Case Studies in Cardiac Diagnostic Testing

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SESSION OBJECTIVES

• Describe common diagnostics cardiac tests.
• Explain which test is most desirable in which patient.
• Summarize management strategies to consider once a diagnosis is established.
CARDIAC DIAGNOSTIC TESTING

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Objectives

- Describe common diagnostics cardiac tests.
- Explain which test is most desirable in which patient.
- Review management strategies to consider once a diagnosis is established.
Diagnostic Tests

- Electrocardiogram
- Cardiac stress testing
- Echocardiography
- Coronary calcium imaging
- Holter monitor, event monitor, zio patch, loop recorder
- Cardiac MRI
- Cardiac CT
- Oh Yeah, Don’t forget the CXR
Signs/Symptoms

- Chest Discomfort
- Palpitations
- Lightheadedness
- Syncope
- Murmur
- Fatigue
- Dyspnea
What about the patient with chest discomfort?
Normal ECG
ST Segment changes
Patient 1

- Peter, a 73 y.o. with no cardiac hx
- Mild HTN, slightly overweight
- VS nl, BMI 26
- Lipid panel: chol 198, tri 286, HDL 38, LDL 142
- C/O intermittent burning in throat for the past 3 months
- EKG in office normal
- On no routine medication
- ??s to ask
Patient 2

- Debra, 49 y.o. female
- Hx fibromyalgia, depression, arthritis
- VS normal, BMI 33
- EKG nl
- C/O dyspnea walking up 2 flights of stairs
- Routine ST 18 mos ago which was normal
Patient 3

- Amy, 36 y.o. with c/o chest discomfort, non exertional, no pattern.
- Also notes “passing out” on 2 previous occasions.
- States her heart “often feels like it is going crazy”
- Recently put on trazadone for insomnia and feeling better
- Only other med is citalopram
- Fixed splitting of S2
REASONS FOR STRESS TEST

- Detect obstructive CAD in person with typical angina
- Assess ischemia in patient with known CAD (evaluate treatment)
- Screening for person with high risk
- Prognostic test in patient with known CAD (functional significance)
- Exercise capacity & safety if starting exercise program.
TYPES OF TEST

- Routine exercise test
- Imaging study
  - Exercise
  - Pharmacological (dobutamine, persantine...)
  - Stress Echocardiogram
- WOM
- WOT
- TMR
Routine Exercise Testing

- Exercise performed on a motorized treadmill
- Set protocol (speed, incline / % grade)
- Modified protocol for patients with specific issues or physical impairment
- Symptom-limited protocol
- Reproduction of clinical symptoms
- Exercise duration less critical but good info
- Target heart rate > 85% predicted maximum
- BP response, arrhythmias
NUCLEAR IMAGING TEST

- Can be performed in all patients compared to stress echo
- Good negative predictive value – no perfusion defects or wall motion abnormalities
- If negative scan and positive findings on cath, good prognosis
- Less costly than cath
NUCLEAR IMAGING TEST

- **Exercise type**
  - Radionuclide images at rest
  - Exercise to 85% age predicted with tracer injected at peak exercise. Need to walk one more minute
  - Radionuclide images after stress
PHARMACOLOGICAL TESTING

- Vasodilator stress imaging
  - Based on coronary flow reserve
  - Dipyridamole (Persantine®)
  - Adenosine
  - Lexiscan
  - Images at rest
  - Injection of agent (stress part)
  - Perfusion images after “stress”

- Inotropic stress
  - Dobutamine
Stress Echocardiography

- Used with routine treadmill exercise or dobutamine infusion protocol
- Baseline study compared with immediate post-exercise images
- End-points include global LV function and regional wall motion analysis
- Image quality limited in some cases
- Post-exercise imaging is time sensitive
STRESS ECHOCARDIOGRAPHY

- Echo done first - remember it is not a complete echo.
- After reaching peak HR, have pt go as long as possible
- Quickly move to stretcher for echo images at maximum HR
## Comparative Advantages of Stress Echo and Radionuclide Perfusion Imaging

<table>
<thead>
<tr>
<th>Stress Echo</th>
<th>Perfusion Imaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher specificity</td>
<td>Higher success rate</td>
</tr>
<tr>
<td>More clinical information</td>
<td>Higher sensitivity, particularly LCX</td>
</tr>
<tr>
<td>Greater availability and convenience</td>
<td>Better accuracy in evaluating ischemia in setting of resting abnormalities</td>
</tr>
<tr>
<td>Lower cost</td>
<td>Higher cost</td>
</tr>
<tr>
<td>No radiation</td>
<td>Radiation exposure</td>
</tr>
</tbody>
</table>
Interpretation Issues

