A CURRICULUM IN CARDIOTHORACIC RADIOLOGY FOR MEDICAL STUDENTS WITH GOALS AND OBJECTIVES

From the Training Committee of the Society of Thoracic Radiology

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Introduction

The Liaison Committee on Medical Education (LCME) is the accrediting body for medical education programs leading to the M.D. degree in the United States and Canada. The LCME Accreditation Standards (http://www.lcme.org/stndtext.htm) state, "The curriculum must provide grounding in the body of knowledge represented in the disciplines that support the fundamental clinical subjects, for example, diagnostic imaging and clinical pathology".

In a survey of 119 directors of medical student education in radiology, 46 (39%) responded to questions regarding the teaching of radiology to medical students at their institution. A core radiology clerkship was required at 13 (29%) of 46 schools responding, and was an elective at 33 (72%) [1]. The number of schools with a required radiology clerkship has not changed since 1994 [2]. The clerkship is given in the 3rd year at 12 (26%) of 46 schools, in the 4th year at 20 (44%), and in either the 3rd or 4th year at 14 (30%) [1]. Twenty-six (57%) of 46 programs have computers in the department that students use during the course, usually shared with residents. Simultaneously reported with these survey results were results from a second survey of directors of medical student education, in which 69 (50%) of 139 responded. Six (9%) of 69 responding programs directed the medical school gross anatomy course, and 14 (20%) taught some portion of the course.

A phone survey showed that a formal dedicated radiology clerkship was a graduation requirement in only 5 (Cornell, Duke, Harvard, University of California at San Francisco, and University of California at Los Angeles) of the 16 top-ranked medical schools in *U.S. News and World Report* [3]. In contrast, a survey of 322 nonradiologist physicians showed that 87% believed formal radiology instruction should be mandatory [4].

Radiology can be taught to medical students through an integrated or an independent curriculum, or a combination of integrated and independent curricula. In an integrated curriculum, radiology faculty provide radiology instruction to medical students rotating through a non-radiology course, or a course that is jointly sponsored by radiology and non-radiology departments. For example, radiologists teach projectional and cross-

sectional imaging to medical students enrolled in a gross anatomy course. Radiologists may give a series of imaging lectures to medical students related to topics medical students are exposed to while on a required medicine clerkship. Collaboration can occur when radiology participates in required introductory to medicine courses, where students are exposed early in medical school to physical examination techniques, history taking, and writing patient notes. These courses may have various titles such as "Introduction to Clinical Medicine" and "Patient, Doctor and Society". Radiology faculty can provide correlative imaging instruction in most courses that students are required to take.

The Alliance of Medical Student Educators in Radiology (AMSER) is a group associated with the Association of University Radiologists whose purpose is to promote radiology as an essential component of the medical student curriculum (http://www.aur.org/amser/). The benefits of having a radiology clerkship as an independent course in medical school include autonomy in curriculum design and implementation, a focused period of time to teach radiology, and ease in accounting of radiology faculty efforts in teaching medical students.

Traditionally, radiology has been taught to medical students during a 2-4 week required, or more often, elective clerkship. Students are taught through didactic lectures, participation at the viewing station, and self-study of reading material, slide-tape programs, and more recently, electronic teaching materials. Problem-based, interactive, small-group learning is employed as a method of teaching at many medical schools. Radiology is a discipline that is well suited to this type of teaching.

The curriculum outlined in this document describes suggested content for medical student instruction in cardiothoracic radiology, and is meant to be one component of an overall radiology curriculum for medical students. Eight goals, each with related objectives, have been identified as important content for students to master by the end of four years of medical school. The curriculum follows a format similar to that of the Society of Thoracic Radiology's curriculum in chest radiology for diagnostic radiology residents [5] (http://www.thoracicrad.org/str99/rescurr/index.htm). The medical student curriculum can be implemented in both integrated and independent programs. Based on specific curriculum requirements and available resources, the curriculum can be modified to meet individual institutional needs.

