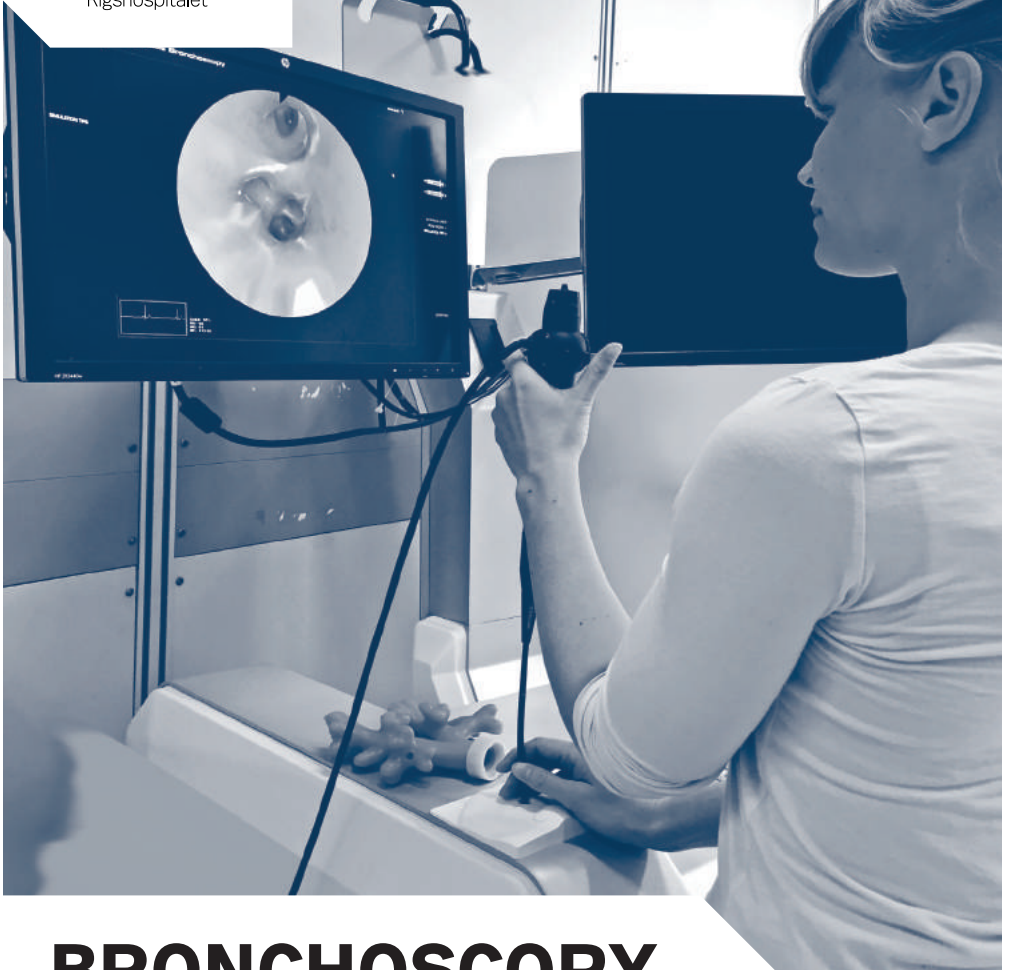




Simulationscenter
Rigshospitalet



BRONCHOSCOPY

A Practical Handbook

Paul Frost Clementsen
Leizl Joy Nayahangan
Lars Konge

Bronchoscopy

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Paul Frost Clementsen, Leizl Joy Nayahangan and Lars Konge

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PREFACE

This booklet contains a short review of the most basic theoretical knowledge that as a minimum must be known in order to learn flexible bronchoscopy at the Simulation Center at Copenhagen Academy for Medical Education and Simulation, Denmark. It can also be used by physicians in connection with clinical training.

The educational program consists of

1. Theory. This booklet as a minimum. It is recommended to supplement with reading in anatomical textbooks and other literature.
2. Introduction to the simulator. Training starts with an introduction to the procedure and the various training modalities that are available. The introduction lasts for approximately one hour and is conducted by a specialist in pulmonary medicine.
3. Training. Self-training includes training on the different simulators and phantoms. It is facilitated and supervised by medical students or nurses who know the simulators and the equipment.
4. Test. A validated test is conducted at the end of training. The test is facilitated by a specialist in pulmonary medicine and takes about an hour. A certificate is given upon passing of the test.

