Evaluation and Risk Stratification in Patients with Acute Chest Pain

David M. Larson, MD, FACEP
MMIC Webinar
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USA Today
Oct 25, 2006

When a heart attack goes undiagnosed
James Pettty, 74, right, died a day after being told at an emergency room his chest pains were not a heart attack. It's a fate that befalls thousands of people a year in the USA.

Chest Pain in the ED
6 million chest pain visits
2nd most common presenting complaint

Discharged
2,000,000
Non Cardiac
Acute Myocardial Infarction
80,000
Non Cardiac
Stable Angina
1,500,000
Non Ischemic Cardiac
1,360,000
Non Cardiac
Non Ischemic Cardiac
910,000
Non Cardiac
Non Ischemic Cardiac
360,000
Stable Angina
4,000,000
Suspected or Actual Cardiac
Admitted/Observed
1,400,000
Non Cardiac
1,360,000
Non Cardiac
NCHS, ED Utilization and Hospital Discharge Data, 2002
Page et al, JAMA, 2002
Malpractice Claims by Specialty
Missed MI - Diagnostic Misadventure

Emergency Medicine - 19.7%

Malpractice Claims by Specialty
Missed MI - Diagnostic Misadventure

Cardiology - 4.3%

Malpractice Claims by Specialty
Missed MI - Diagnostic Misadventure

IM - 24.7%  FP - 42.8%
Life Threatening Causes of Chest Pain

- Acute Coronary Syndrome
- Pulmonary Embolism
- Acute Aortic Dissection
- Tension Pneumothorax
- Esophageal Rupture
- Pericardial Tamponade
- Stress Cardiomyopathy (Takotsubo)

Other Causes of chest pain

- Pneumonia
- Anxiety
- Gastrointestinal
  - Esophageal reflux, spasm
  - Biliary colic
  - Peptic ulcer disease
- Musculoskeletal
- No cause determined

Diagnostic Approach to Undifferentiated Chest Pain

- History and physical exam
- Electrocardiogram
- Chest xray
- Limited bedside echocardiography
- Cardiac biomarkers
- D-dimer
- CBC, Cr, Liver tests, Lipase
- Chest CT – pulmonary angiogram, Aorta
Hospitalizations in the U.S. Due to ACS

Acute Coronary Syndromes

1.57 Million Hospital Admissions - ACS

- UA/NSTEMI
- STEMI

1.24 million (75%) Admissions per year
0.33 million (25%) Admissions per year

*Primary and secondary diagnoses. †About 0.57 million NSTEMI and 0.67 million UA.


Plaque rupture
Platelet adhesion
Platelet activation

Partially occlusive arterial thrombosis & unstable angina

Microembolization & non-ST elevation MI

Totally occlusive arterial thrombosis & ST elevation MI

Pathogenesis of ACS

Adapted from Davies MJ. Circulation. 1990; 82 (supl II): 30 - 46.
10,689 patients
> 30 yrs, sx of possible ischemia
30 day follow-up (99%)
19/889 AMIs missed (2.1%)
22/966 UA missed (2.3%)

What Types of AMI Patients Are More Likely to be Missed

- Younger age
- Atypical symptoms
- Non white race
- Women < 55 yrs old
- Physicians with less experience
- Lower volume EDs
The primary objective when evaluating patients with chest pain in the outpatient or ED setting is **Risk Stratification**

**Primary Risk Stratification**

- History and Physical Exam
- Electrocardiogram
- Initial Biomarker results

**Question: Home vs Admit**

**Secondary Risk Stratification**

- Serial Electrocardiogram
- Serial Biomarker results
- Stress testing
- Imaging
  - Echocardiography
  - Nuclear
  - CTCA

**Question: Home vs Cath Lab**
First description of ischemic chest pain: "A painful sensation in the breast accompanied by a strangling sensation, anxiety and occasional radiation of pain to the left shoulder." *Medical Transactions, 1772*

