Ischemic cascade

Myocardial ischemia

Diastolic dysfunction

Regional systolic dysfunction

ECG changes

Chest pain

Diastolic dysfunction

Myocardial ischemia
ART OF IMAGING

- Different imaging modalities
  - Nuclear Cardiology
  - PET
  - MSCT
  - CMR
  - Echocardiography
  - Fusion Imaging
Cardiovascular Imaging

• What the clinician needs to know
  • Understanding pathophysiology
  • Differential Diagnosis
  • Diagnosing correctly
  • Establish therapeutic strategy
  • Follow-up/monitoring situations
  • Assess prognosis (risk stratification)
Cardiovascular Imaging

• What is the clinician worried about:
  • Accuracy
  • Safety
  • Cost
New Frontiers in CV Imaging

• Main goals:
  • Identify the causes and establish the links
  • Assess prognosis
  • Plan therapeutic strategy

• Solve clinical problems
Role of Imaging in patients with ischemic heart disease

• Detection of ischemia
  • Stable Angina
  • Acute chest pain (Acute Coronary Syndromes/Acute Complications)

• Assessing Prognosis (ex. Post AMI)
• Selecting patients for revascularization (viability issue)
• Pre operative assessment of non cardiac surgery patients
• Assessing myocardial revascularization procedures (PTCA, CABG)
• End stage IHD: Pt selection for CRT/ICD
ASSESSMENT OF CORONARY ARTERY DISEASE

- Assessment of coronary anatomy
- Assessment of myocardial perfusion and ischemia
- Assessment of myocardial viability
Myocardial Viability

- The heart is unique among other organs in that coronary arterial flow is exclusively diastolic and venous out-flow is systolic. That is, arterial blood flows into intramyocardial coronary vessels during diastole and the stored blood is squeezed out mostly to epicardial veins and partly to the proximal arteries during the subsequent systole.
• Furthermore, coronary vessels function as highly organized flow regulators to match local blood flows with myocardial energy demands to support the viability of the heart.
Myocardial Viability

• It has been known for some time that left ventricular dysfunction is not always the result of irreversible myocardial necrosis and scarring.
Myocardial Viability

• After an initial ischemic injury, various processes can occur that lead to left ventricular dysfunction, including left ventricular remodeling, impairment of energetics, myocyte dysfunction, and cell death via necrosis and/or apoptosis.
• “Stunned myocardium,” is defined as myocardium that has become dysfunctional because of a transient coronary occlusion, has been salvaged by coronary reperfusion, yet exhibits prolonged but transient postischemic dysfunction, lasting hours to weeks.
Stunned Myocardium

• Thus, in myocardial stunning, blood flow has been restored but contraction has not returned to baseline, ie, there is a flow-contraction mismatch.
Hibernating Myocardium

• “Hibernating myocardium,” is defined as a state of persistently impaired left ventricular function at rest as the result of reduced coronary blood flow.
Hibernating Myocardium

• It is hypothesized that the deprived myocytes are preferentially using the energy that they are able to generate to preserve cellular integrity at the expense of contractile function.
Hibernating Myocardium

- Myocyte function can be partially or completely restored to normal if the myocardial oxygen supply/demand relationship is favorably altered, either by improving blood flow and/or by reducing demand. By this definition, hibernating myocardium is a flow-contraction match.
Myocardial Viability

- Other than cell death, these processes are, to an extent, reversible, and left ventricular function often can be improved, resulting in better patient outcome. Although medical therapy can be extremely beneficial, revascularization in the appropriate patient often is the best therapy.
Influence of Myocardial Viability on Revascularization Benefit in LV Dysfunction

Cardiac Death Rate (%/yr)

<table>
<thead>
<tr>
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<th>Revasc</th>
<th>Medical Rx</th>
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</thead>
<tbody>
<tr>
<td>Viable</td>
<td>3.2</td>
<td>16.0</td>
</tr>
<tr>
<td>Non-Viable</td>
<td>7.7</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Allman et al Circ 2000

p < 0.000

P = NS
Myocardial viability

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M.D.CARDIOLOGY,
JMHP  MEDICAL EDUCATION, Holland SCU E Teaching Diploma, Norway
Myocardial Viability Requirements