When these four steps are successfully passed the participant is ready for introduction and training in the clinical setting.

Copenhagen 2016

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Leizl Joy Nayahangan
Lars Konge

1. INTRODUCTION

In patients with lung infiltrates, the clinical task is to confirm or invalidate the suspicion of lung cancer and to determine the TNM – classification if lung cancer is demonstrated.

The diagnostic approach can be divided into two phases:

1. **Imaging techniques:** Computed tomographic evaluation (CT scanning) and positron emission tomographic (PET) scanning and in some cases Magnetic Resonance Imaging (MR) and ultrasound examination (UL).
2. **Invasive techniques for obtaining a tissue diagnosis:** Bronchoscopy, transthoracic needle aspiration lung biopsy, pleuracentesis, thoracoscopy, endoscopic ultrasound via the trachea or the esophagus (EBUS and EUS respectively) and other techniques for example mediastinoscopy, video-assisted thoracic surgery and thoracotomy.

2. BRONCHOSCOPY

The purpose of flexible bronchoscopy is to examine the central airways of patients suspected of lung cancer or other pulmonary diseases. Diagnostic sensitivity of bronchoscopy increases when the tumor is more centrally located (> 90%) and decreases when the tumor is located more peripherally in the airways (10-30%).

Indications

Diagnostic bronchoscopy: The indications include diffuse or localized lung infiltrates, recurrent and/or unresolved pneumonia, bronchiectasis, hemoptysis, persistent cough and other symptoms of endobronchial obstruction and other conditions.

Therapeutic bronchoscopy: The indications include airway obstruction due to secretions, with accompanying atelectasis, removal of foreign bodies or endobronchial tumor tissue, insertion of stent, laser removal of tumor, drainage of lung abscess and other conditions.

Proper assessment of both the indication and contraindication is important before planning bronchoscopy. In some cases, the contraindications may overrule the indication. In other cases, another invasive procedure may be more appropriate. For example, endoscopic ultrasound with biopsy via the esophagus (EUS-FNA) or via the trachea (EBUS-TBNA) should be considered if the patient presents with an abnormal mediastinum.

Contraindications

Flexible bronchoscopy is a well-tolerated procedure that can be performed safely on an outpatient basis. Contraindications include severe cardiac decompensation, unstable angina, cardiac arrhythmias, recent myocardial infarction, dysregulated diabetes, unstable

bronchial asthma, severe impairment of lung function, hypoxemia and severe untreated hypertension. Transbronchial biopsy (TBB) should not be performed in patients on mechanical ventilation because of the risk of pneumothorax.

As in all patients undergoing invasive procedures, careful attention to antithrombotic therapy that may increase the risk of bleeding must be kept in mind, for example in patients with mechanical heart valves, atrial fibrillation or deep vein thrombosis (1).

Medication and monitoring

In most patients, bronchoscopy is performed using intravenously administered midazolam supplemented with lidocaine as a local anesthetic in the bronchial tree. General anesthesia may be necessary in selected cases. Sedation degree, breathing, heart rate and oxygen saturation is monitored during the procedure (2).

Complications

Adverse events related to the bronchoscopy are rare and the lethality is < 0.01%. The common adverse events are pneumonia, bleeding, heart arrhythmias and pneumothorax.

Treatment of intra-bronchial bleeding

1. Tranexamic acid 500-1000 mg intravenously.
2. The patient is placed in a lateral position with the bleeding lung in a dependent position.
3. Noradrenaline 0.5 mg placed through the bronchoscope at the bleeding site.
4. Tamponade with the bronchoscope – keep it in the bleeding segment.

5. Balloon catheter (demonstrated during the simulation-based education)
6. In the case of persistent heavy bleeding despite above, call the cardiac arrest team.

3. THE PATIENT

No procedure must be started before you have made sure it is the right patient, the indication and eventual contraindications are secured and you and your staff know how to handle complications. Be sure that you know how to treat bleeding and ensure that a pleural drainage system is in the room ready for use.

