

# Continuing professional development

## Respiratory Critical Care

### **Module 1. Anatomy and development of the respiratory system including malformations**

1. Pleura
2. Lungs
3. Bronchopulmonary segments
4. Trachea and bronchi
5. Hila
6. Pulmonary vasculature and lymphatic drainage
7. Mediastinum
8. Diaphragm
9. Development

### **Module 2. Immunology and defence mechanisms**

1. Anatomical barriers including epithelial cell function
2. Reflex mechanisms (sneezing, cough and smooth muscle contraction)
3. Mucociliary clearance and fluid homeostasis

### **Module 3. Ventilation**

1. Physiology of tidal breathing: active inspiration and passive expiration
2. Relative elastic properties of the lungs and chest wall
3. Lung volumes
4. The Rahn diagram and transpulmonary pressures

### **Module 4. Pulmonary circulation**

1. Normal pulmonary vascular pressures and flows
2. Active hypoxic regulation of the pulmonary circulation
3. Non-invasive evaluation of the pulmonary circulation

### **Module 5. Control of breathing**

1. Control systems
2. Peripheral chemoreceptors
3. Central chemoreceptors
4. Neural organisation in the brain stem for control of respiration
5. Testing the control system
6. Ventilatory responses to CO<sub>2</sub>
7. The hypoxic ventilatory response
8. Interaction between hypoxic and hypercapnic responses
9. Disturbances in the control of breathing
10. Control of breathing in pulmonary diseases
11. Type 1 respiratory failure
12. Type 2 respiratory failure
13. Respiratory stimulants

### **Module 6. Respiratory mechanics**

1. Airway resistance
2. Lung and chest wall compliance
3. Measurement of respiratory mechanics in mechanical ventilation
4. Respiratory muscle strength: maximum inspiratory pressure, maximum expiratory pressure and sniff nasal inspiratory pressure, Magnetic twitch pressure

### **Module 7. Gas exchange**

1. Transfer factor of the lung for carbon monoxide (TLCO)
2. Definition

3. Technique
4. Calculation of TLCO and measurement of the carbon monoxide transfer coefficient (KCO)
5. Implications of  $KCO \times VA = TLCO$
6. Transfer factor of the lung for nitric oxide (TLNO) and TLCO/TLNO measurement

### **Module 8. Arterial blood gas (ABG) and acid-base status assessment**

1. ABG:
  - 1.1. Step 1: evaluation of the utility of ABG, capillary blood gas and venous blood gas
  - 1.2. Step 2: diagnosis of A-B disorders: Henderson-Hasselbalch equation and the relationship between partial pressure of oxygen ( $PO_2$ ), partial pressure of carbon dioxide ( $PCO_2$ ) and pH
  - 1.3. Step 3: more on A-B disorders: importance of the D(A-a) difference, fraction of inspired oxygen ( $FiO_2$ ), the alveolar gas equation and measuring oxygen shunts
2. ABG analysis
  - 1.1. Principles of measured and calculated ABG data
  - 1.2. Physiology and pathophysiology of oxygenation, carbon dioxide removal and acid-base homeostasis
  - 1.3. Assessment and appropriate use of ABG data during the diagnostic process
  - 1.4. Calculation of secondary parameters such as the A-a $O_2$  gradient,  $PaO_2/FiO_2$  ratio and anion gap
  - 1.5. Selection of appropriate treatment to correct ABG abnormalities

### **Module 9. Lung function tests**

1. Spirometry interpretation:
  - 1.1. Interpret the flow-volume loop (by shape)
  - 1.2. Pulmonary function testing to assess respiratory mechanics and gas exchange, including spirometry, flow-volume studies, lung volumes and diffusing capacity
2. Measurement principles of flow spirometry, body plethysmography, gas dilution methods and diffusion capacity including all measured (primary) and calculated (secondary) parameters

### **Module 10. Symptoms**

1. Sensation of dyspnoea
  - 1.1. Pathophysiology of dyspnoea sensation
  - 1.2. Quantification of dyspnoea sensation
  - 1.3. Treatment for dyspnoea sensation
2. Thoracic pain/tightness
3. Cough and sputum
4. Systemic symptoms

