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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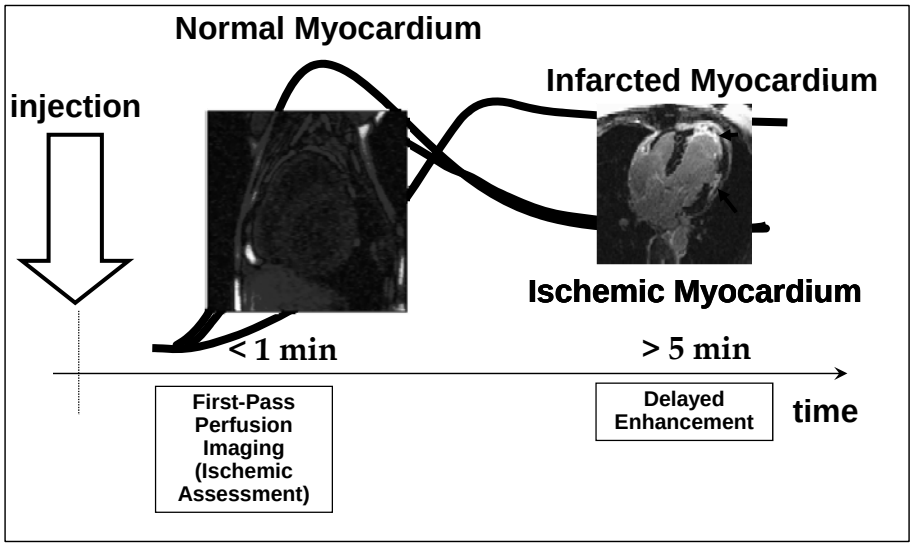
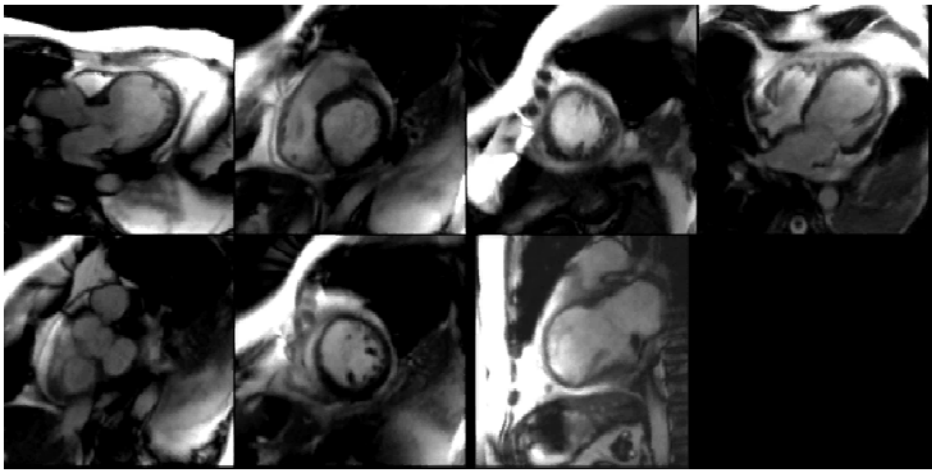
Gadolinium Contrast: Two Phases of Myocardial Enhancement

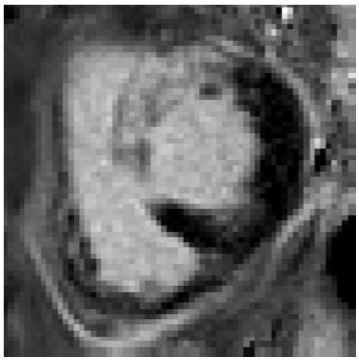


Patterns of Hyperenhancement

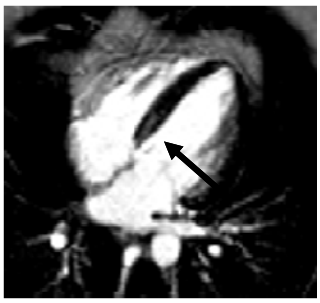
- **Transmural**
  - **Involves entire wall**
  - **Consistent with myocardial infarction/ischemic event**
  - **If more than 50% of wall involved, felt to be non-viable**
- **Non-transmural**
  - **Endocardial, epicardial, mid-wall**
  - **Non-ischemic myopathies, infiltrative diseases**