- Test graded positive or negative based on ST segment changes and +/- symptoms. May be “equivocal”.
  - 1 mm horizontal or downsloping changes 0.08s after end of QRS
  - 2 mm upsloping ST segment depression
  - 1 mm ST segment elevation

- Inferior lead changes → higher false (+) rate, especially in women

- T wave changes common
WHAT WE NEED

- Able to walk or willing to try
- Encouragement by PCP for patient to do walking test
- Able to lie down for 20 minutes twice
- Discussion about what to do with information once test done
PRETEST PROBABILITY

- Exercise testing is most valuable when pretest probability is intermediate
- To assess pretest probability need:
  - Age
  - Gender
  - Symptom (description of chest pain)
TYPES OF CHEST DISCOMFORT/PAIN

- Typical
- Atypical
- Non anginal
Typical vs atypical angina (AHA/ACC definition)

- **Typical**
  - Substernal or characteristic quality
  - Exertional
  - Resolves with rest or nitroglycerin

- **Atypical**
  - Two of three characteristics

- **Nonanginal**
  - Only one or none of the characteristics

Clinicians must avoid characterizing type of angina based on gut feelings or opinions.
WHAT ABOUT WOMEN

- Different descriptors: burning, numbness
- Other common symptoms: SOB, fatigue, back pain
- More likely to have one vessel than men
- THINK OF MICROVASCULAR DISEASE
### How to determine pretest probability of coronary artery disease

**STEP 1**

3 questions:

- Is chest pain substernal?
- Is chest pain brought on by exertion?
- Is chest pain relieved within 10 minutes by rest or nitrolycerin?

**STEP 2**

Total the number of “yes” answers to identify symptom pattern:

<table>
<thead>
<tr>
<th>0 of 3</th>
<th>1 of 3</th>
<th>2 of 3</th>
<th>3 of 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymptomatic</td>
<td>Nonanginal chest pain</td>
<td>Atypical angina</td>
<td>Typical angina</td>
</tr>
</tbody>
</table>

**STEP 3**

Find the cell in the matrix (below) where age, gender, and symptom pattern converge:

<table>
<thead>
<tr>
<th></th>
<th>High probability</th>
<th>Intermediate</th>
<th>Low</th>
<th>Very low</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;90%</td>
<td>10%-90%</td>
<td>10%-90%</td>
<td>&lt;10%</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>AGE (YRS)</td>
<td>ASYMPTOMATIC</td>
<td>NONANGINAL CHEST PAIN</td>
<td>ATYPICAL ANGINA</td>
<td>TYPICAL ANGINA</td>
</tr>
<tr>
<td>-----------</td>
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<td>-----------------------</td>
<td>-----------------</td>
<td>---------------</td>
</tr>
<tr>
<td>35-45</td>
<td>Very low</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td>45-55</td>
<td>Low</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>High</td>
</tr>
<tr>
<td>55-65</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>High</td>
</tr>
<tr>
<td>65-75</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>High</td>
</tr>
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</table>

Adapted from Diamond GA.²
Comparative Sensitivity and Specificity Results

<table>
<thead>
<tr>
<th>Test</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treadmill (ECG)</td>
<td>68%</td>
<td>77%</td>
</tr>
<tr>
<td>Exercise Perfusion Scan</td>
<td>87%</td>
<td>73%</td>
</tr>
<tr>
<td>Pharmacologic Perfusion</td>
<td>89%</td>
<td>75%</td>
</tr>
<tr>
<td>PET Scan</td>
<td>89%</td>
<td>86%</td>
</tr>
<tr>
<td>Stress Echo</td>
<td>80-85%</td>
<td>90-95%</td>
</tr>
</tbody>
</table>
"An appropriate imaging study is one in which the expected incremental information, combined with clinical judgment, exceeds the expected negative consequences* by a sufficiently wide margin for a specific indication that the procedure is generally considered acceptable care and a reasonable approach for the indication."

* Expected negative consequences include risks of the procedure (i.e., radiation or contrast exposure) and the downstream impact of poor test performance, such as delay in diagnosis (false negatives) or inappropriate diagnosis (false positives).
Avoid doing stress tests using echocardiographic images to assess cardiovascular risk in persons who have no symptoms and a low risk of having coronary disease. The recommendation states that there is very little information on the benefit of using stress echocardiography in asymptomatic individuals for the purposes of cardiovascular risk assessment.

