Cardiac Masses: a multimodality approach

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No disclosures
Overview of cardiac masses

Cardiac mass

Intracardiac

Normal variants/iatrogenic
- RA: Eustachian valve, Dilatation within mitral annulus, systemic hypertension of M.R., IAS aneurysm, pericardial masses
- LA: Suture line following transplant, Coronary ridge, pericardial muscle, fibrous tissue in tricuspid valve
- RV: Mediator band
- LV: False tendon, papillary muscles

Nontumor mass like pathology
- Theobomatic
- Vegetation
- Atrial arrhythmia calcification
- Inflammatory myofibroblastic tumor (IMT)
- Ciliated adenomatous tumor (CAT)
- Fully intubation of TV annulus
- Laminar excess of muscular tracts
- Hypereosinophilic syndrome

Primary
- Benign
  - Myxoma
  - Papillary fibroelastoma
  - Lipoma
  - Papillary fibroelastoma
  - Fibroma
  - Hemangioma
  - Teratoma
  - Pericardial/Teratoma
  - Blood-filled cyst of the valve

Malignant
- Angiosarcoma
- Rhabdomyosarcoma
- Leiomyosarcoma
- Lymphoma
- Mesothelioma
- Teratoma
- Intraventricular teratoma
- Other sarcomas

Secondary
- Direct extension
  - Breast
  - Lung
  - Esophageal
  - Mediastinal tumor

Hematogenous
- Melanoma
- Lung
- Gastrointestinal
- Kidney

Venous
- Renal
- Adrenal
- Thyroid
- Lung
- RCC

Lymphatic
- Lymphoma
- Leukemia

Extracardiac

Pericardial
- Tumor
- Benign
- Cyst
- Dendroblastoma
- Teratoma
- Lipoma
- Hemangioma
- Lymphangiosis

Malignant
- Mesothelioma
- Angiosarcoma

Others
- Mediastinal tumor
- Large hemangioendothelioma
- Lung tumor
- Carcinoma hemorrhage, bile and pancreatic cancer
- Diaphragmatic hernia
- Dilated esophagus
- Achalasia
- Zenker diverticulum
- Dilated portal venous system
- Left lower lobe abscess

*May be classified as hemangioendothelioma and considered carcinoid-like.
+ E.g., Undifferentiated cardiac tumors, primary synovial sarcoma

Figure 146.1. Overview of the classification of cardiac mass and normal variants.

From Yingchoncharon and Klein, Chapter 146 ASE's Comprehensive Echo
Intracardiac masses

Cardiac tumors
Thrombi
Vegetations
Cysts
Infiltrative disorders
Iatrogenic materials
Normal structures

1st questions in evaluation of a cardiac mass

Is it artifact (image in at least 2 views) ?
Is it thrombus or something else ?
Intracardiac thrombus

• Company it keeps
  – AF, dilated LA, MS, LV aneurysm, myocardial scar

• Echo
  – Reflectivity different from myocardium
  – Motion pattern
  – Use contrast

• cMR
  – Low T1 and T2 signals relative to myocardium
    • Depends on age of thrombus
  – No perfusion
Cardiac tumors

- Rare
- Benign
- Malignant
- Primary
- Secondary (Metastatic)
- Symptoms
  - obstruction, regurgitation, myocardial invasion (impaired wall motion, arrhythmia, altered conduction), constitutional symptoms
- Often incidental findings
# Relative Incidences of Primary Cardiac Tumors

## Benign

<table>
<thead>
<tr>
<th>Tumor Type</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myxoma</td>
<td>30%</td>
</tr>
<tr>
<td>Lipoma</td>
<td>10%</td>
</tr>
<tr>
<td>Fibroelastoma</td>
<td>10%</td>
</tr>
<tr>
<td>Rhabdomyoma</td>
<td>8%</td>
</tr>
<tr>
<td>Fibroma</td>
<td>4%</td>
</tr>
<tr>
<td>Hemangioma</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Teratoma</td>
<td>3%</td>
</tr>
<tr>
<td>Other</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>70-75%</td>
</tr>
</tbody>
</table>

## Malignant

<table>
<thead>
<tr>
<th>Tumor Type</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angiosarcoma</td>
<td>9%</td>
</tr>
<tr>
<td>Rhabdomyosarcoma</td>
<td>9%</td>
</tr>
<tr>
<td>Mesothelioma</td>
<td>4%</td>
</tr>
<tr>
<td>Other Sarcoma</td>
<td>3%</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>2%</td>
</tr>
<tr>
<td>Other Sarcoma</td>
<td>3%</td>
</tr>
<tr>
<td>Teratoma</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Other</td>
<td>&lt;1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>25-30%</td>
</tr>
</tbody>
</table>