4. THE BRONCHOSCOPE

Bronchoscopes can be flexible or rigid. This booklet and the simulation-based education focuses only on flexible bronchoscopes, as shown in figure 4.1.



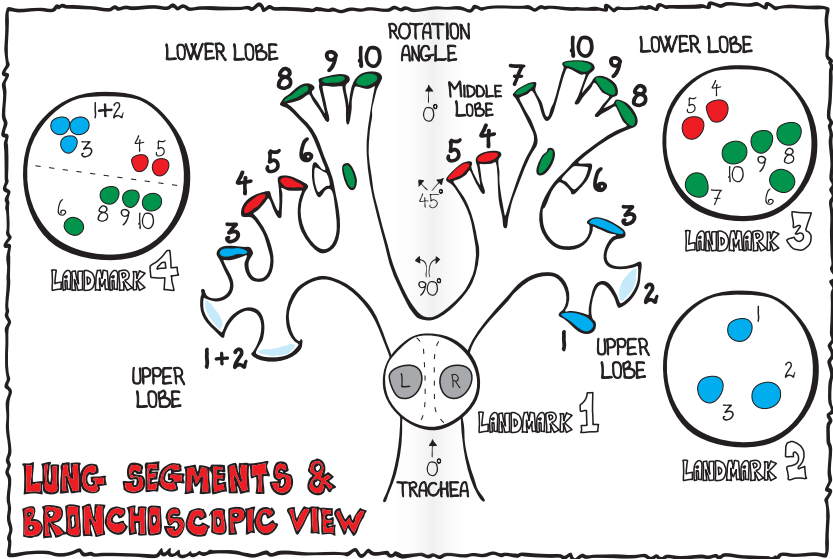
Figure 4.1: Example of a flexible diagnostic bronchoscope

5. HOW TO HANDLE THE BRONCHOSCOPE

- The handle of the bronchoscope is designed for the left hand. The left hand holds the endoscope and steers the way into the bronchial tree.
- The distal part of the bronchoscope should be held using the right hand. The right hand stabilizes the endoscope and handles syringes and biopsy equipment.
- Before introducing the bronchoscope into the phantom, you should practice how to control your left wrist and hand (on the handle), your left thumb (on the steering lever) and your left forefinger (on the suction button). Carefully observe what happens to the distal part of the bronchoscope when you move your wrist and fingers.
- The thumb moves the lever up and down to flex and to extend the distal end of the endoscope. The tip can be moved 180 degrees upwards and 90 degrees backwards. This difference is important to notice before you introduce the endoscope.
- By twisting the wrist, you turn the tip from the neutral position which is 0 degree angle to 90 – 45 – 0 degree angles to find the four landmarks.
- Thereafter, feel free to move the tip in the necessary angles to inspect the segments and sub-segments.
- Move your hands, not your body (3). Do not dance around the patient.

- Insert the endoscope through the nose or the mouth and into the larynx, where you find the epiglottis and the vocal cords. Give topical Lidocaine.
- When you have passed the vocal cords, the bronchoscope should be slightly flexed downwards.
- Then gently move on to the trachea. Topical lidocaine should also be given in the trachea and then the right and the left main bronchus.
- Keep the bronchoscope in the middle of the airway lumen.

6. PATTERN RECOGNITION



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Figure 6.1

Seek out the four landmarks systematically in the order mentioned and notice the correct angle of the endoscope in each position.

1. Landmark one: The right and the left main bronchus as seen from the trachea.

The bronchoscope is located in the distal part of the trachea in a 0 degree angle, meaning that the suction button is pointing directly forward (the suction button serves as a pointer during the procedure).

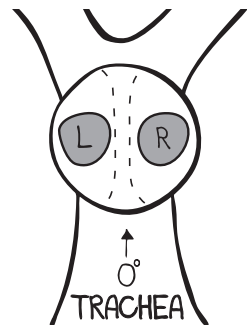


Figure 6.2

2. **Landmark two: Right segment 1, 2 and 3.** You move on to the right upper lobe bronchus by turning the endoscope 90 degrees to the right while at the same time tilting the distal end of the bronchoscope upwards by pushing your left thumb down. This landmark resembles a Mercedes Star.

