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MGH Thoracic and Cardiac Imaging Fellows are trained and mentored in the 6 general competencies put forward by the ACGME. Throughout this document, the following abbreviations for the specific competencies are used:

**Patient care and Procedural Skills (PC)**

**Medical knowledge (MK)**

**Interpersonal/communication skills (ICS)**

**Practice-based learning and improvement (PBLI)**

**Professionalism (PROF)**

**Systems-based practice (SBP)**
GOAL OF FELLOWSHIP TRAINING
The goal of the MGH Cardiothoracic Fellowship program is for fellows to acquire the knowledge, skills and efficiency to become outstanding thoracic and cardiothoracic radiologists. This includes thoracic intervention, thoracic and cardiac imaging interpretation, consultation, teaching and research.

GENERAL ASPECTS OF TRAINING

FELLOWSHIP DURATION AND DIRECTORS
The MGH Cardiothoracic Imaging fellowship is 12 months in duration. This consists of 9 months in the Division of Thoracic Imaging under the direction of Dr. Jo-Anne Shepard; and 3 months in the Division of Cardiac Imaging under the direction of Drs. Brian Ghoshhajra and Udo Hoffman.

PROGRAM FACULTY

Thoracic Faculty

Jo-Anne O. Shepard, M.D.
Program Director, Cardiothoracic Imaging Fellowship
Director, Thoracic Imaging and Intervention
Matthew D. Gilman, M.D.
Associate Director, Cardiothoracic Imaging Fellowship
Gerald F. Abbott, M.D.
Jeanne B. Ackman, M.D.
Garry Choy, M.D.
Subba R. Digumarthy, M.D.
Florian Fintelmann, M.D.
Efren Flores, M.D.
Mannudeep Kalra, M.D.
Shaunagh McDermott, M.D.
Theresa C. McLoud, M.D.
Victorine V. Muse, M.D.
John Patti, M.D.
Milena Petranovic, M.D.
Melissa C. Price, M.D.
Richard Sacknoff, M.D.
Amita Sharma, M.D.

Cardiovascular Faculty

Udo Hoffman, MD, MPH
Division Chief, Cardiac Imaging
Brian Ghoshhajra, MD, MBA
Section Chief, Cardiac CT and MRI, Program Director Cardiothoracic Imaging Fellowship
Nina Meyersohn, M.D.
Associate Cardiovascular Program Director
George Oliveira, MD
Co-director, Cardiovascular Imaging
PROGRAM CONTENT

The cardiothoracic imaging fellowship provides the environment for acquiring the knowledge (MK), interpretive skills (MK), procedural skills (PC), clinical judgment (MK), and professionalism (PROF) essential to the practice of cardiothoracic imaging. The program emphasizes the role of the cardiopulmonary imager as consultant (PC) and the need to communicate effectively with referring physicians (ICS). Additionally, fellows will increase their knowledge, teaching skills and skills in conducting research (MK, ICS, PBLI).

Clinical Experience (PC, MK, PBLI, SBP)

Imaging Modalities Available

Trainees will be exposed to a high volume and large variety of the common and uncommon thoracic and cardiac diseases encountered in academic clinical practice. The Cardiothoracic fellowship gives exposure and training in all cardiopulmonary imaging modalities including:

- Outpatient chest radiography
- Inpatient chest radiography
- Critical care chest radiography (Medical ICU, Surgical ICU, Cardiac Surgical ICU, Cardiac ICU, Neuro ICU, Burn ICU)
- Chest Fluoroscopy
- Thoracic CT
- High Resolution Chest CT
- Pulmonary CTA
- Thoracic PET/CT
- Thoracic MRI
- PET/MR
- Cardiac Calcium Scoring
- Cardiac CTA
- Cardiac MRI
- 3D CT and MR reconstruction

The fellows rotate through the variety of clinical imaging services of the Divisions of Thoracic and Cardiac Imaging which include:
Outpatient Chest
Inpatient Chest
Thoracic CT
PET/CT
Thoracic MRI
Cardiac CT
Cardiac MRI

On these rotations fellows will increase their knowledge and experience in the interpretation, proper reporting, consultative skills, and overall knowledge of the common and uncommon diseases presenting to Massachusetts General Hospital (PC, MK, ICS, PROF). Fellows will also receive didactic and clinical instruction on thoracic imaging protocols and radiation control (PC, MK, SBP).

