

A CURRICULUM IN CHEST RADIOLOGY FOR DIAGNOSTIC RADIOLOGY RESIDENCY WITH GOALS AND OBJECTIVES

**From the Training Committee of the Society of Thoracic Radiology
Chair, Ella A. Kazerooni, M.D.**

Members:

**Poonam V. Batra
Lawrence M. Boxt
Jannette Collins
Andre J. Duerinckx
Jeremy Erasmus
Joel Fishman
Ann Leung
Hyrudaya P. Nath
Gautham P. Reddy
Robert D. Tarver
Lewis Wexler
Helen Winer-Muram**

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Revisions by Ella Kazerooni, MD, November 1999 and January/February
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Introduction

Effective July 1999, the Accreditation Council for Graduate Medical Education (ACGME) Program Requirements for Residency Education in Diagnostic Radiology were revised, as published in the 1999-2000 Graduate Medical Education (GME) Directory [1]. In addition to defining requirements for institutional organization, faculty qualifications and responsibilities, facilities and resources, the educational program, evaluation, and board certification, specific educational goals and objectives for residents at each level of training are required. The residency program director is 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 nine subspecialty areas of a radiology residency program listed in the GME Directory are neuroradiology, musculoskeletal radiology, vascular and interventional radiology, chest radiology, breast imaging, abdominal radiology, pediatric radiology, ultrasonography (including obstetrical and vascular ultrasound), and nuclear radiology [1]. Radiologic education must provide the

opportunity for residents to develop adequate knowledge regarding normal and pathologic anatomy and physiology. Note, that while there is no specific subspecialty defined as cardiac radiology, the Radiology Residency Review Committee (RRC) requires training and experience in plain film interpretation, computed tomography, magnetic resonance imaging, ultrasonography, angiography, and nuclear radiology examinations related to pulmonary, pleural, mediastinal and cardiovascular disease. Instruction is required in cardiac anatomy, physiology, and pathology, including the coronary arteries, as essential to the interpretation of cardiac imaging studies, to include both the adult and the pediatric age group. The Society of Thoracic Radiology Training Committee has therefore incorporated traditional “chest” or pulmonary, pleural and mediastinal radiology with adult acquired and congenital cardiac radiology into a single curriculum document. This curriculum document focuses on adult radiology, as pediatric radiology is recognized as a separate subspecialty in the GME directory. Similarly, nuclear radiology is listed as a separate subspecialty. Components of a chest radiology curriculum may practically occur during one or more organ-specific or technology-specific rotations during residency, including rotations in chest radiology, cardiac radiology, pediatric radiology, nuclear medicine, magnetic resonance imaging, computed tomography and/or vascular and interventional radiology (e.g. lung biopsy procedure skills). Recognizing that it is difficult to draw clear boundaries between subspecialties, aspects of pediatric radiology, nuclear radiology and interventional radiology pertinent to adult chest radiology are also included in this curriculum document. Physics, as applied to cardiopulmonary radiology, is generally covered in a separate physics course, and is not included in this document.

The residency program director is responsible for regular evaluation of residents’ knowledge, skills, and overall performance, including the development of professional attitudes consistent with being a physician. The evaluation must concern itself with **intellectual abilities**, **attitudes** and **character skills**, and clinical and **technical competence**. The goals and objectives provided in this graduated curriculum can be used as a template by program directors and/or the faculty evaluators in chest radiology, as part of the evaluation process.

This curriculum is based on three 4-week rotations in chest radiology. Programs may be organized into a different number of rotations of different length, and this curriculum can be modified to reflect variations in training programs. Goals and objectives encompassing clinical knowledge, technical, communication, and decision-making skills are outlined for each level of training, based on three rotations in chest radiology. Since the timing of resident exposure to each part of the curriculum will depend on the organization of individual residency programs, the individual program should modify this curriculum. Recommended study materials and required conference attendance are an important component of a complete curriculum document. Similarly, since they are often specific to individual departments, a detailed listing is not provided in this document.

