**EUROPEAN SOCIETY OF THORACIC IMAGING (ESTI)**

**CURRICULUM FOR THORACIC IMAGING**

**FOR DIAGNOSTIC RADIOLOGY RESIDENTS**

**Introduction**

The purpose of this document is to describe a curriculum for Residency training in Thoracic Imaging prepared by the European Society of Thoracic Imaging (ESTI), taking the recommendations of the European Association of Radiology (EAR, February 1999) into consideration.

It should be noted that the curriculum covers thoracic imaging within the four years of general radiological training. Subspecialty training in thoracic imaging, for those trainees who wish to subspecialise, in the field usually takes place in the fifth and sixth years, and is covered by the separate EAR subspecialty curriculum.

The EAR guidelines for residency training in Diagnostic Radiology recommend that each program director should be responsible for the "preparation of a written statement outlining the curriculum and educational goals and objectives of the program with respect to knowledge, skills, and other attributes of residents at each level of training and for each major rotation or other program assignment".

The thoracic imaging curriculum describes:

- the core of knowledge for general thoracic imaging
- the required technical, communication and decision-making skills.

Physics, radiography and contrast media are generally covered in separate courses, and therefore are 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 for adults, newborns, infants and children
- mean exposure doses at skin entrance, KVp, antiscatter techniques
- principles of digital imaging and image processing pertinent to chest radiology

Training programmes should ensure that there are mechanisms for regular evaluation of a resident's knowledge, skills, and overall performance, including the
development of professional attitudes consistent with being a physician. The evaluation should include not only the items indicated in the curriculum but also:

1. attitudes and character
2. clinical competence
3. technical competence.

According to the European Association of Radiology guidelines, a total of 17 weeks should be devoted to thoracic imaging, in general consisting of:
- 3 weeks in the 18-week first year rotation devoted to conventional radiology
- 14 weeks devoted to chest radiology during the second to fourth years.

In addition there may be up to 2 weeks devoted to thoracic imaging during the emergency radiology rotation. In practice, components of the thoracic imaging curriculum may also occur during rotations in cardiac imaging, paediatric imaging, magnetic resonance imaging, computed tomography and/or vascular and interventional radiology (e.g. lung biopsy procedure skills).

Training in cardiac radiology is not covered in this thoracic imaging curriculum

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.


It is important to note the difference between a curriculum for training and an examination syllabus. A curriculum indicates the knowledge and skills to be acquired by the end of a course of training. Examinations, which may be taken at any time during or after training, usually only cover part of what is contained in the training curriculum; an examination syllabus, therefore, describes what might be asked of a candidate during the particular examination.

The inspiration for this document was the curriculum prepared by the Society for Thoracic Radiology (STR). Several sections of the following curriculum are based on the STR version.

A. KNOWLEDGE-BASED OBJECTIVES OF THE CURRICULUM

At the end of the 4th year the resident should have achieved the knowledge-based objectives listed below. Reasonable progression is to be expected during the four years of training, bearing in mind that institutions organise their rotations differently.

Normal Anatomy

1. Be able to:
   • list the lobar and segmental bronchi
   • describe the relationships of the hilar vessels and bronchi
   • define a secondary pulmonary lobule and its component parts
   • use the correct terminology for describing the site of mediastinal and hilar lymph nodes

1. 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, superior accessory, inferior accessory, and azygos
   • airway - trachea, carina, main bronchi, posterior wall of intermediate bronchus, and lobar bronchi
• heart – position of the two atria, two 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

1. Identify the following structures on chest CT and/or chest MRI:
• all pulmonary lobes and segments
• a secondary pulmonary lobule
• 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 ventricle, right ventricle, left atrium, left atrial appendage, right atrium, right atrial appendage.
• 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
• azygesophageal recess
• inferior pulmonary ligaments

Generic signs on chest radiographs
Be able to recognise and state the significance of the following chest radiographic signs:

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. air bronchogram - indicates airless alveoli and, therefore, a parenchymal process as distinguished from a pleural or mediastinal processes
3. air crescent sign - indicates solid material in a lung cavity, often due to a fungus ball, or crescentic cavitation in invasive fungal infection
4. cervicothoracic sign - a mediastinal opacity that projects above the clavicles is situated posterior to the plane of the trachea, while an opacity projecting at or below the clavicles is situated anteriorly
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
6. gloved finger sign - indicates bronchial impaction, eg in allergic broncho-pulmonary aspergillosis, or other chronic obstructive process
7. Golden S sign - indicates lobar collapse with a central mass, suggesting an obstructing bronchogenic carcinoma in an adult
8. deep sulcus sign on a supine radiograph - indicates pneumothorax

Features of diffuse infiltrative lung disease on chest radiographs and chest CT

Be able to:

1. recognise the effects of various pathological processes on the component parts of the secondary pulmonary lobule as seen on HRCT
2. list and be able to identify the following patterns: air space shadowing, ground glass opacity (and understand its pathophysiology), reticular pattern, honeycombing, nodular pattern, bronchiolar opacities ("tree-in-bud"), air trapping and cysts
3. identify septal lines (thickened interlobular septa) and explain the possible causes
4. make a specific diagnosis of interstitial lung disease (ILD) when supportive findings are present in the history or on chest imaging (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)

5. 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, including septal lines and thickening of fissures

6. define the terms "asbestos-related pleural disease" and "asbestosis"; identify the imaging findings

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

Differential Diagnosis of Diffuse Infiltrative Lung Disease

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:

1. on chest radiographs (according to whether the pattern is upper, mid or lower zone predominant; or shows central or peripheral predominance):
   - air space shadowing
   - ground glass opacity
   - nodular pattern
   - reticular pattern
   - cystic pattern
   - widespread septal lines

2. on HRCT (according to whether the pattern is upper, mid or lower zone predominant; or shows perihilar or subpleural predominance; or shows centrilobular, bronchocentric, lymphocentric or random distributions)
   - septal thickening/nodularity
   - ground glass opacity
   - reticular pattern
   - honeycombing
   - nodular pattern
   - air space consolidation
• tree-in-bud pattern
• mosaic attenuation
• cyst and cyst-like pattern

Alveolar Lung Diseases and Atelectasis

Be able to:

1. recognise segmental and lobar consolidation
2. list four common causes of segmental consolidation
3. recognise partial or complete atelectasis of single or combined lobes on chest radiographs and list the likely causes
4. recognise complete collapse of the right or left lung on a chest radiograph and list an appropriate causes for the collapse
5. distinguish lung collapse from massive pleural effusion on a frontal chest radiograph
6. list five of the most common causes of adult (acute) respiratory distress syndrome
7. name four predisposing causes or associations of organising pneumonia
8. recognise the halo sign and suggest a diagnosis of invasive aspergillosis in a leukaemic patient

Airways and Obstructive Lung Disease

Be able to:

1. recognise the signs of bronchiectasis on chest radiographs and chest CT
2. name four common causes of bronchiectasis
3. recognise the HRCT signs of small airways disease (tree-in-bud, air trapping, mosaic pattern, and associated bronchiectasis)
4. recognise the typical appearance of cystic fibrosis on chest radiographs and chest CT
5. list the causes of wheeze that may be detected on chest radiographs
6. recognise tracheal and bronchial stenosis on chest CT and name the most common causes
7. define centrilobular, paraseptal and panacinar emphysema
8. recognise the signs of emphysema on chest radiographs and CT
9. state the imaging findings used to identify surgical candidates for giant bullectomy or lung volume reduction surgery

**Unilateral Hyperlucent Lung /Hemithorax**

Be able to:

1. recognise a unilateral hyperlucent lung on chest radiographs or chest CT
2. give an appropriate differential diagnosis when a hyperlucent lung/hemithorax is seen on a chest radiograph, and indicate the signs that allow a specific diagnosis

**Solitary and Multiple Pulmonary Nodules**

Be able to:

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

**Benign and Malignant Neoplasms of the Lung**

Be able to:
1. name the four major histologic types of bronchogenic carcinoma, and state the difference in treatment between non-small cell and small cell lung cancer
2. describe the TNM classification for staging non-small cell lung cancer, including the components of each stage (I, II, III, IV, and substages) and the definition of each component (T1-4, N0-3, M0-1)
7. state up to which stage a non-small cell lung cancer is generally regarded as surgically resectable for cure
1. state the staging of small cell lung cancer
2. name the four most common extrathoracic metastatic sites for non-small cell lung cancer and for small cell lung cancer
3. recognise abnormal contralateral mediastinal shift on a post-pneumonectomy chest radiograph and state two possible aetiologies for the abnormal shift
4. 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
5. state the role of MR in lung cancer staging (e.g. chest wall invasion, superior sulcus or Pancoast tumor)
6. state the role of positron emission tomography (PET) in lung cancer staging
7. name the most common location and appearance of adenoid cystic and carcinoid tumors
8. describe the appearances of hamartoma of the lung on chest radiographs and CT
9. state the manifestations of and the role of imaging in thoracic lymphoma
10. describe the typical chest radiograph and chest CT appearances of Kaposi sarcoma

Thoracic Disease in Immunocompetent, Immunocompromised and Post-transplant Patients

Be able to:

1. name and recognise the radiographic manifestations of pulmonary tuberculosis on a radiograph and CT
2. describe the types of pulmonary Aspergillus disease, understand that they form part of a continuum, and recognise these entities on chest radiographs and CT
3. name the major categories of disease causing chest radiographic or chest CT abnormalities in the immunocompromised patient
4. name two common infections and two common neoplasms in patients with AIDS and chest radiographic or chest CT abnormalities
5. describe the chest radiographic and chest CT appearances of *Pneumocystis carinii* pneumonia
6. name the three most important aetiologies of hilar and mediastinal adenopathy in patients with AIDS
7. list the differential diagnoses for widespread consolidation in an immunocompromised host
8. describe the chest radiographic and CT findings of post-transplant lymphoproliferative disorders
9. describe the chest radiographic and CT findings of graft-versus-host-disease.

***Congenital Lung Disease***

Be able to:

1. name and recognise the components of the pulmonary venolobar syndrome (scimitar syndrome) on a frontal chest radiograph, chest CT and chest MRI
2. list the signs of intralobar pulmonary sequestration and cystic adenomatoid malformation on chest radiographs and chest CT
3. explain the differences between intralobar and extralobar pulmonary sequestration
4. recognise bronchial atresia on a radiograph and chest CT, and state the most common lobes of the lungs in which it occurs

***Pulmonary Vascular Disease***

Be able to:

1. recognise enlarged pulmonary arteries on a chest radiograph and distinguish them from enlarged hilar lymph nodes
2. name five of the most common causes of pulmonary artery hypertension
3. recognise lobar and segmental pulmonary emboli on CT angiography and chest MRI (including MR angiography)

4. define the role of ventilation-perfusion scintigraphy, CT angiography, MRI/MRA, and lower extremity venous studies in the evaluation of a patient with suspected venous thromboembolic disease, including the advantages and limitations of each modality depending on patient presentation

5. recognise the vascular redistribution seen in raised pulmonary venous pressure

**Pleura and Diaphragm**

Be able to:

1. 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
2. recognise a pneumothorax on an upright and supine chest radiograph
3. 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
4. recognise the various forms of pleural calcification on a radiograph or chest CT and suggest the diagnosis of asbestos exposure (bilateral involvement) or old TB, old empyema, or old hemothorax (unilateral involvement)
5. 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)
6. recognise tension pneumothorax
7. recognise diffuse pleural thickening and list four causes
8. recognise the split pleura sign in empyema
9. state and recognise the chest radiographic and CT findings of malignant mesothelioma

**Mediastinal and Hilar Disease**

Be able to:
1. name the four most common causes of an anterior mediastinal mass and localise a mass to the anterior mediastinum on chest radiographs, chest CT and chest MRI
2. 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
3. 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
4. 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
5. identify normal vessels or vascular abnormality on chest CT and chest MRI that may mimic a solid mass
6. recognise mediastinal and hilar lymphadenopathy on chest radiographs, CT and MRI
7. name four aetiologies of bilateral hilar lymph node enlargement
8. list the four most common aetiologies of “egg-shell” calcified lymph nodes in the chest
9. name four causes of a mass arising in the thymus
10. list the imaging features and common associations of thymoma
11. list three types of malignant germ cell tumor of the mediastinum
12. recognise the imaging signs of benign cystic teratoma
13. list five signs of intrathoracic thyroid masses
14. recognise a cystic mass in the mediastinum and suggest the possible diagnosis of a bronchogenic, pericardial, thymic or esophageal duplication cyst
15. state the mechanisms and list the signs of pneumomediastinum

