

# Detailed Curriculum for the Initial Structured Common Programme

## Chest Radiology

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### 1. Introduction

Physics, radiography and contrast media are generally covered in separate courses and are therefore not included in this document, but physics and radiography topics specific to thoracic imaging should be covered either in the thoracic rotation or included in the physics/radiography courses, particularly:

- Positioning/views of chest radiographs and of chest CT examinations for adults, newborns, infants and children
- Mean exposure doses of chest radiographs and of chest CT examinations and techniques to reduce this dose
- Principles of digital imaging and image processing pertinent to chest radiology

### 2. Core of knowledge

#### 2.1. Normal anatomy

2.1.1. To be able to:

- List the lobar and segmental bronchi
- Describe the relationships of the hilar vessels and bronchi
- Define a pulmonary lobule and its component parts
- Use the correct terminology for describing the site of mediastinal and hilar lymph nodes

2.1.2. Identify the following structures on posteroanterior (PA) and lateral chest radiographs:

- Right upper, middle and lower lobes; left upper and lower lobes; and lingula
- Fissures – major, minor, and azygos
- Airway – trachea, main bronchi, posterior wall of intermediate bronchus, and lobar bronchi
- Heart – position of the atria, ventricles, left atrial appendage, and the location of the four cardiac valves
- Pulmonary arteries – main, right, left, and interlobar
- Aorta – ascending, arch and descending aorta
- Arteries – brachiocephalic (innominate), carotid, and subclavian arteries
- Veins – superior and inferior vena cava, azygos, left superior intercostal ("aortic nipple"), and left brachiocephalic (innominate) veins
- The components of the thoracic skeleton
- Mediastinal stripes and interfaces
- Aortopulmonary window
- Both hemidiaphragms

2.1.3. Identify the following structures on chest CT:

- All pulmonary lobes and segments
- A pulmonary lobule and associated structures
- Fissures – major, minor, azygos and common accessory fissures
- Extrapleural fat
- Inferior pulmonary ligaments
- Airway – trachea, carina, main bronchi, lobar bronchi, and segmental bronchi

- Heart – left and right ventricles, left and right atria, atrial appendages
- Pericardium – including superior pericardial recesses
- Pulmonary arteries – main, right, left, interlobar, segmental
- Aorta – sinuses of Valsalva, ascending, arch, and descending aorta
- Arteries – brachiocephalic (innominate), common carotid, subclavian, axillary, vertebral, internal mammary arteries
- Veins – pulmonary, superior vena cava, inferior vena cava, brachiocephalic, subclavian, internal jugular, external jugular, azygos, hemiazygos, left superior intercostal, internal mammary
- Esophagus
- Thymus
- Normal mediastinal and hilar lymph nodes
- Azygoesophageal recess

## **2.2. Generic signs on chest radiographs**

To be able to recognise and state the significance of the following chest radiographic signs:

- 2.2.1. Silhouette sign - loss of the contour of the heart or diaphragm indicating adjacent pathology (e.g. atelectasis of the right middle lobe obscures the right heart border).
- 2.2.2. Air bronchogram - indicates airless alveoli and, therefore, a parenchymal process as distinguished from a pleural or mediastinal process.
- 2.2.3. Air crescent sign - indicates solid material in a lung cavity, often due to a fungus ball, or crescentic cavitation in invasive fungal infection.
- 2.2.4. Cervicothoracic sign - a mediastinal opacity that projects above the clavicles, situated posterior to the plane of the trachea, while an opacity projecting at or below the clavicles is more likely to be situated anteriorly.
- 2.2.5. Tapered margins - a lesion in the chest wall, mediastinum or pleura may have smooth tapered borders and obtuse angles with the chest wall or mediastinum, while parenchymal lesions usually form acute angles.
- 2.2.6. Gloved finger sign - indicates bronchial impaction, e.g. in allergic bronchopulmonary aspergillosis, or other chronic obstructive processes.
- 2.2.7. Golden S sign - indicates lobar collapse with a central mass, often due to an obstructing bronchogenic carcinoma in an adult.
- 2.2.8. Deep sulcus sign on a supine radiograph - indicates pneumothorax.

