Coronary CTA for Emergency Department Chest Pain

Do we finally have a better evaluation strategy?

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Disclosures:

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Dilemma

• > 6 million ER visits for chest pain annually in US
• Large majority are not due to ACS
• <5% are ACS STEMI and <15% NSTEMI
• Missed ACS shown to occur in up to 5% of cases when patients were discharged without additional testing (clinical judgment only) with up to two-fold increase in risk of death
• > $10 billion estimated annual cost
Chest Pain – Impact

• CP is common – one of the most frequent reasons for ER visits
• Consumes ER and hospital beds while minority of cases are ACS
• Can impact other patient’s care due to misallocation of resources
Perspective – ER Physician

- Difficult to stratify patients based on history and physical exam only in this population (insufficient positive and negative predictive value for any given feature)
- Litigation concerns for missed ACS
- Need <1% miss rate to be comfortable with discharge
- Additional cardiac testing or hospitalization is common to improve risk stratification and guide management
- Safe, rapid, and effective triage is goal
Current Standard of Care (SOC)

- Clinical assessment – history, risk factors, exam, enzymes, ECG, TIMI score, etc
- If very low risk – discharge
- Low to intermediate risk – Obs (ER vs hospitalist), serial enzymes, stress test, home vs cath
- High risk – Cardiologist evaluation
Ideal Test

- High negative and positive predictive value
- Safe
- Quick turnaround time
- Acceptable cost
- Acceptable outcomes

CCTA – Nearly 100% negative predictive demonstrated in low to intermediate prevalence groups excludes obstructive CAD
Table 1. Detection of CAD in Symptomatic Patients Without Known Heart Disease*

<table>
<thead>
<tr>
<th>Indication</th>
<th>Pretest Probability of CAD</th>
<th>Appropriate Use Score (1–9)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Intermediate</td>
</tr>
<tr>
<td>1. ECG interpretable AND Able to exercise</td>
<td>U (5)</td>
<td>A (7)</td>
</tr>
<tr>
<td>2. ECG uninterpretable OR Unable to exercise</td>
<td></td>
<td>A (7)</td>
</tr>
<tr>
<td>Acute Symptoms With Suspicion of ACS (Urgent Presentation)</td>
<td></td>
<td>U (6)</td>
</tr>
<tr>
<td>3. Definite MI</td>
<td>I (1)</td>
<td></td>
</tr>
<tr>
<td>4. Persistent ECG ST-segment elevation following exclusion of MI</td>
<td>U (6)</td>
<td></td>
</tr>
<tr>
<td>5. Acute chest pain of uncertain cause (differential diagnosis includes pulmonary embolism, aortic dissection, and ACS [<em>“triple rule out”</em>])</td>
<td>U (6)</td>
<td></td>
</tr>
</tbody>
</table>

**Table Notes:**
- Low: U (5)
- Intermediate: A (7)
- High: I (3), U (4)
ER CCTA Trial Data

- 3 major randomized multicenter trials
- Compare ER CCTA approach vs. SOC
- Look at safety outcomes, time to discharge from ER, and cost
- Included – Low to intermediate risk patients for ACS
- Excluded – Factors that adversely impact CCTA image quality or patient safety
TIMI Risk Score

Score (0-7), 1 pt each

- **Age** ≥ 65
- **Markers**
- **ECG**
- **Risk factors** (≥3)
- **Ischemic episodes** (≥2)
- **CAD** (≥50% stenosis)
- **Aspirin use** (in last 7 days)

### Table 4. TIMI Risk Score for Unstable Angina/Non-ST-Elevation MI

<table>
<thead>
<tr>
<th>TIMI Risk Score</th>
<th>All-Cause Mortality, New or Recurrent MI, or Severe Recurrent Ischemia Requiring Urgent Revascularization Through 14 d After Randomization, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>4.7</td>
</tr>
<tr>
<td>2</td>
<td>8.3</td>
</tr>
<tr>
<td>3</td>
<td>13.2</td>
</tr>
<tr>
<td>4</td>
<td>19.9</td>
</tr>
<tr>
<td>5</td>
<td>26.2</td>
</tr>
<tr>
<td>6-7</td>
<td>40.9</td>
</tr>
</tbody>
</table>
*Primary outcome = Diagnostic efficiency (time to diagnosis) of CCTA vs nuclear stress
*Secondary outcomes = Comparison 6 month safety data and index visit costs
CT-STAT (JACC, 2011)

- 1st multicenter randomized trial comparing CCTA to nuclear stress test in ER
- 700 patients with CP suspicious for angina
- Included patients with TIMI ≤ 4, age ≥ 25
- Excluded patients based on known CAD, + troponin, +ECG, BMI ≥ 39, creatinine ≥ 1.5, arrhythmia, AR to contrast or BB
- 2% ACS prevalence
CT STAT Findings