**Thoracic Aorta and Great Vessels**

Be able to:

1. state the normal dimensions of the thoracic aorta
2. describe the Stanford A and B classification of aortic dissection, and the implications of the classification for medical versus surgical management
3. 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 pseudocoarctation
• cervical aortic arch

4. state the significance of a right aortic arch with mirror image branching versus with an aberrant subclavian artery
5. recognise the two standard types of right aortic arch and a double aortic arch on chest radiographs, chest CT and chest MR
6. recognise an aberrant subclavian artery on chest CT
7. recognise normal variants of aortic arch branching, including common origin of brachiocephalic and left common carotid arteries ("bovine arch"), separate origin of vertebral artery from arch
8. define the terms aneurysm and pseudoaneurysm
9. state and identify the findings seen in arteritis of the aorta on chest CT and chest MR
10. state the advantages and disadvantages of CT, MRI/MRA and transesophageal echocardiography in the evaluation of the thoracic aorta

Chest Trauma

Be able to:

1. 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)
2. identify the indirect and direct signs of aortic injury on contrast-enhanced chest CT scan
3. identify and state the significance of chronic traumatic pseudoaneurysm on chest radiographs, CT or MRI
4. identify fractured ribs, clavicle, spine and scapula on chest radiographs or chest CT
5. name three common causes of abnormal lung opacity following trauma on chest radiographs or CT
6. 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 ruptured diaphragm
7. identify a pneumothorax and pneumomediastinum following trauma on chest radiographs
8. 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
9. name the three most common causes of pneumomediastinum following trauma
10. recognise and distinguish between pulmonary contusion, laceration and aspiration

Monitoring and Support Devices - “Tubes and Lines”

Be able to:

Be able to identify and state the preferred placement of the following devices and lines. 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
- intraesophageal manometer, temperature probe or pH probe
- tracheal or bronchial stent
Postoperative Chest

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

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

B. TECHNICAL, COMMUNICATION AND DECISION-MAKING SKILLS

At the end of all chest rotations in the first four years of training, the resident should be able to demonstrate the following technical, communication, and decision-making skills:

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
2. supervise technical staff to ensure appropriate images are obtained
3. discuss significant or unexpected radiologic findings with referring clinicians and know when to contact a clinician
4. describe patient positioning and indications for a PA, lateral, decubitus, and lordotic chest radiograph
5. decide when it is appropriate to obtain help from supervisory faculty in interpreting radiographs
6. understand the clinical indications for obtaining chest radiographs and when further views or a chest CT or MR may be necessary
7. develop skills in protocolling, monitoring, and interpreting chest CT scans, including HRCT, appropriate to the patient history and other clinical information.
8. describe a chest CT protocol optimised for evaluating each of the following:
   - thoracic aorta and great vessels
   - superior vena cava and brachiocephalic vein stenosis or obstruction
   - suspected pulmonary embolism
   - tracheobronchial tree
   - suspected bronchiectasis
   - suspected small airway disease
   - lung cancer staging
   - esophageal cancer staging
   - superior sulcus tumor
   - suspected pulmonary metastases
   - suspected pulmonary nodule on a radiograph
   - shortness of breath
   - hemoptysis
9. develop skills in protocoling, monitoring and interpreting chest MR studies
10. demonstrate the ability to effectively present chest imaging in a conference setting
11. recommend the appropriate use of imaging studies to referring clinicians
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
   - arteriography of thoracic aorta and great vessels
   - venography of major intrathoracic systemic veins of bronchial arteries, anatomy, important collaterals
   - pulmonary arteriography
   - principles of bronchial artery embolization: indications, technique and complications
   - principles of intrathoracic vein recanalization and stenting: indications, technique
   - principles of interventional procedures in the pulmonary circulation:
     - local thrombolysis
     - AVM embolization
1. correlate pathologic and clinical data with radiographic and chest CT and MRI findings
C. 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 programs. 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.

1. Radiology resident-specific chest radiology teaching conference
2. An appropriate proportion of radiology grand rounds devoted to chest radiology
3. Pulmonary medicine conference
4. Intensive care unit conference
5. Thoracic oncology conference
6. Thoracic surgery conference