Intervention (PC, MK, ICS, PROF)
Fellows will rotate through the Thoracic Intervention rotation which performs thoracic biopsy and thoracic radiofrequency ablation. Thoracic biopsies are performed on a variety of benign and malignant lung lesions, mediastinal masses, chest wall lesions and occasionally pleural lesions. Fellows will learn all aspects of thoracic intervention including:

1. The indications for thoracic procedures, procedural risks, benefits and alternatives to the procedure.
2. Patient selection, appropriate use of pertinent pre-procedural tests, and the relative/absolute contraindications of each procedure.
3. How to effectively obtain informed consent and adhere to institutional universal “time out” procedural protocols.
4. How to monitor sedation/analgesia, plan an appropriate biopsy approach, recognize pertinent anatomic landmarks, appropriately execute the biopsy, appropriately obtain samples (cytology, core biopsy and microbiology specimens), and recognize intra-procedural complications.
6. How to effectively communicate with patients and provide appropriate follow up and discharge instructions.

Consultative Skills (PC, ICS, PROF, SBP)
In addition to interpretive and procedural skills, fellows are mentored to be expert consultants in thoracic and cardiac imaging. Fellows will learn to perform imaging consultations with primary care physicians thoracic and cardiac subspecialists with increasing independence through the fellowship year. Through this experience, the fellow will learn to become the leader of the health care team with respect to the thoracic and cardiac imaging of the patient. Fellows also rotate with staff at the Medical Thoracic Oncology Clinic intake clinic (Yawkey 7) which provides intensive experience in image consultation. Later in the year, fellows may also rotate with staff in ICU rounds.

Academic and Nonclinical Activities

Conferences (PC, MK, ICS, PBLI, PROF, SBP)
Care of patients with cardiothoracic diseases often requires a multidisciplinary approach. Fellows will learn to actively participate in multidisciplinary conferences in conjunction with imaging staff and
members of other specialties; ultimately learning to lead the imaging discussion of the patient. MGH Cardiothoracic Imaging fellows participate in a number of clinical and didactic conferences including:

THORACIC IMAGING CLINICAL CONFERENCES (PC, MK, ICS, PBLI, PROF, SBP)

- **Thoracic Imaging Conference**
  Weekly conference prepared by the Thoracic CT resident of current interesting thoracic CT and thoracic MRI cases. The outstanding case material serves as an excellent resource for didactic teaching of residents and fellows.

- **Interstitial Lung Disease Rad-Path Conference**
  A bi-weekly conference presented jointly by the Pulmonary Medicine, Thoracic Radiology and Pulmonary Pathology Services. Interesting Interstitial Lung Disease cases are presented with clinical, radiology and pathology correlation.

- **ICU Rounds**
  Daily ICU rounds with Thoracic Radiologists and ICU staff in Medical, Surgical and Cardiac Intensive Care Units.

- **PET-CT Conference**
  A monthly conference presented to discuss chest and abdominal PET-CT cases.

- **Thoracic Surgical Conference**
  A weekly conference presented by the Thoracic Surgical Service at which radiological correlation and patient management of thoracic surgical conditions are discussed.

- **Medical Thoracic Oncology 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.

- **Pulmonary Medicine Conference**
  A weekly conference in which the Pulmonary service reviews radiology studies on their inpatients.

- **Pulmonary Grand Rounds**
  A weekly conference presented by the Department of Pulmonary and Critical Care Medicine, including case presentation and invited lecturers.

- **Infectious Disease Conference**
  A conference presented jointly by Radiology and the Infectious Disease Services. Interesting Infectious Disease cases are presented with radiology correlation.

- **Cytology Conference**
  A quarterly conference during which interesting biopsy cases are reviewed. The indications, technique and cytology results of thoracic biopsy are reviewed with radiology and pathology in attendance. This conference provides an excellent opportunity to see the yield, usefulness of thoracic fine needle aspiration and core biopsy.

THORACIC IMAGING DIDACTIC CONFERENCES (PC, MK, PBLI)

- **Thoracic and Cardiac Mini-Courses**
  A total of two months of noon lectures focused on Thoracic and Cardiac Imaging. This series of lectures is given to the residents, fellows and staff of Mass General. Several expert grand rounds speakers are invited as visiting professors.