Year one (1st 4-week rotation)

I. Goals

After completion of the first chest rotation, the resident will be able to:

1. Demonstrate learning of the knowledge-based objectives
2. Accurately and concisely dictate a chest radiograph report
3. Communicate effectively with referring clinicians and supervisory staff
4. Understand standard patient positioning in chest radiology
5. Obtain pertinent patient information relative to radiologic examinations
6. Demonstrate learning of the clinical indications for obtaining chest radiographs and when a chest CT or MR may be necessary
7. Demonstrate a responsible work ethic

II. Objectives

Part A. Knowledge-based: At the end of the first chest rotation, the resident will demonstrate learning of at least one-third of the following **knowledge-based** objectives:

Normal Anatomy

1. Name and define the three zones of the airways
2. Define a secondary pulmonary lobule
3. Define an acinus
4. List the lobar and segmental bronchi of both lungs
5. Identify the following structures on the posteroanterior (PA) chest radiograph:
 - Lungs – right, left, right upper, middle and lower lobes, left upper and lower lobes, lingula
 - Fissures – minor, superior accessory, inferior accessory, azygous
 - Airway - trachea, carina, main bronchi
 - Heart - right atrium, left atrial appendage, left ventricle, location of the four cardiac valves
 - Pulmonary arteries – main, right, left, interlobar
 - Aorta – ascending, arch, descending
 - Veins – superior vena cava, azygous, left superior intercostal (“aortic nipple”)
 - Bones – spine, ribs, clavicles, scapulae, humerus
 - Right paratracheal stripe
 - Junction lines – anterior, posterior
 - Aortopulmonary window
 - Azygoesophageal recess
 - Paraspinal lines
 - Left subclavian artery
6. Identify the following structures on the lateral chest radiograph:
 - Lungs – right, left, right upper, middle and lower lobes, left upper and lower lobes, lingula

- Fissures – major, minor, superior accessory
- Airway - trachea, upper lobe bronchi, posterior wall of bronchus intermedius
- Heart – right ventricle, right ventricular outflow stripe, left atrium, left ventricle, the location of the four cardiac valves
- Pulmonary arteries – right, left
- Aorta – ascending, arch, descending
- Veins – SVC, IVC, left brachiocephalic (innominate), pulmonary vein confluences
- Bones – spine, ribs, scapulae, humerus
- Retrosternal line
- Posterior tracheal stripe
- Right and left hemidiaphragms
- Raider's triangle
- Brachiocephalic (innominate) artery

Signs in Chest Radiology

1. Be able to define, identify and state the significance of the following on a radiograph:
 - air bronchogram - indicates a parenchymal process, including non-obstructive atelectasis, as distinguished from pleural or mediastinal processes
 - air crescent sign – indicates a lung cavity, often due to fungal infection
 - deep sulcus sign on a supine radiograph - indicates pneumothorax
 - continuous diaphragm sign - indicates pneumomediastinum
 - ring around the artery sign (around pulmonary artery on lateral chest radiograph) - indicates pneumomediastinum
 - fallen lung sign - indicates a fractured bronchus
 - flat waist sign- indicates left lower lobe collapse
 - gloved finger sign - indicates bronchial impaction, which can be seen in allergic bronchopulmonary aspergillosis
 - Golden S sign - indicates lobar collapse with a central mass, suggesting an obstructing bronchogenic carcinoma in an adult
 - luftsichel sign - indicates upper lobe collapse, potentially due to an obstructing bronchogenic carcinoma in an adult
 - Hampton's hump - indicates a pulmonary infarct
 - silhouette sign - loss of the contour of the heart or diaphragm used to localize a parenchymal process (e.g. a process involving the medial segment of the right middle lobe obscures the right heart border; a lingula process obscures the left heart border; a basilar segmental lower lobe process obscures the diaphragm)
 - cervicothoracic sign – a mediastinal opacity that projects above the clavicles is retrotracheal and posteriorly situated while an opacity effaced along its superior aspect and projecting at or below the clavicles is situated anteriorly

- tapered margins sign - a lesion in the chest wall, mediastinum or pleura will have smooth tapered borders and obtuse angles with the chest wall or mediastinum while parenchymal lesions usually form acute angles
 - figure 3 sign – abnormal contour of the descending aorta, indicating coarctation of the aorta
 - fat pad sign or sandwich sign – indicates pericardial effusion on lateral chest radiograph
 - scimitar sign – an abnormal pulmonary vein in venolobar syndrome
 - double density sign – contour projecting over the right side of the heart, indicating enlargement of the left atrium
 - hilum overlay sign and hilum convergence sign – used to distinguish a hilar mass from a non-hilar mass
2. Be able to define, identify and state the significance of the following on a chest CT:
- CT angiogram sign - enhancing pulmonary vessels against a background of low attenuation material in the lung
 - halo sign - suggesting invasive pulmonary aspergillosis in a leukemic patients
 - split pleura sign - a sign of empyema