Goals

I. Understand the basic principles in producing radiologic images of the heart, lungs, mediastinum, pleura, and chest wall

Objectives

A. Identify cardiothoracic examinations with (chest radiography, CT, nuclear medicine ventilation perfusion studies) and without (MRI, ultrasound) exposure to ionizing radiation

B. Describe patient positioning for anteroposterior supine, posteroanterior upright, apical lordotic, lateral, and decubitus chest radiographs

C. State the result of giving intravenous contrast material prior to a chest CT scan (e.g. enhancement of vascular structures), indications for administration of intravenous contrast, contraindications to giving intravenous contrast (e.g. elevated creatinine, previous contrast allergy), and potential complications from giving intravenous contrast (e.g. spectrum of contrast reactions, kidney failure, extravasation)

D. State the approximate costs/charges for a 1-view chest radiograph, 2-view chest radiograph, chest CT with or without intravenous contrast, chest MRI/MRA, and ventilation/perfusion study

II. Understand cardiothoracic anatomy as shown on chest radiographs and chest computed tomography scans

Objectives

A. Identify the following anatomic structures on a posteroanterior (PA) chest radiograph, with 75% or greater accuracy:

1. Lung lobes – right upper, left upper, right middle, right lower, and left lower
2. Fissures – right minor
3. Trachea and carina
4. Heart – right atrial, left atrial, and left ventricular margins
5. Pulmonary arteries – main, right, left, interlobar, left lower lobe, right lower lobe
6. Aorta – ascending, transverse, and descending portions
7. Veins – superior vena cava and azygos

8. Bones – spine, ribs, clavicles, scapulae, humeri, manubrium
9. Aortopulmonary window
10. Lateral costophrenic angles

B. Identify the following anatomic structures on a lateral chest radiograph with 75% or greater accuracy:
   1. Lung lobes – right upper, left upper, right middle, left lower, right lower
   2. Fissures – right major, left major, right minor
   3. Trachea, left upper lobe bronchus
   4. Heart – right ventricular, left atrial, and left ventricular margins
   5. Pulmonary arteries – right and left
   6. Aorta – ascending, transverse and descending portions
   7. Veins – superior and inferior vena cavae
   8. Bones – spine, ribs, scapulae, sternum
   9. Right and left hemidiaphragms
   10. Retrosternal clear space
   11. Posterior costophrenic angles

C. Identify the following structures on chest CT studies with 75% or greater accuracy:
   1. Lung lobes – right upper lobe, left upper lobe, right middle lobe, lingula, right lower lobe, left lower lobe
   2. Pleura
   3. Airway – trachea, carina, right main bronchus, left main bronchus
   4. Heart – right ventricle, left ventricle, right atrium, left atrium
   5. Pericardium
   6. Aorta – ascending, transverse, and descending portions
   7. Pulmonary arteries – main, right, interlobar, left lower lobe, right lower lobe
   8. Arteries – right brachiocephalic, (innominate), left common carotid, left subclavian
   9. Veins – right brachiocephalic, left brachiocephalic, superior vena cava, inferior vena cava, azygos
   10. Bones – ribs, clavicles, scapulae, sternum
   11. Esophagus

12. Thymus
13. Thyroid
14. Muscles – pectoralis major and minor
15. Aortopulmonary window
16. Fissures – right major, left major, right minor
17. Diaphragm

III. Become familiar with the interpretation of cardiothoracic imaging studies

Objectives

A. The student will demonstrate learning of the following objectives with 75% or greater accuracy:
   1. Identify a pneumothorax on an upright chest radiograph and list several causes for this condition
   2. Identify a pneumothorax on a supine chest radiograph and state why the location may be different than on an upright chest radiograph
   3. Identify pneumomediastinum on a chest radiograph and list several causes for this condition
   4. Identify and list several possible causes of collapse of the following as seen on a chest radiograph: right lung, left lung, right upper lobe, right lower lobe, left upper lobe, left lower lobe
   5. Identify lobar consolidation on a chest radiograph and CT scan and list several possible causes for this condition
   6. Differentiate complete opacification of a hemithorax as either pleural effusion, lung collapse, or lung consolidation/mass based on the position of the mediastinum
   7. Describe the different appearances of pleural effusion on a chest radiograph, given differences in patient positioning
   8. Recognize the development of an enlarging pleural fluid collection on a chest radiograph of a patient with pneumonia and suggest the diagnosis of empyema and role of chest CT scanning

