag and cough reflexes by diminishing contact of the bronchoscope with pharyngeal tissues during insertion and advancement of the flexible bronchoscope.
- Potentially reduce the need for additional sedation and analgesia because cough and gag reflexes are lessened if the bronchoscope is passed easily to and beyond an open glottis.
- Diminish the risk for hypoventilation by improving expiratory flow through an increase in lung volumes and pneumatic splinting of airway structures in both the upper and lower airway.
- Prevent or improve hypoxemia because of PEEP effect.

The Video: http://www.youtube.com/watch?v=-MP-WdVcCxY

1. Redundant tissue obstructs visualization of the glottis. Note floppy epiglottis.
2. Swivel adaptor and resuscitation mask attached to patient's face using elastic straps.
3. Pneumatic splinting effect of CPAP facilitates visualization of the larynx and vocal cords.

References

1. Popper RA, Leidinger MJ, Williams AJ. Endoscopic observations of the pharyngeal airway during treatment of obstructive sleep apnea with nasal continuous positive airway pressure-A pneumatic splint. West J Med 1986 144:83-85.
2. Chhajed PN AC, Malouf MA, Hopkins PM, Plit M, Grunstein RR, Glanville AR. Management of acute hypoxemia during flexible bronchoscopy with insertion of a nasopharyngeal tube in lung transplant recipients. Chest 2002; 4:1350-1354.
3. Rothfleisch R DL, Kuebel DA, deBoisblanc BP. Facilitation of fiberoptic nasotracheal intubation in a morbidly obese patient by simultaneous use of nasal CPAP. Chest 1994; 106:287-288.
4. Behazin N, Jones SB, Cohen RI, Loring SH. Respiratory restriction and elevated pleural and esophageal pressures in morbid obesity. J Appl Physiol. 2010; 108: 212-8.

BronchAtlas™ Video Series[i]

Classification of laryngotracheal stenosis

Authors: Henri Colt MD, FCCP, Septimiu Murgu MD, FCCP

THE PROBLEM:

There is no universally accepted classification for laryngotracheal stenosis

- No classification system addresses all clinically relevant parameters
    - Myer-Cotton classification addresses the degree of airway narrowing: grade I (0-50%); grade II (51-70%); grade III (71-99%); grade IV (no detectable lumen) (1)
    - McCaffrey classification addresses location and length of the stenosis: stage I lesions are confined to the subglottis or trachea and < 1cm long; stage II lesions are isolated to the subglottis and > 1 cm long; Stage III lesions are subglottic/tracheal not involving the glottis; stage IV lesions involve only the glottis (2).
    - Lano classification addresses the number of locations involved including glottis, subglottis and trachea: stage I (one site); stage II (two sites); stage III (three sites) (3).
    - ADVS classification addresses effect of stenosis on airway, dyspnea, voice, and swallowing (4).
    - The "simple versus complex" classification addresses extent of airway narrowing and presence or absence of associated malacia at the level of the stricture: "simple" if vertical extent is 1 cm or less, if only one tracheal ring is involved and if no malacia is noted; "complex" if the extent is longer than 1 cm, two or more tracheal rings are involved and/or associated malacia is present.
- Laryngotracheal stenosis can affect speech, swallowing, breathing and functional status (4).
- Treatment strategies also depend on various parameters:
    - Strictures longer than 5 cm may be considered surgically unresectable.
    - Strictures involving the subglottis have higher risk of complications after endoscopic or open surgical interventions.
    - Strictures with associated malacia or structural airway wall deformities usually require surgery or stent insertion.

[i] Click on VIDEO hyperlink to view video (Videoclip includes sequences 1, 2 and 3)

- Strategy and planning of therapeutic procedures may be problematic because of miscommunications between interventional pulmonologists, laryngologists, tracheal surgeons, and anesthesiologists.