DME: LAD-territory infarct scar



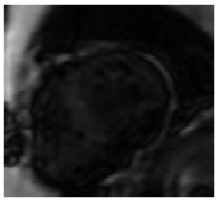
Mid-Myocardial Hyperenhancement



Infiltrative Cardiomyopathies

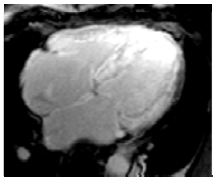
- Myocardial biopsies subject to sampling error
- CMR ‘samples’ the entire myocardium
- Sarcoidosis
- Amyloidosis
- Hemochromatosis
- Chagas disease
- Gaucher’s disease, Anderson-Fabry disease, etc.

Cardiac Amyloid

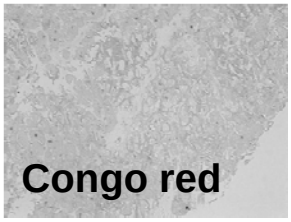


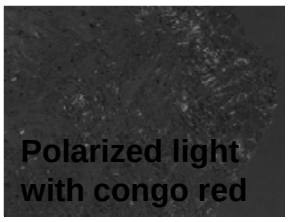
DME TI Scout

DME TI 70msec

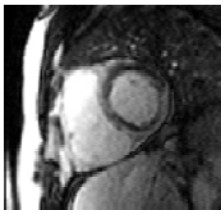


DME TI 200msec

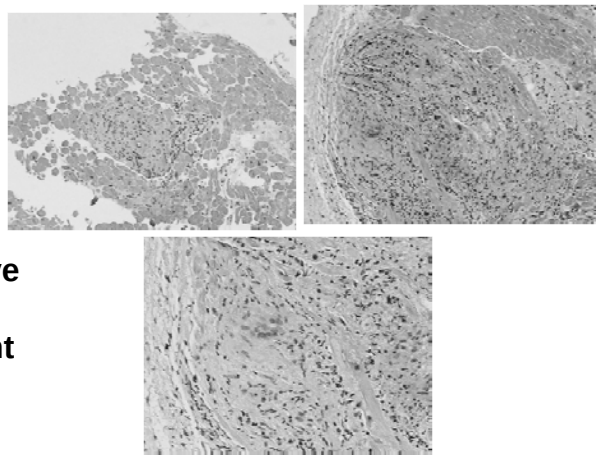




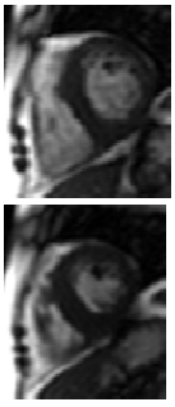
Myocarditis: Giant Cell



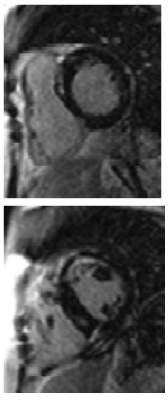
DME with extensive epicardial hyperenhancement