Interstitial lung disease

1. List and identify on a chest radiograph and chest CT four patterns of interstitial lung disease (ILD)
2. Make a specific diagnosis of ILD when supportive findings are present in the history or on radiologic 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)
3. Identify Kerley A and B lines on a chest radiograph and explain their etiology
4. Recognize the changes of congestive heart failure on a chest radiograph - enlarged cardiac silhouette, pleural effusions, vascular redistribution, interstitial and/or alveolar edema, Kerley lines
5. Define the terms “asbestos-related pleural disease” and “asbestosis;” identify each on a chest radiograph and chest CT
6. Describe what a “B” reader is as related to the evaluation of pneumoconiosis
7. Identify honeycombing on a radiograph and high resolution chest CT (HRCT), state the significance of this finding (end-stage lung disease), and list the common causes of honeycomb lung
8. State the radiographic classification of sarcoidosis
9. Recognize progressive massive fibrosis/conglomerate masses secondary to silicosis or coal worker’s pneumoconiosis on radiography and chest CT
10. Recognize the typical appearance of irregular lung cysts and/or nodules on chest CT of a patient with Langerhan’s cell histiocytosis

11. List four causes of unilateral ILD
12. List three causes of lower lobe predominant ILD
13. List two causes of upper lobe predominant ILD
14. Identify a secondary pulmonary lobule on HRCT
15. Identify lymphangiomyomatosis on a chest radiograph and HRCT
16. Identify and give appropriate differential diagnoses when the patterns of septal thickening, perilymphatic nodules, bronchiolar opacities (“tree-in-bud”), air trapping, cysts, and ground glass opacities are seen on HRCT

Alveolar lung disease

1. List four broad categories of acute alveolar lung disease (ALD)
2. List five broad categories of chronic ALD
3. Name three pulmonary-renal syndromes
4. List five of the most common causes of adult respiratory distress syndrome
5. Name four predisposing causes of bronchiolitis obliterans organizing pneumonia (BOOP)
6. Suggest a specific diagnosis of ALD when supportive findings are present in the history or on the chest radiograph (e.g. broken femur and ALD in fat embolization syndrome, ALD and renal failure in a pulmonary-renal syndrome, ALD treated with bronchoalveolar lavage in alveolar proteinosis)
7. Recognize a pattern of peripheral alveolar lung disease on radiography or chest CT and give an appropriate differential diagnosis, including a single most likely diagnosis when supported by associated radiologic findings or clinical information (e.g. peripheral lung disease associated with paratracheal and bilateral hilar adenopathy in an asymptomatic patient with “alveolar” sarcoidosis, peripheral lung disease associated with a markedly elevated blood eosinophil count in a patient with eosinophilic pneumonia, peripheral opacities associated with multiple rib fractures and pneumothorax in a patient with acute chest trauma and pulmonary contusions)

Atelectasis, Airways and Obstructive Lung Disease

1. Recognize partial or complete atelectasis of the following on a chest radiograph:
 - right upper lobe
 - right middle lobe
 - right lower lobe
 - right upper and middle lobe
 - right middle and lower lobe
 - left upper lobe
 - left lower lobe
2. Recognize complete collapse of the right or left lung on a chest radiograph and list an appropriate differential diagnosis for the etiology of the collapse

3. Distinguish lung collapse from massive pleural effusion on a frontal chest radiograph
4. Name the 4 types of bronchiectasis and identify each type on a chest CT
5. Name 5 common causes of bronchiectasis
6. Recognize the typical appearance of cystic fibrosis on a radiograph and chest CT
7. Name the important things to look for on a chest radiograph when the patient history is "asthma"
8. Define tracheomegaly
9. Recognize tracheal and bronchial stenosis on chest CT and name the most common causes
10. Name the 3 types of pulmonary emphysema and identify each type on a chest CT
11. Recognize alpha-1-antitrypsin deficiency on a chest radiograph and chest CT
12. Recognize Kartagener's syndrome on a chest radiograph and name the 3 components of the syndrome
13. Define the term giant bulla, differentiate giant bulla from pulmonary emphysema and state the role of imaging in patient selection for bullectomy
14. State the imaging findings used to identify surgical candidates for giant bullectomy and for lung volume reduction surgery

Mediastinal Masses and Mediastinal/Hilar Lymph Node Enlargement

1. State the anatomic boundaries of the anterior, middle, posterior and superior mediastinum
2. Name the four most common causes of an anterior mediastinal mass and localize a mass to the anterior mediastinum on a radiograph, chest CT and chest MRI
3. Name the three most common causes of a middle mediastinal mass and localize a mass in the middle mediastinum on a radiograph, chest CT and chest MRI
4. Name the most common cause of a posterior mediastinal mass and localize a mass in the posterior mediastinum on a radiograph, chest CT and chest MRI
5. Name two causes of a mass that straddles the thoracic inlet and localize a mass to the thoracic inlet on a radiograph, chest CT and chest MRI
6. Identify normal vessels or vascular abnormality on chest CT and chest MRI that may mimic a solid mass
7. Name five etiologies of bilateral hilar lymph node enlargement
8. State the three most common locations (Garland's triad) for lymph node enlargement to occur in the chest of patients with sarcoidosis
9. List the four most common etiologies of "egg-shell" calcified lymph nodes in the chest