THE SOLUTIONS:

- Communication with other health care providers is enhanced by using at least one, if not multiple descriptors (classifications) in the bronchoscopy report (Video sequences 1 and 2).
- Qualitative assessment should address *morphology* (e.g. circumferential, triangular) *origin* (idiopathic or secondary to other disorders/processes such as Wegener's granulomatosis or post intubation), *associated findings* (airway wall deformities and mucosal abnormalities), and the *effects* of the stricture on voice and swallowing (4,5).
- Quantitative assessment should address: *functional impairment* (ADVS classification and/or a validated scale such as MRC dyspnea scale); *extent* (length, and precise location in regards to vocal cords and main carina using McCaffrey or Lano systems, for example); and *degree of narrowing* (using Myer-Cotton system or other classification systems, for example).
- Treatment strategies should be individualized using numerous parameters as well as impact of functional impairment on daily living activities and quality of life (Video sequence 3).

THE VIDEO: http://www.youtube.com/watch?v=3EJSIOTu9cc&feature=channel&list=UL

1. Four examples of complex laryngotracheal stenoses classified using the Myer-Cotton (MC), McCaffrey (M) and Lano (L) systems Examples are classified as MC4,M3,L2 and MC3,M3,L2, and MC2,M1,L1, and MC3,M1,L1.
2. Single example of laryngotracheal stenosis classified using the ADVS classification system.
3. Examples of two patients with laryngotracheal stenosis and similar degrees of narrowing but different impact of narrowing on functional status because patients have different degrees of physical activity causing different flow velocities through the strictures and differences in work of breathing.

References

1. Myer CM, O'Connor DM, Cotton RT. Proposed grading system for subglottic stenosis based on endotracheal tube sizes. *Ann Otol Rhinol Laryngol* 1994; 103: 319–23
2. McCaffrey TV. Classification of laryngotracheal stenosis. *Laryngoscope* 1992;102:1335–1340
3. Lano CF Jr, Duncavage JA, Reinisch L, et al. Laryngotracheal reconstruction in the adult: a ten year experience. Ann Otol Rhinol Laryngol. 1998; 107: 92-7.
4. Nouraei SA, Nouraei SM, Upile T, et al. A proposed system for documenting the functional outcome of adult laryngotracheal stenosis. *Clin Otolaryngol.* 2007;32:407-9.
5. Freitag L, Ernst A, Unger M, Kovitz K, Marguette CH. A proposed classification system of central airway stenosis. Eur Respir J 2007;30:7-12.

BronchAtlas™ Video Series[i]

Describing central airway obstruction

Authors: Henri Colt MD, FCCP, Septimiu Murgu MD, FCCP

THE PROBLEM:

There is no universally accepted nomenclature for describing central airway obstruction

- There is no uniform language for describing central airway obstruction.
- Lack of a universally accepted classification system may negatively impact scientific, multicenter studies of this syndrome.
- Miscommunications or misunderstandings between and among health care providers can adversely affect patient care.
- Strategy and planning of therapeutic procedures may be problematic because of miscommunications between interventional pulmonologists, surgeons, and anesthesiologists.
- Central airway obstruction is caused by a variety of mechanisms, each of which impacts therapeutic management decisions (1, 2).
    - Pure extrinsic (or extraluminal) compression: may warrant stent insertion.
    - Pure endo (or intra)luminal obstruction: may warrant bronchoscopic resection.
    - Mixed (combined): May warrant bronchoscopic resection and airway stent insertion.

THE SOLUTIONS:

- Using multiple descriptors in the bronchoscopy report might enhance communication with other health care providers.
- Classification systems allow stratification of patients according to symptoms, histopathology, and anatomic or radiographic findings (3).
- A common language facilitates comparisons within the same patient over time and between patients with similar central airway disorders.
- Qualitative assessment can include THREE elements:
    - Suspected/known malignant or benign histology (Video sequence 1)
    - Fixed or dynamic airway obstruction assessed at rest, during tidal breathing, forced inhalation/exhalation, or positional changes (Video sequence 2).

[i] Click on VIDEO hyperlink to view video (Videoclip includes sequences 1, 2 and 3)

- Intrinsic, extrinsic, or mixed obstruction (might also use endo or intraluminal, extrinsic or extraluminal, or mixed (Video sequence 3).

- Additional descriptors can address the extent, morphology, and severity of airway narrowing and the resultant functional impairment.

THE VIDEO: http://www.youtube.com/watch?v=BDhOdOizSRA&feature=plcp

1. Examples of malignant and benign causes of central airway obstruction.
2. Examples of fixed and dynamic central airway obstruction during tidal breathing and during functional/dynamic bronchoscopy with positional changes.
3. Examples of intrinsic, extrinsic, and mixed central airway obstruction.