RADIATION EXPOSURE

- One imaging study is equivalent to about 63 chest x rays (some data has suggested similar to 600 CXR depending on amt used)
- Cardiac Catheterization is equivalent to about 30 chest x rays
- 1 in approx 270 women(?170) who have imaging study in early 40s will develop cancer
- 1 in approx 650 men who have imaging study in early 40s will develop cancer
- HAVE YOU COUNSELED YOUR PATIENT ABOUT THESE RISKS??????
Radiation Exposure

- Coronary CT for Calcium Scoring = 1-2 mSv
- CCTA = 2-14 mSv
- Myoview ST = 10 mSv
- Cardiac Cath = 4-7 mSv
- CT scan = 5-60 mSv

- Recommended amount in one year = 2-4 mSv
“There are no benefits to society if we decrease the number of MIs to find out that everyone is developing cancer.”

There is no safe lower limit of xray exposure.

ALARA – as low as reasonably acceptable principle
A Management Strategy

High Risk
- Classic symptoms
- Abnormal ECG
- Positive markers

Intermediate Risk
- Framingham risk > 10%
- Concerning symptoms
- Borderline ECG
- Borderline markers

Low Risk
- Framingham risk < 10%
- Atypical symptoms
- Normal ECG
- Negative markers

Cardiac Catheterization

Routine ECG +/- Imaging Modality

Reassurance Risk Factor Modification
Cardiac Catheterization

- Gold Standard
- Evaluation of coronary artery anatomy and stenosis
- Microvascular disease
Echocardiography

- Evaluate overall heart function
  - Systolic and diastolic function
- Look for wall motion abnormalities
- Assessment of valves
- Ejection Fraction
- Pericardial effusion
- Masses
Tests

- Echocardiography
- Electrocardiogram
- Cardiac stress testing
- Coronary calcium imaging
- Holter monitor, event monitor, zio patch, loop recorder
- Cardiac MRI
- Cardiac CT
- Oh Yeah, Don’t forget the CXR
Case Study 1

- Sam is a 49 y.o. African American male admitted with dyspnea & edema
- Previous dx with “chronic lung disease”
- Multiple prior hospitalizations for dyspnea
- Unemployed, limited financial resources, he does have social security/disability
VS: 190/108, 98.4, 108, 22

BMI – 34.8

Smoker, approx 1 ppd

Meds: torsemide 20, lisinopril 20mg, combivent
On exam: lungs with few basilar crackles, 1+ edema, I-II/VI systolic murmur at apex. A & O, mild dyspnea at rest, no JVD, abd obese, can’t appreciate liver

- Labs: CBC, glucose, TSH nl
- Cr 1.61, BUN 24, K 4.1
Tests:

- Prior echocardiogram
  - Mild to mod LVH
  - No significant valve issues
  - Trace MR
  - EF 50-55%
Interpreting the report: Ejection fraction

- EF < 40% means systolic dysfunction
- Slightly reduced EF with s/sx HF means diastolic dysfunction. Report findings of diastolic dysfunction – staged
- Can have HF with preserved EF = HF-PEF
Interpreting the report: Signs of CAD

- Wall motion abnormality
- Akinesis
- Dyskinesis

- Stress Echo - Changes between rest and stress

- New? Prior MI?
Interpreting the report: Valve function

- Stenotic valves
- Regurgitant valves
- Somewhat subjective
- With significant symptoms: cath or other test (MRI)
Sam’s Tests:

- **repeat echocardiogram**
  - Mild to mod LVH
  - No significant valve issues
  - Trace MR
  - EF 35-40%

- **CXR this admission**
  - Mild pulmonary vascular congestion

What might you do?
Sam’s Medications

- Usual HF soup
  - ACE/ARB
  - Beta Blocker
    - Carvedilol
    - Metoprolol
  - +/- diuretic (at least prn)
  - Spironalactone/Epleronone
  - Statin
  - +/- aspirin
Other things to look at

- PFTs??
- Sleep Study
- Weight loss
- Exercise
- Smoking cessation
- Frequent f/u apts
Transesophageal Echocardiography

- Assess mitral valve
- Assess for clot in the LAA
- Assess for intracardiac mass
- ASD
- Evaluate valves when ? endocarditis

- Used during cardiac surgery
SYNCOPE
Case Study

- Luann is a 58 y.o. female.
- On NYE, had champagne
- At 8:45 walked in the cold to a restaurant that was crowded and warm.
- Waiting for table, onset of lightheadedness lasting 3-4 minutes
- Went outside and sat. Stood and passed out for approx 1 min
- On no meds routinely
- No significant medical hx except had a seizure 7 years previously
- No prior episodes of syncope
- Smoker (ugghhh)
- Good weight
- Normal VS
Patient 2

