Advanced Cardiac Imaging for the General Practitioner

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Outline

- Intro to cardiac imaging/stress testing. Advanced imaging modalities MRI/CT
- Overview of indications and contraindications to cardiac MRI
  - Patient selection
  - Stress Testing with CMR
  - Video for treadmill CMR
- Overview of indications and contraindications to cardiac CT
  - Difference between Calcium score and CTA
  - Patient selection for CTA/calcium score
  - Clinical case for calcium score

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Introduction to Cardiac MRI

- Allows for assessment of anatomical structures in any plane
- Functional information (quantitative)
  - Ventricular function (left and right)
  - Intracardiac shunt assessment
  - Stenotic lesions
- Infiltrative diseases/fibrosis
  - Viability
  - ARVD
  - Sarcoid, Amyloid
- Vascular imaging (aorta)

Cardiac MRI Clinical Applications

- Ischemic Evaluation: Adenosine, dobutamine or treadmill stress testing
- Viability assessment: prior to revascularization
- Cardiomyopathy assessment
  - Biventricular function assessment
  - Ischemic/non-ischemic/infiltrative
  - Risk for Sudden Cardiac Death
  - Response to cardiac resynchronization therapy

Additional Clinical Applications

- Congenital Heart Disease
- Aortic Evaluation
- Intracardiac Mass Evaluation
- Pericardial Disease

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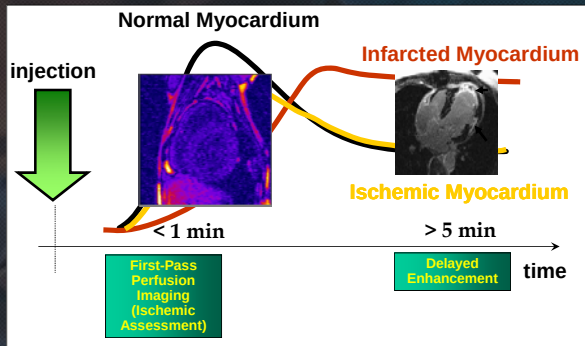
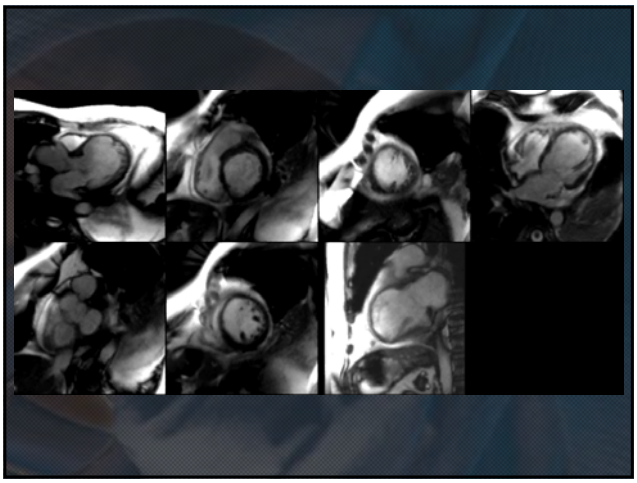
Gadolinium Contrast: Two Phases of Myocardial Enhancement



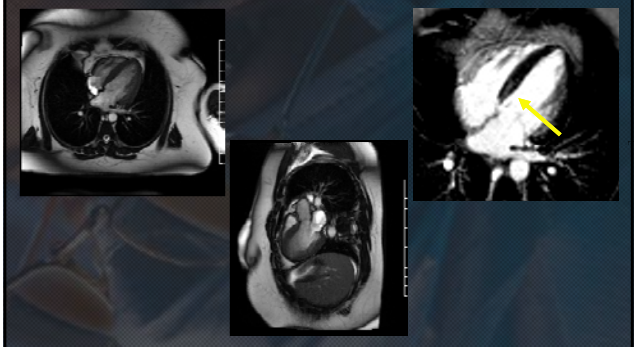
Patterns of Hyperenhancement

- Transmural
  - Involves entire wall
  - Consistent with myocardial infarction/ischemic event
  - If more than 50% of wall involved, felt to be non-viable
- Non-transmural
  - Endocardial, epicardial, mid-wall
  - Non-ischemic myopathies, infiltrative diseases