9. Identify the findings of left heart failure on a chest radiograph (e.g. enlarged cardiac silhouette, redistribution of vascular flow, enlarged vascular pedicle, Kerley lines, interstitial/alveolar opacities, and pleural effusions)
10. Define, identify, and describe the significance of the silhouette sign on a chest radiograph
11. Identify a malpositioned chest tube, feeding/nasogastric tube, endotracheal tube, pacemaker leads, pulmonary artery catheter, and central venous catheter on a chest radiograph and state the desired location for each
12. Identify a widened mediastinum on a frontal chest radiograph and suggest the diagnosis of aortic injury in a patient involved in trauma, or aortic dissection in a patient with an acute onset of back/chest pain in the absence of trauma
13. Identify pulmonary emphysema on a chest radiograph when the findings of hyperinflation, flattened diaphragms, increased retrosternal clear space, and bullae are present
14. Differentiate lung masses from mediastinal masses on a chest radiograph; state whether a mediastinal mass is in the anterior, middle, or posterior mediastinal compartment; list an appropriate differential diagnosis for a mediastinal mass in each compartment
15. Identify a cavitary mass on a chest radiograph and CT scan and suggest the diagnoses of mycobacterial, fungal, and neoplastic disease
16. Identify an enlarged aorta on a chest radiograph, CT scan, and/or MRI/MRA study and list potential etiologies (e.g. aneurysm, dissection, aortic valve stenosis)
17. Identify enlargement of the cardiac silhouette on a frontal chest radiograph and list potential etiologies (including causes of cardiomegaly and pericardial effusion)
18. Identify a calcified granuloma on a chest radiograph and CT scan and state its clinical significance
19. Identify clots within the central pulmonary arteries on a chest CT scan

B. Define the following terms used in describing cardiopulmonary findings on a chest radiograph and/or CT scan: opacity, lucency, consolidation, atelectasis, nodule, mass, attenuation, enhancement
C. Define high, intermediate, and low probability criteria for acute pulmonary embolism diagnoses based on ventilation/perfusion scans
D. State the importance of having prior cardiopulmonary studies for comparison (e.g. differentiate acute from chronic pulmonary processes, evaluate for resolution of cardiopulmonary abnormalities, assess for benignity or malignancy based on chronicity of findings)

IV. Understand the role of the cardiothoracic radiologist

Objectives

A. List 10 or more persons who commonly consult with a cardiothoracic radiologist, including pulmonologists, family practitioners, internists, cardiothoracic surgeons, cardiologists, radiation oncologists, residents from different specialties, medical students, patients, pathologists, and other radiologists.
B. List the types of circumstances leading to consultation with a cardiothoracic radiologist
C. List the interventional procedures often performed by cardiothoracic radiologists (e.g. percutaneous lung biopsies, placement of chest tubes, and pleural fluid drainage).
D. List the types of interdisciplinary conferences in which cardiothoracic radiologists participate (e.g. cardiothoracic surgery conference, pulmonary medicine conference, lung cancer/tumor conference, intensive care unit conference, lung transplant conference), and explain the role of the cardiothoracic radiologist
E. Demonstrate how to access patient information needed in conjunction with interpretation of cardiothoracic imaging studies
F. Describe the role of CT scanning in the staging of bronchogenic carcinoma
G. 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 thromboembolic disease, including the advantages and limitations of each modality