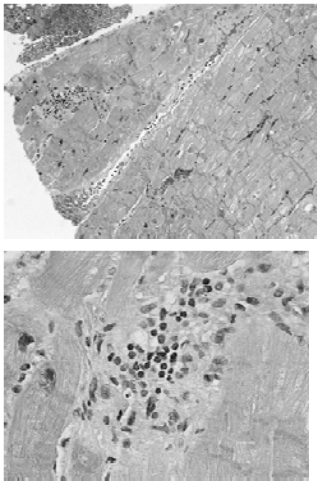
Myocarditis



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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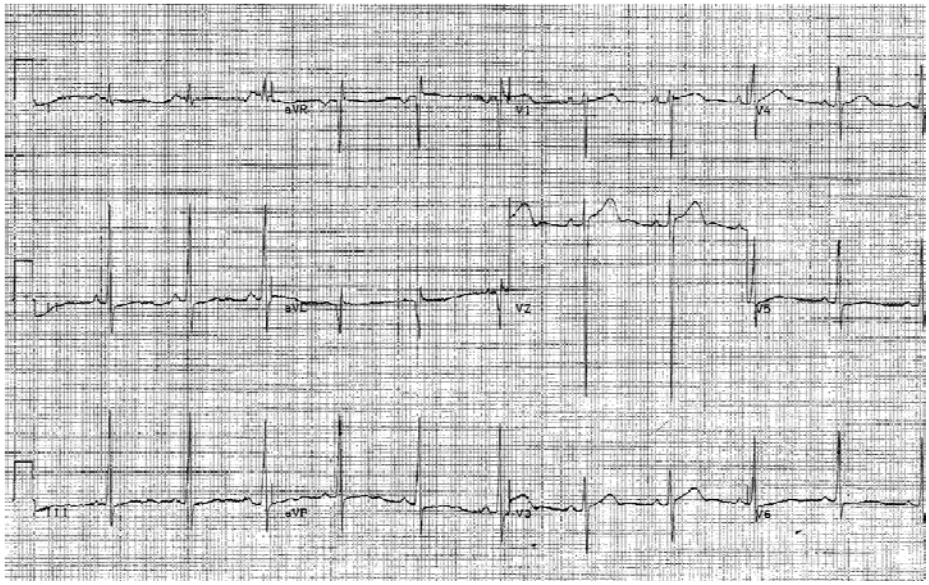
Clinical Case 1

