# Table of Contents

**GENERAL ASPECTS OF TRAINING** .................................................................................................................. 5

**FELLOWSHIP DURATION AND DIRECTORS** .............................................................................................. 5

Program Faculty ........................................................................................................................................ 5

**Program Content** ........................................................................................................................................... 6

Clinical Experience (PC, MK, PBLI, SBP) ..................................................................................................... 6

Imaging Modalities Available ................................................................................................................ 6

Intervention (PC, MK, ICS, PROF) .......................................................................................................... 7

Consultative Skills (PC, ICS, PROF, SBP) ................................................................................................. 7

**Academic and Nonclinical Activities** ......................................................................................................... 7

Conferences (PC, MK, ICS, PBLI, PROF, SBP) ......................................................................................... 7

Teaching Experience (MK, ICS, PBLI) ..................................................................................................... 9

Research Experience (MK, PBLI) ........................................................................................................... 10

Journal Review (MK, PBLI) ................................................................................................................... 10

Lecture/Presentation Experience (MK, ICS, PBLI) ............................................................................... 10

Evaluation of Trainees (PBLI) ...................................................................................................................... 10

Evaluation of Training Program AND Faculty .............................................................................................. 10

Case and Procedural Tracking ..................................................................................................................... 11

**Curriculum in Cardiovascular Radiology** ..................................................................................................... 12

**KNOWLEDGE BASED OBJECTIVES (MK)** ....................................................................................................... 19

**THORACIC TOPICS** ................................................................................................................................... 19

- Benign and Malignant Neoplasms of the Thorax ........................................................................ 19
- Trachea ........................................................................................................................................ 19
- Interstitial Lung Disease .............................................................................................................. 19
- Emphysema: ................................................................................................................................ 20
- Airways Disease .......................................................................................................................... 20
- Pleural Disease ............................................................................................................................ 20
- Mediastinal Disease ..................................................................................................................... 20
- Infections of the Lung, Mediastinum and Pleura ........................................................................ 20
- The Immunocompromised Patient (Neutropenia and HIV/AIDS) .............................................. 21
- Pulmonary Vascular Diseases ........................................................................................................... 21
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational Lung Disease</td>
<td>21</td>
</tr>
<tr>
<td>Critical Care/Intensive Care Unit Imaging</td>
<td>21</td>
</tr>
<tr>
<td>Drug and Radiation Induced Diseases of the Lung</td>
<td>22</td>
</tr>
<tr>
<td>Immunologic and Miscellaneous Diseases</td>
<td>22</td>
</tr>
<tr>
<td>Congenital Diseases of the Thorax</td>
<td>22</td>
</tr>
<tr>
<td>Thoracic Trauma</td>
<td>23</td>
</tr>
<tr>
<td>Transplant Imaging</td>
<td>23</td>
</tr>
<tr>
<td>Post Operative Chest</td>
<td>23</td>
</tr>
<tr>
<td>Thoracic Positron Emission Tomography (PET)</td>
<td>23</td>
</tr>
<tr>
<td>Thoracic Magnetic Resonance Imaging (MRI)</td>
<td>23</td>
</tr>
<tr>
<td>CARDIAC TOPICS</td>
<td>24</td>
</tr>
<tr>
<td>Thoracic Aorta</td>
<td>24</td>
</tr>
<tr>
<td>Cardiac Anatomy</td>
<td>24</td>
</tr>
<tr>
<td>Cardiac Physiology and Measurements</td>
<td>24</td>
</tr>
<tr>
<td>Cardiac CT and MR</td>
<td>24</td>
</tr>
<tr>
<td>Myocardial Disease</td>
<td>24</td>
</tr>
<tr>
<td>Cardiac Valvular Disease</td>
<td>25</td>
</tr>
<tr>
<td>Pericardial Disease</td>
<td>25</td>
</tr>
<tr>
<td>Congenital Heart Disease</td>
<td>25</td>
</tr>
<tr>
<td>Cardiac Tumors and Tumor Like Conditions</td>
<td>25</td>
</tr>
<tr>
<td>Postoperative Heart and Great Vessels</td>
<td>25</td>
</tr>
<tr>
<td>Pharmacology of Drugs Given During Cardiac Exams</td>
<td>26</td>
</tr>
<tr>
<td>TECHNICAL ISSUES</td>
<td>26</td>
</tr>
<tr>
<td>Radiation dose in cardiothoracic imaging: thoracic CT, cardiac CT, chest radiography, PET</td>
<td>26</td>
</tr>
<tr>
<td>Thoracic Computed Tomography (CT) Protocols</td>
<td>26</td>
</tr>
<tr>
<td>Thoracic Magnetic Resonance Imaging (MR) protocols</td>
<td>26</td>
</tr>
<tr>
<td>Cardiac Computed Tomography (CT) protocols</td>
<td>27</td>
</tr>
<tr>
<td>Cardiac Magnetic Resonance Imaging (MR) protocols</td>
<td>27</td>
</tr>
<tr>
<td>Chest Radiography: computed radiography (CR) and digital radiography (DR)</td>
<td>27</td>
</tr>
<tr>
<td>Thoracic Positron Emission Tomography (PET)</td>
<td>27</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>28</td>
</tr>
</tbody>
</table>
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, Nina Meyersohn, and Sandeep Hedgire.

