

Cardiothoracic Fellowship Program



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Program Contacts

Name of Host Institutions: National Jewish Health & University of Colorado
Denver – Anschutz Medical Campus

Program Subspecialty: Cardiothoracic Radiology Fellowship

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Other contact numbers

University Hospital

CT Scan Rooms

Anschutz outpatient campus 720-848-1150
720-848-1151

Anschutz inpatient campus 720-848-6346
720-848-6349

MRI Scan Rooms

Anschutz outpatient campus 720-848-1069

Anschutz inpatient campus 720-848-6011

Reading Rooms 720-848-1121
720-848-6004

National Jewish Health

Main Number 303-388-4461
Radiology Front Desk 303-398-1611

CT Scan Room 303-398-1505

MRI Scan Room 303-270-2445
303-270-2440

Reading Rooms

Consult Room-A331 Bay A 303-270-2588
B-read303-270-2594
Bay C 303-270-2575

L Room-A365 Bay A 303-270-2584
Bay B 303-270-2585
Bay C 303-270-2586

Back Room- A361 Bay A 303-270-2583
Bay B 303-270-2582
Bay C 303-270-2581

Introduction

Radiology offers two fellowship positions for a one year duration in cardiothoracic radiology to radiologists having completed a residency in diagnostic radiology. The Cardiothoracic Radiology fellowship program is designed to develop broad-based expertise in all forms of non-invasive cardiothoracic imaging and image processing. Upon completion of the program, fellows will be able to image all forms of chest and cardiovascular disease with appropriate tools and to answer clinical questions with a high degree of expertise and freedom. **This training program is associated with the ACGME-accredited University of Colorado Diagnostic Radiology Residency.**

The fellow will receive training in:

- interpretation of all aspects of thoracic imaging including digital radiography, CT, MRI, and CT guided biopsy
- CT & MRI of heart and nuclear cardiology
- research activities

Training prerequisite: Potential candidates must have completed diagnostic residency in radiology. Fellows in our program must be a U. S. citizen, lawful permanent resident, refugee, asylee, or possess the appropriate documentation to allow them to legally train at the University of Colorado Denver School of Medicine. In addition they must possess a full Colorado Medical License at the onset of their training.

The foreign medical graduate, in addition should have ECFMG certificate and an appropriate visa. Graduate medical education can be contacted for details.
<http://www.ucdenver.edu/ACADEMICS/COLLEGES/MEDICALSCHOOL/EDUCATION/GRADUATEMEDICALEDUCATION/Pages/graduatemedicaleducation.aspx>

Application Deadlines

Beginning with Radiology Fellowships with start dates of July, 2014, Society of Chairs of Academic Radiology Departments (SCARD) resolves that all Fellowships must limit their interviewing season from the beginning of February of the resident's junior year (which would therefore correspond initially to Spring of 2013), and that offers to external candidates not be made until May 1 of the R3 year (corresponding initially to May 1, 2013).

Goals and Objectives of Fellowship:

Overall Program Goals

On completion of this fellowship, the fellow will have an extensive knowledge of the imaging features of diseases of the heart and lung, and the ability to integrate this knowledge with clinical features. He or she will be competent in the selection, interpretation, and performance of examinations and procedures related to cardiothoracic radiology; will have a thorough knowledge of clinical aspects of diseases of the thorax; and will have developed skills for research in the field of cardiothoracic radiology

What Board certification, Certificate of Added Qualification or other formal recognition will trainees be eligible to apply for at the successful completion of training?

No current certification

Fellowship Objectives:

Pulmonary imaging

- Thorough understanding of the application and interpretation of imaging examinations related to the lungs, pleura, mediastinum, and chest wall.
- Basic understanding of principles of pulmonary medicine and pathology.
- Thoracic interventional procedures including biopsies and drainages
- In depth understanding of clinical, radiologic, physiologic, and pathologic correlations in lung disease
- Understanding and implementation of quantitative pulmonary imaging by CT (and, if appropriate MR).

Cardiac imaging

- Understanding of the techniques required for acquisition of high-quality CT and MRI of the heart and cardiovascular system
- Ability to interpret coronary artery CT angiograms, cardiac MRI, and cardiac functional imaging
- Comprehensive assessment of myocardial perfusion, function, viability, and structure by MR
- Cardiac nuclear imaging, including exercise testing
- Comprehensive vascular imaging by MR

Research principles

- Development, implementation, and completion of an independent research project under faculty mentorship
- Understanding of principles of research
- Use of critical thinking in the evaluation of recent literature
- Completion of at least one research paper

Rotation Schedule:

Rotation is on a monthly basis. Rotation focus will alternate between cardiac and pulmonary with one day per week of dedicated to research.

Sample Rotation Schedule

Month	Location
July	NJH
August	UCD
September	NJH
October	UCD
November	NJH
December	UCD
January	UCD
February	NJH
March	UCD
April	NJH
May	NJH
June	UCD

Core Curriculum

We have adopted the revised curriculum suggested by Education Committee of the Society of Thoracic Radiology. The curriculum reflects an appropriate balance of chest radiography, chest CT, chest MRI, and procedural experience.