**Note:** Metastatic >> Primary Tumor (20:1)
Primary cardiac tumors

- Incidence of 0.002 - 0.19%
- 75% are benign
  - Course may not be benign (altered hemodynamics, emboli, arrhythmia)
  - Mostly mesenchymal in origin
  - 50% are myxomas
- 25% malignant
  - Sarcomas most common followed by lymphoma
    - Metastatic malignant tumors much more common
- Primary tumors of atrial origin mostly intracavitary
- Primary tumors of ventricular origin mostly intramural
Secondary cardiac tumors

- 4X more common than primary tumors
- Most common metastases are to pericardium
- Malignant tumors spread to heart by direct invasion, hematogenous, venous, lymphatic spread
- Lung, breast, melanoma, germ cell tumors, leukemia
Figure 6: The typical locations of the most common masses are illustrated. Note, however, that the location of the various conditions can vary and many cardiac tumors can occur in any chamber.

Motwani et al, Radiology 2013;268;26-43
What to include in report

- Confirmation of presence or absence of mass
- Location, anatomic relationships of mass
- Size (multiple dimensions)
- Margins – smooth, irregular, infiltrating
- Motion and functional significance
- Associated complications (effusions, etc)
- Tissue characterization, perfusion, etc specific to imaging modality
- Differential diagnosis
Diagnosis of cardiac masses

*each modality (echo, CT, MR) has strengths and weaknesses*

- **TTE**
  - Most common screening tool (including fetal echo)
    - Incidental findings?
  - Characterize location, shape, size, relation to other structures, hemodynamic consequences, cardiac function
    - Characteristic anatomic and functional features can permit identification or differential diagnosis of mass
  - Detection sensitivity depends on mass size and location
- 3D
- Contrast - vascularized tumor vs. thrombus
- Weaknesses
  - Mediastinum/extracardiac, IQ or restricted field
Diagnosis of cardiac masses

- TTE
- TEE – improved visualization
  - small masses, right heart masses, LA appendage, SVC, masses associated with prosthetic material, structural details (point of attachment, cystic, compression or infiltration of adjacent structures)
  - 3D
- cCT
- cMR
Diagnosis of cardiac masses

- cCT
  - Short imaging time but radiation exposure
  - Larger field of view than echo
  - Lower temporal resolution c/w echo + cMR
    - Better spatial resolution
  - Image quality less variable c/w echo
  - Better tissue characterization than echo
    - Calcification, fat
    - Lower soft tissue contrast resolution c/w cMR
  - Contrast (nephrotoxic)
    - Delineate borders, differential enhancement of normal myocardium and mass
## cCT features of benign and malignant tumors

<table>
<thead>
<tr>
<th></th>
<th>BENIGN</th>
<th>MALIGNANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size/number</td>
<td>Small (&lt; 5 cm); single</td>
<td>Large (&gt; 5 cm); multiple</td>
</tr>
<tr>
<td>Location</td>
<td>Left &gt;&gt; right</td>
<td>Right &gt;&gt; left</td>
</tr>
<tr>
<td>Morphology</td>
<td>Intracameral</td>
<td>Intramural</td>
</tr>
<tr>
<td>Attachment</td>
<td>Narrow stalk; pedunculated</td>
<td>Broad base</td>
</tr>
<tr>
<td>Enhancement</td>
<td>Absent to minimal</td>
<td>Modest to intense</td>
</tr>
<tr>
<td>Margin</td>
<td>Smooth, well-defined</td>
<td>Irregular, ill-defined</td>
</tr>
<tr>
<td>Invasion</td>
<td>None</td>
<td>Intra-extra-cardiac infiltration</td>
</tr>
<tr>
<td>Metastasis</td>
<td>None</td>
<td>May be present</td>
</tr>
<tr>
<td>Pericardial effusion</td>
<td>None</td>
<td>May be present</td>
</tr>
<tr>
<td>calcification</td>
<td>Rare (except for small foci in fibroma, myxoma, teratoma)</td>
<td>Large foci in osteosarcoma</td>
</tr>
</tbody>
</table>

From Kassop et al, Curr CV Img Rep 2014;7:9281
Diagnosis of cardiac masses

- cMR
  - Large field of view, no radiation
  - Best tissue characterization (except ca+ by CT)
    - Mass vascularity / fibrosis
    - Best soft tissue resolution
  - Myocardial involvement, underlying scar (thrombus)
  - Gadolinium use
  - Long imaging times (breath holds), poorer spatial resolution, claustrophobia, presence of pacemakers, etc
  - May require real time input to optimally characterize mass
  - ECG gating required (arrhythmia)
Cardiac masses - cMR

- MRI relative signal intensity from tissue depends on its proton density and T1/T2 relaxation times
  - Different tissues have different T1/T2 relaxation times due to different internal biochemical environments surrounding the protons
    - Can be exploited to discriminate different tissue types
  - Neoplastic cells
    - Larger than normal cells, contain more water leads to longer relaxation times and contrast between tumor and normal tissue
  - Relative components of fat, vascularity, fibrosis will influence enhancement
### Table 2