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.
Subba R. Digumarthy, M.D.
Florian Fintelmann, M.D.
Mannudeep Kalra, M.D.
Brent Little, 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, Cardiovascular Imaging
Brian Ghoshhajra, MD, MBA
Service Chief, Cardiovascular Imaging
Nina Meyersohn, M.D.
Program Director, Cardiovascular Imaging Fellowship
Sandeep Hedgire, MD
Associate Program 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
- Dual Energy thoracic and cardiac CT and CTA
- 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 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. These outstanding cases serve 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.

- **Thoracic Fellow Conference**
A series of didactic fellow level lectures conducted by thoracic imaging staff in the first 6 months of the fellowship.

- **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)**

- **Structural/TAVR Rounds** (weekly Dept. Surgery Conference Room Cox 6)
- **Adult Congenital Heart Disease multidisciplinary clinical conference** (weekly Yawkey 4-810)
- **Cardiology Cath Conference** (weekly Haber Room Blake 1)
  This conference is focused on cardiac catheterization and when available, the correlative cross-sectional imaging is also reviewed.
- **Cardiac MR/PET/CT Program Research Lab Meeting** (weekly 175 CRP Large Conference Room)
- **Cardiac MR/CT Clinical Case Teaching Conference** (Robbins 244A)
  This conference presented by the Division of Cardiac Imaging presents the interesting cardiac CT and MR cases of the current week.
- **Cardiology Grand Rounds** (weekly O’Keeffe Auditorium Blake 1)
- **Vascular Case Conference** (weekly Cardiovascular area, Dodd Reading Room)
- **Thoracic Aorta Center (TAC) Rounds** (monthly Bigelow Amphitheater White 4)
- **Congenital Heart Disease case review** with cardiology fellows, as needed (weekly Cardiovascular area, Dodd Reading Room)

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

- **Cardiac and Cardiothoracic Fellow Conference**
  A series of didactic fellow level lectures on various cardiac imaging topics in the first several months of the fellowship.
- **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.

**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 are instructed to 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. A formal journal club is conducted in the thoracic minicourse. Fellows have access to a selected library of journal articles stored on the fellowship sharepoint site.

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.
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
- Microwave Ablation and Cryoablation
Curriculum in Cardiovascular Radiology

The Cardiac radiology curriculum is designed for trainees to obtain appropriate training in cardiac CT and MRI. Evaluation of trainee knowledge, skill and overall performance, including fostering an appropriate professional attitude is performed. Interpersonal interactions, image interpretation and technical competence in addition to the ACGME core competencies are assessed. Objectives related to specific competencies are labeled in this document as follows: medical knowledge (MK), Patient care (PC), professionalism (P), interpersonal/communication skills (ICS), practice based learning and improvement (PBLI) and systems based practice (SBP).

Goals

The trainee will be able to:
1. Demonstrate learning of the knowledge-based objectives (MK)
2. Demonstrate learning of the clinical indications for obtaining cardiac CT and MRI (MK, PC).
3. Communicate effectively with referring clinicians and supervisory staff (ICS)
4. Obtain pertinent patient information relative to radiologic examinations (PC)
5. Understand standard patient imaging protocols in cardiac CT and MRI, including ECG gating and triggering (PC, MK)
6. Apply adequate retrospective gating parameters for CT raw data processing. (MK)
7. Understand and perform post processing of CT and MRI source images. (MK)
8. Accurately and concisely dictate a cardiac CT or MRI report (PC, ICS).