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. Name 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 (including lingula) and lower lobes
 - Fissures—minor, superior accessory, inferior accessory, azygos
 - 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, truncus anterior
 - Aorta—ascending, arch, descending
 - Veins—superior vena cava, azygos, left superior intercostal (“aortic nipple”)
 - Bones—spine, ribs, clavicles, scapulae, humeri
 - 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 (including lingula) and lower lobes
 - Fissures—major, minor, superior accessory
 - Airway—trachea, upper lobe bronchi, posterior wall of bronchus intermedius
 - Heart—right ventricle, right ventricular outflow tract, left atrium, left ventricle, the location of the four cardiac valves
 - Pulmonary arteries—right, left
 - Aorta—ascending, arch, descending
 - Veins—superior vena cava, inferior vena cava, left brachiocephalic (innominate), pulmonary vein confluence
 - Bones—spine, ribs, scapulae, humeri, sternum
 - Retrosternal line
 - Posterior tracheal stripe
 - Right and left hemidiaphragms

- Raider's triangle
- Brachiocephalic (innominate) artery

Signs in Thoracic Radiology

1. Define, identify and state the significance of the following on a radiograph:

- air bronchogram—indicates a parenchymal process, including nonobstructive atelectasis, as distinguished from pleural or mediastinal processes
- air crescent sign—indicates a lung cavity, often resulting from fungal infection or saprophytic colonization
- deep sulcus sign on a supine radiograph—indicates pneumothorax
- continuous diaphragm sign—indicates pneumomediastinum
- ring around the artery sign (air around pulmonary artery, particularly 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 caused by a central mass, suggesting an obstructing bronchogenic carcinoma in an adult
- luftsichel sign—indicates upper lobe collapse, suggesting an obstructing bronchogenic carcinoma in an adult
- Hampton's hump—pleural-based, wedge-shaped opacity indicating a pulmonary infarct
- silhouette sign—loss of the contour of the heart, aorta or diaphragm allowing localization of a parenchymal process (eg, a process involving the medial segment of the right middle lobe obscures the right heart border, a lingular 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, whereas 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 may 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—opacity 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. 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 patient
 - split pleura sign—a sign of empyema and other inflammatory pleural processes.

Interstitial Lung Disease

1. List and identify on a chest radiograph and chest CT four patterns (nodular, reticular, reticulonodular, and linear) of interstitial lung disease (ILD).
2. Make a specific diagnosis of ILD when supportive findings are present in the history or on radiologic imaging (eg, dilated esophagus and ILD in scleroderma, enlarged heart and a pacemaker or defibrillator in a patient with prior sternotomy and ILD secondary to 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 or alveolar edema, Kerley lines, enlarged azygos vein, increased ratio of artery to bronchus diameter.
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 pneumoconioses.
7. Identify honeycombing on a radiograph and chest CT, state the significance of this finding (end-stage lung disease), and list the common causes of honeycomb lung.
8. Describe 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 and upper lobe predominant distribution of irregular lung cysts or nodules on chest CT of a patient with Langerhans 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 CT.
15. Recognize findings of lymphangioleiomyomatosis on a chest radiograph and CT.
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 CT.

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 acute respiratory distress syndrome.

5. Name four predisposing causes of cryptogenic organizing pneumonia.
6. Suggest a specific diagnosis of ALD when supportive findings are present in the history or on the chest radiograph (eg, 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 ALD 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 (eg, 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 thoracic 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 four types of bronchiectasis and identify each type on a chest CT.
5. Name five common causes of bronchiectasis.
6. Recognize the typical appearance of cystic fibrosis on chest radiography and 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 three types of pulmonary emphysema and identify each type on a chest CT.
11. Recognize alpha-1-antitrypsin deficiency on a chest radiograph and CT.
12. Recognize Kartagener syndrome on a chest radiograph and name the three 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.
15. Recognize and describe the significance of a pattern of mosaic lung attenuation on chest CT. 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 chest radiograph, CT, and MRI.
3. Name the three most common causes of a middle mediastinal mass and localize a mass in the middle mediastinum on a chest radiograph, CT, and MRI.
4. Name the most common cause of a posterior mediastinal mass and localize a mass in the posterior mediastinum on a chest radiograph, CT, and MRI.
5. Name two causes of a mass that straddles the thoracic inlet and localize a mass to the thoracic inlet on a chest radiograph, CT, and 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) of thoracic lymph node enlargement in sarcoidosis.
9. List the four most common etiologies of "egg-shell" calcified lymph nodes in the thorax.
10. Recognize a cystic mass in the mediastinum and suggest the possible diagnosis of a bronchogenic, pericardial, thymic, or esophageal duplication cyst.
11. Recognize the findings of mediastinal fibrosis on chest CT.