- **Resident Thoracic Case Conference**
Every Tuesday morning resident case conference in which the staff present teaching cases to the Mass General Radiology residents. Fellows may participate in the teaching of residents later in the fellowship year.

- **Post-Graduate Chest Course**
  This post-graduate course is presented jointly by the Departments of Radiology at Massachusetts General Hospital and Brigham and Women's Hospital. This course is held every other year in November in even years. Internationally renowned speakers traditionally visit as guest lecturers.

CARDIAC IMAGING CLINICAL CONFERENCES (**PC, MK, PBLI**)

- **Cardiac MR/CT Conference**
  This conference presented by the Division of Cardiac Imaging presents the interesting cardiac CT and MR cases of the last week.

- **Cardiac Catheterization Conference**
  This conference is focused on cardiac catheterization and when available, the correlative cross sectional imaging is also reviewed.

- **Congenital Heart Disease Conference**
- **Cardiology Grand Rounds**
- **Thoracic Aortic Center Rounds**

Teaching Experience (**MK, ICS, PBLI**)  
Fellows are mentored to develop their skills as teacher/educator during fellowship. Opportunities are available to teach medical students, residents, nurses, and members of other medical or surgical disciplines. These opportunities to teach may occur during case readout, as case review sessions, seminars, teaching conferences, board review sessions, and prepared lectures. Fellows will be asked to organize and present one or more relevant lectures during their fellowship year, usually during the thoracic mini course.

Fellows also collect digital teaching file cases throughout the fellowship year (**MK, PBLI**). These cases are added to the cumulative department fellow teaching file which the fellows may access throughout the fellowship year. These cases are invaluable teaching material for future medical students, residents, and fellows in training. The process of collecting case material also serves as an excellent way to learn cardiothoracic imaging.

For fellows accepting post fellowship teaching positions, mentorship on how to develop a resident curriculum, teaching material and organization of a cardiothoracic teaching section is available (**PBLI**).

Research Experience (**MK, PBLI**)  
Opportunities for scholarly activity mentored by fellowship faculty are available to fellows in both the thoracic and cardiac divisions. Opportunities for scholarly activity include educational exhibits, clinical communications, reviews, book chapters, and original research. Fellows are encouraged to participate in original research projects that involve data collection, statistical analysis, and interpretation of results. This work would optimally progress to authorship of a manuscript, presentation at a national meeting, and submission to a peer reviewed journal. This process allows the fellow to learn the methods of scientific investigation and gain the skills necessary to prepare a scientific manuscript.
Journal Review (MK, PBLI)

Fellows have access to the current literature through electronic journals in Treadwell library. Fellows are mentored and encouraged to keep abreast of the current literature in the major journals.

Lecture/Presentation Experience (MK, ICS, PBLI)

Fellows are mentored to organize and present one or more relevant lectures during their fellowship year, usually during the thoracic mini course. Fellows are also mentored to submit and present their scholarly activity at national meetings.

Quality Assurance (QA)/Practice Related Issues (SBP)

To gain exposure to the practical issues of radiology health care delivery, fellows are encouraged to attend the monthly Department Risk Management conferences during their fellowship year. If desired, fellows may perform a Performance Quality Improvement project during their fellowship year. Fellows also participate in the daily Divisional “Grapevine” peer review conferences.

EVALUATION OF TRAINEES (PBLI)

Formal written evaluation of fellow progress and final competence is performed for training program documentation, future credentialing and certification. Every 3 months, formal written evaluations are completed by all cardiothoracic staff members detailing fellow progress in the general competencies evaluated by the ACGME:

See trainee evaluation, appendix 1

Every 4 months, face to face meetings are scheduled with the Fellow and the Fellowship Directors. The purpose of this meeting is to provide verbal feedback regarding progress, mentoring, suggestions for continued improvement and career counseling.

EVALUATION OF TRAINING PROGRAM AND FACULTY

Each fellow completes anonymous written evaluations of the entire faculty and the program as a whole every 6 months. These evaluations are reviewed by the program director.

See faculty evaluation, appendix 2

See program evaluation, appendix 3

In the quarterly face to face meetings with the Fellowship Directors, the fellow is asked to provide verbal feedback regarding the quality of training, whether fellowship training objectives are being met, and any suggestions for improvement.