DME: LAD-territory infarct scar

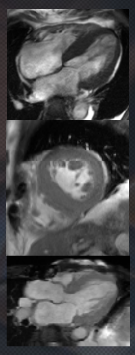
Mid-Myocardial Hyperenhancement

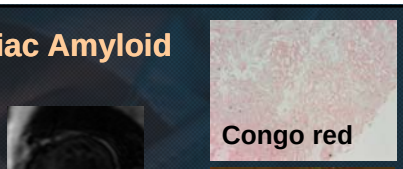


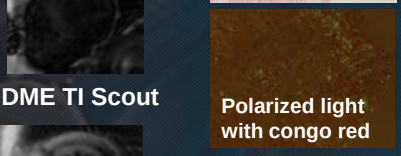
Infiltrative Cardiomyopathies

- Myocardial biopsies subject to sampling error
- CMR 'samples' the entire myocardium
- Sarcoidosis
- Amyloidosis
- Hemochromatosis
- Chagas disease
- Gaucher's disease, Anderson-Fabry disease, etc.

Cardiac Amyloid

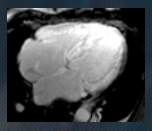




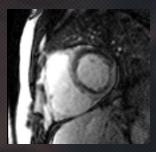


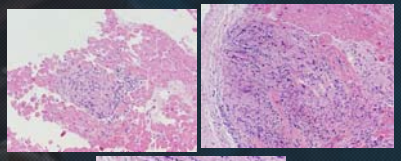
DME TI Scout


DME TI 70msec

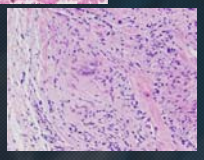

DME TI 200msec

Myocarditis: Giant Cell

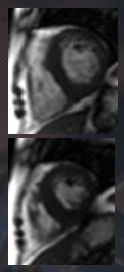


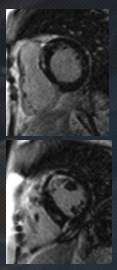


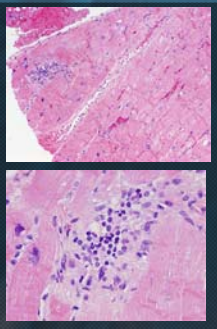
DME with extensive epicardial hyperenhancement



Myocarditis


CMR Cine Images


Markedly abnormal DME-CMR


Small focus of mononuclear cells

Limitations of MRI

- Long acquisition times
  - 45-60 min
- Most imaging sequences require breath holding
  - 10-30 sec breath holds per image sequence
  - 10-16 images required to image entire heart
- Contraindications to MRI
  - Pacemakers/ICDs
  - Any ferrous material within body
  - CKD→Nephrogenic systemic fibrosis (NSF)

Nephrogenic Systemic Fibrosis (NSF)

- Diffuse systemic fibrosis involving skin, skeletal muscle, GI tract, cardiovascular system
  - Skin lesions symmetrical and extend distal to proximal
- After the administration of gadolinium in patients with renal failure (GFR<60)
  - No cases reported in patients with GFR >30
- Diagnosis: skin biopsy
  - Lab testing non-specific
- Treatment supportive
  - Restore renal function (HD not effective once patient develops NSF)
  - Pain management
- For further questions, refer to OSU Radiology Departmental website on OneSource

Overview of Cardiac MRI Stress Testing

- Pharmacologic
  - Adenosine/Regadenoson
  - Dobutamine
- Exercise (Treadmill)
  - Functional data
  - NIH supported research at Ohio State

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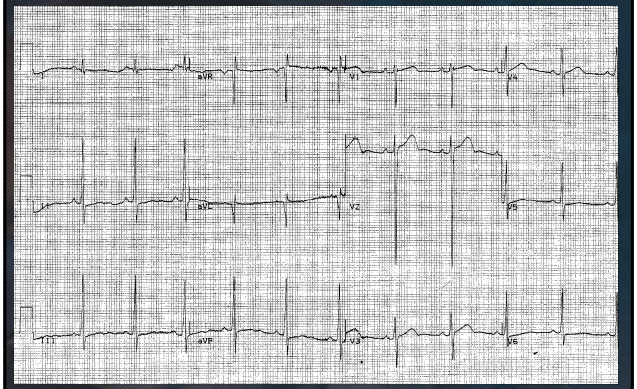
Clinical Case 1

- 16 year-old asymptomatic basketball player
- ROS: no syncope, palpitations, DOE, etc.
- PMH: negative
- FH: unremarkable