- Myocardial Perfusion
- Metabolic Activity
- Cell membrane Integrity
The most tested and clinically used techniques include **nuclear imaging by PET** (nuclear imaging by SPECT evaluating glucose use with $^{18}$FFDG), (evaluating perfusion, cell membrane integrity, and intactness of mitochondria with $^{201}$Tl- or $^{99m}$Tc-labeled agents), **echocardiography with dobutamine** (to assess contractile reserve), **echocardiography with intravenous contrast agents** (to assess perfusion), **MRI with dobutamine** (to assess contractile reserve), **MRI with intravenous contrast agents** (to assess scar tissue), and **CT with intravenous contrast agents** (to assess scar tissue).
NON-INVASIVE ASSESSMENT OF MYOCARDIAL VIABILITY
Dobutamine is a synthetic catecholamine that causes both inotropic and chronotropic effects through its affinity for (β1, β2, and α receptors in the myocardium and vasculature).

**Principle:**

With pharmacological stress, the principle of the test relies on the demonstration of residual contractile reserve in a basally dysfunctional region.
Contractile reserve

• Viability Criteria. Infusions of low-dose dobutamine (5–10 mg/kg/min) have been demonstrated to increase contractility (without a substantial increase in heart rate) in dysfunctional but viable myocardium.

• Segments without viable myocardium do not show this contractile reserve. In recent years, the protocol has been extended to high-dose dobutamine infusion, which allows the assessment of ischemia.
Dobutamine: protocol

Initial dose: 5-10 mcg/kg/min

10 mcg/kg/min every 3-5 min

Maximum dose: 40-50 mcg/kg/min

Suboptimal chronotropic effect
add atropine
Responses to Dobutamine

1) Biphasic Response:
   Improvement in wall motion at low doses which then deteriorates at higher doses of dobutamine = viability with superimposed ischemia

2) Sustained Improvement (Monophasic Response):
   Improvement in wall motion at low dose that persists or further improves by peak dose. probably related to subendocardial necrosis

3) Worsening-(Ischemia-Response):
   Further deterioration of resting wall motion during dobutamine infusion without any initial improvement. This occurs in the presence of critical stenosis with very low coronary flow reserve.

4) No Change (Non Phasic Response):
   No change in wall motion during dobutamine infusion = transmural scar
In short

Myocardial Viability

- Bedside
- Cheap
- Radiation Exposure
- Artifacts attenuation
- Perfusion tracers
- Pregnancy
- Higher Specificity
- Less time

Pregnancy Less time
Sensitivity- Specificity

• Sensitivity refers to the proportion of the times that a test yields true positives. The closer the sensitivity is to 100%, the more likely a positive result actually means that the patient has a disease. Specificity refers to the proportion of the time that a test yields true negatives. The closer the specificity is to 100%, the more likely a negative result means that the patient is truly disease-free.
A PERFECT DIAGNOSTIC TEST

- A perfect test gives only true positives and true negatives. A test that yields a positive result will usually lead to the performance of a second, more accurate test. If the second test used is still simple and non-invasive, then a preliminary test that yields a high number of false positives may be acceptable. If the second test is difficult to perform or risky, the initial test may lead many people to have unnecessary medical procedures. If the first test is imperfect it may incorrectly indicate that patients are healthy, when in fact they are not
“The Best Things in Life are Free”

GOOD NEWS: Imaging modalities improve the diagnostic accuracy of stress ECG testing.

BAD NEWS: Cost is substantial
Sensitivity Comparison of Different Testing Modalities
SPECIFICITY OF DIFFERENT STRESS TESTING MODALITIES

- Stress Nuclear
- Stress ECG
- Stress ECHO
Nuclear Imaging Versus Dobutamine Stress Echo

■ The largest head-to-head comparison included 114 patients who had ischemic cardiomyopathy and who underwent resting perfusion imaging and low-dose dobutamine echocardiography.

■ The agreement between the techniques was 72%; 92% of segments without perfusion did not have contractile reserve, but 47% of segments with perfusion also lacked contractile reserve.