CASE AND PROCEDURAL TRACKING

The thoracic office will keep a record of the procedures fellows perform. This information is helpful for fellows while they are at MGH and may become required information for future employment and credentialing. Large volume procedures such as chest radiographs, chest CTs, PET/CT examinations, and
thoracic MRI will be tracked through automated RIS searches. To ensure complete tracking of exams in
which there may be multiple contributors, fellows are required to keep manual procedure logs of:

- Contrast enhanced cardiac CT
- Calcium scoring
- BOTH calcium scoring and contrast enhanced CT
- Cardiac MRI
- Lung Biopsy
- Radiofrequency Ablation
KNOWLEDGE BASED OBJECTIVES (MK)

The following list contains material pertinent to cardiac and thoracic imaging practice. This document is not intended to be an inclusive list of all thoracic and cardiac diseases, but rather a guide for education. It is recognized that not all patient populations and modalities will be available at all training locations. If a training program finds it impractical to provide clinical experience in an important topic either on site (or at a neighboring institution), instruction may be considered in lecture, conference, syllabus, video/DVD, reading material or other format.

THORACIC TOPICS

- Benign and Malignant Neoplasms of the Thorax
  - Lung cancer:
    - Preinvasive conditions: atypical adenomatous hyperplasia
    - Non small cell lung cancer, small cell carcinoma, adenocarcinoma in situ/minimally invasive adenocarcinoma (formerly known as bronchoalveolar cell carcinoma), invasive adenocarcinoma, neuroendocrine tumors, other forms of lung cancer
    - Staging system update for non small cell lung cancer
    - Standard treatment regimens
  - Mediastinal tumors (see mediastinum)
  - Esophageal cancer
  - Lymphoma
  - Thoracic sarcomas
  - Patterns of metastastic disease, lymphangitic carcinomatosis
  - Hamartoma/mesenchymoma
  - Plasma cell granuloma
  - Other benign tumors
- Trachea
  - Tracheal neoplasms
  - Tracheal stenosis: idiopathic, post traumatic, M. tuberculosi
  - Benign tracheal diseases: relapsing polychondritis, tracheopathia osteochondroplastica, papillomatosis, amyloid, Wegener granulomatosis, sarcoidosis
  - Tracheobronchomalacia
- Interstitial Lung Disease
  - Usual interstitial pneumonia (UIP)
  - Nonspecific interstitial pneumonia (NSIP)
  - Connective tissue disease: rheumatoid arthritis, scleroderma, systemic lupus erythematosi, polymyositis/dermatomyositis, mixed connective tissue disease, Sjogren syndrome, ankylosing spondylitis
  - Hypersensitivity pneumonitis
  - Smoking related interstitial lung disease: respiratory bronchiolitis, respiratory bronchiolitis interstitial lung disease, desquamative interstitial pneumonitis, Langerhan cell histiocyosis
  - Cryptogenic organizing pneumonia
  - Sarcoidosis
Cystic Lung Disease: Langerhans Cell Histiocytosis, lymphangioleiomyomatosis (LAM), lymphocytic interstitial pneumonia (LIP), amyloid, light chain deposition disease, follicular bronchiolitis, Birt Hogg Dubé, tuberous sclerosis

- **Emphysema:**
  - Centrilobular, paraseptal, panlobular, alpha 1 anti trypsin deficiency, giant bullous emphysema

- **Airways Disease**
  - Bronchiolitisasis
  - Large airways disease: bronchiectasis (cylindrical, varicose, cystic), Mounier-Kuhn Syndrome, cystic fibrosis, Williams-Campbell syndrome
  - Small airways disease: obliterative bronchiolitis, diffuse panbronchiolitis, cellular bronchiolitis, bronchocentric granulomatosis

- **Pleural Disease**
  - Pleural effusion: including empyema, parapneumonic effusion, complicated parapneumonic effusion
  - Pleural infection (including tuberculosis)
  - Pleural Tumors/Masses: mesothelioma, pleural metastasis, fibrous tumor of the pleura, lymphoma, lipoma
  - Pneumothorax: primary, secondary, bronchopleural fistula
  - Hemothorax
  - Chylothorax
  - Asbestos related pleural disease: asbestos related pleural effusion, pleural plaques, diffuse pleural thickening, mesothelioma
  - Splenosis