Solitary and Multiple Pulmonary Nodules

1. Define the terms pulmonary nodule and 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 cavitory pulmonary nodules.
5. Name four causes of multiple pulmonary nodules.
6. Describe the indications for percutaneous biopsy of a solitary pulmonary nodule.
7. Describe the indications for percutaneous biopsy when there are multiple pulmonary nodules.
8. Describe the complications and the frequency with which complications occur because of percutaneous lung biopsy using CT or fluoroscopic guidance.
9. Describe the indications for chest tube placement as a treatment for pneumothorax related to percutaneous lung biopsy.
10. Describe the role of positron emission tomography in the evaluation of a solitary pulmonary nodule.

11. Describe an appropriate imaging algorithm to evaluate 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. Describe the staging of small-cell lung cancer.
6. Name the four most common extrathoracic sites of metastases for non–small-cell and small-cell lung cancer.
7. Name the stages of non–small-cell lung cancer are potentially resectable.
8. Recognize abnormal contralateral mediastinal shift on a postpneumonectomy chest radiograph and state five possible etiologies for the abnormal shift.
9. Name the most common thoracic locations for adenoid cystic carcinoma 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 or axillary node dissection.
11. Describe the acute and chronic radiographic and CT appearances of radiation injury in the thorax (lung, pleura, pericardium, esophagus) and the temporal relationship to radiation therapy.
12. State the role of MRI in lung cancer staging (eg, chest wall invasion, superior sulcus, Pancoast tumor).
13. Describe the role of positron emission tomography 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. Describe the role of imaging in the staging of esophageal carcinoma.
16. Name the stages of esophageal carcinoma are potentially resectable.
17. Describe the classification of lymphoma, the role of imaging in the staging of lymphoma and the typical and atypical imaging findings of thoracic lymphoma.
18. Define primary pulmonary lymphoma.
19. Describe the typical chest radiograph and chest CT appearances of Kaposi sarcoma.

Thoracic 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 and describe the indirect and direct signs of aortic injury on contrast-enhanced chest CT.

3. Identify and state the significance of chronic traumatic pseudoaneurysm of the aorta on a chest radiograph, CT, or MRI.
4. Identify fractured ribs, clavicle, spine, and scapula on a chest radiograph or 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. Recognize and describe the signs of diaphragmatic rupture on a chest CT.
8. Identify a pneumothorax, pneumopericardium, and pneumomediastinum on a trauma chest radiograph.
9. Identify the fallen lung sign on a chest radiograph or CT and suggest the diagnosis of tracheobronchial tear.
10. Identify a cavitary lesion on a posttrauma radiograph or chest CT and suggest the diagnosis of laceration with pneumatocele formation, hematoma or abscess secondary to aspiration.
11. Name the three most common causes of pneumomediastinum in the setting of trauma.
12. Recognize and distinguish between pulmonary contusion and laceration.

Chest Wall, Pleura, and Diaphragm

1. Recognize and name four causes of a large unilateral pleural effusion on a chest radiograph or 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 chest radiograph or CT and name four likely causes.
4. Recognize pleural calcification on a chest radiograph or CT and suggest the diagnosis of asbestos exposure (bilateral involvement) or old tuberculosis or trauma (unilateral involvement).
5. Recognize the typical chest radiographic appearances of pleural effusion, given differences in patient positioning, and describe the role of the lateral decubitus view to evaluate pleural effusion.
6. Recognize apparent unilateral elevation of the diaphragm on a chest radiograph and suggest aspecific etiology with supportive history and associated chest radiograph findings (eg, subdiaphragmatic abscess after abdominal surgery, diaphragm rupture after trauma, phrenic nerve involvement with lung cancer).
7. Recognize imaging findings suggesting a tension pneumothorax and understand the acute clinical implications.
8. Recognize diffuse pleural thickening, as seen in fibrothorax, malignant mesothelioma, and pleural metastases.
9. Describe and recognize the radiographic and CT findings of malignant mesothelioma.
10. Describe the difference in appearance of a pulmonary abscess and an empyema on chest CT and how the two are differently managed.

11. Distinguish pleural from intraperitoneal fluid on chest CT.

Infection and Immunity

1. Describe the radiographic manifestations of primary pulmonary tuberculosis.
2. Name the most common segmental sites of involvement for postprimary tuberculosis in the lung.
3. Define a Ghon lesion (calcified pulmonary parenchymal granuloma) and Ranke complex (calcified node and Ghon lesion); recognize both on a chest radiograph and CT and describe their significance.
4. Name and describe the types of pulmonary aspergillus disease.
5. Identify an intracavitary fungus ball on chest radiography and CT.
6. Describe the radiographic appearances of cytomegalovirus pneumonia.
7. Name the major categories of disease causing chest radiograph or CT abnormalities in the immunocompromised patient.
8. Other than bacterial infection, name two important infections and two important neoplasms to consider in patients with AIDS and chest radiograph or CT abnormalities.
9. Describe the chest radiograph and CT appearances of *Pneumocystis carinii* (jiroveci) pneumonia
10. Name the four most important etiologies of hilar and mediastinal lymphadenopathy in patients with AIDS.
11. Describe the time course and chest radiographic appearance of a blood transfusion reaction.
12. Describe the radiographic appearances of mycoplasma pneumonia.
13. Describe the chest 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 and the specific geographic regions where they are found, and describe their radiographic manifestations.
16. Name the most common pulmonary infections seen after solid-organ (ie, liver, renal, lung, cardiac) and bone marrow transplantation.
17. Describe the chest radiographic and CT findings of posttransplant lymphoproliferative disorders.