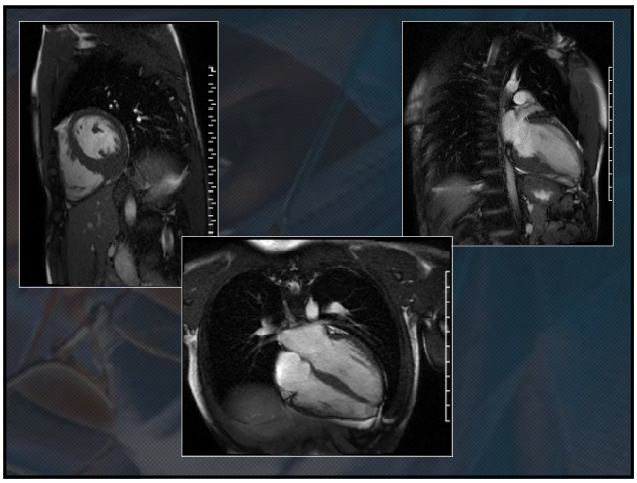
Physical Examination

- Height 182 cm, weight 71 kg
- BP 118/54, HR 45-60
- Symmetric pulses
- II/VI SEM at LUSB, no positional change
- Rest of PE unremarkable



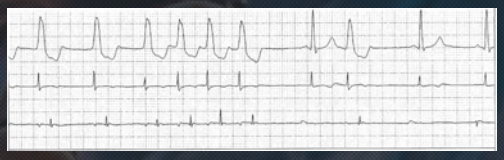
Diagnostic Testing

- Normal echocardiogram ('1cm LV walls')
- Because of abnormal ECG, patient referred for cardiac magnetic resonance
- CMR exam included:
  - 3D cine
  - Post-gad DME for scar/infiltrate
  - Non-contrast MRA for coronary artery origins/ prox course and aorta



Clinical Case 2

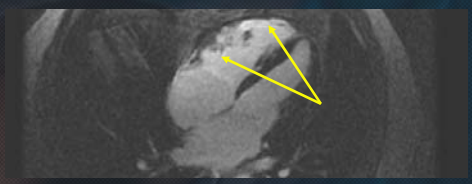
- 36 y/o African-American male with palpitations, near-syncope
- PMH: sarcoidosis
- PE, echocardiogram unremarkable



- CMR to assess myocardium

Clinical Case 3

- 42 y/o male with atrial fibrillation refractory to drug therapy
- FH: no known cardiovascular disease
- PE: unremarkable
- Echocardiogram: low-normal EF
- CMR exam to delineate pulmonary veins pre-ablation



Dx: arrhythmogenic right ventricular cardiomyopathy/dysplasia (ARVC/D)

Change in management:

-RFA plus ICD placement

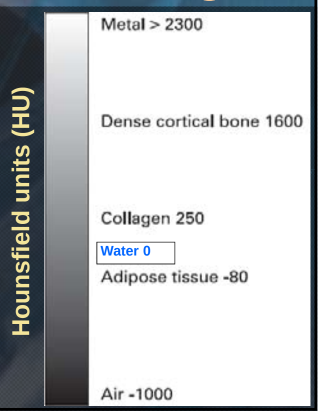
-Screening of family members

Introduction to Cardiac CT

- Calcium scoring
  - No contrast
  - Primarily for risk stratification
- Coronary angiography
  - Contrast administered
  - Calcium scoring typically done with this study
  - Symptomatic patient with low to intermediate risk for CAD
  - Symptomatic with indeterminate stress test
  - Coronary artery anomalies

Calcium Scoring

- Calcium has high signal intensity in CT; based on x-ray attenuation relative to water
- Threshhold for calcium scoring typically 130
- Agatston score: weighted sum of HU over slices covering the heart
- Calcification is one aspect of atherosclerosis
- Calcium score indicates:
  - Plaque burden? Yes
  - Luminal stenosis? No



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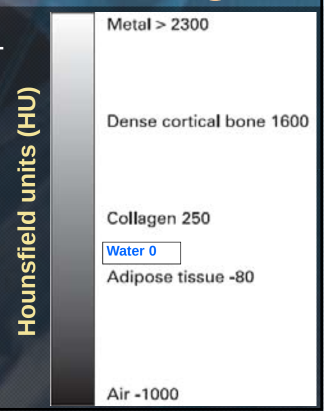