### **Module 11. Signs**

1. Airway secretions
2. Effort of breathing
3. Haemodynamic assessment
4. Systemic signs

### **Module 12. Diagnostic approach**

1. Differential diagnosis of acute hypercapnic respiratory failure
2. Differential diagnosis of acute hypoxic respiratory failure

### **Module 13. Bronchoscopy**

1. Different approaches to flexible bronchoscopy in spontaneously breathing patients and those on high-flow nasal therapy, non-invasive ventilation (NIV) and invasive mechanical ventilation (IMV)
2. Bronchoscopy

- 2.1. Goals of bronchoscopy (therapeutic/diagnostic)
- 2.2. Effects and side effects (risks and benefits) of bronchoscopy in secretion management (*e.g.* risk of atelectasis)
- 2.3. Indications for NIV during bronchoscopy
- 2.4. Monitoring requirements for the procedure
- 2.5. Appropriate setting for bronchoscopy according to the patient's condition
- 2.6. Patient consent
- 2.7. Selection and application of appropriate topical and systemic medications for the procedure
- 2.8. Selection and mounting of appropriate interface that allows bronchoscopy during NIV
- 2.9. Selection and applying the appropriate ventilator settings to achieve optimal ventilator support and minimise the side effects of bronchoscopy
- 2.10. Set up of the monitoring equipment for bronchoscopy
- 2.11. Performance of bronchoscopy
3. Diagnostic bronchoscopy including airway examination and bronchoalveolar lavage
  - 3.1. Indications, contraindications and risks of bronchoscopy and lavage
  - 3.2. Principles of patient preparation for bronchoscopy and evaluation prior to bronchoscopy
  - 3.3. Principles of sedation management during bronchoscopy
  - 3.4. Airway anatomy
  - 3.5. Bronchoscopy technique including biopsy and lavage equipment
  - 3.6. Different routes to perform bronchoscopy (artificial airway, oral cavity, nasal cavity and during NIV)
  - 3.7. Methods to treat endobronchial bleeding during bronchoscopy including the limitations of these measures
  - 3.8. Management of sedation during bronchoscopy
  - 3.9. Bronchoscopy (pass the upper airway and locate all accessible segmental ostia)
  - 3.10. Mucosal biopsy
  - 3.11. Bronchoalveolar lavage
  - 3.12. Therapeutic bronchoscopy (through an artificial airway) to remove secretions
  - 3.13. Indications, contraindications and risks of therapeutic bronchoscopy *via* an artificial airway
  - 3.14. Ventilator management when bronchoscopy is performed during ventilation
  - 3.15. Techniques to supply oxygen when bronchoscopy is performed during spontaneous breathing through an artificial airway
  - 3.16. Therapeutic bronchoscopy through an artificial airway
4. Foreign body airway aspiration
  - 4.1. Pathophysiology and complications of gross and silent aspiration
  - 4.2. Indications for flexible or rigid bronchoscopy
  - 4.3. Performance of flexible bronchoscopy and recognition of indications for rigid bronchoscopy

#### **Module 14. Thoracentesis**

1. Diagnostic and therapeutic thoracentesis
  - 1.1. Indications, contraindications and risks of thoracentesis
  - 1.2. Anatomic sites for thoracentesis
  - 1.3. Different thoracentesis systems (closed *versus* open, cannula, Seldinger technique, *etc.*)
  - 1.4. Performance of thoracentesis

- 1.5. Recognition of appropriate procedure-related complications
- 1.6. Appropriate management of complications with support from different specialties
- 1.7. Chest trauma (*e.g.* flail chest, pulmonary contusion and rib fractures)
- 1.8. Pathophysiology of the clinical signs of haemothorax/pneumothorax, cardiac contusion and aortic injuries
- 1.9. Indications for chest tube drainage/needle thoracentesis in cases with chest trauma
- 1.10. Principles of pain evaluation and its impact on cough
- 1.11. Indications for mechanical ventilation
- 1.12. Diagnostic work-up in cases with suspected chest trauma
- 1.13. Interpretation of imaging in cases with chest trauma
- 1.14. Insertion of a chest tube in cases with tension pneumothorax or haemothorax
- 1.15. Treatment of pain to avoid sputum retention
- 1.16. Recognition of empyema
- 1.17. Principles of empyema treatment (antibiotics, thoracic drainage and thoracic surgery)
- 1.18. Thoracentesis in cases with empyema
- 1.19. Interpretation of laboratory results of thoracentesis in cases with empyema
- 1.20. Initiation of appropriate antibiotic therapy in cases with empyema
2. Performing thoracentesis in cases with pleural effusion
3. Thoracentesis in cases with suspected haemothorax