- **Mediastinal Disease**
  - Pneumomediastinum
  - Thymic Lesions: normal thymus, thymic hyperplasia, thymoma, thymic carcinoma, thymic lymphoma, neuroendocrine tumors of the thymus, thymolipoma, thymic cyst
  - Lymphoma
  - Germ cell tumors: teratoma, seminoma and non seminomatous germ cell tumors
  - Sarcomas of the mediastinum
  - Mediastinal cysts: bronchogenic, foregut duplication, pericardial, thymic cyst
  - Sarcoidosis
  - Castleman disease
  - Lymphangioma
  - Mediastinitis: acute and chronic/fibrosing
  - Neurogenictumors: neurofibroma, schwannoma, ganglioneuroma, paraganglioma
  - Thyroid and parathyroid lesions of the mediastinum
  - Hernias: hiatal hernia, gastric volvulus, Bochdalek and Morgagni hernias

- **Infections of the Lung, Mediastinum and Pleura**
  - Bacterial: staph, strep, gram negative, anaerobic, anthrax, rickettsia, Chlamydia, mycoplasma, septic emboli
  - Viral: influenza, respiratory syncytial virus, adenovirus, emerging viral infections (eg. SARS and H1N1), varicella, etc.
  - Fungal: histoplasmosis, Cryptococcus, coccidiomycosis, blastomycosis, aspergillus (invasive aspergillosis, airway invasive aspergillosis, chronic necrotizing aspergillosis, mycetoma)
  - Mycobacteria: M. tuberculosis and atypical mycobacteria
- Nocardiosis
- Actinomycosis
- Mucormycosis
  - Parasitic: echinococcus, paragonimiasis, strongyloides, schistosomiasis
- The Immunocompromised Patient (Neutropenia and HIV/AIDS)
  - Human Immunodeficiency Virus (HIV) and acquired immunodeficiency syndrome (AIDS)
    - Thoracic manifestations
    - Infection: bacterial, fungal, viral, pneumocystis jiroveci, tuberculosis, atypical mycobacteria
    - Malignancy and lymphoproliferative disease: Kaposi sarcoma, lymphoma, other primary tumors
    - Immune restoration syndrome
    - Highly active antiretroviral therapy (HAART) and implications for imaging
  - Other forms of immunocompromise:
    - Neutropenic infection: bacterial, fungal, viral, pneumocystis jiroveci
    - Common variable immunodeficiency, agammaglobulinema and imaging manifestations
- Pulmonary Vascular Diseases
  - Pulmonary embolism: acute, chronic, pulmonary infarction
  - Non-thrombotic pulmonary emboli: tumor embolism, talcosis
  - Pulmonary arterial hypertension: causes and imaging manifestations
  - Eisenmenger syndrome
  - Inflammatory diseases of the pulmonary arteries: Takayasu disease, Behcet’s disease
  - Pulmonary artery aneurysm/pseudoaneurysm: post infectious, post traumatic and other
  - Pulmonary artery neoplasms: pulmonary artery sarcoma
  - Pulmonary capillary hemangiomatosis
  - Pulmonary arteriovenous malformation (AVM)
  - Pulmonary veno-occlusive disease
  - Hepatopulmonary syndrome
- Occupational Lung Disease
  - Asbestos: asbestosis, asbestos related pleural disease (exudative effusion, pleural plaques, diffuse pleural thickening, mesothelioma), round atelectasis
  - Silica
  - Coal worker’s pneumoconiosis
  - Mineral dust disease
  - Beryllium
  - Hard metals
  - Aluminum dust
  - Hypersensitivity pneumonitis (occupational)
  - Agricultural: organic toxic dust syndrome, silo filler’s disease
- Critical Care/Intensive Care Unit Imaging
  - Tubes, lines, support devices
  - Pulmonary edema: hydrostatic edema, permeability caused by diffuse alveolar damage (DAD), permeability edema without DAD, mixed hydrostatic and permeability edema
  - Unusual causes of pulmonary edema: TRALI (transfusion related acute lung injury), drugs (e.g. all-trans retinoic acid agents), neurogenic, high altitude, re-expansion, amniotic fluid emboli
  - Nosocomial pneumonia
- Acute Respiratory Distress Syndrome
- Diffuse pulmonary hemorrhage
- Aspiration: acute and chronic
- Barotrauma
- Advanced devices: extracorporeal membrane oxygenation (ECMO), aortic conduits, cardiac assist devices