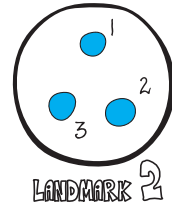


Figure 6.3

3. **Landmark three: Right segment 4, 5 (middle lobe) plus 6, 7, 8, 9 and 10 (lower lobe).** You move on to the bronchus intermedius, where you place the distal end of the endoscope in a 45 degree angle. Now you see segment 4 and 5 (numbers from the lateral side at an oblique angle), segment 6 (just opposite the middle lobe (easy to forget!)), segment 7 (located medially), and in the bottom, segments 8, 9 and 10 (numbers from the lateral side at an oblique angle). When moving to the last mentioned three segments, the angle should again be 0 degrees. This ensures correct identification of the segments from the correct side. This Landmark is called the “Good night window”.

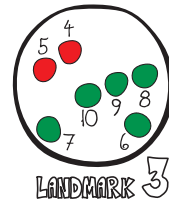


Figure 6.4

4. **Landmark four: Left segments 1+2, 3, 4, 5 (upper lobe) plus segments 8, 9, 10 (lower lobe).** You move the bronchoscope to the left main bronchus, where upwards, you see the upper lobe and downwards, the lower lobe. Please notice that segment 6 is located just opposite to segments 4 and 5 (lingula). Segments 4 and 5 plus 8, 9 and 10 is numbered from the lateral side at an oblique angle. There is no segment 7 on the left side. Turn the distal part of the endoscope to 90 – 45 – 0 degrees while you proceed chronologically.

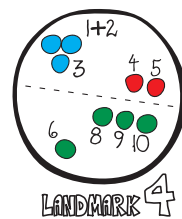
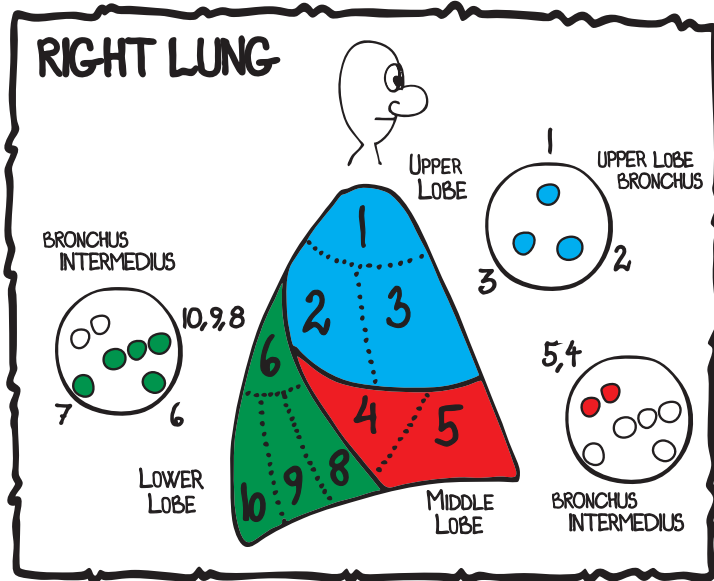
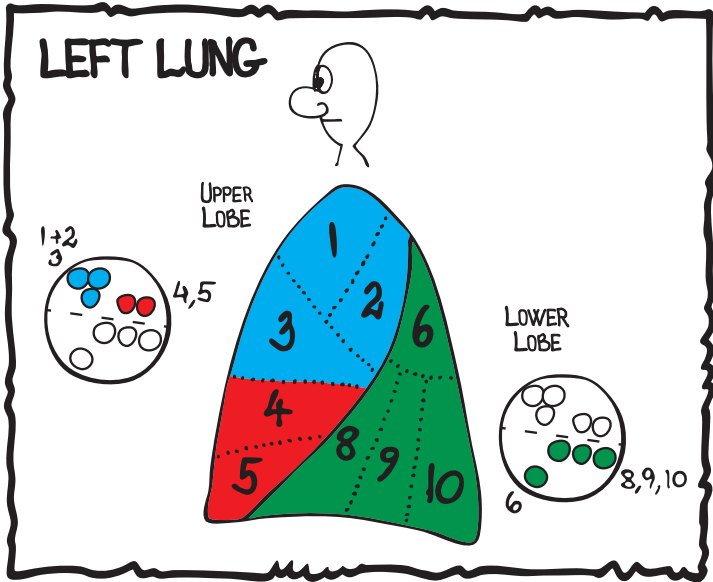