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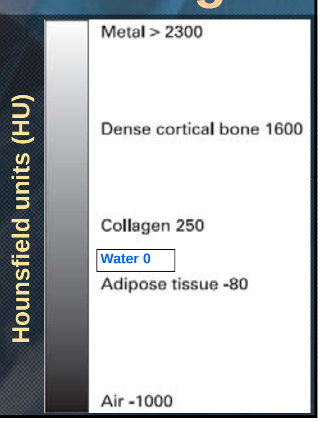

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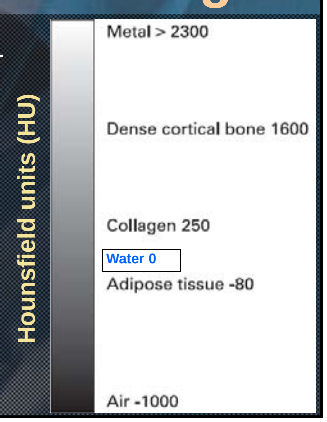

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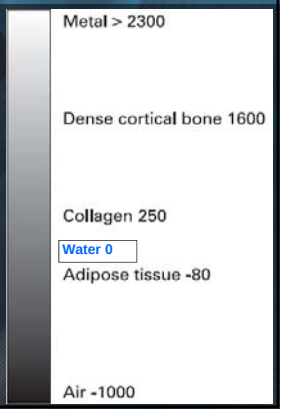

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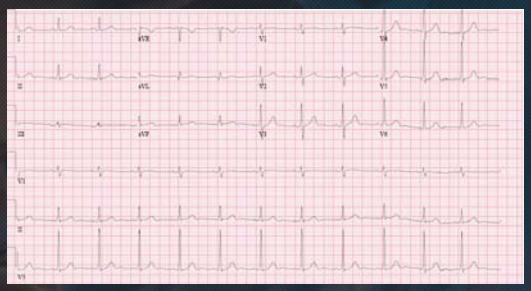
Clinical Case 4

- 65yo Male presents for an annual physical
  - Exercises 5 days a week without any concerning symptoms
    - PMHx: Hyperlipidemia
    - Medications: 20mg Simvastatin, 325mg Aspirin
    - SoHx: 2ppd tobacco x 20 years (quit in 2009)
      - Cigar use 1-2 times a month
    - FmHx: Father with MI age 53, PGM, PGF and mother with MI in their 60s.

Clinical Case 4 Continued

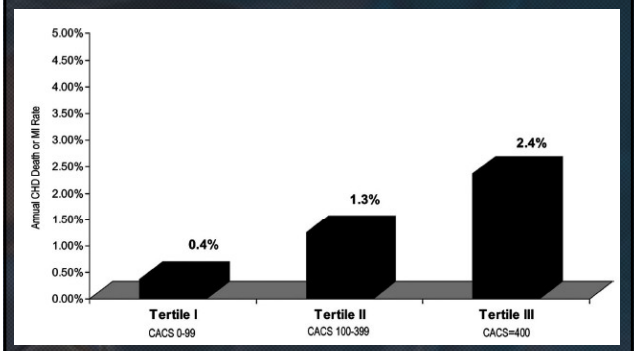
- PE: BP 168/83 HR 65, BMI 29
  - Unremarkable physical findings.
- Lipid
  - Total cholesterol 221
  - LDL 145
  - HDL 41
  - Triglycerides 176



- **“So Doc, how’s my heart doing? I don’t want to end up like my parents.”**

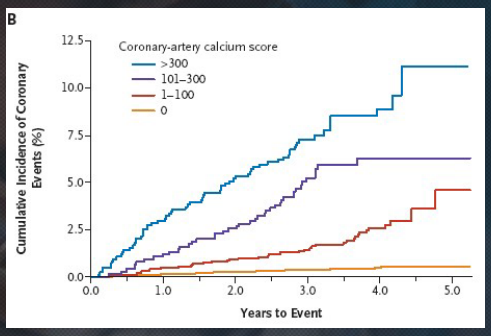
Risk Category	LDL Goal	LDL Level at Which to Initiate Therapeutic Lifestyle Changes (TLC)	LDL Level at Which to Consider Drug Therapy
CHD or CHD Risk Equivalents (10-year risk >20%)	<100 mg/dL	≥100 mg/dL	≥130 mg/dL (100-129 mg/dL: drug optional)*
2+ Risk Factors (10-year risk ≤20%)	<130 mg/dL	≥130 mg/dL	10-year risk 10-20%: ≥130 mg/dL 10-year risk <10%: ≥160 mg/dL
0-1 Risk Factor†	<160 mg/dL	≥160 mg/dL	≥190 mg/dL (160-189 mg/dL: LDL-lowering drug optional)