Unilateral Hyperlucent Hemithorax

1. Recognize a unilateral hyperlucent hemithorax on a chest radiograph or CT.
2. Identify the common causes for unilateral hyperlucent hemithorax on a chest radiograph.
3. Give an appropriate differential diagnosis when a hyperlucent hemithorax is seen on a chest radiograph, and suggest a specific diagnosis when certain associated findings are seen (ie, absence of a breast in a patient after mastectomy, absence of a pectoralis muscle in a patient with Poland 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 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 radiograph.
3. Recognize a mass in the posterior segment of a lower lobe on a chest radiograph and CT and suggest the possible diagnosis of pulmonary sequestration.
4. Describe the differences between intralobar and extralobar sequestration.
5. Recognize bronchial atresia on a chest radiograph and CT and name the most common lobes in which it occurs.

Pulmonary Vasculature

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 on a chest radiograph and suggest the diagnosis of pulmonary arterial hypertension.
3. Name five common causes of pulmonary arterial hypertension.
4. Recognize lobar and segmental pulmonary emboli on chest CT and chest MRI (including magnetic resonance angiography).
5. Define the role of ventilation-perfusion scintigraphy, chest CT, chest MRI/MRA, CT venography, and lower extremity venous ultrasound studies in the evaluation of a patient with suspected venous thromboembolic disease, including the advantages and limitations of each modality depending on patient presentation.
6. Describe the anatomy of and identify the right and left superior and inferior pulmonary veins on chest CT and MRI and the use of radiofrequency ablation of pulmonary veins for treatment of atrial fibrillation.
7. Recognize variations in pulmonary venous anatomy, such as a separate right middle lobe vein and common ostium of the left superior and inferior pulmonary veins.

Thoracic Aorta and Great Vessels

1. State the normal dimensions of the thoracic aorta.
2. Describe the classifications of aortic dissection (De-Bakey I, II, III; Stanford A, B) and implications for classification on medical versus surgical management.
3. Describe 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
 - pulsation artifact at aortic root
4. Recognize a right aortic arch and a double aortic arch on a chest radiograph, chest CT, and chest MRI.
 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 chest radiograph and 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”), and separate origin of vertebral artery from arch on CT and MRI/MRA.
 9. Define the terms aneurysm and pseudoaneurysm.
 10. Describe the cardiac anomalies commonly associated with aortic coarctation.
 11. Describe and identify the findings of Takayasu arteritis on chest CT and chest MRI.
 12. Describe 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, MRI, and CT:
 - right coronary artery
 - left main coronary artery
 - left anterior descending coronary artery
 - left circumflex coronary artery
 - obtuse marginal
 - diagonals
 - acute marginals
 - septal perforators
2. Describe the clinical significance of coronary arterial calcification on a chest radiograph.
3. Recognize coronary arterial calcification on CT and describe the current role of coronary artery calcium scoring with helical or electron beam CT.
4. Name the coronary artery that 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 indicating each.
6. Describe the common late complications of myocardial infarction, including ischemic cardiomyopathy, left ventricular aneurysm, left ventricular pseudoaneurysm, coronary-cameral fistula, dyskinesis, and akinesis, and recognize radiologic findings indicating each.
7. Identify signs of left heart failure on a chest radiograph and CT.
8. Define ejection fraction, including the normal value for left ventricular ejection fraction.

9. Identify myocardial calcification on CT and describe the etiology and significance of this finding.
10. Describe the difference between a left ventricular aneurysm and pseudoaneurysm.
11. Define and identify myocardial bridging on CT.
12. 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 as well as stunned myocardium and hibernating myocardium versus areas of infarction, including the advantages and limitations of each modality.
13. Differentiate viable from nonviable myocardium on MRI.
14. Identify myocardial perfusion defects on MRI.
15. Calculate right and left ventricular volumes, including ejection fraction, stroke volume, end-diastolic volume, and end-systolic volume using MRI and CT.

Myocardial Disease

1. Define the types of cardiomyopathy (dilated, hypertrophic, restrictive) and list the common causes of each.
2. Define right ventricular dysplasia, describe the role of MRI in its diagnosis, and identify MRI findings that support the diagnosis.
3. Name the most common benign primary cardiac tumors, including myxoma, lipoma, fibroma, and rhabdomyoma.
4. Name the most common malignant primary cardiac tumors, including angiosarcoma, rhabdomyosarcoma, and lymphoma.
5. Distinguish cardiac tumor from thrombus on CT and MRI.
6. Name the most common malignancies to metastasize to the heart, and describe the appearance on a chest radiograph, chest CT and chest MR
7. Describe the advantages and disadvantages of echocardiography, CT, and MRI for evaluation of cardiomyopathy and cardiac tumors.
8. Recognize calcification of papillary muscles as distinct from myocardial calcifications and describe the significance of each.