Figure 6.5

7. TIPS AND TRICKS

- As a routine, start at the right side. However, if you expect to find a tumor on the right side, then start at the left side.
- Use the systematic approach as described and use it for every procedure.
- Turn the distal end of the endoscope 90 – 45 – 0 degrees first to the right and then to the left side of the bronchial tree.
- Search for the four landmarks in the order mentioned with the endoscope in the correct angles.
- Thereafter, search for and inspect the segments chronologically with the endoscope in the necessary angles.
- Thereafter, search for and inspect the sub-segments with the endoscope in the necessary angles.
- Notice that each segment in the bronchial tree corresponds to a specific location in the lung (see figure 7.1).



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Figure 7.1

8. BRONCHOSCOPIC T-CLASSIFICATION

If a tumor is demonstrated in the bronchial tree, the T-classification as seen with the endoscope should be noted by measuring the distance of the tumor to the carina. Documentation with a photo should be made. This T-classification is not necessarily consistent with the image-based classification.

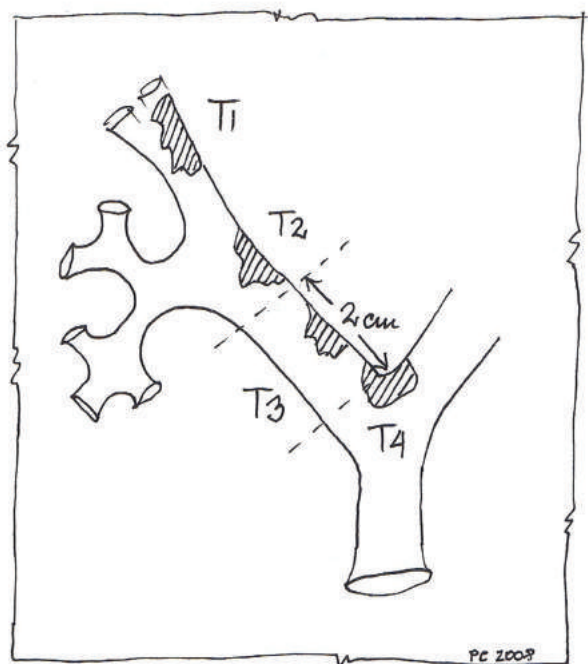


Figure 8.1

Outdated since 2017 TNM v8

new T-classification criteria state:

ANY involvement of main bronchus regardless of distance = T2

Involvement of Main Carina or Trachea = T4

9. SAMPLING TECHNIQUES

Bronchial lavage (BL) or (bronchial washing (BW) involves instillation of 5 to 30 milliliter of sterile isotonic saline in the relevant area. The fluid is then aspirated and used for examination. Main purposes are to clear secretions and mucus and to obtain material for cytological and microbiological tests.



Figure 9.1

Bronchoalveolar lavage (BAL): The middle lobe or lingula are the standard sites for BAL. Typically, three times 50 milliliter of sterile isotonic saline is slowly instilled. Fluid retrieval should be done gently with constant and low suction to prevent bronchial collapse. Approximately 40 – 70 % of the instilled volume is recovered. Main indications are diffuse lung diseases and to diagnose infections.

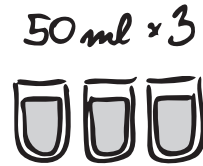


Figure 9.2

Brush biopsy (BB): The brush should be kept inside the catheter while it is advanced through the working channel of the extended bronchoscope and thereafter directed to the target. The assistant advances the brush, after which the operator moves it back and forth and also performs rotating movements over the lesion. The brush is then retracted into the catheter and pulled back through

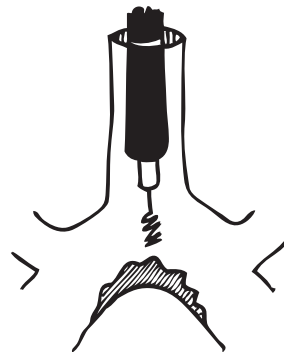


Figure 9.3

the working channel. BB can be performed in two main settings: Biopsy of a visible bronchial lesion or biopsy of a more distal lesion not visible with the bronchoscope biopsied “blindly” or located by fluoroscopy or other navigation systems. Avoid contact with the pleura due to risk of pneumothorax. Main purposes are to obtain material for cytological and microbiological tests.

