Case Studies in Acute Chest Pain: Diagnosis, Risk Stratification, & Test Selection

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OhioHealth Heart & Vascular Physicians
Disclosures:

Kanny S. Grewal
  None

Shirlien Metersky
  • None
Case Study #1

Emergency Room Presentation

• 46 y.o. female with PMH of hypothyroid who presents with isolated episode of nonexertional left sided CP described as sharp and stabbing lasting 2 minutes while sitting on couch watching TV

• Nonsmoker, denies HTN or hyperlipidemia

• She reports that her brother, age 55 just had a PCI last month

• Exam normal

• Troponin: undetectable
Case 1: EKG
Case 1: How would you classify patient’s acute risk and recommended testing?

- A: Low
  - Discharge, outpatient testing
- B: Low
  - Observation, inpatient testing
- C: Intermediate
  - Observation, inpatient testing
- D: High
  - Admit, inpatient testing
Case 1 “b”:

- 86 year old female presents to RMH, dull chest pain intermittent for several weeks, sometimes with exertion. No associated sx. Patient is independent, active for age.
- PMH: HTN, hyperlipidemia, prior smoker
- LHC 20 years ago – “unremarkable”, no h/o PCI
- Exam normal
- Troponin:  < 6
- EKG:
Case Study: 86 y.o. female
Case 1b: How would you classify patient’s acute risk and recommended testing?

- A: Low  
  Discharge, outpatient testing
- B: Low  
  Observation, inpatient testing
- C: Intermediate  
  Observation, inpatient testing
- D: High  
  Admit, inpatient testing
Case Study #2

Observation Status Patient with CP

• 78 yo widowed male living in an independent AL facility with history of PMH of CKD stage 3, HTN, HLD, anemia, diverticular GIB requiring prior blood transfusions, PAF on OAC, and CAD s/p CABG admitted for exertional CP similar to prior angina.

• Admit Labs: Hbg 9.6, WBC 11.3, Creatinine 1.6, CrCL 41, K+ 3.8, troponin trend consistent with NSTE-ACS

• Current cardiac medications: ASA 81mg, Eliquis, atorvastatin, and amlodipine
Case 2: **What is patient’s risk assessment and your recommended evaluation?**

<table>
<thead>
<tr>
<th>Risk</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Low</td>
<td>Medical Management only</td>
</tr>
<tr>
<td>B: Intermediater</td>
<td>Pharmacologic Stress Test</td>
</tr>
<tr>
<td>C: High</td>
<td>Medical Management only</td>
</tr>
<tr>
<td>D: High</td>
<td>Coronary Angio +/- PCI</td>
</tr>
</tbody>
</table>
Case Study #3

Patient Admitted with Chest Pain

- 82 yo female presented to ED with progressive exertional MSCP with associated progressive LE edema and DOE
- Diagnostic testing
  - CXR: small bilateral pleural effusions, mild interstitial edema
  - ECG: nonspecific STTWA
  - Labs: Troponin T: time 0 (32 ng/L), time 3 hrs (36 ng/L)
    - NT-proBNP 2084, creatinine 1.5, Hbg 9.7
  - Physical Exam: Bilateral LE edema 2+ pretibial, bibasilar rales with fine diffuse wheezing, harsh 2/6 SEM
Case 3: What is likely etiology of elevated troponin T?

- A: Type 1 NSTEMI
- B: Type 2 NSTEMI
- C: Aortic Stenosis and CHF with preserved EF (HFpEF)
- D: False positive due to renal disease
Case Study #4

Patient Transferred from OLH with Equivocal Nuclear Stress Test

• 48 y.o. Caucasian male with PMH of poorly controlled HTN, DJD, and cardiac FMH who presented to OLH with left sided CP that woke him up from sleep lasting 1 hour not relieved with SL NTG administered by EMS. Nonsmoker.

• Admit ECG nonischemic, troponin trend negative x 3. BMI = 31.

• Underwent Pharmacologic SPECT (unable to exercise due to DJD) that showed preserved LVEF (58%), suboptimal quality, small primarily fixed defect in basal inferior region with “possible” peri-infarct ischemia.
Case 4: What test do you recommend for further assessment?

- A: Coronary angiography
- B: Dobutamine Stress Echo with contrast
- C: Coronary CT angiogram (CCTA)
- D: Stress PET perfusion scan
Case Study #5

Observation Status Patient with Chest Pain

- 66 yo female with PMH of CAD, HTN, GERD, HLD, and NIDDM who presents to ED with intermittent sharp CP, nonexertional. Chronic dyspnea with exertion, slightly worse recently. On day of presentation her CP woke her from sleep and relieved by SL NTG administered by EMS.