Objectives

At the end of the cardiac rotations, the trainee will demonstrate learning of the following interpretative skills and knowledge-based objectives (A) and technical skills, communication skills and decision making skills (B): (MK, PC, PBLI, ICS)

A) Medical knowledge-based objectives (MK)

Normal Anatomy
1. Name and define the cardiac chambers.
2. Name and define the left ventricular myocardial segments
3. Name and define the coronary artery segments
4. Name and define the coronary sinus and cardiac veins
5. Name and define the pulmonary veins

Identify the following structures on the radiographs, CT and MRI (where applicable):
right atrium, right atrial appendage, crista terminalis
tricuspid valve, septal, posterior, anterior leaflet, Eustachian valve, thebesian valve

Right ventricle (RV), RV outflow tract, RV free wall, diaphragmatic wall, pulmonary valve, tricuspid valve, moderator band, trabecula

Pulmonary arteries – main, right, left, interlobar

Left atrium, left atrial appendage, pulmonary veins,
Mitral valve, coaptation point

Left ventricle (LV), apex, LV thin point, papillary muscles, chordae tendinae, aortic outflow tract

Aortic valve, right, left and noncoronary sinus of Valsalva, coronary artery ostia, aortic annulus, ascending aorta, aortic arch, descending aorta

Coronary arteries:
Right (RCA), acute marginal branches, conus branch, sinoatrial branch, posterior LV branch, posterior descending artery.
Left: left main (LM), circumflex (LCX), anterior descending (LAD), septal branches, diagonal branches, ramus intermedius, obtuse marginal, branches

Thoracic veins – superior vena cava, azygous, left superior intercostal ("aortic nipple"), coronary sinus, great cardiac vein, middle cardiac vein, anterior interventricular vein, marginal vein, small cardiac veins

**Pertinent findings in Cardiac Radiology**

*Ischemic Heart Disease*

1. Describe the anatomy of the coronary arteries and identify the following on a coronary arteriogram, cardiac CT, and MRI scan
   - right coronary artery, acute marginal branches, conus branch, sinoatrial branch, posterior LV branch, posterior descending artery
   - left main coronary artery
   - left anterior descending coronary artery, septal branches, diagonal branches, ramus intermedius
   - left circumflex coronary artery, obtuse marginal branches
2. State the clinical and prognostic significance of coronary arterial calcification on a chest radiograph
3. Recognize coronary arterial calcification on CT and state the current role of coronary artery calcium scoring with multi detector CT (MDCT) or electron beam CT
4. State the different calcium scoring algorithms and their decision rules (Agatston score, mass score, volume score)
5. Recognize coronary artery stenoses on coronary CTA.
6. Recognize presence of non-calcified plaque on coronary CTA
7. State the advantages and current indications for invasive coronary angiography and noninvasive coronary angiography (coronary-CTA and MRA), state the advantages and disadvantages of MRI and CT for coronary imaging.
8. State which coronary artery is usually diseased when there is papillary muscle dysfunction
9. Describe the common acute complications of myocardial infarction, including left ventricular failure, myocardial rupture and papillary muscle rupture, and recognize radiologic findings that may indicate these
10. Describe the common late complications of myocardial infarction, including ischemic cardiomyopathy, left ventricular aneurysm, left ventricular pseudoaneurysm, coronary-cameral fistula, dyskinesia and akinesis and recognize radiologic findings that may indicate these
11. Identify left heart failure on a radiograph and chest CT
12. Recognize acute and chronic myocardial infarction on cMR and cCTA imaging
13. Recognize viable myocardium on cMR
9. Define ejection fraction and state the normal left ventricular ejection fraction
14. Identify myocardial calcification on CT and state the etiology and significance of this finding
15. State the difference between a left ventricular aneurysm and pseudoaneurysm
16. Define and identify myocardial bridging on MR
17. Recognize anomalous origin or course of the coronary arteries on cCTA and cMR.
18. Recognize cardiac bypass grafts and graft complications (stenosis, occlusion, aneurysm) on cCTA and cMR.
18. Define the role of angiography, echocardiography, stress perfusion myocardial perfusion scintigraphy, chest CT, and chest MRI in the evaluation of a patient with suspected ischemic heart disease, including the advantages and limitations of each modality