William Heberden, 1768
Risk Stratification by History

<table>
<thead>
<tr>
<th>Risk Stratification</th>
<th>Chest Pain History</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Risk</td>
<td>Pain that is pleuritic, positional, or reproducible with palpation or is described as stabbing.</td>
</tr>
<tr>
<td>Probable Low Risk</td>
<td>Pain not related to exertion or occurs in a small inframammary area of the chest wall</td>
</tr>
<tr>
<td>Probable High Risk</td>
<td>Pain described as pressure, is similar that of prior myocardial infarction or worse than prior anginal pain, or is accompanied by nausea, vomiting or diaphoresis</td>
</tr>
<tr>
<td>High Risk</td>
<td>Pain that radiates to one or both shoulders or arms or is related to exertion</td>
</tr>
</tbody>
</table>

Does the presence of chest wall tenderness rule out myocardial ischemia?
Chest Wall Tenderness

- Likelihood ratios of chest wall tenderness – 0.3
- Post-test probability of AMI 4.3-6.3%
- Chest wall tenderness suggests that acute coronary syndrome is less likely but does not effectively rule the diagnosis out.

Value and Limitations of Chest Pain History in the Evaluation of Patients With

"Although certain elements of the chest pain history are associated with increased or decreased likelihoods of a diagnosis of ACS or AMI, none of them identify a group of patients that can be discharged without further diagnostic testing."

Symptom Presentation of Women With Acute Coronary Syndromes

Myth vs Reality

Background: Although many symptoms of acute coronary syndrome appear in women, they are different from those seen in men. Men may experience angina pectoris, dyspnea, and palpitations, whereas women may experience symptoms such as fatigue, nausea, or indigestion. This article evaluated the chest pain symptoms of women with ACS and compared them to those of men.

Methods: A review of published literature was conducted to identify studies that evaluated chest pain symptoms in women with ACS. The results were analyzed to determine the most common symptoms reported by women with ACS and compared to those reported by men.

Results: The most common symptoms reported by women with ACS were chest pain, nausea, and shortness of breath. These symptoms were similar to those reported by men with ACS. However, women were more likely to report symptoms such as fatigue and indigestion.

Conclusion: Although the symptoms of ACS are similar in women and men, women may experience different symptoms than men. These findings suggest that women should be evaluated for ACS with the same intensity and aggressiveness as men, regardless of their gender.
Women are significantly less likely to report chest pain or discomfort than men.

Acute MI without chest pain
- One third of AMI patients
- More common in:
  - Diabetics
  - Elderly
  - Women

Is the patient’s response to sublingual nitroglycerin a useful diagnostic test when evaluating a patient with chest pain in the emergency department?

Conclusion: "The response to sublingual nitroglycerin does not appear to be a reliable predictor of the underlying etiology in patients presenting to the ED with chest pain.”


Conclusion: "The response to nitroglycerin was a poor diagnostic and prognostic marker in patients presenting to the ED with chest pain.”


Conclusion: "In this study, the response to nitroglycerin was an unreliable predictor of a cardiac or noncardiac etiology of the discomfort.”


Conclusion: "The belief that relief of chest pain with nitroglycerin is a useful diagnostic test to differentiate cardiac from non-cardiac chest pain appears to be 'more myth than science’.”

Is a “GI Cocktail” helpful in distinguishing cardiac from non-cardiac chest pain?
“GI cocktail” given for chest pain (n=40) or dyspepsia (n=49).
Symptomatic relief in two thirds of patients
No correlation between symptomatic relief and final diagnosis.
2 patients who underwent angioplasty for cardiac ischemia had complete relief of pain with “GI cocktail”

Physical Exam

- Usually normal in Chest Pain patients
- Important findings indicating increased risk:
  - Abnormal Vital signs
  - Signs of heart failure
  - Peripheral vascular exam – BP in both arms
  - Cardiac Murmurs
  - Pericardial friction rub
  - Abnormal lung sounds

Point of care ultrasound – an extension of the physical exam
Point of Care Ultrasound

- Global assessment of LV function
- Pericardial effusion
- RV enlargement – Pulmonary embolism
- Enlarged Aortic Root - Aortic dissection
- Septal Wall - Hypertrophic cardiomyopathy
- Aortic or Mitral regurgitation