- Kevin, 31 y.o. sudden onset of lightheadedness lasting seconds while in store
- Abrupt syncope
- Bystander CPR
- EMS and found in VF
Patient 3

- Gary, 52 y.o. runner
- No significant medical hx
- Reports several prior episodes of passing out associated with a variety of events (blood drawing, several hrs after a run)
- VSS
- EKG normal
OH YEAH

- WHAT ABOUT AMY
Syncope

- Thorough history & PE
- EKG
  - Rhythm
  - AV Conduction
  - Width of QRS
  - Delta Waves
  - Long QTS, Brugada, ARVD
  - Ectopy
Syncope Cont

- Cardiac Monitor to evaluate rhythm
  - Holter, event, zio, ILR
- Tilt Table Test
  - Best if ? Neurocardiogenic syncope
  - Low sensitivity, ? results
- Electrophysiology Study
- Ischemic disease & low EF increases risk of ventricular arrhythmias
Syncope Cont

- Stress testing especially if syncope with exercise
  - Evaluate for ischemia and arrhythmia during exercise

- Echocardiogram
  - Valvular disease
  - HCM/HOCM
  - PE (RV strain)
Our Cases

- Luann
- Kevin
- Gary
- Amy

- Meds to consider for any of them?
Kevin

- Ventricular fibrillation:
  - Possibly antiarrhythmic
    - Sotalol
    - Dofetilide
    - Amiodarone
TLOC Suspected Syncope

Initial Assessment:
1. History & Physical Exam
2. ECG
3. Other tests (when appropriate)

Treatment ← YES ← Diagnosis?

NO

Immediate (in hospital) evaluation & treatment ← YES ← High short-term risk?

NO

Suspected Cardiac Syncope or Reflex Syncope with recurrences in high risk settings?

NO

Laboratory tests & specialists consultation ← YES ← Delayed treatment guided by ECG documentation if no diagnosis is made

No additional studies Education & Reassurance

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Palpitations

- No clear guidelines on evaluation
- Need to differentiate when underlying cardiac condition exists
  - Structural heart disease
  - Cardiac arrhythmia
  - Psychosomatic
  - Underlying non cardiac condition
  - Recreational or prescribed drug effect
Palpitations Cont.

- Assess if “strong beat or fast beat”
- Assess if associated symptoms
- How long do they last? Seconds?
- When do they occur?
- What is the EF?
Arrhythmias

- Sinus tachycardia
- Atrial extrasystoles
- PVCs, nonsustained VT
- Atrial fibrillation/flutter
- AVNRT, AVRT
history, physical examination, ECG, psychosomatic counselling

Definitive§ or suspected diagnosis

confirmation

- unexplained palpitations

heart disease or abnormal ECG

+ Echo, AECG, MRI*, Stress Test*, EPS*

- frequent or severe

+ rare or well tolerated

- stop

no heart disease and normal ECG

† treatment

+ treatment

- ILR

Source: Europace © 2011 Oxford University Press
Cardiovascular CT

- Coronary calcium imaging
- Coronary CT angiography
Calcium imaging

- No calcium (Agastan score 0)
  - Plaque highly unlikely
  - Significant stenosis highly unlikely
  - Risk <0.1% over 2-5 years
- Score >1 confirms plaque
- Score > 100 = risk >2% over 2-5 years
- High score in asymptomatic person—what to do? Risk factor modification
Calcium imaging
Coronary CT angiography

- Use of 3D technology
- Noninvasive means to look at coronary stenosis
- View moving heart and vessels
- Assess for plaque & calcium deposit
- Completed in less than one minute
Coronary CT
Cardiac MRI

- Coronary MR angiography
  - Congenital coronary anomalies
- Perfusion MR/dobutamine MR
  - Chest pain syndrome
  - Known stenosis of unknown significance
- Delayed enhancement MR
  - Myocardial viability
  - Inflammation/myocarditis
  - Valvular structure & abnormalities
- Cardiac mass
- ARVD
Summary

- Evaluate symptoms with basic tests before consulting
- Consider pretest probability of CAD
- Counsel about radiation exposure
- Echo is easy, cheap, noninvasive, no radiation. Body habitus issue.
- For advanced cardiac testing, consult.
- Shared decision making important
Questions?

Thank You