**Myocardial Disease**

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

**Cardiac Valvular Disease**

1. State the findings that indicate each of the following and identify each on chest radiographs, CT and MRI:
   - enlarged right atrium
   - enlarged left atrium
   - enlarged right ventricle
   - enlarged left ventricle
2. Recognize an enlarged left atrium, vascular redistribution, and mitral valve calcification on a chest radiograph and suggest the diagnosis of mitral stenosis
3. Recognize an enlarged ascending aorta and aortic valve calcification on a chest radiograph and suggest the diagnosis of aortic stenosis
4. State the most common etiologies of the following:
   - aortic stenosis
   - aortic regurgitation
- mitral stenosis
- mitral regurgitation
- tricuspid regurgitation
- pulmonary stenosis

5. State the cardiac diseases associated with mitral annulus calcification
6. Identify endocarditis and/or complications of endocarditis on radiographs, chest CT and chest MR
7. State the advantages and disadvantages of echocardiography, MRI and cardiac CT for evaluation of valvular heart disease
8. Understand the role and performance of imaging for pre-TAVR workup
   - 3D imaging for the annular and aortic outflow tract dimensions
   - cross-sectional angiography for aortoliliac access
9. Recognize the role of advanced cross-sectional imaging for mitral valve interventions
10. Recognize the role of advanced CT and MRI for structural heart disease and intervention planning for surgical and minimally invasive therapies

**Pericardial disease**

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

**Congenital Heart Disease in the Adult**

1. Recognize increased vascularity, decreased vascularity and shunt vascularity on a chest radiograph and state the common causes of each
2. Recognize the following on imaging examinations of the chest, including radiographs, CT and/or MRI:
   - Heart disease presenting during adulthood
     - Left-to-right shunts and Eisenmenger physiology
     - Atrial septal defect
     - Ventricular septal defect
     - Partial anomalous pulmonary venous connection
     - Patent ductus arteriosus
     - Coarctation of aorta
     - Tetralogy of Fallot and pulmonary atresia with ventricular septal defect
     - Congenitally corrected transposition of the great arteries
     - Persistent left superior vena cava
     - Truncus arteriosus
- Ebstein anomaly
- Cardiac malposition, including abnormal situs
  *Heart disease originally treated in childhood*
- Coarctation of the aorta
- Tetralogy of Fallot and Pulmonary atresia with ventricular septal defect
- Complete transposition of the great arteries
- Congenitally corrected transposition of the great arteries
- Truncus arteriosus
- Commonly performed surgical corrections for congenital heart disease

3. Define the role of angiography, echocardiography, chest CT, cardiac 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

**Pulmonary Vascular**

1. Recognize enlarged pulmonary arteries on a chest radiograph, CT and MRI
2. Recognize enlargement of the central pulmonary arteries with diminution of the peripheral pulmonary arteries as pulmonary arterial hypertension and suggest the possible diagnosis of primary pulmonary artery hypertension
3. Name five of the most common causes of pulmonary artery hypertension
4. Recognize lobar and segmental pulmonary emboli on chest CT and chest MRI (including MR angiography)
5. Define the role of ventilation-perfusion scintigraphy, chest CT, chest MRI/MRA and lower extremity venous studies in the evaluation of a patient with suspected venous thromboembolic disease, including the advantages and limitations of each modality depending on patient presentation

**Thoracic Aorta and Great Vessels**

1. State the normal dimensions of the thoracic aorta
2. Describe the classifications of aortic dissection (DeBakey I, II, III; Stanford A, B), and implications for classification on medical versus surgical management
3. State and recognize the findings of, and distinguish between each of the following on CT and MR:
   - aortic aneurysm
   - aortic dissection
   - aortic intramural hematoma
   - penetrating atherosclerotic ulcer
   - ulcerated plaque
   - ruptured aortic aneurysm
   - sinus of Valsalva aneurysm
   - subclavian or brachiocephalic artery aneurysm
   - aortic coarctation
   - aortic pseudocoarctation
4. Recognize a right aortic arch and a double aortic arch on a radiograph, thoracic CT and cardiac MR
5. State the significance of a right aortic arch with mirror image branching versus with an aberrant subclavian artery.
6. Recognize a cervical aortic arch on a radiograph and chest CT.
7. Recognize an aberrant subclavian artery on chest CT.
8. Recognize normal variants of aortic arch branching, including common origin of brachiocephalic and left common carotid arteries (“bovine arch”), separate origin of the vertebral artery from arch.
9. Define the terms aneurysm and pseudoaneurysm.
10. State the common cardiac anomalies associated with aortic coarctation.
11. State and identify the findings seen in Takayasu’s arteritis on chest CT and chest MR.
12. State the advantages and disadvantages of CT, MRI/MRA and transesophageal echocardiography in the evaluation of the thoracic aorta.