H. 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

V. Understand the role of quality assurance and quality improvement in cardiothoracic radiology

Objectives

A. Identify upright and supine chest radiographs as suboptimal for interpretation in the following situations:
   1. Low lung volumes
   2. External objects obscuring the lungs and mediastinum
   3. Portions of the lungs not included on the film
   4. Underexposure or overexposure

B. Taking into account medicolegal and patient care considerations, state an appropriate history for ordering a cardiothoracic imaging study (e.g. state signs and symptoms related to the appropriate body part, known diagnoses, and abnormal laboratory values; avoid histories that begin with "rule out" or "suspected")

VI. Understand and apply appropriateness criteria in making decisions regarding cardiothoracic imaging

Objectives

A. State the initial imaging examination of choice for the following clinical conditions:
   1. Shortness of breath, suspected cardiac origin (chest radiograph)
   2. Fever, cough, and elevated white blood cell count (chest radiograph)
   3. Suspected bronchiectasis (chest CT)
   4. Pulmonary nodule seen on a chest radiograph (chest CT)
   5. Staging of bronchogenic carcinoma seen on a chest radiograph (chest CT)
   6. Chest radiograph opacity that does not clear after 2 months treatment for pneumonia (chest CT)

7. Suspected pulmonary embolism (chest radiograph)
8. Blunt trauma, suspected thoracic aortic injury (chest radiograph)
9. Hemoptysis (chest radiograph)
10. Possible pneumothorax related to rib fracture (chest radiograph)
11. Dyspnea, age 40 or older (chest radiograph)
12. Acute asthma, suspected pneumonia or pneumothorax (chest radiograph)
13. Acute exacerbation of chronic obstructive pulmonary disease (chest radiograph)
14. Negative, equivocal or non-specific chest radiograph in HIV+ patient with acute respiratory illness (chest CT)
15. Diffuse opacities on chest radiograph in HIV+ patient with acute respiratory illness (low indication for imaging)
16. Screening for bone and soft tissue sarcoma, renal cell carcinoma, testicular cancer, malignant melanoma, and head and neck carcinoma pulmonary metastases (both chest radiograph and chest CT)
17. Acute chest pain (chest radiograph)
18. Suspected interstitial lung disease on chest radiograph (chest CT)

B. State the indications for obtaining daily chest radiographs in the intensive care unit (e.g. clinical deterioration, mechanical ventilation)
C. State conditions which do NOT require daily chest radiographs in the intensive care unit (e.g. routine follow-up for placement of central venous catheters, pulmonary artery catheters, nasogastric tubes, or chest tubes; stable patients)

VII. Integrate clinical history, imaging findings, and pathology

Objectives

A. Given the appropriate cardiothoracic images, pathologic information, and specific diagnosis, the student will prepare a concise presentation integrating history, imaging findings, differential diagnosis, pathologic correlation, and discussion of the reasons for choosing particular imaging studies

B. Given a clinical scenario of cardiothoracic signs and symptoms, the student will choose the appropriate cardiothoracic imaging study for further work-up
C. Given a clinical scenario of cardiothoracic signs and symptoms and initial imaging studies, the student will discuss the likely diagnoses and appropriate imaging, medical, or surgical management for the following conditions:
    1. Acute chest pain from acute pulmonary embolism
    2. Acute chest pain from acute myocardial infarction
    3. Acute chest pain from aortic dissection
    4. Acute respiratory failure due to adult respiratory distress syndrome
    5. Fever in an immunocompromised host
    6. Fever in an immunocompetent host
    7. Cavitary nodule on a chest radiograph
    8. Pulmonary nodule on a chest radiograph
    9. Pleural effusion on a chest radiograph
    10. Mediastinal mass on a chest radiograph

VIII. Become familiar with cardiothoracic radiology career issues

Objectives

A. Describe the pathway to becoming a cardiothoracic radiologist (e.g. medical school, internship, 4-year radiology residency and 1-year cardiothoracic imaging fellowship)
B. Describe the current job market in cardiothoracic radiology

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