Cardiac Valvular Disease

1. Identify and describe the findings of each on a chest radiograph:
 - enlarged right atrium
 - enlarged left atrium
 - enlarged right ventricle
 - enlarged left ventricle
2. Describe and recognize the chest radiograph findings associated with each of the following valvular diseases:
 - mitral regurgitation
 - mitral stenosis
 - aortic regurgitation
 - aortic stenosis
 - tricuspid regurgitation

3. Recognize an enlarged ascending aorta and aortic valve calcification on a chest radiograph and suggest the diagnosis of aortic stenosis when these findings are present.
4. Recognize an enlarged left atrium, vascular redistribution, and mitral valve calcification on a chest radiograph and suggest the diagnosis of mitral stenosis when these findings are present.
5. State the most common etiologies of the following:
 - aortic stenosis
 - aortic regurgitation
 - mitral stenosis
 - mitral regurgitation
 - tricuspid regurgitation
 - pulmonary stenosis
6. Name the cardiac diseases associated with mitral annulus calcification
7. Identify endocarditis or complications of endocarditis on a chest radiograph, CT, and MRI.
8. Describe the advantages and disadvantages of echocardiography and MRI for evaluation of valvular heart disease.
9. Describe the pulse sequences and appropriate planes for evaluating cardiac valvular disease and making quantitative measurements including pressure gradients, regurgitant fractions, and valve areas.

Pericardial Disease

1. Recognize pericardial calcification on a chest radiograph and CT and name the most common causes.
2. Describe and identify two chest radiographic signs of a pericardial effusion.
3. Name five causes of a pericardial effusion.
4. Describe and recognize the findings of each of the following on a chest radiograph, CT, and MR:
 - pericardial cyst
 - constrictive pericarditis
 - pericardial hematoma
 - pericardial metastases
 - partial and complete absence of the pericardium
 - pneumopericardium
5. Describe the role of MRI in diagnosing constrictive pericarditis and differentiating constrictive pericarditis from restrictive cardiomyopathy.

Congenital Heart Disease in the Adult

1. Recognize increased vascularity and decreased vascularity on a chest radiograph and name the common causes of each.
2. Describe and recognize the following on a chest radiograph, CT, 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 the 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
- Coronary artery anomalies

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. Describe and identify on chest radiography the normal appearance and complications associated with each of the following:

- endotracheal tube
- central venous catheter
- peripherally inserted central venous catheter
- pulmonary artery catheter
- feeding tube
- nasogastric tube
- chest tube
- intra-aortic balloon pump
- pacemaker generator and leads (including triplelead devices)
- automatic implantable cardiac defibrillator
- left ventricular assist device
- atrial septal defect closure device
- pericardial drain
- extracorporeal life support cannulae
- intraesophageal manometer, temperature probe or pH probe
- tracheal, bronchial or esophageal stent

2. Explain how an intra-aortic balloon pump works.

3. Describe the venous anatomy and expected course of veins from the axillary vein to the right atrium relative to anatomic landmarks.

4. Recognize the difference between a skinfold and pneumothorax on a portable chest radiograph.

Postoperative thorax

1. Identify normal postoperative 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 transplantation
- heart transplantation
- lung volume reduction surgery.

Fellow's Responsibilities

Reading Room Duties

When not involved in a procedure, the fellow is responsible for participating in the daily workings of the Cardiothoracic radiology clinical service, including supervision of the residents. At times, in order to assure timely completion of work volumes, readouts may be conducted simultaneously with the attending on 1st review. Other times the fellow will be given ample time to pre-read the cases before reviewing them with an attending. Dictations should be performed with voice recognition, unless otherwise directed. After the 1st three months of training, the fellow may be asked to pre-dictate cases before finalizing the reports with an attending radiologist..

ER cases. All ER cases need their results called immediately upon study completion. Cases may be revised during attending review. ER physicians should be informed that interpretations are preliminary, when an attending physician is not immediately available. Note on the request who you spoke with and when. Fellow do this when checking cases as well. Jot down the impression he communicated to ordering physician, or pre-dictate the case using voice recognition.

Late cases. When urgent or emergent cases are in progress or pending at the end of a work day, please be sure that a responsible party (on-call or CT-call resident) will report the results to the ordering physician.

Protocols: All protocols for scheduled MR and CT procedures should be completed at least one day before the procedure. Two days is preferred, so that the ordering physician can be contacted with any questions before the patient arrives in the department. Check each morning to see if there are added cases that require protocols. The residents and fellows should attempt to protocol all studies first, then consult the attending with any questions. A protocol checklist should be provided with each case. The lists of protocols and protocol parameters are provided at the end of this manual.

The cardiothoracic radiology fellow can utilize the diagnostic radiology resident in assisting with protocols, procedures, etc., dependant on the resident's skill and knowledge level.

Noon coverage. This will be shared between the fellow and attendings. Your pager must be turned on and quickly answered for ER cases, if you leave the reading area.