Primary Risk Stratification

- History and Physical
- Electrocardiogram

Anatomic relation of ECG leads to the human heart
Electrocardiogram

- A snapshot in time in a rapidly evolving process
- ST Segment Elevation
  - New ST elevation at the J point in 2 contiguous leads ≥ 1mm in 2 contiguous leads, (≥ 2mm in V2-3)
- High risk NSTEMI/UA
  - Ischemic ECG changes: ST depression > 0.5mm or T-wave inversion > 2mm

T wave changes in very early LAD occlusion

T wave and ST segment changes in early LAD occlusion
T wave changes 24 hours after successful reperfusion of LAD

Health Services and Outcomes Research

Implications of the Failure to Identify High-Risk Electrocardiogram Findings for the Quality of Care of Patients With Acute Myocardial Infarction

Results of the Emergency Department Quality in Myocardial Infarction (EDQMI) Study

Jennifer A. Mancall, MD, MPH; David J. Magid, MD, MPH; David B. Wexner, MD; Albert J. Thomas, MD; Paul L. Sapsis, MD; Marc Levy, CRNA; MMSc; and M. Michael Lee, MD, PhD

Background—The impact of misinterpretation of the ECG in patients with acute myocardial infarction (AMI) in the emergency department (ED) setting is not well known. Our goal was to assess the prevalence of the failure to identify high-risk ECG findings in ED patients with AMI and to determine whether this failure is associated with lower quality of care.

Methods and Results—In a retrospective cohort study of consecutive patients presenting to 3 EDs in California and Colorado from July 1, 1998, through June 30, 1999, with confirmed AMI (n = 1968), we determined the frequency of the failure by the treating provider to identify significant ST-segment elevation, ST-segment depression, or T wave inversion on the presenting ECG. In multivariable models, we examined the relationship between clinical high-risk ECG findings and the presence of AMI. The ECG results were compared with the final diagnosis in 281 patients (14%). The failure to identify high-risk findings was independently associated with a higher risk of 30-day mortality among the 174 patients with the worst risk ECG findings (OR, 2.57; 95% CI, 1.21 to 5.46; P = .014) and with receipt of thrombolytic therapy (OR, 1.70; 95% CI, 1.11 to 2.61; P = .012) in univariate analysis. Among patients with ST and high-risk ECG findings, in-hospital mortality was 7.9% compared with 0.9% among patients with only ST findings (P < .001). Among patients with only high-risk ECG findings, in-hospital mortality was 16.9% compared with 5.7% among patients with only ST findings (P = .015). Among patients with both ST and high-risk ECG findings, in-hospital mortality was 23.1% compared with 7.9% among patients with only ST findings (P = .001).

Conclusions—The failure to identify high-risk ECG findings in patients with AMI results in lower-quality care in the ED. ECG findings that improve ECG incorporation may have important implications for patient outcome and outcomes. ( Circulation. 2006;114:1059–1067.)

Key Words: diagnosis — electrocardiography — myocardial infarction

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Key Words: diagnosis — electrocardiography — myocardial infarction
76 yo with CP at 7:00am and diaphoresis. ECG at 8:10am. Troponin – neg.

Pain was relieved by a GI cocktail.
Discharged from the ED. Followup in the clinic.

65 yo male with typical chest pain, shortness of breath and diaphoresis
65 yo male with typical chest pain, shortness of breath and diaphoresis

Had occlusion with large amount of clot in RCA
Electrocardiogram in ACS

- 733,191 patients with AMI
  - 4.4% - normal ECG
  - 20.8% - non-specific ECG

Welch, R. JAMA 2001
Patients who are symptomatic during acquisition of a normal or non-specific ECG have rates of adverse cardiovascular events similar to those of patients without symptoms.
Troponin

- Current 4th generation Troponin I or T renders CK-MB and myoglobin obsolete
- Use the 99% upper limit of normal cutoff
- High sensitivity Troponin will be here soon and may allow rapid rule outs (within 2-3 hrs)
- Not all patients with an elevated troponin are having an MI
Universal Definition of Acute MI