10. Recognize a cystic mass in the mediastinum and suggest the possible diagnosis of a bronchogenic, pericardial, thymic or esophageal duplication cyst

Solitary and Multiple Pulmonary Nodules

1. State the definition of a solitary pulmonary nodule and a pulmonary mass
2. Name the three most common causes of a solitary pulmonary nodule
3. Name four important considerations in the evaluation of a solitary pulmonary nodule
4. Name six causes of cavitary pulmonary nodules
5. Name four causes of multiple pulmonary nodules
6. State the indications for percutaneous biopsy of a solitary pulmonary nodule
7. State the indications for percutaneous biopsy when there are multiple pulmonary nodules
8. State the complications and the frequency with which complications occur due to percutaneous lung biopsy using CT or fluoroscopic guidance
9. State the indications for chest tube placement as a treatment for pneumothorax related to percutaneous lung biopsy
10. State the role of positron emission tomography (PET) in the evaluation of a solitary pulmonary nodule

Benign and Malignant Neoplasms of the Lung and Esophagus

1. Name the four major histologic types of bronchogenic carcinoma, and state the difference between non-small cell and small cell lung cancer
2. Name the type of non-small cell lung cancer that most commonly cavitates
3. Name the types of bronchogenic carcinoma that are usually central
4. 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)
5. State the staging of small cell lung cancer
6. Name the four most common extrathoracic sites for non-small cell lung cancer and small cell lung cancer to metastasize
7. State which stages of non-small cell lung cancer are potentially respectable
8. Recognize abnormal contralateral mediastinal shift on a post-pneumonectomy chest radiograph and state five possible etiologies for the abnormal shift
9. Name the most common location for adenoid cystic and carcinoid tumors to occur
10. Suggest the possibility of radiation change as a cause of new apical opacification on a chest radiograph of a patient with evidence of mastectomy and/or axillary node dissection
11. Describe the acute and chronic radiographic and CT appearance of radiation injury in the thorax (lung, pleura, pericardium, esophagus) and the temporal relationship to radiation therapy

12. State the role of MR in lung cancer staging (e.g. chest wall invasion, superior sulcus or Pancoast tumor)
13. State the role of positron emission tomography (PET) in lung cancer staging
14. Describe the TNM classification for staging esophageal carcinoma, including the components of each stage (I, II, III, IV) and the definition of each component (T, N and M)
15. State the role of imaging in the staging of esophageal carcinoma
16. State which stages of esophageal carcinoma are potentially respectable
17. State the classification of lymphoma, the role of imaging in the staging of lymphoma, and the typical and atypical manifestations of thoracic lymphoma
18. Define primary pulmonary lymphoma
19. Describe the typical chest radiograph and chest CT appearances of Kaposi sarcoma

Chest Trauma

1. Identify a widened mediastinum on a trauma radiograph and state the differential diagnosis (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 a chest radiograph, CT or MRI
4. Identify fractured ribs, clavicle, spine and scapula on a chest radiograph or chest CT
5. Name five common causes of abnormal lung opacity on a trauma radiograph or CT
6. Identify an abnormally positioned diaphragm or loss of definition of a diaphragm on a trauma chest radiograph and suggest the diagnosis of a ruptured diaphragm
7. Identify a pneumothorax and pneumomediastinum on a trauma chest radiograph
8. Identify the fallen lung sign on a radiograph or chest CT scan and suggest the diagnosis of tracheobronchial tear
9. Identify a cavitory lesion on a post-trauma radiograph or chest CT and suggest the diagnosis of laceration with pneumatocele formation, hematoma or abscess secondary to aspiration
10. Name the three most common causes of pneumomediastinum in the setting of trauma
11. Recognize and distinguish between pulmonary contusion, laceration and aspiration