#### **Module 15. Basic interpretation of a chest radiograph**

1. Radiological correlates of chest organs and bony chest structures
2. Describing radiological findings of a chest radiograph
3. Recognition of abnormal results and formulation of a diagnosis
4. Changes in chest X-rays during mechanical ventilation, recruitment manoeuvres and positive pressure ventilation
5. Position of central venous lines, a endotracheal tube and a nasogastric tube
6. Risks associated with chest radiography (irradiation)

#### **Module 16. Thoracic ultrasound**

1. Lung ultrasound for differential diagnosis of acute respiratory failure
2. Lung ultrasound for monitoring treatment effects
3. Ultrasound for diaphragm assessment
4. Ultrasound for haemodynamic assessment

#### **Module 17. Computed tomography scan**

1. Identify causes of acute respiratory failure (ARF)
2. Effects of ventilator settings (recruitments) on atelectasis
3. Risks associated with CT in (ventilated) patient (irradiation, transport)

#### **Module 18. Basic microbiological methods**

1. Culture, PCR results and ELISA
2. Choose and obtain the appropriate respiratory sample

#### **Module 19. Inhaled drug therapy**

1. Inhalation therapies and humidification
2. Principles and the physiologic and anatomic basis of airway conditioning
3. Principles of inhaled drug therapy in invasively and non-invasively mechanically ventilated patients
4. Indications, limitations and side effects

#### **Module 20. Respiratory physiotherapy**

1. Basic principles of physiotherapy

2. Physiological rationale and technical issues of non-invasive tools for secretion management and cough assist in spontaneously breathing and non-invasively supported patients
3. Use of devices to train inspiratory muscles
4. Positive expiratory pressure therapy: rationale and devices

**Module 21. Palliative care**

1. End-of-life relief of dyspnoea by:
  - 1.1. Drug administration
  - 1.2. NIV
  - 1.3. High-flow nasal oxygen (HFNO)
  - 1.4. Discuss end-of-life decisions with patients and their relatives

**Module 22. Oxygen therapy**

1. Oxygen transport and utilisation
  - 1.1. Mechanisms involved in oxygen transport and tissue oxygenation
  - 1.2. Clinical conditions that compromise oxygen transport and utilisation
  - 1.3. Diagnostic and therapeutic strategies aimed at improving oxygen transport and utilisation
  - 1.4. Physiology oxygen delivery (*i.e.* cardiac output  $\times$  arterial oxygen content)
  - 1.5. Early recognition and treatment of generalised or local hypoxia/hypoxaemia
  - 1.6. Differentiation between oxygen saturation (SaO<sub>2</sub>) and pO<sub>2</sub> in blood gas analysis (BGA)
  - 1.7. Proactive attitude in early recognition and management
2. Practical skills: modes and principles of oxygen supplementation
  - 2.1. Oxygen uptake and delivery
  - 2.2. Indications and contraindications for oxygen therapy
  - 2.3. Gas pressure and liquid oxygen systems as well as oxygen blenders
  - 2.4. Different probe systems used to administer oxygen during spontaneous breathing, including their impact on FiO<sub>2</sub>
  - 2.5. Oxygen humidification
  - 2.6. Appropriate selection of an oxygen system, flow rate and FiO<sub>2</sub>
  - 2.7. Appropriate selection of tests to monitor oxygen supplementation
  - 2.8. Selection of appropriate patients for HFNO, excluding patients who require (non)invasive ventilation or low-flow oxygen