ATPIII Executive summary



JACC: vol 49, 3:2007

Multi-Ethnic Study of Atherosclerosis



NEJM 2008; 358;13:1336-45

Patient selection for Calcium scoring

- CAC for intermediate risk patients (10-20% 10 year risk) without symptoms (IIa)
- CAC may be reasonable for low to intermediate risk patients (6-10%) (IIb)
- No data to support use in low risk (<6% 10-year risk). Typically young population of men less than 40 and women less than 50.

Greenland et al JACC vol 56, 25, 2010

Clinical Case 4 Continued

- Calcium score
  - RCA 237
  - LAD 298
  - LM none
  - Cx none
- Change treatment to secondary prevention guidelines
- Ideal patient is in the Intermediate risk (10-20% 10 yr) risk strata
  - asymptomatic patient
  - Result might reclassify patient to higher risk status

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Contraindications for calcium scoring

- Known CAD
- Symptomatic patient
- Cardiac “hardware”: pacemakers, stents, prosthetic valves

Clinical Case 5

- 12 year old female with no significant past medical history had syncopal event while playing in basketball game
- No prodrome
- Awoke spontaneously

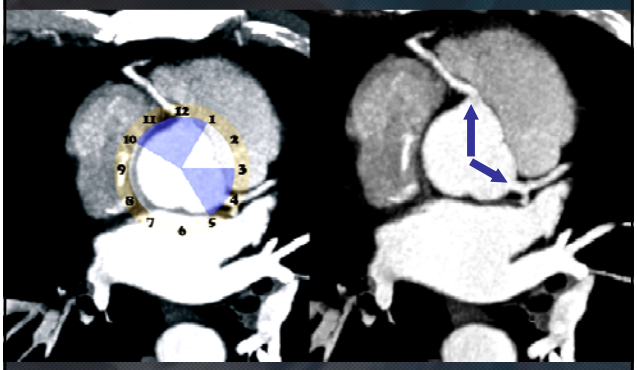
Physical Examination

- Afebrile, P-80, BP 90/50
- Quiet precordium, I/IV short systolic ejection murmur, no diastolic murmur, gallop or rubs
- Abdomen unremarkable

Diagnostic Testing

- ECG showed sinus rhythm with 0.5 mm ST elevation in precordial leads.
- Echo showed normal biventricular function, no significant valvular disease, unable to visualize coronary arteries
- Referred for coronary CTA

Normal Anatomy



Clinical Case 6

- 45 year old perimenopausal female with hypertension presents with dyspnea on exertion
- PMH: HTN, obesity
- Meds: Lisinopril/HCTZ 10/12.5mg
- Non-smoker
- Family history of coronary artery disease in her mom (60's) and dad (60's)

Clinical Case 6: Physical Exam

- PE: P-70; BP 132/75, BMI 30
- HEENT: Normocephalic, +acanthosis nigrans, no carotid bruits
- CV: Quiet precordium, RRR, no murmurs, gallops or rubs. 2+peripheral pulses.
- Ext: No edema

Clinical Case 6: Treadmill Nuclear Stress Testing

- Exercised for 9 minutes no Bruce protocol achieving 10.1 METs and 96% of age-predicted maximal heart rate
- Baseline ECG: Sinus rhythm with 0.5 mm ST depression in anterior leads
- Stress ECG: Sinus tachycardia with 1.5 mm horizontal ST depression in precordial leads (indeterminate due to baseline abnormalities
- Imaging: Mild perfusion defect in anterior wall likely due to breast attenuation although ischemia cannot be excluded. Normal function, EF 55%

References

- ACC/AHA Cardiovascular CT Appropriateness Criteria, Journal of the American College Cardiology. 2012; 59 (9): 857-881.
- ACC/AHA Guidelines for Exercise Testing: Executive Summary, Circulation. 1991; 96: 345-354.
- OSU Department of Radiology website. https://onesource.osumc.edu/departments/radiology