Imaging of Heart Transplantation

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Learning Objectives

1. Brief overview of the history of heart transplantation
2. Review the Indications for heart transplantation
3. Describe the current techniques for transplantation
4. Review relevant imaging findings that are important both Pre and Post-transplant
5. Review imaging findings associated with complications after heart transplantation
Heart Transplantation- History

- First heart transplantation performed in a canine by Charles Guthrie in 1905

- First human-human heart transplant in 1967 by Christiaan Barnard

- Initial heart transplantations were performed heterotopically (native heart left in), prior to development of cyclosporine, to maintain cardiac function in the setting of acute rejection

- Heart transplantations today performed orthotopically (majority of native heart is removed)
Indications for Transplantation

Systolic heart failure (EF<35%):
- In the absence of HIV infection, cardiac sarcoma, or amyloid

Intractable angina:
- Failed maximal medical therapy
- Not a candidate for or unsuccessful revascularization

Intractable Arrhythmia:
- Uncontrolled with defibrillator
- Not candidate for ablative therapy
Indications for Transplantation

Hypertrophic Cardiomyopathy
- Class IV with persistent symptoms despite medical and interventional therapies

Congenital heart disease
- Persistent symptoms without complication of severe pulmonary hypertension

Cardiac tumor
- Confined to myocardium and no evidence of metastatic disease
In this approach, the native heart is left in and the allograft is attached adjacent the native heart. NRV = Native Right Ventricle, NLV = Native Left ventricle, TRV = transplant Right Ventricle, TLV = Transplant Left Ventricle. Note rim calcified apical aneurysm from prior LAD territory infarct.
Current Surgical Approach - Orthotopic

In this approach, the majority of the native heart is removed, except for a portion of the posterior wall of the left atrium and the pulmonary veins. In some cases, portions of the right atrium are also left behind. Alternatively, entire recipient right atrium is removed, and bicaval anastomosis is performed.

In addition to usual support devices, note bypass cannulas and Rummel tourniquets which are used for hemostasis.

Schematic diagram showing suturing of the allograft left atrium with the native left atrium (blue oval).
Pre-Transplant: What to look for:
Radiologists role -- Important to recognize subtle findings of pathology that may prevent patients from receiving a transplant or require additional work-up prior to transplantation.

1. Anatomic barriers to transplant:
   Example – A heavily calcified aorta may be difficult to cross clamp and carries the risk of atherosclerotic plaque embolization

2. Systemic Illnesses:
   Examples: AIDS, Sarcoidosis, Amyloid. Since these systemic diseases can directly affect the heart, they may affect allograft function after transplantation.

3. Emphysema:
   This may affect pre-operative PFTs and influence ventilator management. Additionally, bullae and other cavities may become infected easily with immunosuppression.

4. Neoplasm
Pre-Transplant – Systemic Illness

**ABSOLUTE CONTRAINDICATIONS:**
- Systemic disease with **poor prognosis AND potential to recur in transplanted heart OR potential for exacerbation** secondary to immunosuppressive drugs post heart transplantation.

- Radiologist role to look for systemic illness on preoperative chest radiograph. Patients will need further work-up prior to transplantation.
Pre Transplant: Pulmonary HTN

ABSOLUTE CONTRAINDICATIONS:

- Fixed pulmonary hypertension despite medical therapy.
- Increases risk for acute right ventricular allograft failure in the immediate post-operative period due to inability to adapt to elevated pressures.
- May be candidate for dual heart-lung transplantation.
PreTransplant: Emphysemia

RELATIVE CONTRAINDICATION:

- Increased risk of infections.
- Will need further work-up with PFTs. If FEV <50% of predicted, poor transplant candidate.
- Patient’s with poor pulmonary reserve may have trouble being extubated post-operatively, increasing risk of ventilator acquired pneumonias.
Pre Transplant: Neoplasm

Spiculated left upper lobe mass causing architectural distortion

POTENTIAL RELATIVE CONTRAINDICATION:
- Still may be a candidate if disease free for 5 years.
Imaging of the Transplanted Heart: Post

Things to Know:
- Usually only chest radiographs post-op and after discharge.
- Cross-sectional imaging if suspect complication.
- Clues to identify patient has had a heart transplant:
  - Cardiomegaly- post-op
  - Evidence of median sternotomy AND suture around left atrium in absence of trauma. May see sutures around other anastomotic sites.
Imaging findings of a Heart Transplant in the absence of history

May not get complete patient history prior to imaging.

- On this patient:
  - Enlarged left atrium (*) in the setting of mitral valve calcifications (Image 1).
  - Surgical material around the left atrium (Image 2 – blue arrow).
  - Evidence of prior median sternotomy and aortic surgical material (Image 3).

- Important to know what a heart transplant looks like
- Knowing these findings will help avoid incorrect diagnosis of severe mitral stenosis.
Imaging findings of a Heart Transplant in the absence of history

Another case with incomplete patient history. Patient presenting with shortness of breath.