■ Accordingly, the available studies showed a higher sensitivity of nuclear imaging than of dobutamine echocardiography for detecting myocardial viability.
Conversely, the specificity of low-dose dobutamine echocardiography was higher (57% vs. 78%; P < 0.05). In a meta-analysis, the superior sensitivity of TI-201 was balanced by a greater specificity with echocardiography, so the Accordingly, the integration of perfusion (a very sensitive marker) and contractile reserve (a very specific marker) may further improve the prediction of functional recovery.
Factors decreasing sensitivity of exercise stress echocardiography

- Ischemic myocardium can resume function in as little as 10 seconds after exercise so the “ischemic moment” can be missed if images are obtained too long after exercise completed.

- Small vessels may not create large enough of an ischemic zone to generate a wall motion abnormality that is detectable.

Suboptimal visualization of endocardium

Contrast STRESS ECHO
Role of Thallium In Detection Of Myocardial Viability

Artifacts and Pitfalls in Myocardial Perfusion Imaging

Diagram:

- **Patient**
  - Patient preparation
  - Adequacy of stress

- **Equipment**
  - Camera limitations
  - Attenuation correction

- **Heart**
  - LBBB
  - Hypertrophy
  - Balanced ischemia
  - Dextrocardia

- **Motion**
- **Gating**
- **Attenuation**
- **GI activity**

- **Injection**
- **Processing**

- **Technologist**
Common Normal Variations In SPECT Imaging

1. the "dropout" of the upper septum because of the muscular septum merging with the membranous septum.

2. Apical thinning is another variation of normal that can be mistaken for a perfusion defect.

3. the lateral wall may often appear brighter than the contralateral septum.

4. Attenuation
Left Bundle Branch Block and Stress Testing
Left Bundle Branch Block and Stress Testing

- Abnormal septal motion is noted during stress echocardiography resulting in decreased accuracy in physician interpretation.

- Reversible defects of the septum are noted during exercise or dobutamine nuclear imaging resulting in increased false positives.
CMR in CAD
Comprehensive Study

- Ischemia
  - contractility
  - perfusion
- LV Function
  - gold-standard
- Irreversible lesion vs viability
  - Validated against pathology
Myocardial perfusion (1.5 vs 3 Tesla)
CMR – How to diagnose ischemia?

stress/perfusion

stress/dobutamine
Fusion Imaging of a myocardial perfusion SPECT bull’s-eye plot and computed tomography coronary angiography
Image fusion of a low-dose gated adenosine stress SPECT-MPI with 13 MBq 99mTc-tetrofosmin and CT coronary angiography using prospective ECG-triggering.
Multivessel disease: What is the culprit lesion?

FFR = 0.94

FFR = 0.54

FFR = 0.63
Coronary CT Angiography – 3D Stress Echo
Innovation: Image Fusion for detecting ischaemia
Fusion (PET-CT) Imaging in a 66-Year-Old Woman With a History of Stress-Associated Chest Pain, Risk Factors, and Electrocardiographic Evidence of LVH With Strain
Heart Flow
Plaque Characteristics, CT Angio-FFR and Lesion-specific Ischaemia Added Integrative Information

Prospective International Multicenter Trial

252 patients (407 lesions) with suspected or known CAD (64-row CT) + IC Angio-FFR

Stenosis Severity
CAD ≥ 50%

Functional Evaluation
FFR < 0.80

Plaque Characteristics
The history and physical exam remain the backbone of medical evaluation and assessment.

"Observe, record, tabulate, communicate. Use your five senses….Learn to see, learn to hear, learn to feel, learn to smell, and know that by practice alone you can become expert."

Sir William Osler
The Real Story

- Medicine is very different than what you see on *Grey’s Anatomy*, *ER*, and *Scrubs*
- It is truly a noble, challenging, and incredibly rewarding profession
  - Consistently rated the most respected profession in national pools every year
- It can be physically demanding. Training is tough. It is hierarchical, traditional, and tough to gain entrance into.
- However, *it is worth every second.*
Maslow’s Hierarchy of Needs

Self-actualization
personal growth and fulfilment

Esteem needs
achievement, status, responsibility, reputation

Belongingness and Love needs
family, affection, relationships, work group, etc.

Safety needs
protection, security, order, law, limits, stability, etc.

Biological and Physiological needs
basic life needs - air, food, drink, shelter, warmth, sex, sleep, etc.