References

1. Ernst A, Feller-Kopman D, Becker HD et al. Central airway obstruction. *Am J Respir Crit Care Med* 2004; 169: 1278–1297
2. Murgu SD, Colt HG. Interventional bronchoscopy from bench to bedside: new techniques for central and peripheral airway obstruction. *Clin Chest Med*. 2010; 31:101-15
3. Classifications. *The WHO Family of International Classifications* available at: http://www.who.int/classifications/en; accessed on 6/10/12

BronchAtlas™ Video Series[i]

EBUS AND NONDIAGNOSTIC TBNA

Authors: Henri Colt MD, FCCP and Septimiu Murgu MD, FCCP

THE PROBLEM:

Diagnostic material is not obtained despite convex probe endobronchial ultrasound-guided transbronchial needle aspiration because:

- The aspirate is bloody: some lymph nodes are hyper-vascularized (i.e. metastatic renal cell cancer).
- The aspirate is bloody: intranodal blood vessels, even when visualized on ultrasound examination, can be inadvertently punctured during needle aspiration. Doppler is useful for identification (Video sequence 1).
- The aspirate contains only scant lymphocytes and /or benign bronchial cells[1].
- The aspirate is necrotic[2]: hypoechoic, Doppler negative areas of intranodal necrosis can be inadvertently or intentionally sampled during needle aspiration (Video sequence 2).
- No aspirate is possible: the firm, rubbery lymph node capsule prevents the needle from entering the node.
- Only one or two aspirates are obtained from the target lymph node.
- The aspirate is not examined using rapid on-site cytology.
- The aspirate is not sent for immunohistochemistry or tumor markers.

THE SOLUTIONS:

- Avoid excessive negative pressure (suctioning) during TBNA and limit needle transit time inside the node, especially when nodes are Doppler positive.
- Avoid intranodal vessels while moving the needle into, within, and out of the lymph node.
- Bronchial cells may be pushed into the lymph node itself by the stylet or needle, and then inadvertently aspirated. This can occasionally be documented by endobronchial ultrasound[3].

---

[i] Click on VIDEO hyperlink to view video (Videoclip includes sequences 1, 2 and 3)

- Avoid sampling necrotic lymph nodes (if possible) when EBUS-guided TBNA is performed for diagnostic purposes only. If nodal staging is indicated, all identified nodes should be sampled according to established algorithms.
- If the needle does not enter the lymph node, or the node is pushed away from the needle, a forceful sustained jab movement may cause the needle to penetrate through the firm capsule. Another alternative is to remove the needle and access the node at a different angle (Video sequence 3).
- Malignant lymph nodes may have areas of central necrosis, which, if sampled, may show no evidence of malignancy in the aspiration specimen. Additional aspirates obtained from a more peripheral, non-necrotic area of the lymph node can increase diagnostic yield[4].
- At least three aspirates per target lymph node should be obtained for diagnostic purposes. A greater number is warranted if immunohistochemistry or tumor markers are requested[5].
- Rapid on-site examination by an experienced cytopathologist is recommended, especially if immunohistochemistry or tumor markers are requested (for known or suspected non-small, non-squamous cell lung cancer).

THE VIDEO: http://www.youtube.com/watch?v=Mi3m3LHmjj0

1. Intranodal blood vessels are identified.
2. Intranodal, Doppler negative, hypoechoic necrotic areas are identified.
3. Needle can be repositioned in case of difficulty penetrating the firm nodal capsule.

References

1. Fujiwara T, Yasufuku K, Nakajima T et al. The utility of sonographic features during endobronchial ultrasound-guided transbronchial needle aspiration for lymph node staging in patients with lung cancer: a standard endobronchial ultrasound image classification system. Chest 2010;138:641-7.
2. Alsharif M, Andrade RS, Groth SS, Stelow EB, Pambuccian SE. Endobronchial ultrasound-guided transbronchial fine-needle aspiration: the University of Minnesota experience, with emphasis on usefulness, adequacy assessment, and diagnostic difficulties. Am J Clin Pathol 2008; 130:434-43.
3. EBUS Curiosities. Instructional video, Murgu S and Colt HG. YouTube video accessed November 9, 2011. http://www.youtube.com/watch?v=UlfwoZoxx4g.
4. Kurimoto N, Osada H, Miyazawa T, et al. Targeting Area in Metastatic Lymph Nodes in Lung Cancer for Endobronchial Ultrasonography-guided Transbronchial Needle Aspiration. Journal of Bronchology & Interventional Pulmonology 2008; 15:134-138.
5. Lee HS, Lee GK, Lee HS, et al. Real-time endobronchial ultrasound-guided transbronchial needle aspiration in mediastinal staging of non-small cell lung cancer: how many aspirations per target lymph node station? Chest 2008 ;134:368-74.