- Exam normal, BMI = 37.

- PCI to RCA 12 years ago. Left heart cath 3 years ago: patent stent, mild CAD.

- Vasodilator SPECT 18 months ago: probable normal with breast attenuation artifact

- Admit ECG nonischemic, troponin trend negative

- Admitted to Observation Unit for further evaluation
Case 5: What test do you recommend for further assessment?

- A: Coronary angiography
- B: Dobutamine Stress Echo with contrast
- C: Coronary CTA (CCTA)
- D: Stress PET perfusion scan
Reference Slides
Cases 1-5
HEART Score Tool

- Risk stratification tool used in ED for patients presenting with CP that the physician deems appropriate for ACS workup to predict risk of major adverse cardiac events (MACE)

<table>
<thead>
<tr>
<th>HEART score for chest pain patients</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highly suspicious</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Moderately suspicious</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Slightly suspicious</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>ECG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significant ST-deviation</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Non specific repolarisation</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>disturbance / LBBB / PM</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 65 years</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&gt; 45 and &lt; 65 years</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>≤ 45 years</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Risk factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 3 risk factors or history of</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>atherosclerotic disease*</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1 or 2 risk factors</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>No risk factors known</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Troponin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 3x normal limit</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&gt; 1 and &lt; 3x normal limit</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>≤ 1x normal limit</td>
<td>0</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>HEART Score</th>
<th>Risk of MACE</th>
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</thead>
<tbody>
<tr>
<td>0 - 3</td>
<td>1.6%</td>
</tr>
<tr>
<td>4 - 6</td>
<td>13%</td>
</tr>
<tr>
<td>7 - 10</td>
<td>50%</td>
</tr>
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</table>

www.heartscore.nl
## OhioHealth HEART Score Criteria

### History

<table>
<thead>
<tr>
<th>Chest Pain Risk Features</th>
<th>0: No features (noncardiac)</th>
<th>1: 1-2 features (atypical)</th>
<th>2: 3 or more features (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Retrosternal pressure</td>
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<td></td>
</tr>
<tr>
<td>• Radiation (jaw, arm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Exertion</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Relief (nitrates or rest)</td>
<td></td>
<td></td>
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<tr>
<td>• Duration (5-15 min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Diaphoresis/Nausea</td>
<td></td>
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</table>

### EKG

<table>
<thead>
<tr>
<th>Definite Ischemia:</th>
<th>Nonspecific:</th>
<th>0: Normal EKG</th>
<th>1: Nonspecific</th>
<th>2: Definite Ischemic</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ST elevation</td>
<td>• LBBB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• &gt;1 mm ST depression</td>
<td>• LVH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• New T wave inversion</td>
<td>• Nonspecific ST/T wave changes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• No LBBB, LVH, etc</td>
<td></td>
<td></td>
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</tbody>
</table>

### Age

| 0: <45                   | 1: 45-64                  | 2: >65        |

### Risk Factors

<table>
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<tr>
<th>- Hypertension (Treated, or &gt; 160/100)</th>
<th>- Hyperlipidemia (Treated)</th>
<th>- Diabetes</th>
<th>- Smoker (Current or quit &lt;90 d)</th>
<th>- BMI &gt; 30</th>
<th>- Family History of premature CAD (men &lt; 55, women &lt; 65)</th>
<th>0: No RF and no known CVD</th>
<th>1: 1-2 RF and no known CVD</th>
<th>2: &gt; 3 RF, or known CVD (CAD, PVD or CVA/TIA)</th>
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### Troponin

(Use local lab cutoffs)

<table>
<thead>
<tr>
<th>0: &lt; 15/23 ng/L</th>
<th>1: 15/23 to 50 ng/L</th>
<th>2: &gt; 50 ng/dl</th>
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**OhioHealth**
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| 0 : Normal EKG |
| 1: Nonspecific |
| 2: Definite Ischemic |

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<td></td>
</tr>
</tbody>
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<tr>
<th>Heart Score</th>
<th>Risk level</th>
<th>30 day event rate:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>Very Low</td>
<td>&lt; 0.5%</td>
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<tr>
<td>0-3</td>
<td>Low</td>
<td>0.5 – 1.5%</td>
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<tr>
<td>4-6</td>
<td>Intermediate</td>
<td>&gt;5%</td>
</tr>
<tr>
<td>7-10</td>
<td>High</td>
<td>&gt;20%</td>
</tr>
</tbody>
</table>