**Module 23. Noninvasive mechanical ventilation (NIV)**

1. Indications for NIV
2. Contraindications for NIV
3. Side effects and complications of NIV
4. Continuous positive airway pressure
5. Failure of NIV
6. Humidification during NIV
7. Circuits
8. Synchronies/dyssynchronies during NIV
9. Ventilator modes and parameters
10. Technical maintenance
11. Withdrawal of NIV
12. Interfaces for NIV

**Module 24. General principles of IMV**

1. Principles of IMV in the general intensive care unit (ICU) population
2. Principles of IMV in ICU patients with specific pulmonary conditions (*e.g.* acute respiratory distress syndrome (ARDS))

3. Modes of ventilation and their indications and principles of intelligent modes of ventilation.
4. Effects of positive airway pressure on gas exchange, respiratory mechanics and haemodynamics
5. Ventilation modes (*e.g.* assist *versus* assisted modes, and auto-modes)
6. Interpretation of flow and pressure curves
7. Types of humidification systems and their indications
8. Indications for nebulisation of bronchodilators and mucolytic drugs
9. Nebulisation systems and their advantages and disadvantages
10. Adjustment of ventilator settings to:
  - 10.1. Optimise gas exchange according to BGA
  - 10.2. Prevent haemodynamic compromise
  - 10.3. Minimise the risks of ventilator-induced lung injury (VILI)
11. Titrate positive end expiratory pressure (PEEP) according to different methods
12. Initiate and set the right level of PEEP
13. Diagnosis and recognition of barotrauma
14. Management of barotrauma (pneumothorax)
15. Effectively communicate with patients about the risks and benefits of invasive ventilation *versus* NIV
16. General principles of monitoring
17. Pressure and volumes (applied)
18. Hazards of mechanical ventilation
19. Patient-ventilator interaction
20. Rescue
21. IMV in specific patient groups
22. Weaning
23. Long-term complications

#### **Module 25. Chest tube insertion**

1. Chest tube insertion, maintenance of the tube and drainage systems and insertion of a decompression needle for tension pneumothorax
2. Indications, contraindications and risks of chest tube insertion and needle decompression
3. Anatomic sites for tube placement or needle insertion
4. Different thoracentesis systems (open preparation *versus* trocar tubes)
5. Drainage and suction systems
6. Perform chest tube insertion and needle decompression
7. Manage complications as appropriate with support from different specialties

#### **Module 26. Respiratory emergencies**

1. Evaluation, differential diagnosis, immediate management steps, first-line treatment and specific conditions
2. Diagnosis and first-line treatment of:
  - 2.1. Massive pulmonary bleeding
  - 2.2. Massive pulmonary embolism
  - 2.3. Acute pulmonary oedema
  - 2.4. Acute respiratory distress syndrome
  - 2.5. Tension pneumothorax
  - 2.6. Tracheal stenosis

#### **Module 27. Asthma**

1. Pathophysiology of asthma
2. Status asthmaticus

3. Principles of recognition of status asthmaticus
4. Indications for oxygen therapy, NIV and intubation
5. Pharmacology and side effects of anti-asthmatic drugs
6. Principles of delivery of and response to aerosol therapy
7. Possible complications of status asthmaticus (*e.g.* pneumothorax and pneumomediastinum) and their management
8. Indications for non-pharmacological treatment (*e.g.* oxygen therapy and mechanical ventilation)
9. Provision of outpatient and inpatient care as well as emergency and ICU treatment
10. Translation of national and international management recommendations for status asthmaticus to individualised management
11. Recognition and management of patients at risk of life-threatening asthma requiring intubation
12. Mechanical ventilation of status asthmaticus patients
13. Knowledge of emergency therapeutic strategies

**Module 28. Infections in an immunocompromised host**

1. Hospital-acquired and opportunistic infections in critically ill patients
2. Most frequent infections acquired in the ICU, their predisposing factors including immunosuppression, their diagnostic criteria, the most frequent etiologic pathogens and recommended empiric treatment for each infection
3. Detection and diagnosis of these patients
4. Implementation of appropriate diagnostic methods
5. Appropriate selection of empiric treatment
6. Most frequent support measures in critically ill and immunosuppressed patients, including haemotherapy, antimicrobial treatment and life support measures such as mechanical ventilation, vasoactive drugs, renal replacement therapy and immunostimulation
7. Establishment of indications for each support measure and selection of the most appropriate measure in each clinical condition