- **Drug and Radiation Induced Diseases of the Lung**
  - Radiation pneumonitis
  - Patterns of drug induced interstitial lung disease: fibrosis, cryptogenic organizing pneumonia (COP), pulmonary edema, diffuse alveolar damage, obliterative bronchiolitis
  - Specific drugs: Amiodarone, Bleomycin, Busulfan, nitrofurantoin, epidermal growth factor receptor (EGFR) inhibitors

- **Immunologic and Miscellaneous Diseases**
  - Eosinophilic lung disease: acute and chronic
  - Allergic bronchopulmonary aspergillosis
  - Pulmonary Vasculitis: leukocytoclastic vasculitis, Churg Strauss
  - Sarcoïdosis
    - Manifestations: lymph node, lung parenchymal, airway, pleural, bone
    - Radiographic staging
    - Diagnosis
    - Complications
  - Manifestations of connective tissue disease
    - Rheumatoid Arthritis: interstitial lung disease, necrobiotic nodules, airways disease, obliterative bronchiolitis, pulmonary vascular, pleural manifestations
    - Systemic lupus erythematosus: pleural disease, pericardial disease, interstitial lung disease, lupus pneumonitis, pulmonary hemorrhage, pulmonary vascular disease, diaphragm dysfunction
    - Scleroderma: interstitial lung disease, esophageal disorders, pulmonary vascular disease, calcinosis
    - Polymyositis/Dermatomyositis: interstitial lung disease, pulmonary vascular disease, diaphragmatic myositis, calcinosis
    - Sjogren syndrome: interstitial lung disease, lymphocytic interstitial pneumonia (LIP), follicular bronchiolitis, lymphoma

- Amyloidosis
  - Systemic: types, imaging manifestations
  - Localized: tracheobronchial amyloidosis, parenchymal nodular amyloidosis, parenchymal alveolar amyloidosis

- Pulmonary Alveolar Proteinosis
- Pulmonary alveolar microlithiasis
- Neurocutaneous syndromes: neurofibromatosis, tuberous sclerosis complex (chest wall, mediastinal, lung parenchymal involvement)

- **Congenital Diseases of the Thorax**
  - Airway: bronchial atresia, congenital lobar overinflation, tracheal bronchus, cardiac bronchus, situs abnormalities
  - Lung: hypoplasia, agenesis, congenital pulmonary airway malformation, pulmonary sequestration (intralobar and extralobar sequestration)
• Vascular: Scimitar syndrome, anomalous pulmonary venous return (total and partial), proximal interruption of the pulmonary artery, arteriovenous malformation (AVM), pulmonary sling
  • Cysts: bronchogenic, esophageal duplication cyst

• Thoracic Trauma
  o Tracheobronchial Injury
  o Lung parenchymal injury (contusion and laceration)
  o Post traumatic pleural disease (hemothorax, pneumothorax)
  o Vascular injuries (aorta and great vessels)
  o Cardiac Injury
  o Diaphragmatic injury
  o Skeletal injuries

• Transplant Imaging
  o General transplant complications: rejection, infection, post transplant lymphoproliferative disease (PTLD), malignancy
  o Lung transplantation: unique complications including patterns of rejection, surgical failure, airway stenosis
  o Heart transplantation: unique complications including patterns of rejection, surgical complications
  o Bone marrow transplantation
    ▪ Complications: temporal occurrence post transplant (1st month, early, late)
    ▪ Infection
    ▪ Pulmonary hemorrhage
    ▪ Patterns of rejection and graft versus host disease
  o Pulmonary complications of extrathoracic organ transplantation (e.g. renal, liver)

• Post Operative Chest
  o Lung cancer related procedures: thoracotomy, video assisted thoracic surgery (VATS), muscle flaps (intercostal muscle, serratus muscle), fat pads (omentum, pericardial), cervical mediastinal exploration, Chamberlain procedure
  o Esophageal cancer related procedures: Ivor Lewis esophagectomy, left thoracotomy, transhiatal esophagectomy, minimally invasive esophagectomy
  o Cardiac devices: pacers, implantable cardioverter defibrillator (ICD)/biventricular pacers, septal occlusion devices, stent grafts, ventricular assist devices
  o Surgical complications: sternal dehiscence, bronchial dehiscence, bronchopleural fistula, gastric tip necrosis, esophageal leak, tracheo-esophageal fistula, cardiac herniation, cardiac torsion, lobar torsion, post pneumonectomy syndrome
  o Lung Transplant: technique and post operative appearance
  o Heart Transplant: orthotopic vs heterotopic technique, post operative appearance