Chest Wall, Pleura and Diaphragm

1. Recognize and name four causes of a large unilateral pleural effusion on a radiograph or chest CT

2. Recognize a pneumothorax on an upright and supine chest radiograph
3. Recognize 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. Recognize pleural calcification on a radiograph or chest CT and suggest the diagnosis of asbestos exposure (bilateral involvement) or old TB or trauma (unilateral involvement)
5. Recognize the typical chest radiographic appearances of pleural effusion, given differences in patient positioning
6. Recognize apparent unilateral elevation of the diaphragm on a chest radiograph and suggest a specific etiology with supportive history and associated chest radiograph findings (e.g. subdiaphragmatic abscess after abdominal surgery, diaphragm rupture after trauma, and phrenic nerve involvement with lung cancer)
7. Recognize a tension pneumothorax and understand the acute clinical implications
8. Recognize diffuse pleural thickening, as seen in fibrothorax, malignant mesothelioma and pleural metastases
9. State and recognize the radiographic and CT findings of malignant mesothelioma

Infection (Immunocompetent, Immunocompromised and Post-transplant Patients)

1. Name the radiographic manifestations of primary pulmonary tuberculosis
2. Name the three most common segmental sites of involvement for reactivation tuberculosis in the lung
3. Define Ranke complex and Ghon lesion; recognize both on a radiograph and CT
4. Name and describe the four types of pulmonary Aspergillus disease
5. Identify an intracavitary fungus ball on chest radiography and chest CT
6. State the radiographic appearances of *Cytomegalovirus* pneumonia
7. Name the major categories of disease causing chest radiograph or chest CT abnormalities in the immunocompromised patient
8. Other than bacterial infection, name 2 important infections and 2 important neoplasms to consider in patients with AIDS and chest radiograph or chest CT abnormalities
9. Describe the chest radiograph and chest CT appearances of *Pneumocystis carinii* pneumonia
10. Name the 4 most important etiologies of hilar and mediastinal adenopathy in patients with AIDS
11. Describe the time course and chest radiographic appearance of a blood transfusion reaction
12. State the radiographic appearances of mycoplasma pneumonia
13. Describe the radiographic and CT appearance of a miliary pattern and provide a differential diagnosis
14. Name the diagnostic considerations in a patient who presents with recurrent or persistent pneumonias

15. Name the endemic mycoses, the specific geographic regions where they are found, and their radiographic manifestations
16. State the most common pulmonary infections seen after solid-organ (i.e. liver, renal, cardiac) transplantation
17. Describe the radiographic and CT findings of post-transplant lymphoproliferative disorders

Unilateral Hyperlucent Lung (or hemithorax)

1. Recognize a unilateral hyperlucent lung on a radiograph or chest CT
2. Identify the common causes for unilateral hyperlucent lung on a chest radiograph
3. Give an appropriate differential diagnosis when a hyperlucent lung is seen on a chest radiograph, and suggest a specific diagnosis when certain associated findings are seen (i.e. absence of a breast in a patient after mastectomy for breast cancer, absence of a pectoralis muscle in a patient with Poland's syndrome, unilateral bullous disease/emphysema, or air trapping on expiration in a patient with Swyer-James syndrome or an endobronchial foreign body)

Congenital Lung Disease

1. Name the components of the pulmonary venolobar syndrome
2. Recognize venolobar syndrome on a frontal chest radiograph, chest CT and chest MRI, and explain the etiology of the retrosternal band of opacity seen on the lateral view
3. Recognize a mass in the posterior segment of a lower lobe on a chest radiograph and chest CT, and suggest the possible diagnosis of pulmonary sequestration
4. Explain the differences between intralobar and extralobar sequestration
5. Recognize bronchial atresia on a radiograph and chest CT, and state the most common lobes of the lungs in which it occurs

Pulmonary Vascular

1. Recognize enlarged pulmonary arteries on a chest radiograph and distinguish them from enlarged hilar lymph nodes
2. Recognize enlargement of the central pulmonary arteries with diminution of the peripheral pulmonary arteries as pulmonary arterial hypertension and suggest the possible diagnosis of primary pulmonary artery hypertension
3. Name five of the most common causes of pulmonary artery hypertension
4. Recognize lobar and segmental pulmonary emboli on chest CT and chest MRI (including MR angiography)
5. Define the role of ventilation-perfusion scintigraphy, chest CT, chest 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

Thoracic Aorta and Great Vessels

1. State the normal dimensions of the thoracic aorta
2. Describe the classifications of aortic dissection (DeBakey I,II, III; Stanford A, B), and implications for classification on medical versus surgical management
3. State and recognize the findings of, and distinguish between each of the following on 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
4. Recognize a right aortic arch and a double aortic arch on a radiograph, chest CT and chest MR
5. State the significance of a right aortic arch with mirror image branching versus with an aberrant subclavian artery
6. Recognize a cervical aortic arch on a radiograph and chest CT
7. Recognize an aberrant subclavian artery on chest CT
8. Recognize 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
9. Define the terms aneurysm and pseudoaneurysm
10. State the common cardiac anomalies associated with aortic coarctation
11. State and identify the findings seen in Takayasu's arteritis on chest CT and chest MR
12. State the advantages and disadvantages of CT, MRI/MRA and transesophageal echocardiography in the evaluation of the thoracic aorta