**Module 29. Aspiration pneumonitis**

1. Detection and diagnosis of these patients
2. Implementation of appropriate diagnostic methods
3. Selection of empiric treatment

**Module 30. Lung cancer (including paraneoplastic syndromes)**

1. Identify immunotherapy and diffuse metastasis as causes of respiratory failure
2. Discuss the appropriateness of mechanical ventilation for patients with lung cancer during the diagnostic process

**Module 31. Sleep-disordered breathing**

1. Physiology and pathophysiology of sleep apnoea syndromes relevant to ARF
2. Diagnosis and screening of obstructive sleep apnoea, upper airway obstruction and hypoventilation
3. Interpretation of blood gases and other tests for sleep-disordered breathing
4. Recognition of obesity as a cause of weaning failure in obese patients

**Module 32. ARF and chronic respiratory failure**

1. ARF
  - 1.1. Physiology and pathophysiology of ARF
  - 1.2. Respiratory pump function and dysfunction
  - 1.3. BGA
  - 1.4. Difference between hypoxia and hypoxaemia
  - 1.5. Imaging (*e.g.* chest X-ray)

- 1.6. National and international guidelines for treatment of ARF
- 1.7. Evaluation, performance, interpretation and reporting of BGA, O<sub>2</sub> saturation, transcutaneous CO<sub>2</sub> measurement, chest X-ray (imaging) and lung/chest wall mechanics
2. Hypoxemic respiratory failure including ARDS
  - 2.1. Causes of hypoxemic ARF
  - 2.2. Definition and classification of ARDS
  - 2.3. Ventilator and tube-associated complications
  - 2.4. Intubation-associated pneumonia (IAP)
  - 2.5. Protective mechanical ventilation and VILI
  - 2.6. Identification and management of hypoxemic ARF
  - 2.7. Indications for NIV in patients with hypoxemic ARF
  - 2.8. Risk assessment and management of NIV failure and indications for intubation
  - 2.9. Intubation and IMV
3. Acute and chronic hypercapnic respiratory failure
  - 3.1. Causes of respiratory failure
  - 3.2. Principles of interpretation of BGA
  - 3.3. National and international guidelines for treatment of acute and chronic hypercapnic respiratory failure
  - 3.4. Indications for additional O<sub>2</sub> treatment
  - 3.5. Indications for long-term (home) mechanical ventilation
  - 3.6. Management of patients with prolonged weaning
  - 3.7. Non-IVM
  - 3.8. Care for patients that are highly dependent on mechanical ventilation, *e.g.* those with a tracheostomy
4. Pleural diseases in patients with severe respiratory failure
  - 4.1. Pathophysiology of restrictive thoracic/pleural diseases that cause severe respiratory failure
  - 4.2. Various types of chest tubes and insertion techniques
  - 4.3. Recognition of pleural diseases as a cause of severe respiratory failure
  - 4.4. Performance of ultrasound examination of the pleural space
  - 4.5. Interpretation of pleural pathology on chest X-rays
  - 4.6. Chest tube insertion: technical issues must be considered to drain located effusions in some cases with organising parapneumonic pleural effusions
  - 4.7. Interpretation of laboratory findings in patients with pleural effusion

### **Module 33. Interstitial lung disease (ILD)**

1. Identify acute ILD as a cause of ARF
2. Differential diagnosis and optimal testing
3. Choose the optimal treatment
4. Prognostication of the identified ILD
5. Hypersensitivity pneumonitis
6. Sarcoidosis
7. Idiopathic interstitial pneumonias
8. Cryptogenic organising pneumonia of unknown aetiology/bronchiolitis obliterans organising pneumonia
9. Connective tissue disease related to ILD
10. Langerhans cell histiocytosis
11. Amyloidosis
12. Lymphangiomyomatosis
13. Pulmonary alveolar proteinosis