BronchAtlas™ Video Series[i]

EBUS: Distinguishing lymph node station 10R from 4R

Authors: Septimiu Murgu MD, FCCP, Henri Colt MD, FCCP

THE PROBLEM:

Identifying right lymph node station 10 R can be difficult:

- According to the IASLC lymph node map, the bronchial segment limited by the proximal and distal margins of station 10R is very short (1) (Video sequence 1).
- Bronchoscopically, this segment extends for a maximum of 2 centimeters, and can thus be easily overlooked during an endobronchial ultrasound (EBUS) examination.
- Station 10R lymph nodes are anatomically located very close to station 4R lymph nodes, especially when 4R nodes are lateral to the right border of the trachea.
- Distinguishing between 10 R and 4R nodal involvement is essential for accurate staging and subsequent treatment of patients with ipsilateral lung cancer. In the absence of other nodal involvement, malignant 10R is classified as an N1 nodal disease whereas malignant 4R nodes are classified as N2 disease.

THE SOLUTIONS:

- Proceed with systematic EBUS exploration of the mediastinum starting with N3 nodes, followed by N2 nodes and then N1 nodes (1).
- To visualize 10R, the EBUS scope can usually be advanced from the carina into the right main bronchus. The transducer is oriented antero-laterally towards the 2-o'clock position (2).
- Station 10R nodes are often located more cephalad, so the scope can be pulled back from the distal right main bronchus while scanning laterally and identifying the azygos vein (Video sequence 2).
- Recognize and understand regional limits defining stations 10R and 4R based on the IASLC lymph node map and nodal classification system (3).
- Station 10 R lies below the inferior border of the azygos vein, whereas station 4R is above the inferior border of the azygos vein (Video sequence 3).

[i] Click on VIDEO hyperlink to view video (Video-clip includes sequences 1, 2 and 3)

THE VIDEO: http://www.youtube.com/watch?v=yBBy-Qpwfv4

1. Annotated drawings of stations 10R and relationship of station 10R to station 4R.
2. Performance of EBUS within the right main bronchus to locate station 10 R in its usual location at approximately the 2’o’clock position anterolaterally.
3. According to the IASLC lymph node map and using EBUS imaging, station 10R is located below the inferior border of the azygos vein, whereas station 4R is above the inferior border of the azygos vein.

References

1. Herth FJ, Ernst A, Eberhardt R, Vilmann P, Dienemann H, Krasnik M. Endobronchial ultrasound-guided transbronchial needle aspiration of lymph nodes in the radiologically normal mediastinum. Eur Respir J. 2006;28(5):910-4
2. Herth FJF, Krasnik M, Yasufuku K, et al. Endobronchial Ultrasound-guided Transbronchial Needle Aspiration. Journal of Bronchology & Interventional Pulmonology 2006; 13 (2) :84-91
3. Rusch VW, Asamura H, Watanabe H, Giroux DJ, Rami-Porta R, Goldstraw P; Members of IASLC Staging Committee. The IASLC lung cancer staging project: a proposal for a new international lymph node map in the forthcoming seventh edition of the TNM classification for lung cancer. J Thorac Oncol. 2009;4(5):568-77

BronchAtlas™ Video Series[i]

EBUS: Identification of lymph node station 4R

Authors: Septimiu Murgu MD, FCCP, Henri Colt MD, FCCP

THE PROBLEM:

Identification and examination of station 4R is confusing because of territorial boundaries, adjacent mediastinal structures, location of 4R lymph nodes, and scanning plane orientation:

- Station 4R is the second most commonly sampled lymph node station for diagnosis and staging of lung cancer (subcarinal node station 7 is the most common) (1).
- Station 4R includes right lower paratracheal nodes and pretracheal nodes extending to the left lateral border of trachea (2).
- Because the lymphatic drainage in the superior mediastinum predominantly occurs to the right paratracheal area and extends past the midline of the trachea, the boundary between the right- and left-sided lymph node stations 2 and 4 is now the left lateral wall of the trachea according to current IASLC lymph node map and nodal classification system (2) (Video sequence 1).