Ischemic Heart Disease

1. Describe the anatomy of the coronary arteries and identify the following on a coronary arteriogram and CT scan
 - right coronary artery
 - left main coronary artery
 - left anterior descending coronary artery
 - left circumflex coronary artery
2. State the clinical significance of coronary arterial calcification on a chest radiograph
3. Recognize coronary arterial calcification on CT and state the current role of coronary artery calcium scoring with helical or electron beam CT

4. State which coronary artery is usually diseased when there is papillary muscle dysfunction
5. Describe the common acute complications of myocardial infarction, including left ventricular failure, myocardial rupture and papillary muscle rupture, and recognize radiologic findings that may indicate these
6. Describe the common late complications of myocardial infarction, including ischemic cardiomyopathy, left ventricular aneurysm, left ventricular pseudoaneurysm, coronary-cameral fistula, dyskinesia and akinesia and recognize radiologic findings that may indicate these
7. Identify left heart failure on a radiograph and chest CT
8. Recognize acute myocardial infarction on MR imaging
9. Define ejection fraction and state the normal left ventricular ejection fraction
10. Identify myocardial calcification on CT and state the etiology and significance of this finding
11. State the difference between a left ventricular aneurysm and pseudoaneurysm
12. Define and identify myocardial bridging on MR
13. Define the role of angiography, echocardiography, stress perfusion scintigraphy, chest CT, and chest MRI in the evaluation of a patient with suspected ischemic heart disease, including the advantages and limitations of each modality

Myocardial Disease

1. Define the types of cardiomyopathy (dilated, hypertrophic, restrictive) and list the common causes of each
2. Define right ventricular dysplasia and identify on MRI
3. State the most common benign primary cardiac tumors, including myxoma, lipoma, fibroma and rhabdomyoma
4. State the most common malignant primary cardiac tumors, including angiosarcoma, rhabdomyosarcoma, lymphoma
5. Distinguish cardiac tumor from thrombus on CT and MRI
6. State the most common malignancies to metastasize to the heart, and the appearance on a radiograph, chest CT and chest MR
7. State the advantages and disadvantages of echocardiography, CT, and MRI for evaluation of cardiomyopathy and cardiac tumors

Cardiac Valvular Disease

1. State the findings that indicate each of the following and identify each on chest radiographs:
 - enlarged right atrium
 - enlarged left atrium
 - enlarged right ventricle
 - enlarged left ventricle

2. Recognize an enlarged left atrium, vascular redistribution, and mitral valve calcification on a chest radiograph and suggest the diagnosis of mitral stenosis
3. Recognize an enlarged ascending aorta and aortic valve calcification on a chest radiograph and suggest the diagnosis of aortic stenosis
4. State the most common etiologies of the following:
 - aortic stenosis
 - aortic regurgitation
 - mitral stenosis
 - mitral regurgitation
 - tricuspid regurgitation
 - pulmonary stenosis
5. State the cardiac diseases associated with mitral annulus calcification
6. Identify endocarditis and/or complications of endocarditis on radiographs, chest CT and chest MR
7. State the advantages and disadvantages of echocardiography and MRI for evaluation of valvular heart disease

Pericardial disease

1. Recognize pericardial calcification on a radiograph and chest CT and list the most common causes
2. Describe and identify two chest radiographic signs of a pericardial effusion
3. State five causes of a pericardial effusion
4. State and recognize the findings of a each of the following on radiography, CT and MR:
 - pericardial cyst
 - constrictive pericarditis
 - pericardial hematoma
 - pericardial metastases
 - partial absence of the pericardium
 - pneumopericardium

Congenital Heart Disease in the Adult

1. Recognize increased vascularity, decreased vascularity and shunt vascularity on a chest radiograph and state the common causes of each
2. Recognize the following on imaging examinations of the chest, including radiographs, CT and/or MRI:

Heart disease presenting during adulthood

- Left-to-right shunts and Eisenmenger physiology
- Atrial septal defect
- Ventricular septal defect
- Partial anomalous pulmonary venous connection
- Patent ductus arteriosus
- Coarctation of aorta
- Tetralogy of Fallot and pulmonary atresia with ventricular septal defect

- Congenitally corrected transposition of the great arteries
- Persistent left superior vena cava
- Truncus arteriosus
- Ebstein anomaly
- Cardiac malposition, including abnormal situs