Monitoring and support devices – “tubes and lines”

1. Be able to identify, state the preferred placement of, complications associated with malposition and identify the location on chest radiography for each of the following:
   - pacemaker and pacemaker leads, automatic implantable cardiac defibrillator, left ventricular assist device, atrial septal defect closure devices, pericardial drain, extracorporeal life support cannulae, Swan-Ganz catheter, intra-aortic balloon pump, endotracheal tube, central venous catheter, left atrial occlusion device, transcatheter aortic valve replacement devices
   - feeding tube, nasogastric tube, chest tube, intraesophageal manometer, temperature probe or pH probe, tracheal or bronchial stent,

Post-operative chest

1. Identify normal post-operative findings and complications of the following procedures, on chest radiography, CT and MRI:
   venous and arterial coronary artery bypass graft surgery, coronary artery stents, cardiac valve replacement, aortic conduits, aortic graft, aortic stent and types of endoleak, heart transplant, ASD and VSD closure devices, pulmonary vein radiofrequency isolation (PV-stenosis)

B) Patient Care (PC)

1. State the indications and contraindications for obtaining a coronary CTA
2. State the imaging parameters for coronary CTA, including tube current, tube modulation, kVp, collimation, delay time, gating and triggering modes,
3. Determine the adequate delay time and bolus volume.
4. Perform raw data reconstructions at adequate R-to-R intervals. State the three different definitions of raw data reconstruction.
5. Describe and perform post processing of source image datasets, including 3-D image reconstructions, VRT, MPR, MIP
6. State MRI protocols for various indications. Know the advantages and disadvantages of gradient echo, spin echo, turbo spin echo, phase contrast, perfusion and delayed enhancement pulse sequences.
7. Describe and use MRI post processing tools to evaluate wall motion, perfusion, flow measurements, 3-D image reconstructions, T-2 decay times.
8. Communicate effectively with referring clinicians and tailor imaging protocol to the specific clinical question
9. Recognize and communicate the appropriate and inappropriate uses of coronary CTA in the acute chest pain patient presenting to the Emergency Department.

C) Practice Based Learning (PBLI)

1. Be able to analyze the quality of cardiovascular imaging studies
2. Be able to analyze the radiation dose used for cardiovascular imaging studies
3. Maintain an academic portfolio. A portfolio is a collection of every activity the resident is involved in. It is an expanded CV. Fellows should include committees they sit on, presentations given, awards won, letters from patients and faculty, case logs, summary of challenging cases, etc. This will be useful when applying for a position and can be used as a reminder of how a certain issue was handled or how to avoid a mistake the next time.

D) Systems Based Practice (SBP)

1. Know the cost/risks/benefits of various cardiovascular imaging tests
2. Attend interdisciplinary conferences to learn the role of cardiovascular imaging for the cardiovascular patient care team

E) Interpersonal and Communication Skills (ICS)

1. Be able to present verbally the findings on cardiovascular imaging studies to radiologists of all training levels and to consulting physicians
2. Be able to create clear, standardized, and accurate written reports of the findings on cardiovascular imaging studies
3. Function as an expert consultant cardiac imaging, performing imaging consultations with primary care physicians and cardiac subspecialists with increasing independence through the fellowship year

F) Professionalism (PROF)

1. Treat all patients and healthcare providers with respect, compassion, and dignity
2. Dress appropriately and with cleanliness.
3. Be on time and prepared for all professional interactions.
4. Accept accountability and admit errors, maintain self-awareness of limitations, consistently evaluate knowledge base and strive to improve it, and seek guidance and supervision as needed.
5. Be a “team player”: support and work cooperatively with all staff to provide a positive patient experience, using all available resources to serve each individual’s need.
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 bronchioalveolar 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 metastatic disease, lymphangitic carcinomatosis
  - Hamartoma/mesenchymoma
  - Plasma cell granuloma
  - Other benign tumors
- Trachea
  - Tracheal neoplasms
  - Tracheal stenosis: idiopathic, post traumatic, M. tuberculosis
  - 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 erythematosis, 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 pneumonia, Langerhan cell histiocytosis
  - 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:
  o Centrilobular, paraseptal, panlobular, alpha 1 anti trypsin deficiency, giant bullous emphysema