THE SOLUTIONS:

- Identify station 4R lymph nodes on axial, sagittal and/or coronal CT images.
- Chest computed tomography images can be oriented so reference points are identical to those shown on EBUS display (3).
- The anterior, antero-lateral, and lateral locations of lymph nodes located in station 4R are identified by up to three different sonographic patterns.
- When the EBUS transducer is oriented laterally, 4R lymph nodes are seen above the azygous vein, whereas when the EBUS transducer is oriented antero-laterally, 4R lymph nodes are seen in front of the superior vena cava (SVC) (Video sequence 2).
- As the EBUS transducer is oriented anteriorly the scanning plane becomes the same as that of the sagittal plane of chest computed tomography (Video sequence 3).

THE VIDEO: http://www.youtube.com/watch?v=ymRmhBdkbZY&feature=g-upl

---

[i] Click on VIDEO hyperlink to view video (Videoclip includes sequences 1, 2 and 3)

1. Lymph node station 4R (Right paratracheal) boundaries.
2. Two distinct EBUS patterns help identify lymph nodes located in the lateral and antero-lateral portions of station 4R.
3. A third scanning plane (and EBUS pattern) is defined as the transducer is oriented anteriorly during EBUS examination of nodal station 4R.

References

1. Herth FJ, Eberhardt R, Vilmann P, Krasnik M, Ernst A. Real-time endobronchial ultrasound guided transbronchial needle aspiration for sampling mediastinal lymph nodes. Thorax. 2006 Sep;61(9):795-8.
2. Rusch VW, Asamura H, Watanabe H, Giroux DJ, Rami-Porta R, Goldstraw P; Members of IASLC Staging Committee. The IASLC lung cancer staging project: a proposal for a new international lymph node map in the forthcoming seventh edition of the TNM classification for lung cancer. J Thorac Oncol. 2009 May;4(5):568-77.
3. Chapter IV.16. EBUS-TBNA of right lower paratracheal lymph node (station 4R). In Colt HG, Murgu SD. Textbook on Bronchoscopy and Central Airway Disorders; A patient-centered approach. Expert commentary by *Ibrahim Ramzy, MD*; Elsevier 2012.

BronchAtlas™ Video Series[i]

Extent of tracheal stenosis

Authors: Henri Colt MD, FCCP, Septimiu Murgu MD, FCCP

THE PROBLEM:

Determining the vertical extent of tracheal stricture can be difficult:

- Knowing the exact length and location of the stricture impacts therapeutic management decision-making (1), but a subjective estimate of length may be inaccurate.
    - The length of the stenotic segment varies with respiration (the airway shrinks during expiration and lengthens during inspiration).
    - Local inflammation may prevent accurate determinations of proximal and distal margins of the stricture.
    - Dyspnea and cough hinder bronchoscopic measurements (Video sequence 1).

THE SOLUTIONS:

- Measure the vertical extent of the stricture during suspended respiration, ideally at the end of a tidal expiration, at functional residual capacity.
- Chest computed tomography with 3D reconstruction may be necessary if bronchoscopic measurements are difficult (2).
- Determine the presence or absence of inflammation and edema according to color, appearance and feel of airway mucosa.
- Determine the impact of the stricture on vocal cord mobility (Video sequence 2).
- Use one or more accepted classification systems (3, 4).
- Measure the lengths of the involved and normal airway (Video sequence 3).
    - Measure the distance from the vocal cords to the proximal margin of the stenosis.
    - Measure the distance from the carina to the distal margin of the stenosis.
    - Measure the length of the stenosis.
    - Measure the total length of the trachea from the vocal cords to the carina, and confirm with the sum of the three previous measurements

[i] Click on VIDEO hyperlink to view video (Videoclip includes sequences 1, 2 and 3)

THE VIDEO: http://www.youtube.com/watch?v=QzCrlLzroZI&feature=channel&list=UL

1. Cough may hinder precise bronchoscopic measurements.
2. Examples of vocal cord mobility in cases of subglottic stenosis (normal phonation, normal tidal breathing, normal laryngeal function during respiration and deglutition, unilateral vocal cord paralysis, bilateral vocal cord closure and abnormal function, laryngeal obstruction by granulation tissue and swelling.
3. Example of a bronchoscopic technique for measuring the length of a tracheal stricture and its distance from the vocal cords and main carina.