**MR Imaging Tissue Characteristics of Common Cardiac Masses**

<table>
<thead>
<tr>
<th>Cardiac Mass</th>
<th>T1-weighted Imaging*</th>
<th>T2-weighted Imaging*</th>
<th>After Contrast Enhancement (LGE Imaging)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudotumor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrombus</td>
<td>Low (high if recent)</td>
<td>Low (high if recent)</td>
<td>No uptake¹</td>
</tr>
<tr>
<td>Pericardial cyst</td>
<td>Low</td>
<td>High</td>
<td>No uptake</td>
</tr>
<tr>
<td>Benign</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myxoma</td>
<td>Isointense</td>
<td>High</td>
<td>Heterogeneous</td>
</tr>
<tr>
<td>Lipoma</td>
<td>High¹</td>
<td>High¹</td>
<td>No uptake</td>
</tr>
<tr>
<td>Fibroma</td>
<td>Isointense</td>
<td>Low</td>
<td>Hyperenhancement²</td>
</tr>
<tr>
<td>Rhabdomyoma</td>
<td>Isointense</td>
<td>Isointense/high</td>
<td>No/minimal uptake</td>
</tr>
<tr>
<td>Malignant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angiosarcoma</td>
<td>Heterogenous</td>
<td>Heterogeneous</td>
<td>Heterogeneous</td>
</tr>
<tr>
<td>Rhabdomyosarcoma</td>
<td>Isointense</td>
<td>Hyperintense</td>
<td>Homogeneous</td>
</tr>
<tr>
<td>Undifferentiated sarcoma</td>
<td>Isointense</td>
<td>Hyperintense</td>
<td>Heterogeneous/variable</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>Isointense</td>
<td>Isointense</td>
<td>No/minimal uptake</td>
</tr>
<tr>
<td>Metastasis³</td>
<td>Low</td>
<td>High</td>
<td>Heterogeneous</td>
</tr>
</tbody>
</table>

Note.—Table presents typical characteristics, but all tumors can have atypical appearances owing to altered tissue composition.
* T1- and T2-weighted imaging signal intensity is given relative to myocardium.
¹ Best seen on ECG images (no uptake) 2 minutes after contrast agent administration (Fig 1).
² Similar to surrounding fat signal intensity and characterized by marked suppression with a fat-saturation prepulse.
³ However, fibromas are nonenhancing at perfusion imaging because of avascularity.
⁴ The exception is metastatic melanoma, which has a high T1-weighted and a low T2-weighted signal intensity.
### Some features of primary cardiac tumors (Curr CV Img Rep 2014;7:9281)

<table>
<thead>
<tr>
<th>Tumor</th>
<th>Location</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benign</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myxoma</td>
<td>LA&gt;RA, ventricles</td>
<td>Pedunculated, mobile, heterogeneous, low attenuation, scattered Calcification</td>
</tr>
<tr>
<td>Lipoma</td>
<td>Varies</td>
<td>Smooth, encapsulated, fat attenuation, multiple if tuberous sclerosis</td>
</tr>
<tr>
<td>Fibroelastoma</td>
<td>Valves</td>
<td>Small, smooth, pedunculated, mobile</td>
</tr>
<tr>
<td>Rhabdomyoma</td>
<td>LV&gt;RV</td>
<td>Smooth, multiple, attenuation similar to myocardium, mostly in children</td>
</tr>
<tr>
<td>Fibroma</td>
<td>LV&gt;RV</td>
<td>Homogenous, low attenuation, minimal enhancement, central calcification</td>
</tr>
<tr>
<td>Hemangioma</td>
<td>LV&gt;RV</td>
<td>Heterogeneous, intense enhancement</td>
</tr>
<tr>
<td>Teratoma</td>
<td>Pericardium</td>
<td>Multicystic, moderate enhancement, partially Ca+</td>
</tr>
<tr>
<td><strong>Malignant</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angiosarcoma</td>
<td>RA&gt;RV, pericardium</td>
<td>Broad base, irregular, heterogeneous, low attenuation, infiltrative, PE, mets</td>
</tr>
<tr>
<td>Rhabdomyosarcoma</td>
<td>Myocardium, valves</td>
<td>Irregular, low attenuation, infiltrative</td>
</tr>
<tr>
<td>Fibrosarcoma</td>
<td>LA, pericardium</td>
<td>Large, irregular, low attenuation, central nec</td>
</tr>
<tr>
<td>Osteosarcoma</td>
<td>LA&gt;RA, RV</td>
<td>Broad base, low attenuation, infiltrative, ext ca+</td>
</tr>
<tr>
<td>Liposarcoma</td>
<td>LA&gt;RA, pericardium</td>
<td>Large, fat and soft tissue attenuation, infiltrative, extensive calcification</td>
</tr>
<tr>
<td>Mesothelioma</td>
<td>pericardium</td>
<td>Infiltrative, variable attenuation, PE</td>
</tr>
</tbody>
</table>
CASES of masses where multimodality cardiac imaging was key!!
• 52 yo F
• TTE for source of embolus
Papillary fibroelastoma