Endobronchial needle aspiration biopsy (EBNAB): The needle should be kept inside the catheter while it is advanced through the working channel of the bronchoscope and thereafter directed to the target. The operator advances the needle, after which it is moved back and forth in the target. At its proximal end suction can be applied to the needle and material aspirated. A variety of needles are available. A 22 G needle is usually used to obtain cytology specimens. The needle is advanced into a tumor located in the bronchial tree or located under the mucosa. Main purposes are to obtain material for cytological and microbiological tests.



Figure 9.4

Trans-bronchial needle aspiration

biopsy (TBNAB): The technique, which is used for sampling mediastinal structures adjacent to the bronchial tree, is the same as described for EBNAB, however, the needle is advanced “blindly” into a lymph node or a tumor for example located below the main carina. Main purposes are to obtain material for cytological and microbiological tests.

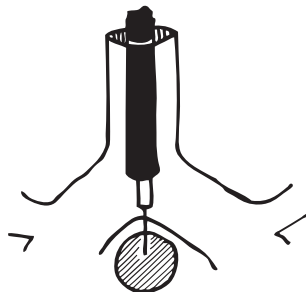


Figure 9.5

Mucosal biopsy (MB): Biopsies for histological examination are taken with a forceps, which is introduced through the working channel. There are different types of forceps which include serrated edge, smooth edge, and spiked (needle between the cups). There are also other types that allow rotation of the blades for better approach of the lesions. The main indication is suspicion of malignancy.

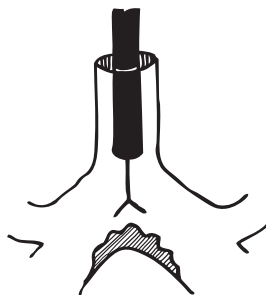


Figure 9.6

Trans-bronchial biopsy (TBB):

Biopsies for histological examination are taken from the alveolar lung tissue often under fluoroscopic guidance. The main indication is suspicion of malignancy and interstitial lung diseases. The biopsies may also be taken under guidance of other navigation systems.

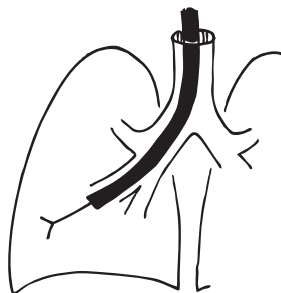


Figure 9.7

10. OTHER TECHNIQUES

Radial probe ultrasound (mini probe):

This technique can be used to guide biopsy during peripheral bronchoscopy (4). It provides real time ultrasound based on confirmation of target lesion localization prior to biopsy.



Figure 10.1

Linear probe ultrasound: Endoscopic ultrasound (endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) and esophageal ultrasound guided fine needle aspiration (EUS-FNA)) (5) give access to biopsy from mediastinal lymph nodes, lung tumors and other structures.

EUS gives access to the left and lower paraesophageal structures plus structures under the diaphragm, while EBUS provides access to structures close to the large airways on both sides. EBUS and EUS are complementary to each other.

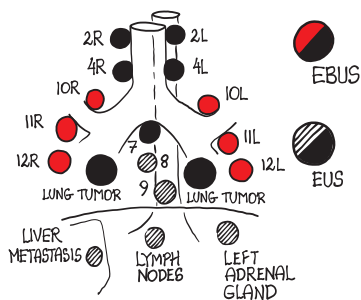


Figure 10.2

Others: The field of bronchoscopy is evolving rapidly and includes the use of different complex procedures for example electromagnetic navigation bronchoscopy, autofluorescence bronchoscopy, cryoextraction, endobronchial valves and bronchial thermoplasty (6).

11. HOW TO HANDLE THE BIOPSY MATERIAL

Even the most perfect endoscopic procedure is worthless if you do not know how to handle the material correctly. It is advisable that you stay in close touch with your pathologist and others to ensure optimal handling.