14. Drug-induced disease
15. Radiation-induced disease
16. Non-asthmatic eosinophilic bronchitis
17. Acute and chronic eosinophilic pneumonia
18. Hypereosinophilic syndrome
19. Identification of exacerbation of idiopathic pulmonary fibrosis as a cause of ARF and provide differential diagnosis as well as optimal treatment

**Module 34. Thromboembolic disease**

1. Conditions/diseases associated with an increased risk of thromboembolic disease
2. Adverse effects associated with anticoagulation therapy
3. Interpretation of coagulation laboratory tests
4. Drug indications and their appropriate dosages

**Module 35. Pulmonary hypertension and cor pulmonale**

1. Pathophysiology of pulmonary hypertension
2. Pharmacological treatment of pulmonary hypertension according to the underlying disease
3. Diagnosis of pulmonary hypertension and cor pulmonale
4. Insertion of pulmonary artery catheter and interpretation of wave-forms.
5. Translating national and international management guidelines to an individual patient
6. Appropriate decisions for referral and transfer to specialised referral centres
7. Prognosis of patients with pulmonary hypertension in acute care settings

**Module 36. Vasculitis and diffuse pulmonary haemorrhage**

1. Differential diagnoses, diagnostic steps and therapeutic options for pulmonary haemorrhage and haemoptysis
2. Triage by severity
3. Localisation of haemorrhage by bronchoscopy
4. Performance of bronchoscopic interventions
5. Initiation of ventilatory assistance
6. Recognition of the technical limitations of bronchoscopic interventions and immediate referral of patients to the appropriate specialty

**Module 37. Arteriovenous (AV) malformation**

1. Symptoms of AV malformation
2. Diseases associated with AV malformation
3. Diagnostic strategies when AV malformation is suspected
4. Therapeutic interventions

**Module 38. Chest wall deformities**

1. Identify chest wall abnormalities as a cause of restrictive lung disease, respiratory failure and weaning failure

**Module 39. Neuromuscular diseases that cause respiratory failure**

1. Neuromuscular conditions associated with respiratory muscle weakness
2. Symptoms and signs of nocturnal hypoventilation and the probability of respiratory failure
3. Role of NIV *versus* invasive ventilation and cough augmentation (cough assist) techniques
4. Assessment of respiratory muscle strength (*e.g.* vital capacity)
5. Assessment of non-invasive respiratory muscle strength (*e.g.* mouth pressures and sniff inspiratory pressure)
6. Measurement of cough peak flow
7. Use of NIV
8. Clinical assessment of bulbar function

9. Causes, assessment and prognosis of coma
10. Principles of the assessment of coma severity (*i.e.* Glasgow coma scale)
11. Clinical assessment of coma
12. Differential diagnosis of coma
13. Indications for airway protection and mechanical ventilation
14. Guillain-Barré syndrome
  - 14.1. Causes, subtypes, pathophysiology and natural history
  - 14.2. Diagnostic methods and treatments (plasmapheresis and immunoglobulin)
  - 14.3. Amyotrophic lateral sclerosis (ALS)
  - 14.4. Different presentations of the motor neuron disease ALS: types (bulbar/non-bulbar), diagnosis (electromyography and nerve conduction studies) and natural history
  - 14.5. Role of riluzole and symptom palliation
  - 14.6. Respiratory muscle strength and bulbar function assessment
  - 14.7. Careful handling of symptom palliation and discussion of advance directives
15. Myasthenia gravis
  - 15.1. Pathophysiology of acquired myasthenia and congenital variants, diagnostic methods and therapies including anticholinesterases
  - 15.2. Assessment of respiratory muscle strength
  - 15.3. Myopathies and muscular dystrophies (Duchenne, *etc.*)
  - 15.4. Understanding the classification of common myopathies (*e.g.* nemaline, Pompe disease and myotubular), muscular dystrophies (Duchenne and limb girdle) and neuropathies
  - 15.5. Natural history of disorders such as cardiomyopathy in some conditions and the likelihood of respiratory failure
  - 15.6. Assessment of respiratory muscle strength
  - 15.7. Performance of sleep studies and NIV
  - 15.8. Effective communication with patients and their families
  - 15.9. Establish effective interactions with the multidisciplinary team of health professionals
16. Postoperative phrenic nerve dysfunction
  - 16.1. Types of phrenic nerve dysfunction (nerve transection and paresis)
  - 16.2. Predisposing surgical procedures
  - 16.3. Natural history and clinical features
  - 16.4. Assessment of respiratory muscle strength
  - 16.5. Referral for phrenic nerve conduction studies
17. Principles of sedation
  - 17.1. Diagnostic and therapeutic procedures for sedation and analgesia
  - 17.2. Pharmacological basis of sedative agents
  - 17.3. Indications for sedation and analgesia
  - 17.4. Scores and scales for assessment of sedation in conscious and unconscious patients
  - 17.5. Sedation and pain management including treatment of delirium and anxiety in critically ill patients using both pharmacologic and non-pharmacologic methods
  - 17.6. Use of sedative drugs and reversal drugs