References

1. Patelli M, Gasparini S. Post-intubation tracheal stenoses: what is the curative yield of the interventional pulmonology procedures? *Monaldi Arch Chest Dis.* 2007;67:71-2.
2. Shitrit D, Valdsislav P, Grubstein A, et al. Accuracy of virtual bronchoscopy for grading tracheobronchial stenosis: correlation with pulmonary function test and fiberoptic bronchoscopy. *Chest* 2005; 128:3545-3550.
3. McCaffrey TV. Classification of laryngotracheal stenosis. *Laryngoscope* 1992; 102: 1335-1340.
4. Lano CF Jr, Duncavage JA, Reinisch L, et al. Laryngotracheal reconstruction in the adult: a ten year experience. Ann Otol Rhinol Laryngol. 1998; 107: 92-7.

BronchAtlas™ Video Series[i]

Morphology of tracheal stenosis

Authors: Henri Colt MD, FCCP, Septimiu Murgu MD, FCCP

THE PROBLEM:

Many different morphology (aka shape) descriptors are used for tracheal strictures:

- There is no uniform language for describing the shape of airway strictures
  - For example, the stomal post tracheostomy stricture is often described as “triangular”, “lambdoid”, “pseudoglottic” or “A-shaped” (1, 2).
- The lack of a precise and consistent language may adversely affect communication with interventional pulmonologists, surgeons, and anesthesiologists making strategy and planning of therapeutic procedures more problematic.
- Tracheal stenosis is caused by a variety of processes with some resulting in a characteristic morphology (e.g. triangular shape for stomal post-tracheostomy).
- The presence of malacia at the level of the stricture impacts management by predicting lack of sustained response to simple bronchoscopic dilation (3).
- Morphology of the stricture, independent of extent and severity of airway narrowing, may affect flow dynamics and symptoms (4).

THE SOLUTIONS:

- Use consistent terminology in the bronchoscopy procedure note.
- Describe the stricture’s morphology: circumferential, concentric, web-like, triangular, elliptical or A-shaped for example (Video sequence 1).
- Describe associated findings: edema, hyperemia, mucus, granulation tissue (Video sequence 2).
- Describe the presence or absence of malacia and its resulting effect of airway narrowing (Video sequence 3).
- Describe changes in morphology that occur during various phases of respiration.
- Describe changes in morphology that occur with neck movements (flexion-extension).
- Describe precise location of hypertrophic fibrotic tissues.

---

[i] Click on VIDEO hyperlink to view video (Videoclip includes sequences 1, 2 and 3)

THE VIDEO: http://www.youtube.com/watch?v=N8wEnjJ1HV0&feature=channel&list=UL

1. Examples of circumferential, concentric, elliptical or web-like strictures, compared to triangular or A-shaped laryngotracheal strictures with associated cartilaginous deformities.
2. Examples of strictures with associated findings such as infection, inflammation, residual scar tissue, granulation tissue and malacia.
3. Examples of strictures with multilevel chronic hypertrophic tissues, hyperemia and acute inflammation, and focal malacia and granulation tissues.

References

1. Freitag L, Ernst A, Unger M, et al. A proposed classification system of central airway stenosis. *Eur Respir J* 2007;30:7-12.
2. Murgu SD, Colt HG. Chapter II 9. Bronchoscopic treatment of post tracheostomy tracheal stenosis with chondritis. Expert commentary by Lutz Freitag. *In Bronchoscopy and Central Airway Disorders*; Elsevier, 2012.
3. Cavaliere S, Bezzi M, Toninelli C, et al. Management of post-intubation tracheal stenoses using the endoscopic approach. *Monaldi Arch Chest Dis* 2007; 67: 2: 73-80.
4. Brouns M, Jayaraju ST, Lacor C, et al. Tracheal stenosis: a flow dynamics study. *J Appl Physiol* 2007;102:1178-84.