The material can be sent for histological examination, cytological examination, immune-histochemistry, molecular analysis, microbiological examination, and other examinations.

12. HOW TO LEARN BRONCHOSCOPY

New trainees in bronchoscopy should follow a structured training curriculum consisting of simulation-based training followed by supervised practice on patients including systematic feedback. Competency should be assessed using available validated assessment tools (7,8).

When the simulation-based education is completed, the supervised training in the clinical setting follows. During supervised clinical training, the following three steps should be addressed in this order:

Pattern recognition: To observe the procedure when performed by an experienced colleague, to recognize anatomic landmarks and to identify bronchial segments and sub-segments.

How to handle the endoscope: To be able to insert and maneuver the endoscope, which can be surprisingly more difficult than to watch an experienced examiner doing the procedure.

How to take biopsies: To learn correct positioning of the bronchoscope and to use the equipment for tissue sampling.

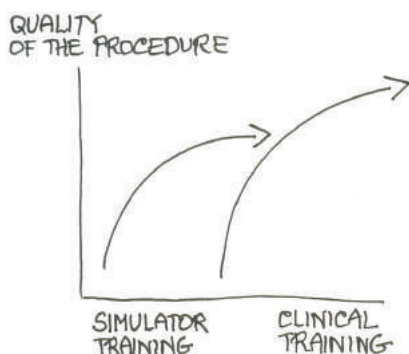


Figure 12.1

13. INTRODUCTION TO THE SIMULATION BASED EDUCATION

MODULE with two simulators

	TASK	MODULE	DESCRIPTION
1	Anatomy As seen from the outside	Lung model ¹	The teacher demonstrates the anatomy of the bronchial tree using a lung model.
2	Demonstration of the bronchoscope	The real bronchoscope ²	The teacher demonstrates how to handle the endoscope, thereafter the participants will show the teacher how to do it.
3	Anatomy As seen from the inside	Phantom ³ plus The real bronchoscope	The teacher demonstrates a bronchoscopy identifying the four landmarks, thereafter the participants will show how to do the procedure.
4	Demonstration of the sampling techniques	The real bronchoscope plus sampling equipment	The teacher demonstrates the different sampling techniques including: Bronchial lavage (BL) Bronchoalveolar lavage (BAL) Brush biopsy (BB) Needle biopsy (EBNAB, TBNAB) Forceps biopsy (MB, TBB)
5	Treatment of bleeding	The real bronchoscope plus balloon catheter	The teacher instructs the participants on how to use the balloon catheter
6	How to handle the bronchoscope	Simulator I ⁴ Essential bronchoscopy Task 1	Each participant will perform one exercise, following the “blue ball” with the bronchoscope. <i>A performance score is given at the end of each exercise.</i>

	TASK	MODULE	DESCRIPTION
7	Anatomy As seen from the inside	Simulator I Essential bronchoscopy Task 2: Guided anatomical navigation	The teacher demonstrates the anatomy including the four landmarks <i>Directional guidance: OFF</i> <i>Compass: OFF</i> <i>Labels 1: ON</i>
8	Anatomy BL and BAL	Simulator II ⁵ Bronchoscopy procedures: Bronchoalveolar lavage Case 1	The participant will identify the landmarks and sub-segments and perform BL and BAL. Participant 1: Right side plus BL in the lower lobe Participant 2: Left side plus BAL in lingula <i>Road signs: ON</i>
9	Anatomy BB, EBNAB, MB	Simulator II Bronchoscopy procedures: Endobronchial sampling Case 3	The participants will identify the landmarks and sub-segments and perform biopsy procedures. Participant 2: Right side plus BB, EBNAB, MB Participant 1: Left side plus BB, EBNAB, MB <i>Road signs: OFF</i>
10	How to handle the endoscope Sampling techniques	Phantom The real bronchoscope plus sampling equipment	A complete procedure is performed. A plastic bead simulating a tumor is placed in the phantom for forceps biopsy (MB). One participant is the operator, while the other assists. The participants will identify the correct anatomical location of the tumor and then remove it using the forceps.