## **2.3. Features of diffuse lung disease on chest radiographs and chest CT**

- 2.3.1. To recognise the effects of various pathological processes on the component parts of the pulmonary lobule as seen on HRCT.
- 2.3.2. To list, to be able to identify and to understand the pathophysiology of the following patterns: lung consolidation, ground glass opacity, linear and reticular pattern, honeycombing, nodular pattern, bronchiolar opacities ("tree-in-bud"), air trapping, cysts and mosaic attenuation pattern.
- 2.3.3. To identify thickening of the interlobular septa and list the possible causes.
- 2.3.4. To make a specific diagnosis of interstitial lung disease (ILD) when HRCT appearances are characteristic or when associated findings are present (e.g. dilated esophagus and ILD in scleroderma, enlarged heart and a pacemaker or defibrillator in a patient with prior sternotomy and ILD suggesting amiodarone drug toxicity).

2.3.5. To recognise the spectrum of changes of heart failure on chest radiographs, notably: pleural effusions, vascular redistribution on erect chest radiographs, and the features of interstitial and alveolar edema.

2.3.6. To define the terms "asbestos-related pleural disease" and "asbestosis" and be able to identify the imaging findings.

2.3.7. To recognise progressive massive fibrosis/conglomerate masses secondary to silicosis or coal worker's pneumoconiosis on radiography and chest CT.

## **2.4. Differential diagnosis of diffuse lung disease**

To be able to develop a differential diagnostic list for the following patterns taking account of the anatomical and imaging distribution of the signs and the clinical information:

2.4.1. on chest radiographs (according to whether the pattern is upper, mid or lower zone predominant; or shows central or peripheral predominance):

- Lung consolidation
- Ground glass opacity
- Nodular pattern
- Reticular pattern
- Cystic pattern
- Widespread septal lines

2.4.2. on HRCT (according to whether the pattern is upper, mid or lower zone predominant; or shows perihilar or subpleural predominance; or shows a vascular or perivascular, an airway, a lymphatic or perilymphatic or an interstitial distribution.

- Septal thickening/nodularity
- Ground glass opacity
- Reticular pattern
- Honeycombing
- Nodular pattern
- Air space consolidation
- Tree-in-bud pattern
- Mosaic attenuation pattern
- Cyst and cyst-like pattern

## **2.5. Consolidation and atelectasis**

- To recognise segmental and lobar consolidation
- To list four common causes of segmental consolidation
- To recognise partial or complete atelectasis of single or combined lobes on chest radiographs and list the likely causes
- To recognise complete collapse of the right or left lung on a chest radiograph and list appropriate causes for the collapse
- To distinguish lung collapse from massive pleural effusion on a frontal chest radiograph
- To list five of the most common causes of adult (acute) respiratory distress syndrome
- To name four predisposing causes of or associations with organizing pneumonia
- To recognise the halo sign and suggest a diagnosis of invasive aspergillosis in an immunosuppressed patient

## **2.6. Airways and obstructive lung disease**

- To recognise the signs of bronchiectasis on chest radiographs and chest CT
- To name the most common causes of bronchiectasis
- To recognise the HRCT signs of small airways disease and to be able to differentiate between the direct signs (tree-in-bud, centrilobular changes) of exudative bronchiolitis and the indirect signs (mosaic pattern, air-trapping of obliterative bronchiolitis (bronchiolitis obliterans))
- To recognise the typical appearance of cystic fibrosis on chest radiographs and chest CT

- To recognise tracheal and bronchial stenosis on chest CT and name the most common causes
- To define centrilobular, paraseptal and panacinar emphysema and to recognise their patterns on chest radiograph and CT
- To recognise the signs of panacinar emphysema on chest radiographs and CT
- To state the imaging findings used to identify surgical candidates for giant bullectomy or lung volume reduction

### **2.7. Unilateral hyperlucent lung/hemithorax**

- To recognise a unilateral hyperlucent lung on chest radiographs or chest CT and to give an appropriate differential diagnosis

### **2.8. Solitary and multiple pulmonary nodules**

- To state the definition of a solitary pulmonary nodule and a pulmonary mass
- To name the four most common causes of a solitary pulmonary nodule, cavitory pulmonary nodules and multiple pulmonary nodules
- To provide a strategy for managing an incidental or screening-detected solitary pulmonary nodule
- To state the role of contrast-enhanced CT, positron emission tomography (PET) and integrated PET/CT in the evaluation of a solitary pulmonary nodule
- To describe the features that indicate benignity of a solitary pulmonary nodule and their limitations
- To state the complications of percutaneous lung biopsy and their frequency
- To state the indications for chest tube placement as a treatment for pneumothorax related to percutaneous lung biopsy