Heart disease originally treated in childhood

- Coarctation of the aorta
- Tetralogy of Fallot and Pulmonary atresia with ventricular septal defect
- Complete transposition of the great arteries
- Congenitally corrected transposition of the great arteries
- Truncus arteriosus
- Commonly performed surgical corrections for congenital heart disease

3. Define the role of angiography, echocardiography, chest CT, and chest MRI in the evaluation of an adult patient with congenital heart disease, including the advantages and limitations of each modality depending on patient presentation

Monitoring and support devices – “tubes and lines”

1. Be able to identify, state the preferred placement of, complications associated with malposition and identify the location on chest radiography for each of the following :
 - endotracheal tube
 - central venous catheter
 - Swan-Ganz catheter
 - feeding tube
 - nasogastric tube
 - chest tube
 - intra-aortic balloon pump
 - pacemaker and pacemaker leads
 - automatic 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
2. Explain how an intra-aortic balloon pump works

Post-operative chest

1. Identify normal post-operative findings and complications of the following procedures, on chest radiography, 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

Part B. Technical, Communication and Decision-Making Skills:

At the end of the first chest rotation, the resident will demonstrate the following ***technical, communication, and decision-making skills***:

1. Dictate understandable chest radiograph reports that include patient name, patient medical record number, date of exam, date of comparison exam, type of exam, indication for exam, brief and concise description of the findings and short impression
2. Call ordering physicians about all significant or unexpected radiologic findings and document who was called and the date and time of the call in the dictated report
3. Obtain relevant patient history from computer records, dictated reports, or by calling referring clinicians
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 when answering questions for referring clinicians
6. Arrive for the rotation assignment on time and prepared, after reviewing recommended study materials

III. Conferences and study materials

A. Conferences:

The Accreditation Council on Graduate Medical Education (ACGME) and Radiology Residency Review Committee (RRC) require didactic conferences as part of the radiology residency training program. This list is an example of the types of conferences that should be considered for this portion of the curriculum document. Some, such as a chest radiology teaching conference, are mandatory. Others, such as a lung transplantation conference, are not available at all training programs; when available, they should be considered for inclusion in the curriculum document depending on the specifics of the individual training program and medical center. Note, while some of these conferences are sponsored by a Radiology Department, others may be sponsored 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.

- Radiology resident-specific chest radiology teaching conference
- Radiology Grand Rounds

- Pulmonary Medicine conference
- Intensive Care Unit Conference
- Thoracic Oncology Conference
- Cardiothoracic Surgery conference
- Lung Transplantation Conference
- Other

B. Study materials

1. Many types of educational materials may be included in this portion of a curriculum document, including books, book chapters and/or review articles. Hard-copy teaching files (e.g. American College of Radiology or individual department file), computer-based educational programs and radiology education web-sites or teaching files should also be included, as recommended by the residency program director or designated faculty within the subspecialty of chest radiology.

Year 2 (or 2nd 4-week rotation)

I. Goals

After completion of the second chest rotation, the resident will:

1. Demonstrate learning of the knowledge-based learning objectives
2. Continue to build on chest radiograph interpretive skills
3. Develop skills in protocolling, monitoring, and interpreting chest CT scans
4. Demonstrate an understanding of ACR appropriateness criteria for chest radiology

II. Objectives

A. The resident will demonstrate learning of at least two-thirds of the **knowledge-based** objectives listed for Year 1, in addition to the following:

1. Identify the following structures on chest CT and chest MRI:
 - Lungs – right, left, right upper, middle and lower lobes, left upper and lower lobes, lingual
 - Pleura and extrapleural fat
 - Airway – trachea, main bronchi, carina
 - Heart – left ventricle, right ventricle, moderator band, left atrium, left atrial appendage, right atrium, right atrial appendage, mitral valve, aortic valve, tricuspid valve, pulmonary valve, coronary arteries (left main, left anterior descending, left circumflex, right), coronary veins, coronary sinus
 - Pericardium – including pericardial recesses
 - Pulmonary arteries – main, right, left, interlobar, segmental
 - Aorta – ascending, sinuses of Valsalva, arch, descending
 - Arteries – brachiocephalic (innominate), common carotid, subclavian, axillary, vertebral, internal mammary