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

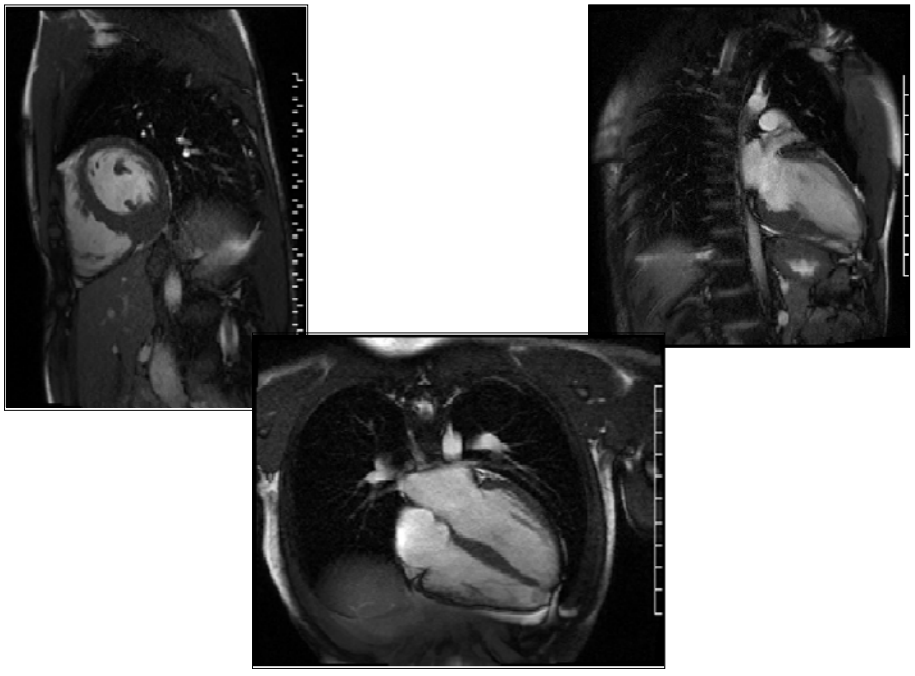
Physical Examination

- **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**



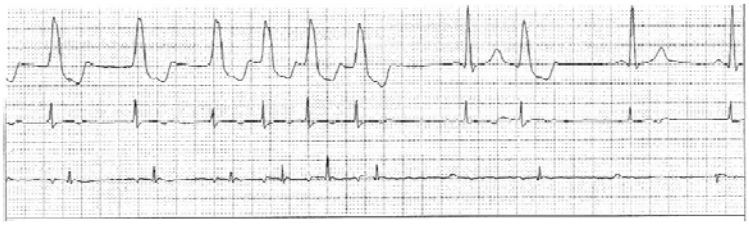
Diagnostic Testing

- **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**

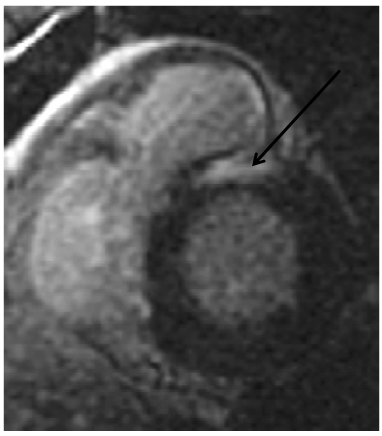


Clinical Case 2

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

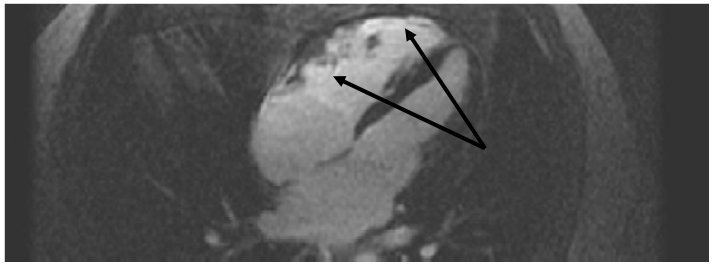


- **CMR to assess myocardium**



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

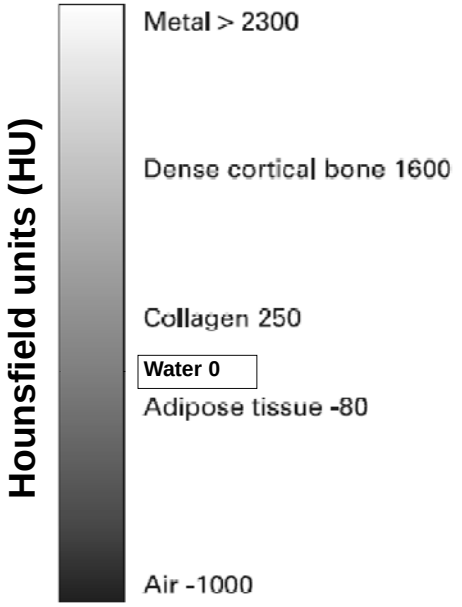
-Screening of family members

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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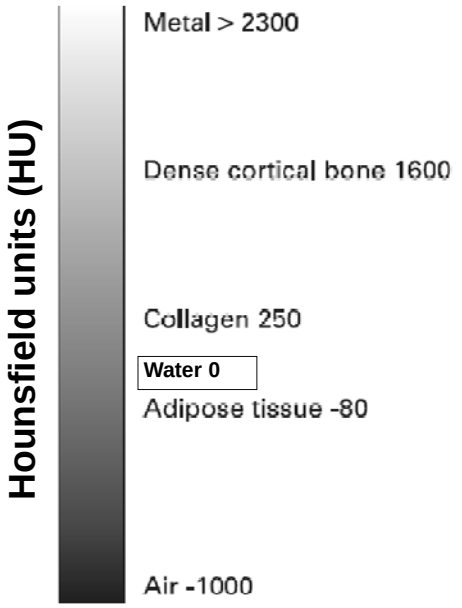

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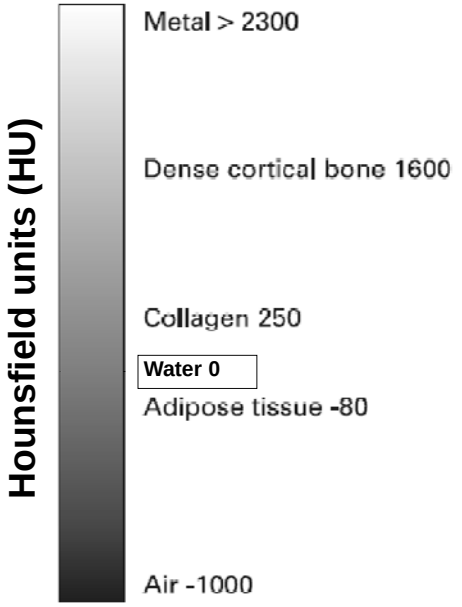