### **2.9. Benign and malignant neoplasms of the lung**

- To name the four major histologic types of bronchogenic carcinoma, and state the difference in treatment between non-small cell and small cell lung cancer
- To describe the TNM classification for staging non-small cell lung cancer, including the components of each stage
- To state up to which stage a non-small cell lung cancer is generally regarded as surgically resectable for cure
- To state the staging of small cell lung cancer
- To name the four most common extrathoracic metastatic sites for non-small cell lung cancer and for small cell lung cancer
- To recognise abnormal contralateral mediastinal shift on a post-pneumonectomy chest radiograph and state two possible aetiologies for the abnormal shift
- To describe the acute and chronic radiographic and CT appearance of radiation injury in the thorax (lung, pleura, pericardium) and the temporal relationship to radiation therapy
- To state the roles of CT and MR in lung cancer staging
- To state the role of positron emission tomography (PET) and integrated PET/CT in lung cancer staging
- To state the manifestations and the role of imaging in thoracic lymphoma

### **2.10. Thoracic disease in immunocompetent, immunocompromised and post-transplant patients**

- To name and recognise the manifestations of pulmonary mycobacteria infections on a radiograph and CT
- To describe the types of pulmonary Aspergillus disease, understand that they form part of a continuum, and recognise these entities on chest radiographs and CT

- To name the major categories of disease-causing chest radiographic or chest CT abnormalities in the immunocompromised patient
- To name two common infections and two common neoplasms in patients with AIDS and chest radiographic or chest CT abnormalities
- To describe the chest radiographic and chest CT appearances of pneumocystis jiroveci pneumonia
- To name the three most important aetiologies of hilar and mediastinal adenopathy in patients with AIDS
- To list the differential diagnoses for widespread consolidation in an immunocompromised host
- To describe the chest radiographic and CT findings of post-transplant lymphoproliferative disorders
- To describe the chest radiographic and CT findings of graft-versus-host-disease

### **2.11. Congenital lung disease**

- To name and recognise the components of the pulmonary venobar syndrome (scimitar syndrome) on a frontal chest radiograph, chest CT and chest MRI
- To list the signs of intralobar pulmonary sequestration and cystic adenomatoid malformation on chest radiographs and chest CT
- To recognise bronchial atresia on a radiograph and chest CT, and state the most common lobes of the lungs in which it occurs

### **2.12. Pulmonary vascular disease**

- To recognise enlarged pulmonary arteries on a chest radiograph and distinguish them from enlarged hilar lymph nodes
- To name five of the most common causes of pulmonary artery hypertension and to recognise the chest radiographic and CT signs
- To recognise acute and chronic lobar and segmental pulmonary emboli on CT angiography
- To define the role of CT pulmonary angiography (CTPA), MRI/MRA, scintigraphy and lower extremity venous studies in the evaluation of a patient with suspected venous thromboembolic disease, including the advantages and limitations of each test
- To recognise the vascular redistribution seen in raised pulmonary venous pressure

### **2.13. Pleura and diaphragm**

- To recognise the typical chest radiographic appearances of pleural effusion in erect, supine and lateral decubitus chest radiographs and name four causes of a large unilateral pleural effusion
- To recognise a pneumothorax on an upright and supine chest radiograph
- To recognise a pleural-based mass with bone destruction or infiltration of the chest wall on a radiograph or chest CT, and name four likely causes
- To recognise the various forms of pleural calcification on a radiograph or chest CT and suggest the diagnosis of asbestos exposure or old TB, old empyema, or old haemothorax
- To recognise unilateral elevation of one hemidiaphragm on chest radiographs and list five causes (e.g. subdiaphragmatic abscess, diaphragm rupture, and phrenic nerve involvement with lung cancer, postcardiac surgery, eventration)
- To recognise tension pneumothorax

- To recognise diffuse pleural thickening and list four causes
- To recognise the split pleura sign in empyema
- To state and recognise the chest radiographic and CT findings of malignant mesothelioma