Resources

The cardiothoracic section is staffed exclusively by sub specialist cardiothoracic radiology attending physicians that guide and supervise the program. There is a dedicated radiology technologist that performs post processing of all cardiac studies.

Teaching staff

Program Director: David A Lynch, MB

Key faculty members (all fellowship trained)

John D Armstrong, MD

Kern Buckner, MD

Jonathan Chung, MD

Christian Cox, MD

Debra Dyer, MD

Brett Fenster, MD

Andrew Freeman, MD

Valerie Hale, MD

Darlene Kim, MD

Robert Quaife, MD

Nicole Restauri, MD

Peter Sachs, MD

Joyce Schroeder, MD

Thomas Suby-Long, MD

Howard Weinberger, MD

Program Coordinator/Administrative Support

Tanya Mann

Facilities

Facilities and resources available to residents including:

- The fellowship will be based at National Jewish Health and University of Colorado Hospital.
- Availability and diversity of patient population: At National Jewish there is a diverse population of outpatients with respiratory and cardiac disease, while at UCH there is a more general population of patients requiring chest imaging studies, with particular emphasis on thoracic oncology, and cardiothoracic surgical issues. UCH and National Jewish are currently implementing major expansions of their cardiothoracic imaging facilities, including Coronary CT angiography, ultrasound, Cardiac MRI, and nuclear imaging. An interventional

thoracic radiology service is provided at UCHSC, and also planned for NJH.

- Volume of cases:
 - UCD
 - Pulmonary imaging
 - Plain films 100-150/day
 - CT 15-25/day
 - High resolution CT 5/day
 - Cardiac imaging
 - MRI 8-10/week
 - Coronary/cardiac CT 5-10/week
 - Nuclear imaging 5-10/day
 - NJH
 - Pulmonary imaging
 - Plain films 30/day
 - CT 45/day
 - High resolution CT 35/day
 - Cardiac imaging
 - MRI 5-8/week
 - Coronary/cardiac CT 2-3/week
 - Nuclear imaging 5/day
- Equipment
 - UCD
 - CT
 - Philips 16 and 64 Brilliance detector scanners (used to perform coronary angiogram)
 - Siemens 16 and 64 Sensation slice scanners
 - MRI
 - Two Siemens 1.5T scanners
 - One GE 3T HDx magnet
 - Philips 1.5T scanner
 - Nuclear medicine
 - Siemens PET-CT scanner
 - 2 SPECT scanners
 - Fluoroscopy
 - Available if needed
 - Ultrasound
 - Available if needed
 - Image analysis
 - Dedicated image analysis - Vitrea
 - NJH
 - CT

- Siemens Definition Dual Source64 detector CT scanner
- Siemens AS 128 detector CT scanner
- MRI
 - Siemens Avanto 1.5T scanner
- Nuclear Medicine
 - Siemens Biograph PET-CT scanner
 - 2 SPECT scanners
- Fluoroscopy
 - Available if needed
- Ultrasound
 - Available if needed
- Image analysis
 - Dedicated image analysis stations

Library Facilities

Library services and facilities are available through both institutions. Fellows have privileges at the University of Colorado Denver-Anschutz Medical Campus and the Tucker Medical Library at National Jewish Health. Between the two libraries, fellows have online access to all major radiology journals, some electronic books, medical databases, and STATdx Radiology. Both facilities are conducive to quiet study and research, including WiFi connections for laptops. Librarians are available to consult on computerized MEDLINE searching and other publications issues. Article linking and full document delivery services are available. The Imaging Departments in both institutions have their own library which complements these services with a comprehensive selection of imaging books, journals and teaching files.

Laboratories

- Quantitative Imaging Lab at NJH. Access to patient databases at NJH for research purposes.

Office

- Office space and computer are provided.

Educational Program

Educational conferences:

Name of Conference	Day(s) Scheduled	Length (hours)	Specific Location
NJH			
Gastroenterology	3 rd Monday	1 hr	A431
Occupational Medicine	Tuesday	.5 hour	A431
Chest Surgery Conference	Thursday	1 hr	Heitler Hall
Thoracic Surgery	Thursday	45 min.	Heitler Hall
Pulmonary Grand Rounds	Thursday	1 hr	Heitler Hall
Radiology Rounds	Thursday	1 hr	A431
Radiology/Cardiology Rounds	3 rd Thursday	1 hr	A431
Interstitial Lung Disease	Thursday	1.5 hr	A431
Mycobacterial Disease	Friday	1 hr	A431
UCD			
Tumor Board	Monday	1 hr	UCD
Transplant Conference	Tuesday, Thursday	.5 hr	UCD
ProvenCase Conference	Wednesday	1 hr	UCD
Daily Case Conference	M-F	.5 hr	UC
Monthly Case Conference	varies	1 hr	UCD

National Jewish Health

- ***Gastroenterology Conference***
A monthly conference that features GI cases presented by radiologists and gastroenterologist.
- ***Occupational Disease Conference***
A weekly joint conference between Thoracic Radiology and the occupational medicine to discuss diagnosis and management of patients with occupational exposures.
- ***Chest surgery Conference***

Discussion of surgery cases from VA, University of Colorado, Denver Health with interpretation given by NJH radiologists.