- Often incidental finding
- Most Valvular tumor
- often on stalk, highly mobile
- Embolic potential
65 yo F with known PFE on right coronary leaflet of AV

- Presents with inferior STEMI after drainage of tubo-ovarian abscess
- TTE
  - Normal LV function
  - RV dilated and diffuse dysfunction
  - AV PFE not seen
- Clinical RV MI
  - r/o PE also
CT after recovery from RV MI embolization of AV PFE

- Total occlusion of proximal 1.6cm RCA which is dilated
- Restoration of flow (likely retrograde) from the conus branch origin
- 7mm x4mm low attenuation structure protruding from the RCA ostium into the right sinus of valsalva
- No significant stenosis LM, LAD CX
43 yo M with Hepatocellular carcinoma

- Originally detected during w/u for elevated LFTs noted on routine blood work
  - US of abd – liver masses; them CT and bx
- s/p resection
  - 6.5 cm moderately differentiated HCC with vascular invasion (margins clear)
- s/p chemotherapy, radiation therapy (liver and abd node)
- Now on experimental protocol for recurrence and metastases to lungs
  - Protocol directed CT shows abnormality in hepatic vein/IVC/RA and pulmonary thrombo-emboli in LLL
RVIT
Metastatic HCC Tumor vs. thrombus vs. both?

- Progressed on anticoagulation
- Plan to receive focused radiation to IVC, continued anticoagulation and continue on experimental chemo protocol
46 yo M with htn presents with stroke

- CNS imaging
  - Bilateral frontal and cerebellar infarcts (acute and subacute)
LA myxoma – TEE at surgical resection
Post op

• No other tumors noted in heart on thorough TEE evaluation at time of surgery

• Excellent neurologic recovery

• 1 yr echo for follow up of LA myxoma
LV mass 1 year after LA myxoma resection
cMR – 2 small masses attached to PM papillary muscle and lateral wall. T1 isointense so not fat and T2 hyperintense c/w myocardium. Prominent delayed gad enhancement c/w perfusion (excludes thrombus). Myxoma vs. fibroelastoma
Lesion 1

T2 short axis FSE showing an intracavitary hyperintense T2 lesion abutting the base of the posteromedial papillary muscle (7 x 8-9 mm)
• delayed post gadolinium image showing the enhancing lesion
Recurrent cardiac mass 1 year after LA myxoma resection

- Surgical resection of LV tumor
  - Myxoma
- Focal skin hyperpigmentation
  - Extremities, abdomen, chest
- Carney Syndrome
  - PRKAR1A mutation
- Has had multiple LV myxomas, multiple emboli since
Carney complex

- Myxomas of skin and heart
- Hyperpigmentation
- Endocrinopathies
- Autosomal dominant
- 70% have PRKAR1A mutation
  - Tumor suppressor protein
- Difficult to treat
Caseous Mitral Annular Calcification
liquefaction necrosis of calcium

- Echo findings:
  - Posterior annulus
  - Echo brightness: suggestive of calcification
  - Central areas of echolucency (liquefied contents)

- Usually benign.
- Often mistaken for cardiac tumor, abscess.
- Rare complications: emboli, local compression
Angiosarcoma invading RA
Tuberous sclerosis and rhabdomyomas
Cardiac masses: a multi-modality approach

text

- Identify in at least 2 views
- Intracardiac / extracardiac
- Normal variants/iatrogenic vs non tumor masses vs tumor
  - Tumors (rare)
    - 1\textsuperscript{o}
      - Benign vs malignant
    - 2\textsuperscript{o} (more common than 1\textsuperscript{o} tumor)
      - Direct extension vs hematogenous vs venous vs lymphatic
- Clinical history, age, location, imaging characteristics can provide important clues
Cardiac masses: a multi-modality approach

**summary**

- TTE is typically the first line tool
  - Dynamic assessment of masses in relation to cardiac structures
- TEE, cCT, CMR
  - Each have strengths and weaknesses
- Synergistic use of non invasive imaging for diagnosis and monitoring of cardiac masses and tumors
  - Echo + cMR
    - Superior soft-tissue characterization/high temp res/multiplanar img, no ionizing radiation (cMR – fat, vascularity, tissue invasion)
  - Echo + cCT
    - Alternative when cMR not available or patient not suitable – high spatial res, Calc masses, cor anatomy, clearer assessment of margins