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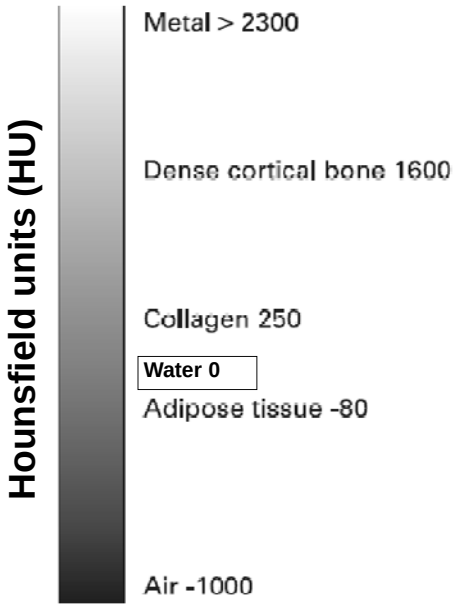

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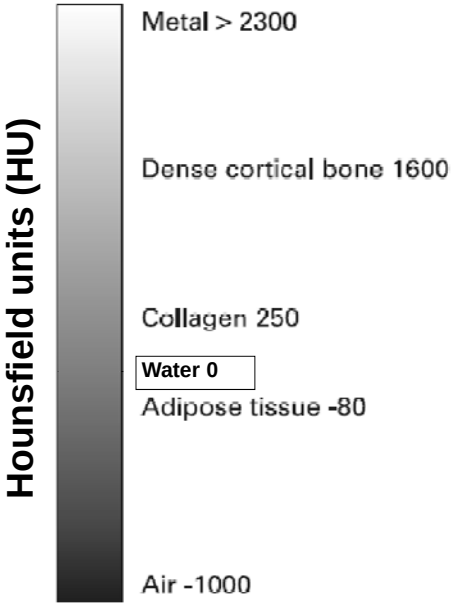

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Clinical Case 4

- 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.