- ***Pulmonary Grand Rounds***
A weekly conference presented by the Department of Pulmonary and Critical Care Medicine, including case presentation and invited lecturers.
- ***Interstitial Lung Disease Conference***
A weekly conference held among sections of chest radiology and interstitial lung disease. Once a month the focus is changed to include the Radiology Pathology Conference which discusses the important findings on cases that have been seen over the last few months.
- ***Infectious Disease Conference (aka TB Conference)***
The fellows are expected to present cases along with chest medicine fellows and discuss the outcome of treatment in TB patients.
- ***Cardiology/Radiology Rounds***
A monthly conference based on interesting cases encountered in clinical medicine and their course
- ***Radiology Rounds***
A weekly conference giving radiologists an opportunity to share and discuss interesting cases.

University of Colorado Denver

- ***Tumor Board Conference***
A weekly conference presented by the Thoracic Oncology Conference at which the diagnosis and management of lung, esophageal and other thoracic tumors are discussed.
- ***Transplant conference***
Film review in Transplant Clinic of all patients being seen that day.
- ***Proven Case Conference***
A weekly conference at which unknown cardiac and thoracic cases are presented to residents for discussion of findings.
- ***Monthly Resident Case Conference***
A monthly conference for all residents of interesting cases collected on the service. The fellow will be expected to prepare 2-3 of these (with help from the staff).
Daily Case Conference
30 minute case or subject review for the residents and fellow on the Thoracic rotation

Education Policy

Fellows have \$1500 to spend towards:

- Conferences – air travel, registration fees are arranged and paid directly by the University. Fellows are reimbursed for hotel, parking, taxi (need original receipts) and paid a per diem rate for meals.
- Books – Educational books
- Not covered – software or electronic devices.

If the fellows present a paper at a national conference, they are provided with educational leave and financial support to attend.

Research:

All fellows are provided ample opportunity and facilities for research and are expected to complete and present their work at an annual scientific meeting, as well as publish their findings in peer-reviewed literature. The multidisciplinary teams described above work together to deliver outstanding clinical care, offering extensive opportunities for research.

Duty Hours

Policy

The program policy on duty hours for residents follows the intent and language found in the Accreditation Council for Graduate Medical Education (ACGME) guidelines addressing this topic and is consistent with policy adopted by the Graduate Medical Education Committee. The program director and faculty monitor the demands of at-home call and make scheduling adjustments as necessary to mitigate excessive service demands and/ or fatigue.

Duty hours

- a. Duty hours are defined as all clinical and academic activities related to the fellowship program, i.e, patient care (inpatient and outpatient), administrative duties related to patient care, the provision of transfer of patient care, time spent in-house during call activities and scheduled academic activities such as conferences. Duty hours do not include reading and preparation time spent away from the duty site.
- b. Duty hours are limited to <80 hours per week, averaged over a four-week period, inclusive of all in-house call activities.
- c. Fellows must be provided with 1 day in 7 free from all educational and clinical responsibilities, averaged over a four-week period, inclusive of call. One day is defined as one continuous 24-hour free from all clinical, educational and administrative activities.
- d. Adequate time for rest and personal activities must be provided. This consists of a 10-hour time period provided between all daily duty periods and after in-house call. This will involve weekend day shift but only during the 6 months of University rotation. The number of shifts commensurate with other staff and fellows. There is no mandatory evening or night shift call only beeper call during the week associated with the assigned weekend.

Evaluation

Fellows are evaluated quarterly and receive written evaluation forms which are reviewed with the program director. The fellow also completes quarterly reviews of the program and faculty. Sample evaluation forms are listed in the appendix.

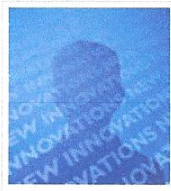
The fellow is assessed on the 6 categories of “competencies” as set forth by the ACGME outcome project. These consist of the following categories:

- Patient care
- Medical knowledge
- Practice-based learning and improvement
- Interpersonal and communication skills
- Professionalism
- Systems-based practice

Table of Appendices

Appendix A Fellow Evaluation Form

Appendix A



[Subject Name]
 [Subject Status]
 [Subject Program]
[Subject Rotation]
 [Evaluation Dates]

Evaluator
[Evaluator Name]
[Evaluator Status]
[Evaluator Program]

Please score by indicating at what level the fellow is operating, and where within that level the fellow's performance falls.

MEDICAL KNOWLEDGE - Residents should be knowledgeable, scholarly, and committed to lifetime learning.

Refers to understanding of relevant clinical and scientific concepts and the ability to apply those concepts.

OUTSTANDING = [9] [8] [7]

Able to correctly protocol studies and appropriately modify protocols according to pathology. Correctly triages procedures. Correctly prepares patients for interventions. Conducts, patient consultations, consents and post-procedure follow-up. Increasing skill level in procedures. Exceeds expectations.