- On this patient:
  - Abnormal LA configuration with enlarged pulmonary veins (•).
  - Evidence of prior median sternotomy (○)-subtle midline area of sclerosis.
1. Pulmonary hypertension
   - Right heart failure
2. Ischemic injury
3. Infection – LEADING CAUSE OF MORBIDITY AND MORTALITY
3. Acute rejection
   - Occurs within first 6 months.
   - To monitor for acute rejection, cardiology performs biopsies every 7-10 days in the immediate postoperative period, then every 3 to 6 months after the first year.

**RIGHT HEART FAILURE**

**IMAGING FINDINGS:** Dilated IVC, straightening intraventricular septum, pleural effusions.

Echo guided biopsy of the IV septum via R IJ to RV approach

**Early Complications (<1 year)**
Complications – Infection

Greatest risk first three months after transplantation.

‘Early’ infections usually bacterial (<1 month post transplant)
- Pneumonia
- Catheter-associated bacteremia
- Urinary tract infections
- Mucocutaneous infections

‘Late’ Infections usually atypical (>1 month post transplant)
- Pneumonia – viral such as PCP, or cavitary such as cryptococcus
- Central nervous system infections
  - Abscess, meningoencephalitis
- GI infections
  - Esophagitis, diarrhea, lower GI hemorrhage
- Cutaneous infections

Axial and coronal chest CT images showing either solitary nodular (A, B) or acinar (C) nodular and (D) cavitary(*) appearance of infection in post-transplant patients. In all cases either sputum or biopsy confirmed fungal infection.
Complications– Pericardial Effusion

PATIENT ONE- Chest discomfort after cardiac biopsy.

- Heart transplant patients get biopsied frequently in the first year to check for rejection.
- Potential complications include pericardial effusion, pneumothorax, and hemothorax.

PATIENT TWO- Chest discomfort and fevers.

- Patient discharged on IV antibiotics for bacteremia after transplantation.
- Presented to emergency department with worsening fevers and shortness of breath
- Subsequently diagnosed with mediastinitis.

Complication after Endomyocardial Biopsy (Patient One):

- Potential complications include pericardial effusion, pneumothorax, and hemothorax.

Complication after heart transplantation (Patient Two)

- Make sure to check for sternal dehiscence
Complications – Aortic Dissection/Pseudoaneurysm formation

**PATIENT ONE** - Pseudoaneurysm

- Initial CT: Febrile patient, contrast outside aortic lumen adjacent to cannulation site.
- Follow-up MRI 3 months later with increase in size of pseudaneurysm.

**PATIENT TWO** - Type A Aortic Dissection at aortic anastomosis.

- Reactive adenopathy. Normal appearance of pledgets at prior cannulation site.
- Dissection proximal to prior aortic anastomosis.

### Timing
- Can occur at anytime after transplantation.

### Causes
- Infection - can weaken suture lines and eventually lead to pseudoaneurysm formation or dissection
- Hypertension
- Rejection can cause dehiscence and hematoma formation

In transplant patient, may not see secondary findings of infection such as fat stranding. Important to raise concern for mycotic aneurysm.
Late Complications (>1 year)

1. Chronic Rejection
2. Malignancy
3. Accelerated Atherosclerosis
   - No calcifications.
4. Pericardial Constriction
5. Radiographically occult late complications:
   - Hypertension
   - Renal Dysfunction
Late Complications – 1. Chronic Rejection

57 y/o F post orthotopic transplant 10 years ago, now with decreased EF, shortness of breath.

Short Axis SSFP image showing diffuse hypokinesis, with focal severity along the inferior septum. LVEF estimated at 50%.

Short Axis delayed enhancement images demonstrate diffuse subendocardial (red arrow) as well as transmural enhancement (*).

4-chamber and short axis T1 maps showing prolonged T1 times in the interventricular septum. A normal T1 map time is 900-1000 msec.
Complications – Late

2. Malignancy
   - Post transplant lymphoproliferative disorders (PTLD)
   - Skin carcinomas

Important cause of death. Look for solitary mass, multiple non-cavitating nodules, adenopathy.

Post contrast axial CT in a ?? y/o ?? X months after transplant. Note, enhancing mediastinal and supraclavicular adenopathy.
3. Accelerated atherosclerosis
- Usually noncalcified plaque
- Symptoms: Silent ischemia, arrhythmias, congestive heart failure, sudden death
- Monitoring:
  - Current: Annual coronary angiogram, IVUS
  - Possible future: CT, MRI
4. Pericardial Constriction
- Result of repeated episodes of inflammation.
- Extremely rare, but can happen at anytime.
- Symptoms: Right-sided heart failure, lower extremity edema
- Evaluation:
  - First line is echocardiography. MRI/CT complimentary studies.
Conclusions

• Radiologists should identify pathology that may require further workup prior to heart transplantation. Attention should be given to systemic illnesses, opportunistic infections, aortic calcifications, and malignancy.

• Familiarity with typical appearance of a heart allograft is important, especially in the absence of patient history.

• Most cardiac transplant patients are at risk for the same complications as other transplant patients. However, these patients additionally are at risk for: Pericardial effusions, aortic dissections and pseudoaneurysms, accelerated atherosclerosis and constriction.
References


THANK YOU

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