- Veins – pulmonary, superior vena cava, inferior vena cava, brachiocephalic, subclavian, internal jugular, external jugular, azygous, hemiazygous, left superior intercostal (aortic nipple), internal mammary
 - Bones – ribs, clavicles, scapulae, sternum
 - Esophagus
 - Thymus
 - Thyroid
 - Muscles – sternocleidomastoid, anterior and middle scalene, strap, pectoralis major and minor, deltoid, trapezius, infraspinatus, supraspinatus, subscapularis, latissimus dorsi, serratus anterior
 - Aortopulmonary window
 - Azygoesophageal recess
 - Gastrohepatic ligament, celiac
2. Identify the following additional structures on chest CT:
- Lungs – all lobes and segments; secondary pulmonary lobules
 - Fissures – major, minor, azygous, accessory
 - Airway – lobar and segmental bronchi
 - Inferior pulmonary ligament

B. At the end of the second chest rotation, the resident will demonstrate the following ***technical, communication, and decision-making*** skills, in addition to those listed for Year 1:

1. Appropriately protocol all requests for chest CT, given patient history
2. Monitor all chest CT exams and determine if additional imaging is needed before the patient CT examination is completed
3. Demonstrate the ability to effectively present chest radiology cases in a conference setting to other residents by appropriately selecting cases, interacting with residents, and presenting a brief discussion of the diagnosis for each case
4. Demonstrate the ability to manage an intravenous contrast reaction that occurs during a chest CT examination
5. Act as a consultant for referring clinicians and recommend the appropriate use of imaging studies
6. Describe the principles of chest fluoroscopy, including the assessment of the diaphragm

III. Conferences and Study Materials

A. Conferences – same as for Year 1

B. Study materials:

Compared to the first rotation, more advanced educational resources should be provided for the second rotation in chest radiology. While materials for the first rotation may be books, book chapters or teaching files based primarily on chest radiography, with more advanced rotations primary journal citations, and books, book chapters or teaching files specific to advanced modalities (e.g. chest CT, MR) or interventional chest radiology (e.g. lung biopsy) should be incorporated.

Year 3-4 (3rd 4-week rotation)

I. Goals

After completion of the third chest rotation, the resident will:

1. Demonstrate learning of the *knowledge-based objectives*
2. Refine skills in interpretation of radiographs and chest CT scans
3. Develop skills in protocolling, monitoring, and interpreting HRCT scans
4. Develop skills in protocolling, monitoring and interpreting chest MR studies, including cardiovascular MRI
5. Become a more autonomous consultant and teacher\
6. Correlate pathologic and clinical data with radiographic and chest CT findings

II. Objectives

1. At the end of the third chest rotation or senior year of radiology residency, the resident will demonstrate knowledge of all of the ***knowledge-based*** objectives introduced in Year 1.

A. Technical and communication skills

After completion of the third chest rotation, the resident will demonstrate the following ***technical, communication, and decision-making skills***, in addition to those listed for Years 1 and 2:

1. Dictate accurate, concise chest radiograph, CT scan and MR study reports with at least 75% accuracy; the reports will contain no major interpretive errors
2. State the clinical indications for performing an HRCT examination
3. Correctly protocol all HRCT exams, obtaining inspiratory, expiratory, and prone images when indicated by the clinical history or findings on conventional or helical CT
4. Correctly protocol and understand the technical principles of all chest MR exams, including cardiovascular MR.
5. Describe a chest CT protocol optimized for evaluating each of the following:
 - thoracic aorta and great vessels
 - suspected pulmonary embolism

- tracheobronchial tree
 - suspected bronchiectasis
 - lung cancer staging
 - esophageal cancer staging
 - suspected pulmonary metastases
 - suspected pulmonary nodule on a radiograph
 - shortness of breath
 - hemoptysis
6. Correctly understand the technical principles of all chest MR exams, and describe a protocol optimized for evaluating each of the following:
 - thoracic aorta
 - pulmonary arteries
 - thoracic veins (superior vena cava, brachiocephalic veins)
 - pericardium
 - cardiomyopathy and cardiac tumors
 - ischemic heart disease
 - valvular heart disease
 - right ventricular dysplasia
 - congenital heart disease in an adult
 - superior sulcus tumor
 7. In collaboration with a pathologist, present an interesting cardiopulmonary case, with a confirmed diagnosis, correlating clinical history with pathology and radiologic imaging, to residents and faculty
 8. Work in the reading room independently, assisting clinicians with radiologic interpretation, and teaching other residents and medical students assigned to chest radiology
 9. Perform a lung biopsy with faculty supervision

III. Conferences and Study Materials

- A. Conferences** – same as for Year 1; may require preparation and presentation of radiology materials for multidisciplinary conferences.
- B. Study materials** – In addition to the materials listed for the first two rotations, more detailed technical references should be assigned, whether in books or supplemented by state of the art technical publications in radiology journals.

REFERENCES

1. Graduate Medical Education Directory. American Medical Association 1999. Chicago, IL. pp. 310-313