References: Mark et al, *JACC* 2018; 71(606)  
McCord *Circ CV Outcomes* 2017
RMH: Acute Care Chest Pain Pathway

Acute Chest Pain: Immediate History, EKG, TnT

- No STEMI/ACS
  - Document HEARTscore
  - Very Low (HS 0-2 with undetectable TnT)
    - Consider:
      - No Cardiac Testing
      - Outpatient Stress Pathway
      - Non-cardiac Eval
  - Low/Intermediate (HS 3-6, +/- detectable TnT)
    - Immediate testing available?
      - Yes
        - Cardiac CTA:
          - Age < 65 (M) or 70 (F)
          - No Hx of CAD/PCI/CABG
          - BMI < 35
          - No Contraindication to b-blocker/ nitrates
          - For Very Low HS, consider Ca++ Score alone
      - No
        - “Zero-Hr” Stress Echo:
          - Able to Exercise, Normal EKG
          - Undetectable TnT (>2 hrs w CP)
          - BMI ≤ 30
          - Atypical Chest Pain (H = 0/1)
          - For Very Low HS, consider stress EKG alone
  - High (HS 7-10)
    - OBS Pathway
- (+) STEMI/ACS
  - Admit Acute Therapy

TnT = Serum Troponin T
HS = HEARTscore

OBS Pathway

*For Immediate testing, discuss with Cardiology IF:
- Hx of CAD
- Detectable TpT
- Equivocal EKG
- Unable to exercise or BMI > 35
HeartScore Results and Disposition
(410 consecutive patients with Chest Pain in RMH ED)
Heart Score Results (4G vs hsTNT)
N = 410 ED patients with Chest Pain

Positive Predictive Value (4G vs hsTNT)

P = NS

P = NS
- Risk calculator to predict the risk of bleeding in individual patients with CAD, treated with coronary stenting and subsequent DAPT
- Developed from a collaborative data set including date from 8 RCT
- Risk calculator made up of 5 items with total score range 0-100
  - Hbg level
  - Age
  - WBC level
  - Creatinine Clearance
  - Prior bleeding (defined as history of spontaneous bleeding requiring medical attention)
- Score of > 25 – patient may benefit from shorter course of DAPT (< 12 months)
<table>
<thead>
<tr>
<th>Cluster of Risk</th>
<th>HBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>YES</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimated 12 months bleeding risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major or Minor</td>
</tr>
<tr>
<td>&gt; 4.14%</td>
</tr>
</tbody>
</table>
Decision making on type of ischemic workup

• Age and frailty
  – Functional capacity
  – Is there underlying dementia and to what degree
  – Can their symptoms be managed conservatively

• Anemia
  – Stress test and heart catheterization routinely not performed with Hbg < 8.0
  – Is the patient receiving routine blood transfusions
  – Is the source of their anemia known

• Renal Insufficiency
  – Risk for contrast induced nephropathy with LHC that may lead to risk of needing dialysis

• Can the patient tolerate DAPT?
  – Is there upcoming surgery planned with need for DAPT to be held and patient now with new DES
  – Anemia considerations; oral AC considerations
The Cardiac Troponin Complex

- Troponin I
  - Multiple assays
  - Values are not transferable

- Troponin T
  - Single assay (Roche)
  - 5th generation approved in USA 2017
5th Generation (“high-sensitive”) Troponin-T – ng/L

- Detects very low circulating cTn-T (ng/L) – below “normal” threshold (Emphasis on serial change - “delta troponin”)
- Detects acute myocardial injury EARLIER (faster “rule-in”) and excludes acute injury SOONER (faster “rule-out”)
- “Flat” elevation in renal disease, non-ischemic cardiac disease, etc.
- Sex-specific cutoffs (to maximize specificity and sensitivity)
Myocardial Infarction: 4th Universal Definition
(WHF/ACC/AHA/ESC expert consensus, 2018)

- **MYOCARDIAL INJURY**: Cardiac Troponin (cTn) > 99th percentile of URL

- **ACUTE INJURY**: >99th URL plus rise or fall >20% (“delta” cTn)