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

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

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

• Infections of the Lung, Mediastinum and Pleura
  o Bacterial: staph, strep, gram negative, anaerobic, anthrax, rickettsia, Chlamydia, mycoplasma, septic emboli
  o Viral: influenza, respiratory syncytial virus, adenovirus, emerging viral infections (eg. SARS and H1N1), varicella, etc.
  o Fungal: histoplasmosis, Cryptococcus, coccidioidomycosis, blastomycosis, aspergillus (invasive aspergillosis, airway invasive aspergillosis, chronic necrotizing aspergillosis, mycetoma)
  o 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, agammaglobulinemia 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: 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**
- Tracheobronchial Injury
- Lung parenchymal injury (contusion and laceration)
- Post traumatic pleural disease (hemothorax, pneumothorax)
- Vascular injuries (aorta and great vessels)
- Cardiac Injury
- Diaphragmatic injury
- Skeletal injuries

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

**Post Operative Chest**
- Lung cancer related procedures: thoracotomy, video assisted thoracic surgery (VATS), muscle flaps (intercostal muscle, serratus muscle), fat pads (omental, pericardial), cervical mediastinal exploration, Chamberlain procedure
- Esophageal cancer related procedures: Ivor Lewis esophagectomy, left thoracotomy, transhiatal esophagectomy, minimally invasive esophagectomy
- Cardiac devices: pacers, implantable cardioverter defibrillator (ICD)/biventricular pacers, septal occlusion devices, stent grafts, ventricular assist devices
- 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
- Lung Transplant: technique and post operative appearance
- Heart Transplant: orthotopic vs heterotopic technique, post operative appearance

**Thoracic Positron Emission Tomography (PET)**
- Lung Cancer
- Esophageal cancer
- Lymphoma
- Sarcoma
- Metastatic disease
- Mesothelioma
- Post transplant lymphoproliferative disease
- 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 psueudoaneurysms
  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
- Percarditis
- 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 arteriosis, Tetralogy of Fallot
- Truncus arteriosis
- 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
- Paraganglioma
- 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
o Post CABG complications (including aneurysm and pseudoaneurysm)
o Coronary artery stent imaging: in stent restenosis
o Post op valvular anatomy
o Atrial septal defect (ASD)/patent foramen ovale (PFO) closure devices
o Left ventricular apical aortic conduit
o Endovascular aortic aneurysm repair (EVAR): normal imaging appearance, complications, endoleak evaluation and categorization
o Aortic and cardiac aneurysm repair
o Post operative appearance after congenital heart surgeries (e.g. Hemi-Fontan, Fontan, Ross, Rastalli, Norwood, Jantene, Mustard and Blalock-Taussig)
o Cardiac herniation and torsion

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

**TECHNICAL ISSUES**

- Radiation dose in cardiothoracic imaging: thoracic CT, cardiac CT, chest radiography, PET
  o Understand the data of the radiation dose report
  o Understand computed tomography dose index (CTDI), dose length product (DLP), tissue weighting factors and effective dose
  o Radiation dose reduction techniques in thoracic and cardiac CT
- Thoracic Computed Tomography (CT) Protocols
  o Acquisition parameters: mA, kV, pitch, thickness, collimation, detector configuration, gantry rotation speed, dose modulation techniques, reconstruction algorithm/kernel, etc.
  o Intravenous (IV) contrast administration, contraindications and premedication
  o IV contrast enhancement and injection techniques for routine chest, pulmonary CTA and aortic CTA: injection rate, contrast delay, bolus tracking techniques, saline chaser
  o Routine Chest CT protocol
  o High resolution chest CT (HRCT) protocol: including targeted reconstruction, expiratory and prone imaging
  o Pulmonary CT angiography (CTA) protocol
  o Aortic CTA protocol
  o Lung cancer screening and low dose chest CT protocol
  o Specialty protocols: airway imaging, thoracic outlet, 3D reconstruction techniques
  o Reconstructions: multiplanar reformations (MPR), maximum intensity projection (MIP)
  o Quality control in thoracic CT
- Thoracic Magnetic Resonance Imaging (MR) protocols
  o MR safety
  o MR contrast administration and contraindications
  o Acquisition parameters
  o Mediastinal mass MR protocol
  o Pleural evaluation MR protocol
  o Hilar evaluation MR protocol
  o Chest wall evaluation for lung cancer staging MR protocol

26
• Quality control in thoracic MR

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

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

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

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