- Detection of a rise and/or fall of Troponin I with at least one value ≥ 99% of the upper reference limit, with at least one of the following:
  - Symptoms of ischemia
  - ECG changes indicative of new ischemia (new ST-T changes or new LBBB)

Non-ACS related Troponin Elevation

- Myopericarditis
- Acute pulmonary embolism
- Acute Heart Failure
- Atrial Tachyarrhythmias
- Severe sepsis
- Aortic dissection
- Stroke, Subarachnoid hemorrhage
- Stress cardiomyopathy
- Drug toxicity
- Extreme exertion

Chronic Stable Elevations of Troponin

- Stable Coronary Artery Disease
- Stable Chronic Heart Failure
- Diabetes
- Chronic Kidney Disease
- Chronic Pulmonary Hypertension
- Left Ventricular Hypertrophy
- Elderly patients
Risk Scores

- TIMI
- GRACE
- PURSUIT

TIMI RISK SCORE for UA/NSTEMI

<table>
<thead>
<tr>
<th>HISTORICAL</th>
<th>POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 65</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 3 CAD risk factors</td>
<td>1</td>
</tr>
<tr>
<td>Eligible TIMI risk score</td>
<td>1</td>
</tr>
<tr>
<td>Known CAD (unstable)</td>
<td>1</td>
</tr>
<tr>
<td>ASA use in past 7 days</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRESENTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent UA/NSTEMI</td>
</tr>
<tr>
<td>Cardiac markers</td>
</tr>
<tr>
<td>ST deviation 0.5 mm</td>
</tr>
</tbody>
</table>

RISK SCORE = Total Points (0 - 7)

Risk of cardiac events (%) by 14 days in TIMI trial:

- High
- Medium
- Low
- Very low

For more info go to timi.org

GRACE UA/NSTEMI

<table>
<thead>
<tr>
<th>GRACE</th>
<th>TIMI UA/NSTEMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Rate (bpm)</td>
<td>70-89</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>120-139</td>
</tr>
<tr>
<td>Creatinine (mg/dl)</td>
<td>1.20-1.59</td>
</tr>
<tr>
<td>CHF (Kaplan class)</td>
<td>II</td>
</tr>
<tr>
<td>Cardiac arrest at admission</td>
<td>ST changes &gt; 0.5 mm</td>
</tr>
<tr>
<td>ST-segment elevation</td>
<td>Cardiac Marker</td>
</tr>
<tr>
<td>Elevated cardiac enzymes/markers</td>
<td></td>
</tr>
</tbody>
</table>

GRACE In-hospital Risk

- Death Risk Score/Probability 121 / 7%
- MI Risk Score/Probability 205 / 17%

Download Risk Calculator for PDA – www.TIMI.org
Are Risk Scores Useful?

- Derived from ACS Clinical Trials that excluded the highest and lowest risk patients
- Not used very often in clinical practice

Chest Pain Protocols

- All hospitals should have chest pain protocols that are specific for that institution
- Based on risk stratification
- Allows standardization and implementation of evidenced based therapies for patients with acute coronary syndromes
Primary Risk Stratification

- History and Physical Exam
  - Past Medical History
- Electrocardiogram
- Initial Biomarker results

Chest Pain Risk Stratification

- Level 1: STEMI
- Level 2: NSTEMI and High risk UA
- Level 3: Probable ACS (Intermediate risk)
- Level 4: Possible ACS (low risk)

Level 1: STEMI

- Symptoms < 24 hr
- New ST elevation at the J point in 2 contiguous leads ≥ 1mm in 2 contiguous leads, (≥ 2mm in V2-3)
- New LBBB?
Level 1: STEMI

- Protocol:
  - Aspirin 325mg
  - Clopidogrel 600mg PO
  - Heparin 60u/kg load
  - Metoprolol 25mg PO
  - Activate and transfer to Cath lab