- **INFARCTION** = Acute Injury Plus Clinical ischemia
  - Type 1 (primary thrombosis) or Type 2 (secondary ischemia)
  - ST elevation or non-ST elevation
    - Ischemic EKG changes
    - Ischemic Symptoms
4th Generation Troponin-T (4G) – ng/ml

- "Undetectable"
- "Possible injury"
- "Definite Injury"

5th Generation Troponin-T (5G) – ng/L

- "Undetectable"
- "Normal"
- "Possible injury"
5G Troponin T: Non-MI elevation

- Renal disease (reduced clearance)
- Skeletal Myopathies (cross reaction with assay)
- Non-MI myocardial injury
  - Cardiac
    - Heart Failure
    - Arrhythmia
    - Hypertensive Urgency
    - Valvular Disease
    - Drug toxicity
    - Myocarditis, infiltrative diseases
    - Takotsubo Cardiomyopathy
    - Cardiac contusion / trauma
  - Non-Cardiac
    - Aortic Dissection
    - Sepsis
    - Shock
    - Pulmonary Embolism
    - Acute Neurologic event
    - Thyroid disease
    - Rhabdomyolysis
    - Extreme endurance efforts
4G vs. 5G Troponin T: Results (2060 patients, 3891 total samples)

- 4G elevated: 35%
- 4G normal: 18%
- 5G elevated: 46%
- 5G normal: 32%

"DISCORDANT"
OhioHealth 5G Troponin T study: In-hospital Death Rate (Any Cause)

- Concordant (-): 0.9%
- Discordant: 3.7%
- Concordant (+): 8.8%

P < .05
Initial Troponin

3° Troponin (range, 3-12°)
- Normal
- Normal (<20%)

3° Delta (range, 3-12°)
- Normal
- Elevated

Conclusion
- No Biomarker evidence of injury
- Possible injury
- Nonacute or Late Injury
- Non-MI elevation
- Probable Acute Injury / Infarction

Management
- Serial assays
- Disposition based on HeartScore
- Non-MI causes
- Consider Echo
- Admit
- Confirm/exclude STEMI
- Initiate therapy
Suspected CAD:

- Stress EKG
- Stress Nuclear MPI
- Stress Echo

Definite Normal
CCTA
Advanced Imaging
Cardiac PET
Definite Abnormal

Clinical Suspicion:
- Low
- Mod/High

Age:
- <70
- Any

BMI:
- Lower
- Any

Known CAD:
- No
- Yes

Arrhythmia:
- No
- Yes
Cardiac Stress Testing: A Practical Guide for Test Selection

Kanny S. Grewal, MD (kanny.grewal@ohiohealth.com) *please obtain permission to reproduce

1. Assess clinical probability of CAD (symptoms, risk factors, EKG, cardiac markers)

<table>
<thead>
<tr>
<th>Very low (&lt;5%)</th>
<th>Low</th>
<th>Moderate</th>
<th>High (&gt;85%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consider:</td>
<td></td>
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<tr>
<td><em>Noncardiac workup</em></td>
<td></td>
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<tr>
<td><em>Stress EKG or Echo</em></td>
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<tr>
<td><em>Coronary CTA</em></td>
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</tbody>
</table>

Imaging Stress Test:
1. Is patient unable to walk at steady pace (3 mph)?
   - Or
2. Does resting EKG show LBBB, Atrial Fibrillation, or Paced Rhythm?

No: Exercise Stress

Yes: Pharmacologic Stress

Coronary CTA

Consider if:
- Low-moderate probability
- No prior PCI or CABG
- Prior equivocal stress test
- Low radiation protocol available

- Very obese (250-350 lbs)?
- Prior nondiagnostic stress echo or SPECT?
- Highest accuracy desired?

- Obese?
- Atrial fibrillation, LBBB or paced EKG?
- Known CAD (prior CABG/PCI)?

- Normal EKG?
- High Exercise Capacity?
- Lower cost and accuracy desired?

- COPO with wheezing?
- AND: no LBBB/pacing?