• Thoracic Positron Emission Tomography (PET)
  o Lung Cancer
  o Esophageal cancer
  o Lymphoma
  o Sarcoma
  o Metastatic disease
  o Mesothelioma
  o Post transplant lymphoproliferative disease
  o PET in inflammatory diseases

• Thoracic Magnetic Resonance Imaging (MRI)
o Mediastinal mass evaluation
o Pleural evaluation: pleural mass, mesothelioma, diaphragm and chest wall invasion
o Hilar evaluation
o Chest wall evaluation for lung cancer staging

CARDIAC TOPICS

- Thoracic Aorta
  o Congenital disorders: coarctation, pseudocoarct, double aortic arch, right aortic arch
  o Aortic aneurysms and psuedoaneurysms
  o Acute aortic syndromes: dissection, intramural hematoma, penetrating ulcer
  o Trauma: traumatic aortic and great vessel injury
  o Inflammatory aortic diseases: aortitis, mycotic aneurysms
  o Connective tissue disease: Marfan syndrome, Ehler Danlos, cystic medial necrosis
- Cardiac Anatomy
  o Normal anatomy: coronary arteries, cardiac venous anatomy, pulmonary venous anatomy, cardiac chambers, papillary muscles, moderator/parietal bands
  o Pericardium
  o Sinuses of valsalva
  o Great vessel anatomy
- Cardiac Physiology and Measurements
  o Cardiac cycle and function: systole, diastole, systolic and diastolic ventricular function
  o Preload and afterload
  o Cardiac measurements: ejection fraction, stroke volume, left ventricular mass, gradient calculation (Bernoulli equation G=4V²), Qp/Qs ratio, normal cardiac chamber pressures, normal pulmonary pressure, normal cardiac chamber measurements, normal aortic valve area
  o Eisenmenger physiology
- Cardiac CT and MR
  o Levels of Training
  o Assessment of Function
- Coronary Arteries
  o Variant anatomy
  o Myocardial bridging
  o Anomalous origins of coronary arteries
  o Coronary artery aneurysms (e.g. Kawasaki Disease)
- Ischemic Heart Disease
  o Coronary calcium assessment
  o Coronary artery disease including stenosis assessment
  o Acute and chronic infarction
  o Microvascular obstruction
  o Transmural and non-transmural infarction
  o Ventricular septal rupture
  o Papillary muscle dysfunction
- Myocardial Disease
  o Hypertrophic cardiomyopathy
  o Restrictive cardiomyopathy
  o Arrhythmogenic right ventricular cardiomyopathy/dysplasia
- Dilated cardiomyopathy
- Takotsubo cardiomyopathy
- Myocarditis
- Infiltrative disease (sarcoidosis and amyloidosis)
- Left ventricular noncompaction
- Ventricular aneurysms: true and false
- Ventricular diverticulum

- **Cardiac Valvular Disease**
  - Mitral valve: stenosis and insufficiency
  - Aortic valve: stenosis, insufficiency, bicuspid aortic valve
  - Tricuspid valve
  - Pulmonic valve: stenosis and insufficiency
  - Prosthetic valves: mechanical and bioprosthetic
  - Endocarditis
  - Carcinoid heart

- **Pericardial Disease**
  - Pericardial cyst
  - Pericarditis
  - Constrictive pericarditis
  - Pericardial absence: partial and complete
  - Malignant pericardial disease
  - Pericardial effusion, hemopericardium, pneumopericardium, tamponade

- **Congenital Heart Disease**
  - Atrial septal defect, patent foramen ovale, ventricular septal defect, patent ductus arteriosus, Tetralogy of Fallot
  - Truncus arteriosus
  - Ebstein anomaly
  - Heterotaxy syndrome
  - Transposition of the great vessels
  - Tricuspid atresia
  - Hypoplastic left heart
  - Anomalous pulmonary venous return: complete and partial
  - Atrioventricular canal (AV Canal) Defects

- **Cardiac Tumors and Tumor Like Conditions**
  - Atrial myxoma
  - Angiosarcoma
  - Lymphoma
  - Cardiac metastases
  - Cardiac rhabdomyoma
  - Fibroma
  - Paragangioma
  - Lipomatous hypertrophy of the interatrial septum
  - Lipoma
  - Cardiac thrombus
  - Papillary fibroelastoma