Level 2: NSTEMI/high risk UA

- Symptoms typical for cardiac ischemia and at least one of the following:
  - Ischemic ECG changes: ST depression > 0.5mm or T-wave inversion > 2mm
  - Elevated troponin
  - New onset CHF presumed secondary to ischemia
  - Hemodynamic instability

- Protocol:
  - Aspirin 325 mg PO
  - Clopidogrel 600mg PO
  - Heparin 60u/kg load, 12u/kg/hr
  - Lopressor 25mg PO
  - Nitroglycerin IV as needed
  - Cardiac cath within 24-48 hrs or immediate if unstable or ongoing pain
Level 3: Intermediate Risk

- Normal or nonspecific ECG
- Normal Troponin (<99% cutoff)
- Typical symptoms suggesting ischemia or
- 3 or more CV risk factors (FH, smoking, DM, HTN, Chol), or
- Past Hx of CAD, PAD, CVD
- Age ≥ 75

Level 3: Intermediate Risk

- Protocol:
  - Aspirin 325mg
  - UFH or Enoxaparin (consider)
  - Admit to hospital (or obs unit) for monitoring
    - Serial ECG
    - Repeat Troponins x 2
    - Imaging Stress test or CTCA

Level 4: Low Risk

- Normal or Nonspecific ECG
- Normal Troponin
- No history of CAD, PAD or CVD
- Age < 75
Level 4: Possible ACS (Low Risk)

- Aspirin only
- ED or Observation Unit
- Repeat ECG,Baseline Troponin
- Exercise Treadmill Test (ETT) or CTCA prior to discharge during daytime.
- After hours, admit to Observation Unit with ETT or CTCA in AM
- Negative ETT or CTCA: discharge with clinic followup

Chest Pain Pocket Card – Front
Risk Stratification

<table>
<thead>
<tr>
<th>Level 1 (10%)</th>
<th>Level 2 (15%)</th>
<th>Level 3 (25%)</th>
<th>Level 4 (52%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEMI</td>
<td>NSTEMI/EUA</td>
<td>NSTEMI/EUA</td>
<td>NSTEMI/EUA</td>
</tr>
<tr>
<td>chest pain</td>
<td>chest pain</td>
<td>chest pain</td>
<td>chest pain</td>
</tr>
<tr>
<td>ECG changes</td>
<td>ECG changes</td>
<td>ECG changes</td>
<td>ECG changes</td>
</tr>
<tr>
<td>2 mm</td>
<td>3 mm</td>
<td>4 mm</td>
<td>5 mm</td>
</tr>
<tr>
<td>Troponin</td>
<td>Troponin</td>
<td>Troponin</td>
<td>Troponin</td>
</tr>
<tr>
<td>&gt; 0.1 ng/L</td>
<td>&gt; 0.2 ng/L</td>
<td>&gt; 0.3 ng/L</td>
<td>&gt; 0.4 ng/L</td>
</tr>
<tr>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>ETT</td>
<td>CTCA</td>
<td>ETT or CTCA</td>
<td>ETT or CTCA</td>
</tr>
<tr>
<td>Negative</td>
<td>Positive</td>
<td>Negative</td>
<td>Positive</td>
</tr>
<tr>
<td>Discharge</td>
<td>Hospital stay</td>
<td>Discharge</td>
<td>Hospital stay</td>
</tr>
</tbody>
</table>

Chest Pain Pocket Card – Back
Initial Therapy

<table>
<thead>
<tr>
<th>Antiplatelet</th>
<th>Anti-thrombotic</th>
<th>Nitrites</th>
<th>E-blocker</th>
<th>Admit to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin 81 mg</td>
<td>Clopidogrel 600 mg</td>
<td>None</td>
<td>None</td>
<td>CTCA</td>
</tr>
<tr>
<td>NSTEMI/EUA (High risk)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetylsalicilic acid 300 mg</td>
<td>Clopidogrel 600 mg</td>
<td>None</td>
<td>None</td>
<td>CTCA</td>
</tr>
<tr>
<td>ETT or CTCA</td>
<td>ETT or CTCA</td>
<td>ETT or CTCA</td>
<td>ETT or CTCA</td>
<td>ETT or CTCA</td>
</tr>
</tbody>
</table>

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Evaluation of the Low Risk Patient

- Variety of protocols based on hospital resources
- Accelerated Diagnostic Protocols
- Chest Pain Units
- Probability of ACS <5%

What is the Question?