#### **2.14. Mediastinal and hilar disease**

- To name the most common causes of an anterior mediastinal mass and localise a mass to the anterior mediastinum on chest radiographs, chest CT and chest MRI
- To name the three most common causes of a middle mediastinal mass and localise a mass in the middle mediastinum on chest radiographs, chest CT and chest MRI
- To name the most common cause of a posterior mediastinal mass and localise a mass in the posterior mediastinum on chest radiographs, chest CT and chest MRI
- To name two causes of a mass that straddles the thoracic inlet and localise a mass to the thoracic inlet on chest radiographs, chest CT and chest MRI
- To identify normal vessels or vascular abnormality on chest CT and chest MRI that may mimic a solid mass
- To recognise mediastinal and hilar lymphadenopathy on chest radiographs, CT and MRI
- To name the most common causes of bilateral hilar lymph node enlargement
- To list the most common causes of "egg-shell" calcified lymph nodes in the chest
- To name the most common causes of a mass arising in the thymus
- To list the imaging features and common associations of thymoma
- To list three types of malignant germ cell tumour of the mediastinum
- To recognise the imaging signs of benign cystic teratoma
- To recognise the signs of intrathoracic thyroid masses
- To recognise a cystic mass and suggest the possible diagnosis of a bronchogenic, pericardial, thymic or oesophageal duplication cyst
- To state the mechanisms and list the signs of Pneumomediastinum

#### **2.15. Thoracic aorta and great vessels**

- To state the normal dimensions of the thoracic aorta
- To describe the Stanford A and B classification of aortic dissection and the implications of the classification for medical versus surgical management
- To state and recognise the findings of, and distinguish between each of the following on chest CT and MR:
  - aortic aneurysm
  - aortic dissection
  - aortic intramural hematoma
  - penetrating atherosclerotic ulcer
  - ulcerated plaque
  - ruptured aortic aneurysm
  - sinus of Valsalva aneurysm
  - subclavian or brachiocephalic artery aneurysm
  - aortic coarctation
  - aortic pseudo-coarctation
  - cervical aortic arch
- To state the significance of a right aortic arch with mirror image branching versus an aberrant subclavian artery
- To recognise the two standard types of right aortic arch

and a double aortic arch on chest radiographs, chest CT and chest MR

- To recognise an aberrant subclavian artery on chest CT
- To recognise normal variants of aortic arch branching, including the common origin of brachiocephalic and left common carotid arteries ("bovine arch"), and separate origin of vertebral artery from arch
- To define the terms aneurysm and pseudoaneurysm
- To state and identify the findings seen in arteritis of the aorta on chest CT and chest MR
- To state the advantages and disadvantages of CT, MRI/MRA and transoesophageal echocardiography in the evaluation of the thoracic aorta

## **2.16. Chest trauma**

- To identify a widened mediastinum on chest radiographs taken for trauma and state the possible causes (including aortic/arterial injury, venous injury, fracture of sternum or spine)
- To identify the indirect and direct signs of aortic injury on contrast-enhanced chest CT scan
- To identify and state the significance of chronic traumatic pseudoaneurysm on chest radiographs, CT or MRI
- To identify fractured ribs, clavicle, spine and scapula on chest radiographs or chest CT
- To name the most common causes of abnormal lung opacity following trauma on chest radiographs or CT
- To identify an abnormally positioned diaphragm or loss of definition of a diaphragm on chest radiographs following trauma and be able to suggest the diagnosis of a ruptured diaphragm
- To identify a pneumothorax and pneumomediastinum following trauma on chest radiographs
- To identify a cavitary lesion following trauma on chest radiographs or chest CT and suggest the diagnosis of laceration with pneumatocele formation, hematoma or abscess secondary to aspiration
- To name the three most common causes of pneumomediastinum following trauma
- To recognise and distinguish between pulmonary contusion, laceration and aspiration

## **2.17. Monitoring and support devices – "tubes and lines"**

To be able to identify and state the preferred placement of the following devices and lines; to be able to list the complications associated with malposition of each of the following:

- endotracheal tube
- central venous catheter
- Swan-Ganz catheter
- nasogastric tube
- chest tube/drain
- intra-aortic balloon pump
- pacemaker and pacemaker leads
- implantable cardiac defibrillator
- left ventricular assist device
- atrial septal defect closure device ("clamshell device")
- pericardial drain
- extracorporeal life support cannulae
- intraoesophageal manometer, temperature probe or pH probe
- tracheal or bronchial stent