Other Findings:
- 58% of all ER acute CP patients screened could qualify for CCTA
- 82% pts had 0-25% range stenoses on CCTA
- 4% had stenosis >70% on CCTA
- 4% CCTA studies nondiagnostic
- 6-7% cath and 2.5% PCI rate for both arms
- Radiation: CCTA 11.5 mSv vs Nuclear 12.8 mSv
*Primary outcome = 30 day safety in patients with negative CCTA (<50% stenosis) compared to SOC
*Secondary outcome = comparison of rate of discharge, length of stay, and revascularization for SOC vs. CCTA
ACRIN – PA (NEJM, 2012)

- Multicenter randomized trial for CCTA vs SOC
- 1370 patients
- Included – Age $\geq$ 30, possible ACS, TIMI $\leq$ 2
- Excluded – Sx felt clearly noncardiac, ischemic ECG, normal cath or CCTA in past year
- 4% ACS prevalence
ACRIN Findings

- No patients with negative CCTA had death or MI at 30 days
- Higher rate of ER discharge for CCTA vs SOC (50% vs 23%)
- Shorter LOS for CCTA vs SOC (18 vs 25 hours)

Other findings:
- Higher CAD detection rate for CCTA vs SOC (9% vs 3.5%)
- 83% CCTA patients had stenosis <50%
- 6% had indeterminate stenosis
- 3% patients with CCTA vs 1% SOC were revascularized
- 96% patients had heart rate >60 bpm at baseline
- 4% CCTA patients did not have CCTA due to persistent high HR
*Primary endpoint = Length of stay for CCTA vs. SOC
*Secondary endpoint = Comparison of rate of ER discharge, MACE at 28 days, and costs for SOC vs. CCTA
*Safety endpoint = Undetected ACS
ROMICAT II (NEJM 2012)

• Multicenter randomized trial CCTA vs SOC
• 1000 patients
• Included – Age 40-74, CP>5min, sinus rhythm, can hold breath >10 sec
• Excluded – Known CAD, Ischemic ECG, troponin>99th%, creatinine>1.5, BMI>40, contrast allergy, current asthma, hemodynamic/clinical instability
• 8% ACS prevalence
ROMICAT II Findings

• Mean length of stay ↓7.6 hours for CCTA vs SOC
• 47% CCTA patients discharged directly from ER vs 12% for SOC
• No undetected ACS for either group (for pts d/c<24 hrs)
• No difference in MACE at 28 days between groups
• Direct ER cost was lower for CCTA. Cumulative cost of care was similar for both groups
• More radiation exposure for CCTA vs SOC (13.9 vs 4.7 mSv)
• Trend toward more cath (11% vs 7%) for CCTA vs SOC
ROMICAT II- Length of Stay

CCTA group – 50% discharged at 8.6 hours
SOC group – 50% discharged at 26.7 hours
Combined Study Findings

- Consistent reduction in length of stay or time to Dx for CCTA
- Consistent safety for either CCTA or SOC
- Reduced ER or neutral cumulative hospital cost for CCTA vs SOC (long term comparative cost data unknown)
- Mild increase in rate of cath (8.4% vs 6.3%) and revascularization (4.6% vs 2.6%) for CCTA vs SOC
- >80% patients evaluated with CCTA have no or nonobstructive CAD (potential candidates for direct discharge from ER)
Other Findings

• Despite multiple exclusions, nearly 60% patients presenting with CP in ER were appropriate CCTA candidates (from CTSTAT data)
• With CCTA, 7-10% had intermediate stenosis, 4% obstructive, 5% inconclusive
• Most patients (>90%) had HR > 60 bpm and could receive beta blocker in absence of contraindication
• Radiation dose with CCTA was lower than nuclear stress but higher than other SOC evaluation
Radiation Exposure

• 1/1000 increased cancer risk per 20 mSv*
• Background- 3.5 mSv/yr
• Airline flight- .005 mSv/hr
• CXR- 0.1 mSv
• Cath: 7 mSv
• Nuclear MPS: MIBI/MIBI- 12 mSv
• CT Calcium Score 1 mSv
• **Coronary CTA: Current generation CT < 5 mSv common (often 2-3 mSv with beta blocker and brief, diastolic only imaging)**

*Estimated risk for 60 yr old. Risk increases with younger age and female gender*
Metoprolol 100 mg po, NTG 0.4 mg SL. Heart Rate 50 bpm, BMI 23. 90 mL contrast
57 year old female, CP + dyslipidemia. <25% ostial LAD with calcified plaque
Metoprolol 100 mg po, NTG 0.8 mg SL. Heart Rate 50 bpm, BMI 25. 100 mL contrast
53 year old male, CP + dyslipidemia. >90% ostial dominant LCX with noncalcific plaque
CCTA Artifact - Arrhythmia