#### **Module 40. Diaphragmatic disorders**

1. Identify diaphragm weakness as a cause of acute respiratory failure and weaning failure
2. Differential diagnosis of diaphragm weakness
3. Therapeutic options for diaphragm weakness

4. Pathophysiology of critical illness associated respiratory muscle weakness
5. Prevention of critical illness associated respiratory muscle weakness

**Module 41. Pleural effusion**

1. Pathophysiology of pleural effusions (exudates *versus* transudate)
2. Differential diagnosis of pleural effusion
3. Laboratory diagnostic tests for pleural effusion
4. Principles of therapy for pleural effusion (diuretics and thoracic drainage)
5. Various drainage devices for use as chest tubes
6. Translating national and international guidelines for diagnosis and treatment of pleural effusion to individualised management
7. Performing ultrasound of the pleural space to establish the diagnosis of pleural effusion
8. Performing thoracentesis in patients with pleural effusion
9. Inserting a drainage tube

**Module 42. Pneumothorax**

1. Pathophysiology of pneumothorax
2. Diagnosis and treatment of pneumothorax
3. Recognition of pneumothorax using imaging techniques
4. Treatment of pneumothorax according to national and international guidelines

**Module 43. Cardiac disease**

1. Differentiate between cardiac and pulmonary disease as a cause of ARF
2. Describe the differential diagnosis of cardiac causes of ARF
3. Basic principles of invasive cardiovascular monitoring (*e.g.* pulmonary artery catheter)
4. Cardiovascular effect of positive pressure ventilation

**Module 44. Obesity**

1. Sleep-disordered breathing
  - 1.1. Physiology and pathophysiology of sleep relevant to ARF
  - 1.2. Diagnosis and screening of obstructive sleep apnoea, upper airway obstruction and hypoventilation
  - 1.3. Interpretation of blood gases and other tests for sleep-disordered breathing
  - 1.4. Recognition of obesity as a cause of weaning failure in obese patients
2. Management of obese patients
  - 2.1. Pathophysiologic effects of morbid obesity on the respiratory system (upper airways, respiratory mechanics and central respiratory drive)
  - 2.2. Principles of drug dosing in morbidly obese patients
  - 2.3. Recognition of obesity as a reason for respiratory impairment
  - 2.4. Interpretation of BGA and polysomnography results
  - 2.5. Initiation of non-invasive respiratory treatment
  - 2.6. Initiation of therapy in obese patients
  - 2.7. Associated respiratory problems

**Module 45. Connective tissue diseases**

1. Identify acute ILD as a cause of ARF
2. Differential diagnosis and optimal testing
3. Choose the optimal treatment
4. Prognostication of the identified ILD

**Module 46. Acute inhalation injuries and their possible sequelae**

1. Identify smoke inhalation and burns as causes of respiratory failure
2. Assessment of the degree of severity of pulmonary involvement
3. Optimal treatment of inhalation injury, including systemic effects

**Module 47. ILD caused by dusts of biologic origin (including extrinsic allergic alveolitis)**

1. Identify acute ILD as a cause of ARF
2. Differential diagnosis and optimal testing
3. Choose the optimal treatment
4. Prognostication of the identified ILD

**Module 48. Big data in the ICU**

1. Integration of physiological and biological data in the ICU
2. Automated interpretation of big data in the ICU