MODULE with one simulator

	TASK	MODULE	DESCRIPTION
1	Anatomy As seen from the outside	Lung model ¹	The teacher demonstrates the anatomy of the bronchial tree using a lung model.
2	Demonstration of the bronchoscope	The real bronchoscope ²	The teacher demonstrates how to handle the endoscope, thereafter the participants will show the teacher how to do it.
3	Anatomy As seen from the inside	Phantom ³ plus The real bronchoscope	The teacher demonstrates a bronchoscopy identifying the four landmarks, thereafter the participants will show how to do the procedure.
4	Demonstration of the sampling techniques	The real bronchoscope plus sampling equipment	The teacher demonstrates the different sampling techniques including: Bronchial lavage (BL) Bronchoalveolar lavage (BAL) Brush biopsy (BB) Needle biopsy (EBNAB, TBNAB) Forceps biopsy (MB, TBB)
5	Treatment of bleeding	The real bronchoscope plus balloon catheter	The teacher instructs the participants on how to use the balloon catheter
6	How to handle the bronchoscope	Simulator I ⁴ Essential bronchoscopy Task 1	Each participant will perform one exercise, following the “blue ball” with the bronchoscope. <i>A performance score is given at the end of each exercise.</i>

	TASK	MODULE	DESCRIPTION
7	Anatomy As seen from the inside	Simulator I Essential bronchoscopy Task 2: Guided anatomical navigation	The teacher demonstrates the anatomy including the four landmarks <i>Directional guidance: OFF</i> <i>Compass: OFF</i> <i>Labels 1: ON</i>
8	Anatomy BL and BAL	Simulator I Bronch Mentor – diagnostic bronchoscopy Case 4	The participant will identify the landmarks and sub-segments and perform BL and BAL. Participant 1: Right side plus BL in the lower lobe Participant 2: Left side plus BAL in lingula <i>Road signs: ON</i>
9	Anatomy BB, EBNAB, MB	Simulator I Bronch Mentor – diagnostic bronchoscopy Case 1	The participants will identify the landmarks and sub-segments and perform biopsy procedures. Participant 2: Right side plus BB, EBNAB, MB Participant 1: Left side plus BB, EBNAB, MB <i>Road signs: OFF</i>
10	How to handle the endoscope Sampling techniques	Phantom The real bronchoscope plus sampling equipment	A complete procedure is performed. A plastic bead simulating a tumor is placed in the phantom for forceps biopsy (MB). One participant is the operator, while the other assists. The participants will identify the correct anatomical location of the tumor and then remove it using the forceps.

Equipment

1. Lung model CLA, Germany
2. Bronchoscope: Olympus BF Q 180
3. Phantom: Broncho Boy, CLA Germany
4. Simulator I: VR Simulator, GI-Bronch Mentor, Simbionix
5. Simulator II: Endo VR, CAE

14. SELF TRAINING

After the introduction to the simulated procedure, the participant will practice on the two different virtual reality simulators and the phantom. During the self-training sessions, the participants follow the structured program in this book. A training assistant will be available for support and guidance.

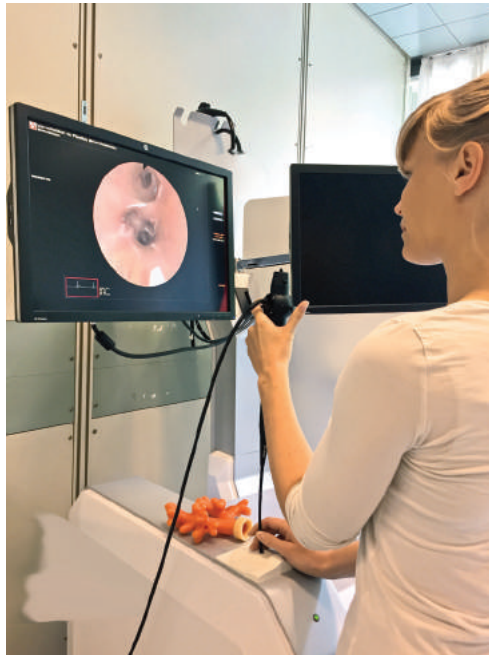


Figure 14.1

15. TEST

The test consists of bronchoscopy procedures on simulator patient cases. The participant performs complete procedures including introduction of the scope, identification of the landmarks, segments and sub-segments and demonstrates different biopsy techniques.

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