Exercise Stress EKG

Exercise Stress Echo

Exercise Stress Nuclear (MPI*)

Dobutamine Stress Echo

Vasodilator* Nuclear (MPI*)

Dobutamine Nuclear (MPI*)

PET Myocardial Perfusion Imaging

*MPI = Myocardial Perfusion Imaging – using sestamibi (Cardiolite*), thallium or alternate perfusion agent
*Vasodilator = Adenosine, Regadenoson (Lexiscan*), or Dipyridamole based on lab protocol
<table>
<thead>
<tr>
<th>Test</th>
<th>Preferred Settings</th>
<th>Avoid if</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise Stress EKG</td>
<td>Lowest cost desired&lt;br&gt;Avoid exercise capacity</td>
<td>Resting EKG abnormalities&lt;br&gt;Unable to exercise&lt;br&gt;Higher accuracy desired&lt;br&gt;Localization of ischemia desired</td>
</tr>
<tr>
<td>Exercise Stress Echo</td>
<td>Good functional capacity&lt;br&gt;BMI &lt; 30&lt;br&gt;Valve disease suspected&lt;br&gt;Avoid Radiation</td>
<td>LBBB or Paced EKG&lt;br&gt;Unable to exercise&lt;br&gt;Obese patients, lung disease&lt;br&gt;Known Cardiomyopathy/ prior MI</td>
</tr>
<tr>
<td>Exercise Stress Nuclear</td>
<td>Able to exercise&lt;br&gt;Higher Accuracy Desired&lt;br&gt;Known CAD (prior PCI/CABG)</td>
<td>Valve disease suspected</td>
</tr>
<tr>
<td>(Myocardial Perfusion Imaging, MPI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dobutamine Echo</td>
<td>Unable to exercise&lt;br&gt;Valve disease suspected&lt;br&gt;Avoid Radiation</td>
<td>LBBB or Paced EKG&lt;br&gt;Atrial or ventricular arrhythmia&lt;br&gt;Obese patients, lung disease</td>
</tr>
<tr>
<td>Vasodilator Stress MPI</td>
<td>Preferred test if unable to exercise&lt;br&gt;Known CAD (prior PCI/CABG)&lt;br&gt;Obese patients (but &lt; 400 lbs.)</td>
<td>Active Bronchospasm&lt;br&gt;Caffeine use ≤ 12 hrs.</td>
</tr>
<tr>
<td>Dobutamine Stress Nuclear MPI</td>
<td>Unable to exercise&lt;br&gt;Active bronchospasm/COPD</td>
<td>LBBB or Paced EKG&lt;br&gt;Atrial or ventricular arrhythmia</td>
</tr>
<tr>
<td>Vasodilator PET MPI</td>
<td>Unable to exercise or LBBB/paced rhythm&lt;br&gt;Prior nondiagnostic Echo/SPECT&lt;br&gt;Obese patients (but &lt; 350 lbs.)</td>
<td>Valve disease suspected&lt;br&gt;Caffeine use ≤ 12 hrs.&lt;br&gt;Currently only for Outpatients</td>
</tr>
<tr>
<td>Cardiac CTA</td>
<td>Age ≤ 70&lt;br&gt;Low/int probability&lt;br&gt;No known CAD&lt;br&gt;Anatomy assessment desired</td>
<td>Known CAD (prior PCI or CABG)&lt;br&gt;Arrhythmia or tachycardia&lt;br&gt;Renal disease or iodine allergy</td>
</tr>
</tbody>
</table>

Cardiac Stress Testing: Practical Guide for Test Selection

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On call imaging physician:
573.5338 or 738.8912
Cardiac PET imaging
PET perfusion imaging

- Highest quality perfusion imaging
- Higher accuracy, less artifact than SPECT
- Short half life, therefore quicker exam and less radiation exposure than SPECT
- Allows
  - rest and stress EF (EF reserve)
  - CT attenuation correction, allows CACS assessment
  - Rest/stress coronary flow assessment
- Assess Viability, Sarcoidosis, Endocarditis
- BUT... Expensive, requires pharmacologic stress
Case 5: Rest and Stress PET perfusion
### Peak Stress
- **EF** = 67%
- **EDV** = 52 ml
- **ESV** = 17 ml

### Resting
- **EF** = 55%
- **EDV** = 62 ml
- **ESV** = 21 ml
Case 5: Quantitative MBF and MBFR
Myocardial Blood Flow Reserve and Cardiac Mortality

N=2783

MBFR < 1.5 vs MBFR > 2.0                  *p < 0.001                   *HR 5.6 (2.5-12.4)
MBFR 1.5-2.0 vs MBFR > 2.0               *p = 0.003                   *HR 3.46 (1.5-7.7)

FFR (Fractional Flow Reserve)

CFR (Coronary Flow Reserve)
Example: **Inferior Ischemia**
Thank You!

Case Studies in Acute Chest Pain: Diagnosis, Risk Stratification, & Test Selection

April 17, 2019

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