- Can I send this patient home?
- Is today’s symptoms (chest pain) due to cardiac ischemia? (or AD, PE)
- Does this patient have coronary artery disease?

Testing Low Risk CP Patients

- Functional data:
  - Exercise Treadmill Testing
  - Myocardial Perfusion Imaging (Nuclear)
  - Stress Echocardiography
- Anatomical data:
  - CT Coronary Angiogram
UC Davis Low risk inclusion criteria

- No hemodynamic instability
- No arrhythmias
- Normal or non-specific ECG
  - Prior CAD also included
- Excluded:
  - Repolarization abnormality

Amsterdam, JACC 2002

UC Davis Protocol

- One set of cardiac biomarkers
- Modified Bruce protocol stress test
  - Negative
  - Non-diagnostic (<85% max predicted HR)
  - Positive (significant symptoms, ECG criteria for ischemia)
- If negative discharge home.
- 30 day follow-up.
- No deaths in any group
- Negative – 1 Non Qwave MI
- Non-diagnostic – 7 revascularizations
- Positive – 4 Non Qwave MI, 12 revascularizations

### Accelerated 2 hr Diagnostic Protocol

- TIMI Risk Score of 0
- No new ischemic ECG changes
- Negative Troponin I at 0 and 2 hrs
- Discharged with return within 72 hrs for ETT
- No difference in MACE at 30 days comparing ADP to standard care pathway

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JAMA Int Med. Jan, 2014
CTCA - Benefits

- High sensitivity and Neg predictive value
- Faster TAT than Functional tests
- Reduced number of repeat evaluation for Chest pain recidivism
- Lower radiation and cost than MPI
- May exclude other life threatening causes of CP – PE, Aortic dissection
- Value in risk factor modification

CTCA - Limitations

- Technical contraindications (25%) – contrast allergy, obesity, renal insufficiency, arrhythmias, unable to tolerate Beta blockade
- Elderly patients with calcified coronary arteries
- Not useful in patients with known CAD (usually)
- Additional testing required in 10-20%
- Higher radiation and cost compared to ETT

Diagnostic Accuracy and Clinical Utility of Noninvasive Testing for CAD

<table>
<thead>
<tr>
<th>Pretest Probability</th>
<th>Stress test</th>
<th>CTCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>78%</td>
<td>99%</td>
</tr>
<tr>
<td>Low</td>
<td>71%</td>
<td>99%</td>
</tr>
<tr>
<td>(≤ 20%)</td>
<td>79%</td>
<td>99%</td>
</tr>
<tr>
<td>Intermediate</td>
<td>79%</td>
<td>100%</td>
</tr>
<tr>
<td>(20-80%)</td>
<td>79%</td>
<td>99%</td>
</tr>
<tr>
<td>High</td>
<td>79%</td>
<td>99%</td>
</tr>
<tr>
<td>(&gt;80%)</td>
<td>79%</td>
<td>99%</td>
</tr>
</tbody>
</table>

Sensitivity, NPV, Specificity, PPV

Weustink et al. Annals Internal Med. 2010;152:630
Outpatient Stress Testing or CTCA

- Low risk patients with the following:
  - No further ischemic discomfort
  - Normal ECG
  - Normal Troponin
  - Stress testing can be performed within 72 hrs (24 hrs preferred) – Schedule the test. Don't rely on the patient to schedule after discharge.
  - Plan to return to ED if any recurrent symptoms

Ridgeview Medical Center
Emergency Department

ED Chest Pain Patients - 2013
Key Points

- Risk stratify patients to determine what workup is needed.
- The history and exam is helpful but not enough to discharge the chest pain patient without further testing.
- Know your institution’s Troponin limits.
- Expertise in ECG interpretation is essential. Send an image to an expert if needed.
- Develop and implement Chest Pain protocols in your institution.
Questions?