PAC – Mid and distal RCA segments obscured and out of expected imaging plane

Repeat same patient, no PAC
CCTA Artifact – Elevated Heart Rate
CCTA Artifact – Breathing

Poor breath hold – breaks in sternum, heart, and coronaries

Same patient rescanned with good breath hold
CCTA Respiratory Artifact

Poor breath hold – breaks in aorta, heart, and coronaries

Same patient rescanned with good breath hold
CCTA – Morbid Obesity

BMI 45 – 36 year old female recurrent CP. TDS with noise throughout Inconclusive mid-distal LAD
Suboptimal CCTA – Obese and Poor Breath Hold
10.3 mSv scan

Metoprolol 100 mg po +15mg iv, NTG 0.8 mg SL. Heart Rate 70 bpm, BMI 38. 110 mL contrast
51 year old male, CP + dyslipidemia. Partially calcified plaque, >70% mLAD
Overcoming Obstacles

• Choose patients wisely
• Heart rate – beta blockade
• IV access
• Coronary dilation – nitrate Rx
• Contrast delivery
• Breath hold
• Tailored Scan protocols
• Artifact prevention and recognition (CT technologist)
ED CCTA – Case 1

- 49 year old female with CP (recurrent pressure/tightness)
- Negative troponin. ECG Normal
- TIMI Score = 1
- CCTA…
ED CCTA – Case 1

CAC Score = 0, CCTA – Normal coronaries.
2.9 mSv
ED CCTA – Case 2

- 50 year old male with CP
- Strong FHx CAD
- Negative troponin. ECG Normal
- TIMI Score = 2
- CCTA…
ED CCTA – Case 2

CAC Score = 223, CCTA – Potentially sig LAD (50-69%)  
1.8 mSv

*CCTA followed by obs admit with negative 17 METS treadmill stress echo
ED CCTA – Case 3

- 61 year old female with recurrent CP
- Obese, FHx CAD
- Negative troponin. ECG – Q’s V1-V2
- TIMI Score = 1
- CCTA…
CAC Score = 124, CCTA – Potentially sig LAD (50-69%)
5.7 mSv

*CCTA followed by obs admit with negative pharmacologic nuclear stress test
ED CCTA – Case 4

- 49 year old female with 6/10 scale CP
- Negative stress test 2 years ago
- Negative troponin. Normal ECG
- TIMI Score = 0
- CCTA…
ED CCTA – Case 4

CAC Score = 0, CCTA – Normal coronaries
2.1 mSv
ED CCTA – Case 5

- 52 year old male with diaphoresis, nausea, near-syncope
- HTN, dyslipidemia, negative/submax treadmill echo year prior (for CP)
- Negative troponin. ECG NSR, LVH with lateral TWI
- TIMI Score = 2
- CCTA…
ED CCTA – Case 5

CAC Score 323, CCTA >70% mid RCA.
4.6 mSv scan

*CCTA followed by cath with PCI of mid RCA
ED Case 5 – Cath
ED CCTA – Case 6

- 56 year old female with persistent CP
- Negative troponin. ECG – LBBB. No old ECG to compare
- TIMI Score = 0
- CCTA…
ED CCTA – Case 6

CAC = 0, Normal coronaries, LVEF 45-50% (abnormal septal motion)
4.8 mSv
ED CCTA – Case 6: LV Function with LBBB
Management Algorithms

- Normal CCTA ➔ ACS excluded and eligible for d/c
- <50% stenosis ➔ ACS very unlikely and eligible for d/c with outpatient follow up for preventive care
- 50-69% stenosis ➔ ACS possible and obs/admission with serial enzymes and decide if stress or cath warranted
- ≥70% stenosis ➔ ACS likely and cath/revascularization should be considered
- Nondiagnostic study (≤6% in trials) ➔ Obs/admit and evaluate per SOC
HEART Score

• 0-2 points for each category based on History, ECG, Age, Risk factors, and Troponin
• Designed to establish risk for undifferentiated chest pain in the ED
• Better predictive value than other risk calculators such as TIMI which were used to stratify patients after ACS
• Anticipate use at CHS facilities to guide management of patients presenting with CP in ED
HEART vs TIMI & GRACE Scores
ED CCTA – Take Homes

• Appropriate patient selection and high quality imaging are important factors for success
• Safe and more expeditious discharge compared to established standard of care
• Unlike stress tests, CCTA determines the presence, absence, and extent of atherosclerosis
• Adds opportunity for more aggressive preventive strategies in patients found to have atherosclerotic CAD not identified by stress tests
Thank you
Supplemental Cases
Case 1

42 year old female with recurrent chest pain with multiple ER visits and recent negative stress echo. Hx of anxiety. + FHx CAD. No other risk factors. ECG Normal. Troponin 0.02. HR 52. BP 135/85. BMI 23.