GOOD = [6] [5] [4]

Not fully conversant with the criteria for protocols. Needs work on patient consultation, consents and postprocedure follow-up. Meets expectations

NEEDS IMPROVEMENT = [3] [2] [1]

Basic inability to assess patient condition in order to optimize patient care. Technical skills not at Residency level. Does not meet expectations



PATIENT CARE - Residents should provide compassionate, appropriate, and effective care for health problems and should make efforts to promote health.

Gathers essential and accurate patient information. Develops a diagnostic plan. Oversees diagnostic imaging. Counsels patients and families. Understands impact of ionizing radiation, contra-indications to MRI and correctly manages contrast rxns.

OUTSTANDING = [9] [8] [7]

Able to make decisions to modify a procedure when unexpected pathology abnormalities occur, then follows through with performance and supervision of procedure. Adjusts decisions based on patient condition pre- or post-procedure.

GOOD = [6] [5] [4]

Not fully able to handle emergencies or unexpected findings during procedures. Often re-directed on decisions regarding patient condition pre- and post-procedure.

NEEDS IMPROVEMENT = [3] [2] [1]

No evidence of progressing in ability to relate knowledge of anatomy, procedures and processes to patient care. Fails to consult with attending on decisions regarding patient condition pre- and post-procedure.



PROFESSIONALISM - Residents should be altruistic and accountable, and adhere to principles of medical ethics by respecting and protecting patient's best interests.

Refers to reliability and commitment to patient care, and ability to interact well with other members of the patient care team. Demonstrates altruism, compassion, honor and integrity. Develops appropriate speed, work ethic and productivity levels.

OUTSTANDING = [9] [8] [7]

Performs duties conscientiously and enthusiastically and reports where and when scheduled. Interested, motivated and engaged in the profession. Target productivity levels met. Does not complain when duties require staying beyond 5:00pm.

GOOD = [6] [5] [4]

Performs duties willingly and without complaint. Generally works well with others. Needs to be prompted to follow up on ideas or problems.

NEEDS IMPROVEMENT = [3] [2] [1]

Avoids duties and/or complains often. Must be told what and how to do each task.



PRACTICE-BASED LEARNING AND IMPROVEMENT - Residents should investigate and evaluate patient care practices, and appraise and assimilate scientific evidence in order to improve their practices

Analyzes and performs practice-based improvement in cognitive knowledge, observation, formulating a synthesis and impression, and procedure skills. Demonstrates critical assessment of scientific literature; knowledge of evidence-based medicine in practice; use of multiple learning sources; facilitation of education for students, peers, other professionals. Participates in QA.

OUTSTANDING = [9] [8] [7]

Participates in critical assessment of scientific literature through Journal Club, conferences and teaching files. Good didactic lectures. Teaches students, peers and other professionals. Makes significant contribution to QA and Qi.

GOOD = [6] [5] [4]

Not fully participant in Journal Club or teaching files. Peripherally involved in teaching students, peers and other professionals. Participates in QA and Qi activities.

NEEDS IMPROVEMENT = [3] [2] [1]

Does not participate in Journal Club, constructs no teaching files. Demonstrates no assessment of scientific literature. Does not participate in teaching. Does not participate in QA and Qi activities.



SYSTEMS BASED PRACTICE - Residents should understand healthcare practice.

Understands the role and is competent in the use of computers, radiology information systems, physics support, risk management, film room and PACS System. Demonstrates a knowledge of, and applies appropriate criteria and other cost-effective healthcare principles to professional practice.

OUTSTANDING = [9] [8] [7]

Utilizes departmental resources appropriately. Has a good understanding of the purpose of extra-departmental resources. Uses online resources to assist decisions regarding patient care. Appropriately protocols studies.

GOOD = [6] [5] [4]

Able to use online and radiology information systems resources but hesitant about extra-departmental support. Fails to use Clinical Workstation to review patient records, path and laboratory results. Fails to use visible human lab to improve anatomic understanding.

NEEDS IMPROVEMENT = [3] [2] [1]

No evidence of the use of technology to assist in patient care. Unclear on the proper function of radiology information systems and extra-departmental support.



INTERPERSONAL/COMMUNICATION SKILLS - Residents should communicate and teach effectively.

Able to relate to other personnel including peers, faculty, support staff, referring physicians and other housestaff members. Is proficient in the consultative role. Skillfully obtains informed consent.

OUTSTANDING = [9] [8] [7]

Excellent interaction with ancillary personnel. Good understanding of the diverse nature of the healthcare environment. Able to consult with referring physicians. Works well as member of a team.

GOOD = [6] [5] [4]

Good interaction with faculty, other attendings, and peers but appears uncomfortable in dealing with technologists, nurses, support staff and patients.

NEEDS IMPROVEMENT = [3] [2] [1]

Neutral, negative, or even abusive to colleagues and/or staff. Received complaints from patients or staff.



COMMENTS

Is this resident deficient in any way to warrant review by the Education Committee?

Yes No N/A

Comments

Remaining Characters: 5000

Overall Comments:

Remaining Characters: 5000