- **Postoperative Heart and Great Vessels**
  - Coronary artery bypass graft (CABG) anatomy
  - CT of coronary artery bypass grafts
Post CABG complications (including aneurysm and pseudoaneurysm)
Coronary artery stent imaging: in stent restenosis
Post op valvular anatomy
Atrial septal defect (ASD)/patent foramen ovale (PFO) closure devices
Left ventricular apical aortic conduit
Endovascular aortic aneurysm repair (EVAR): normal imaging appearance, complications, endoleak evaluation and categorization
Aortic and cardiac aneurysm repair
Post operative appearance after congenital heart surgeries (e.g. Hemi-Fontan, Fontan, Ross, Rastalli, Norwood, Jantene, Mustard and Blalock-Taussig)
Cardiac herniation and torsion

Pharmacology of Drugs Given During Cardiac Exams
Indications, contraindications, drug interactions, pharmacology, dose, mode of administration and monitoring of patients
Beta blockers, calcium channel blockers, nitroglycerine, dobutamine, adenosine

**TECHNICAL ISSUES**

Radiation dose in cardiothoracic imaging: thoracic CT, cardiac CT, chest radiography, PET
Understand the data of the radiation dose report
Understand computed tomography dose index (CTDI), dose length product (DLP), tissue weighting factors and effective dose
Radiation dose reduction techniques in thoracic and cardiac CT

Thoracic Computed Tomography (CT) Protocols
Acquisition parameters: mA, kV, pitch, thickness, collimation, detector configuration, gantry rotation speed, dose modulation techniques, reconstruction algorithm/kernel, etc.
Intravenous (IV) contrast administration, contraindications and premedication
IV contrast enhancement and injection techniques for routine chest, pulmonary CTA and aortic CTA: injection rate, contrast delay, bolus tracking techniques, saline chaser
Routine Chest CT protocol
High resolution chest CT (HRCT) protocol: including targeted reconstruction, expiratory and prone imaging
Pulmonary CT angiography (CTA) protocol
Aortic CTA protocol
Lung cancer screening and low dose chest CT protocol
Specialty protocols: airway imaging, thoracic outlet, 3D reconstruction techniques
Reconstructions: multiplanar reformations (MPR), maximum intensity projection (MIP)
Quality control in thoracic CT

Thoracic Magnetic Resonance Imaging (MR) protocols
MR safety
MR contrast administration and contraindications
Acquisition parameters
Mediastinal mass MR protocol
Pleural evaluation MR protocol
Hilar evaluation MR protocol
Chest wall evaluation for lung cancer staging MR protocol
- Quality control in thoracic MR

- Cardiac Computed Tomography (CT) protocols
  - Acquisition parameters: mA, kV, pitch, thickness, collimation, detector configuration, gantry rotation speed, dose modulation techniques, reconstruction algorithm/kernel, etc.
  - Cardiac CT contrast administration, contraindications and premedication
  - Reconstruction techniques, MPR, curved reconstruction, MIP, 3D reconstructions
  - Cardiac CTA protocols: retrospective and ECG tube modulation
  - Calcium scoring protocol
  - Pulmonary vein protocol
  - Quality control in cardiac CT

- Cardiac Magnetic Resonance Imaging (MR) protocols
  - MR safety
  - MR contrast administration and contraindications
  - Acquisition parameters
  - Cardiomyopathy protocols (including hypertrophic obstructive cardiomyopathy, arrhythmogenic right ventricular dysplasia, sarcoidosis, amyloidosis)
  - Cardiac mass protocol
  - Myocardial function and viability protocol
  - Myocarditis protocol
  - Function and valvular assessment protocol
  - Pericardial/pericardial constriction protocol
  - Congenital heart disease evaluation protocol
  - Coronary magnetic resonance angiography (MRA) protocol
  - Aortic MRA protocol
  - Pulmonary vein magnetic resonance venography (MRV) protocol
  - Cardiac shunt evaluation protocol
  - Quality control in cardiac MR

- Chest Radiography: computed radiography (CR) and digital radiography (DR)
  - Technique, patient positioning
  - Acquisition parameters, post processing techniques
  - Radiation dose
  - Quality control in CR and DR

- Thoracic Positron Emission Tomography (PET)
  - Technique and acquisition parameters
  - Pre procedure patient preparation and assessment
  - Quality control in PET imaging
REFERENCES