## **2.18. Postoperative chest**

To identify normal post-operative findings and complications of the following procedures on chest radiographs, CT and MRI:

- wedge resection, metastectomy, lobectomy
- pneumonectomy
- coronary artery bypass graft surgery
- cardiac valve replacement
- aortic graft
- aortic stent
- transhiatal oesophagectomy
- lung transplant
- heart transplant
- lung volume reduction surgery

## **3. Technical, communication and decision-making skills**

At the end of his/her training, the resident should be able to demonstrate the following:

**3.1.** Dictate intelligible and useful reports on chest radiographs, CT and MR imaging. These reports should contain a brief description of the imaging findings and their significance along with a short summary where necessary.

**3.2.** Supervise technical staff to ensure appropriate images are obtained.

**3.3.** Discuss significant or unexpected radiologic findings with referring clinicians and know when to contact a clinician.

**3.4.** Describe patient positioning and indications for a PA, lateral, decubitus, and lordotic chest radiograph.

**3.5.** Decide when it is appropriate to obtain help from supervisory faculty in interpreting radiographs.

**3.6.** Understand the clinical indications for obtaining chest radiographs and when further views or a chest CT or MR may be necessary.

**3.7.** Develop skills in protocolling, monitoring, and interpreting chest CT scans, including HRCT, appropriate to patient history and other clinical information.

**3.8.** Describe a chest CT protocol optimised for evaluating each of the following (taking into account the patient's age):

- thoracic aorta and great vessels
- superior vena cava and brachiocephalic vein stenosis or obstruction
- pulmonary embolism
- diffuse lung disease
- tracheobronchial tree
- bronchiectasis
- small airway disease
- lung cancer staging
- oesophageal cancer staging
- superior sulcus tumour
- pulmonary metastases
- pulmonary nodule on a radiograph
- shortness of breath
- haemoptysis

**3.9.** Develop skills in protocolling, monitoring, and interpreting chest MR studies and integrated PET/CT studies.

**3.10.** Demonstrate the ability to effectively present chest imaging in a conference setting.

**3.11.** Recommend the appropriate use of imaging studies to referring clinicians.

**3.12.** Be able to perform the following imaging-guided transthoracic interventions under appropriate supervision, and know the indications, contraindications, and management of complications:

- paracentesis and drainage of pleural effusions
- percutaneous lung biopsy
- paracentesis of mediastinal and pericardial fluid collections
- drainage of refractory lung abscess

**3.13.** Correlate pathologic and clinical data with radiographic, chest CT, MRI and integrated PET/CT findings.

#### **4. Conferences**

The following list gives examples of the types of conferences that should be considered part of the chest curriculum. Some of these conferences may be run by the Radiology Department, others may be run by other departments or multidisciplinary programmes. It is recommended that this latter type of conference be included to facilitate the radiology residents' understanding of the use of imaging and clinical circumstances, in which imaging is requested.

- Radiology resident-specific chest radiology teaching conference
- An appropriate proportion of radiology grand rounds devoted to chest radiology
- Pulmonary medicine conference
- Intensive care unit conference
- Thoracic oncology conference
- Thoracic surgery conference

#### **5. Teaching material and suggestions for reading**

Recommended study materials and mandatory conference attendance are an important component of training, but since they vary between individual departments, a detailed listing is not provided in this document. The following short list of textbooks covering a wide range of topics should be available in departmental libraries:

Webb WR, Müller NL, Naidich DP: High-resolution CT of the Lung, published by Lippincott Williams & Wilkins.

Hansell DM, Armstrong P, Lynch DA, McAdams HP: Imaging of Diseases of the Chest, published by Elsevier.

Fraser RS, Müller NL, Colman N, Paré PD: Fraser & Paré's Diagnosis of Diseases of the Chest, published by Saunders.

Colby TV, Lombard C, Yousem SA, Kitaichi M: Atlas of Pulmonary Surgical Pathology, published by Saunders.

McCloud TC: Thoracic Radiology: the Requisites, published by Mosby.

Hansell DM, Bankier AA, MacMahon H, McLod TC, Müller NL, Remy J: Fleischner Society: glossary of terms for thoracic imaging. Published in Radiology 2008