BronchAtlas™ Video Series[i]

Severity of tracheal stenosis

Authors: Henri Colt MD, FCCP, Septimiu Murgu MD, FCCP[ii]

THE PROBLEM:

Determining the severity of airway narrowing of a tracheal stricture is difficult and confusing:

- Methods for estimating degree of airway narrowing are often subjective (1)
- Correlations between bronchoscopic or radiologic measurements and physiologic impact are unclear.
- Airway lumen size can vary with tidal and forced breathing.
- Trauma, local inflammation, and secretions can alter airway lumen diameter.
- Accurate measurements of the degree of airway narrowing in a dyspneic patient can be difficult and risky.

THE SOLUTIONS:

- Inspect the tracheal lumen during inspiration and expiration, as well as in the supine and semi-erect position (Video sequence 1).
- Determine whether the airway abnormality is purely intrinsic, extrinsic, or combined (CT scan may help clarify mechanism of obstruction in equivocal cases) (2).
- Determine the presence or absence of inflammation and edema depending on color, appearance, and feel of airway mucosa (Video sequence 2).
- Use an accepted classification system (e.g. Myer-Cotton) to further describe the stricture (3).
- Use the flexible bronchoscope to estimate the diameter of the tracheal stenosis.
- Use a biopsy forceps (of a known opening) to help measure the diameter of the stricture .
- Use a morphometric bronchoscopic technique (using image analysis software) to determine the degree of airway narrowing as compared with the normal lumen (1) (Video sequence 3).

THE VIDEO: http://www.youtube.com/watch?v=Nl7g1X-ftQc&feature=channel&list=UL

---

[i] Click on VIDEO hyperlink to view video (Videoclip includes sequences 1, 2 and 3)
[ii] The authors thank Navneet Singh for his contributions and digital media.

1. Examples of strictures during tidal breathing and forced inspiration and expiration.
2. Examples of strictures with mucus and edema, inflammatory changes, and ball valve effect.
3. Example of morphometric bronchoscopy using image analysis software.

References

1. Murgu S, Colt HG. Morphometric bronchoscopy in adults with central airway obstruction: case illustrations and review of the literature. *Laryngoscope* 2009;119:1318-24.

2. Murgu SD, Colt HG. Interventional bronchoscopy from bench to bedside: new techniques for central and peripheral airway obstruction. *Clin Chest Med*. 2010; 31:101-15.

3. Myer CM, O'Connor DM, Cotton RT. Proposed grading system for subglottic stenosis based on endotracheal tube sizes. *Ann Otol Rhinol Laryngol* 1994; 103: 319–23.

BronchAtlas™ Video Series[i]

SMEAR PREPARATION AFTER BRONCHOSCOPIC NEEDLE ASPIRATION

Authors: Henri Colt MD, FCCP, Septimiu Murgu MD, FCCP[ii]

THE PROBLEM:

Specimen smears of aspirates from conventional or EBUS-guided needle aspiration procedures are often unsatisfactory because:

- Specimens are acellular.
- Specimens (also known as the aspirate or harvest) can be lost when expulsed from the needle.
- Specimens containing blood may coagulate if smears are not performed quickly after aspiration.
- Poor technique such as incorrect tilting of the slides or exerting insufficient pressure on the slides while smearing results in scrape artifact, thick smears, overlapping cells, or irregular distribution of aspirate on slides [1].
- Crush artifact, thick smears, scrape artifact, and overlapping cells also result when part of the specimen is coagulated, when too much pressure is applied to the smear, or when aspirate contains tissue fragments (Video sequence 1).

THE SOLUTIONS:

- More than one aspirate is usually obtained from each target area.
- Safeguard against specimen loss by using a second slide as a shield while expulsing the aspirated material from the needle.
- Expulse material from the needle onto more than one slide if necessary. A new, air-filled syringe may be used for a final forceful expulsion of material that might have been left behind in the needle.
- Coagulum or tissue fragments can also be expulsed from the needle using the needle's stylet.
- Smearing should be performed immediately after needle aspiration to avoid clot formation.
- An expulsed specimen showing tissue fragments should be smeared first because it is most likely to reveal diagnostic material.
- In case semisolid or solid tissue is seen in the aspirate, it can be removed and placed into formalin for histopathology. A smear can be prepared from the remainder of the specimen.