Recommendation:

- A. Coronary CTA
- B. Obs admit for additional cardiac testing
- C. Cardiology consult for cath
- D. Discharge home
- E. Other
Case 1
Same patient presents to ER 6 months later with same symptoms.

Recommendation:
• A. Coronary CTA
• B. Obs admit for additional cardiac testing
• C. Cardiology consult for cath
• D. Discharge home with follow up as needed
• E. Other
Case 2

53 year old male with chest pain and dyspnea. Hx DM, cigarette smoking, dyslipidemia. ECG with nonspecific ST abnormalities. Troponin 0.35. BP 160/79 HR 92. BMI 35

Recommendation:
• A. Coronary CTA
• B. Obs admit for additional cardiac testing
• C. Cardiology consult for cath
• D. Discharge home
• E. Other
Case 3

59 year old female with burning CP after recent meal. No risk factors. ECG Normal. POC troponin 0.21. BP 128/75. HR 83. BMI 28.

Recommendation:
• A. Coronary CTA
• B. Obs admit for additional cardiac testing
• C. Cardiology consult for cath
• D. Discharge home
• E. Other
Case 3 – Same Patient
CP persists. Repeat troponin sent to lab < .01.

Recommendation:
• A. Coronary CTA
• B. Obs admit for additional cardiac testing
• C. Cardiology consult for cath
• D. Discharge home
• E. Other
Case 4
38 year old male with CP after meal 3 hours ago. Pain resolved in ER. Hx DM, dyslipidemia, and MI with RCA stent placement 6 years ago. ECG small inferior q waves and no ST-T abnormalities. Troponin 0.01. HR 61 bpm. BP 155/83. BMI 29.

Recommendation:
• A. Coronary CTA
• B. Obs admit for additional cardiac testing
• C. Cardiology consult for cath
• D. Discharge home
• E. Other
Case 5

52 year old female with CP, dyspnea, and palpitations. Under stress recently. Hx asthma, dyslipidemia and +FHx. ECG normal except for occasional PVCs. POC troponin <.07. BMI 45. HR 95. BP 98/62. Mild wheezing on exam.

Recommendation:
- A. Coronary CTA
- B. Obs admit for additional cardiac testing
- C. Cardiology consult for cath
- D. Discharge home
- E. Other
Case 6

28 year old male with persistent pleuritic CP with recent URI. CXR normal. ECG normal. POC troponin < .07. BP 125/75. HR 55. BMI 24.

Recommendation:

• A. Coronary CTA
• B. Obs admit for additional cardiac testing
• C. Cardiology consult for cath
• D. Discharge home
• E. Other
Case 7

68 year old male with dementia and diminished hearing. Lives at home with family who brought him in for CP. Hx HTN and dyslipidemia. ECG with nonspecific ST abnormalities. Troponin <.01. HR 61. BP 123/73. BMI 20.

Recommendation:

- A. Coronary CTA
- B. Obs admit for additional cardiac testing
- C. Cardiology consult for cath
- D. Discharge home
- E. Other
Case 8

62 year old female with CP. Hx of anxiety, HTN, and +FHx of premature CAD. ECG with minor nonspecific ST abnormalities. POC troponin <.07. HR 95. BP 165/85. BMI 27.

Recommendation:
- A. Coronary CTA (with beta blocker premed)
- B. Obs admit for additional cardiac testing
- C. Cardiology consult for cath
- D. Discharge home
- E. Other
Case 9

51 year old male presents to ER with substernal chest pain at 10 pm. Hx dyslipidemia and FHx CAD (brother MI at age 38). ECG normal. POC troponin .03. ER CCTA program just established.

Recommendation:
- A. Coronary CTA
- B. Obs admit for additional cardiac testing
- C. Cardiology consult for cath
- D. Discharge home
- E. Other
Case 10
56 year old male with substernal chest pain. Chest pain yesterday evening and this am. Took Viagra last pm. Hx HTN. +FHx CAD. Negative stress echo for dyspnea two weeks ago. ECG normal. Troponin < .01. HR 80 bpm. BP 138/78. BMI 24.

Recommendation:
• A. Coronary CTA (with beta blocker premed and avoid NTG)
• B. Obs admit for additional cardiac testing
• C. Cardiology consult for cath
• D. Discharge home
• E. Other
Case 10 – CCTA

Occluded LCX/OM with RPDA to OM collateral and 50-70% prox RCA

High risk RCA plaque

Normal RCA segment