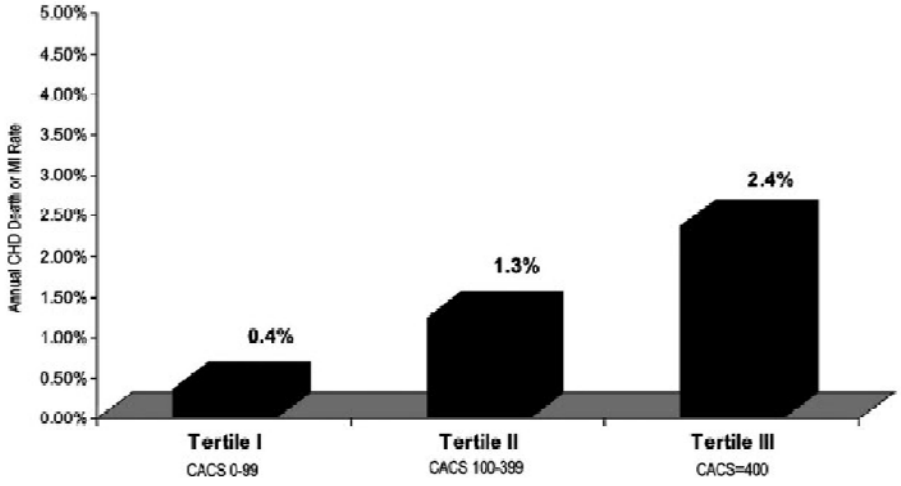
Clinical Case 4 Continued

- 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.”**

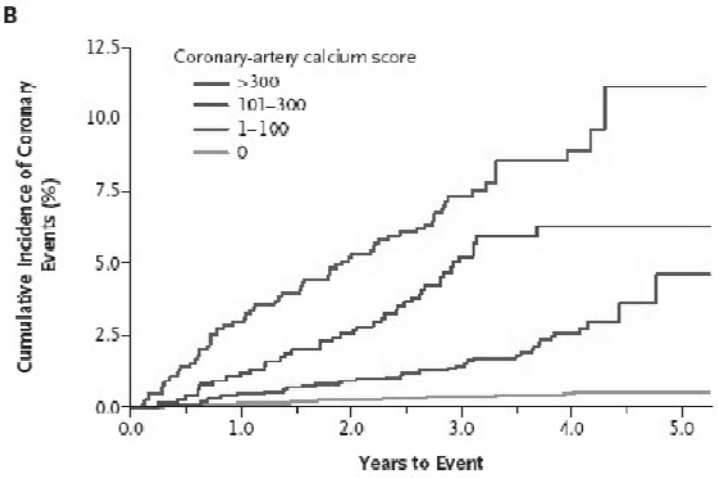
Risk Category	LDL Goal	LDL Level at Which to Initiate Therapeutic Lifestyle Changes (TLC)	LDL Level at Which to Consider Drug Therapy
CHD or CHD Risk Equivalents (10-year risk >20%)	<100 mg/dL	≥100 mg/dL	≥130 mg/dL (100-129 mg/dL: drug optional)*
2+ Risk Factors (10-year risk ≤20%)	<130 mg/dl	≥130 mg/dl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

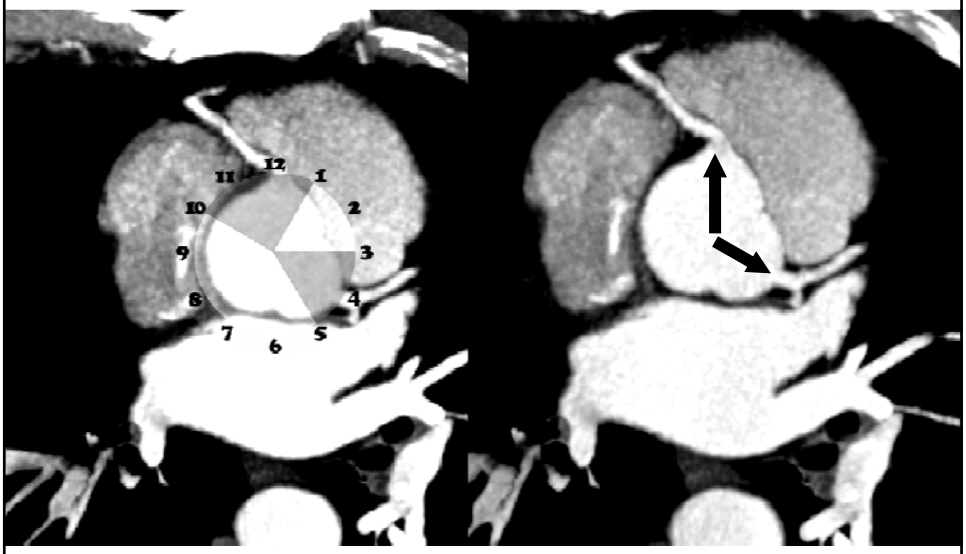
Physical Examination

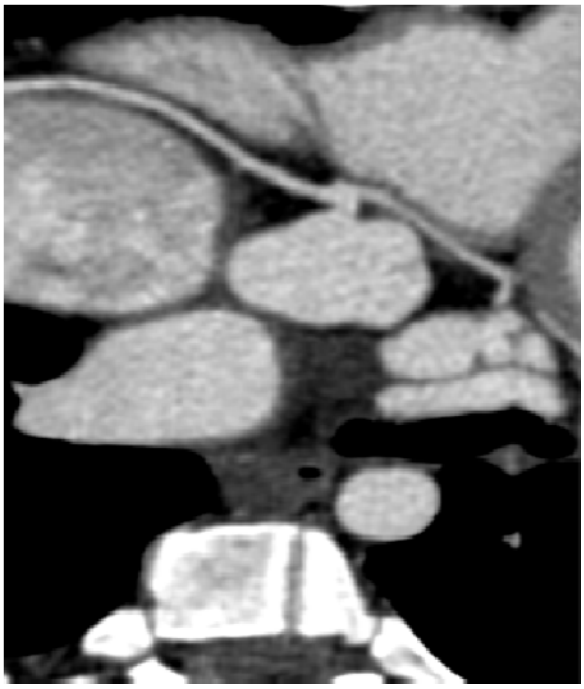
- **Afebrile, P-80, BP 90/50**
- **Quiet precordium, I/IV short systolic ejection murmur, no diastolic murmur, gallop or rubs**
- **Abdomen unremarkable**

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**