---

[i] Click on VIDEO hyperlink to view video (Videoclip includes sequences 1, 2 and 3)
[ii] The authors thank Drs. Bin Hwangbo, Giuseppe Marciano, and Michele Sediari for contributing digital media.

- Proper technique during slide preparation requires keeping slides parallel while gently pushing the slides against each other so that equal and homogeneous distribution of aspirate is dispersed on the surface of each slide[1] (Video sequence 2).
    - First the specimen is expulsed from the needle onto a smooth slide.
    - Second, a frosted slide is gently placed onto the slide with the sample.
    - Third, slight pressure is applied to gently disperse the specimen between the slides.
    - Fourth, the slides are moved gently against each other in a single motion.
    - Fifth, the two slides are separated. The ideal specimen is evenly and thinly distributed on both slide surfaces.
- In case semisolid material is obtained, two twin samples can be created by pressing the material between two slides, and subsequently making a smear of each of the slides.
- Coagulated material or aspirate containing tissue fragments can be smeared by depositing the material first at one extremity of a smooth slide, before smearing it by stretching the specimen using another slide placed at a forty-five degree angle.
- Processing depends on staining procedures and diagnostic tests being requested: slides can be air dried or placed into fixative[2].
- Collaboration with the cytopathology laboratory is essential because cytopathologists can provide immediate specimen evaluation for adequacy[3] as well as a preliminary diagnosis.
- Smearing techniques can be practiced using lotion (Video sequence 3).

THE VIDEO:
http://www.youtube.com/watch?v=LVYGgaQM6LE&list=PLE3CD565A25CE6451&index=3&feature=plpp_video

1. Smear artifacts, needle-related artifacts, faulty technique, and overlapping cells make cytology interpretation difficult.
2. Specimen is collected on the slide. Coagulated or semisolid material can be placed into solution. Slides are kept parallel to assure equal and homogeneous distribution of aspirate material.
3. Smearing techniques practiced using lotion.

References

1. Optimal FNA techniques. Basic smearing technique. http://www.papsociety.org/Basic%20Smearing%20Technique/index.html accessed 11/12/11
2. Bulman W, Saqi A, Powell CA. Acquisition and Processing of Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration Specimens in the Era of Targeted Lung Cancer Chemotherapy. Am J Respir Crit Care Med. 2011 Oct 27. [Epub ahead of print]
3. da Cunha Santos G, Boerner SL, Geddie WR. Maximizing the yield of lymph node cytology: Lessons learned from rapid onsite evaluation of image- and endoscopic-guided biopsies of hilar and mediastinal lymph nodes. Cancer Cytopathol. 2011 Jun 29. [Epub ahead of print].

BronchAtlas™ Video Series is a collection of practice-oriented solutions to problems commonly encountered in bronchoscopy. Lessons include a description of the problem, a bullet list of possible solutions, hyperlinks to an easily accessible short video compiled of three video sequences addressing different elements of the problem and its solutions, as well as a handful of key references. Each module contains ten lessons that can be used to complement other elements of the Fundamentals of Bronchoscopy lesson series, part of the The Bronchoscopy Education Project officially endorsed by numerous national and international professional societies.

The goal of **The Bronchoscopy Education Project** is to encourage uniformity and standardization of bronchoscopic practice so that patients need not suffer the burden of procedure-related medical training*. Based on a philosophy of mastery learning, competency is the minimum threshold accepted for practice.

The Bronchoscopy Education Project Series is designed to assist bronchoscopists, regardless of their specialty, become better practitioners and to thus help patients around the world. Educational resources include:

- A Series of training manuals, checklists and validated assessment tools
- The Essential Bronchoscopist series of books
- Faculty Development Program seminars and training materials
- Fundamentals of Bronchoscopy lesson series
    - BronchAtlas Video Series
    - Patient-Centered practical approach exercises
    - Didactic Lectures and slide presentations

*Bronchoscopy International Foundation for the Advancement of Medicine; a 501-C3 Non Profit Foundation Registry # 33-0593357

BRONCHOSCOPY INTERNATIONAL™

THE BRONCHOSCOPY EDUCATION PROJECT

Visit our website at www.Bronchoscopy.org