



# Evaluation of Chest Pain in 2019

Mohit Bhasin MD, FACC

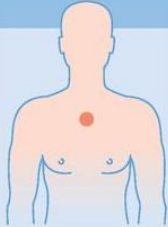









Norfolk, VA

35 min +10 min questions



No Financial  
Disclosures

Chest Pain is one of the most difficult yet common symptoms evaluated by PCPs, Emergency Physicians, Cardiologists, and searches on the internet by patients.

	LOW	Likelihood of myocardial infarction (MI)			HIGH
I. Clinical setting Symptoms and vital signs					 CPR/shock
II. Electrocardiogram (ECG)	 Normal ECG	 ST depression (mild)	 ST depression	 ST elevation	 ST elevation
III. Troponin level at 0h		—	—/+	+	+++ ++++
IV. Troponin change (within 1, 2 or 3h)		—	—/+	+	+++ If any of the above, consider direct rule-in



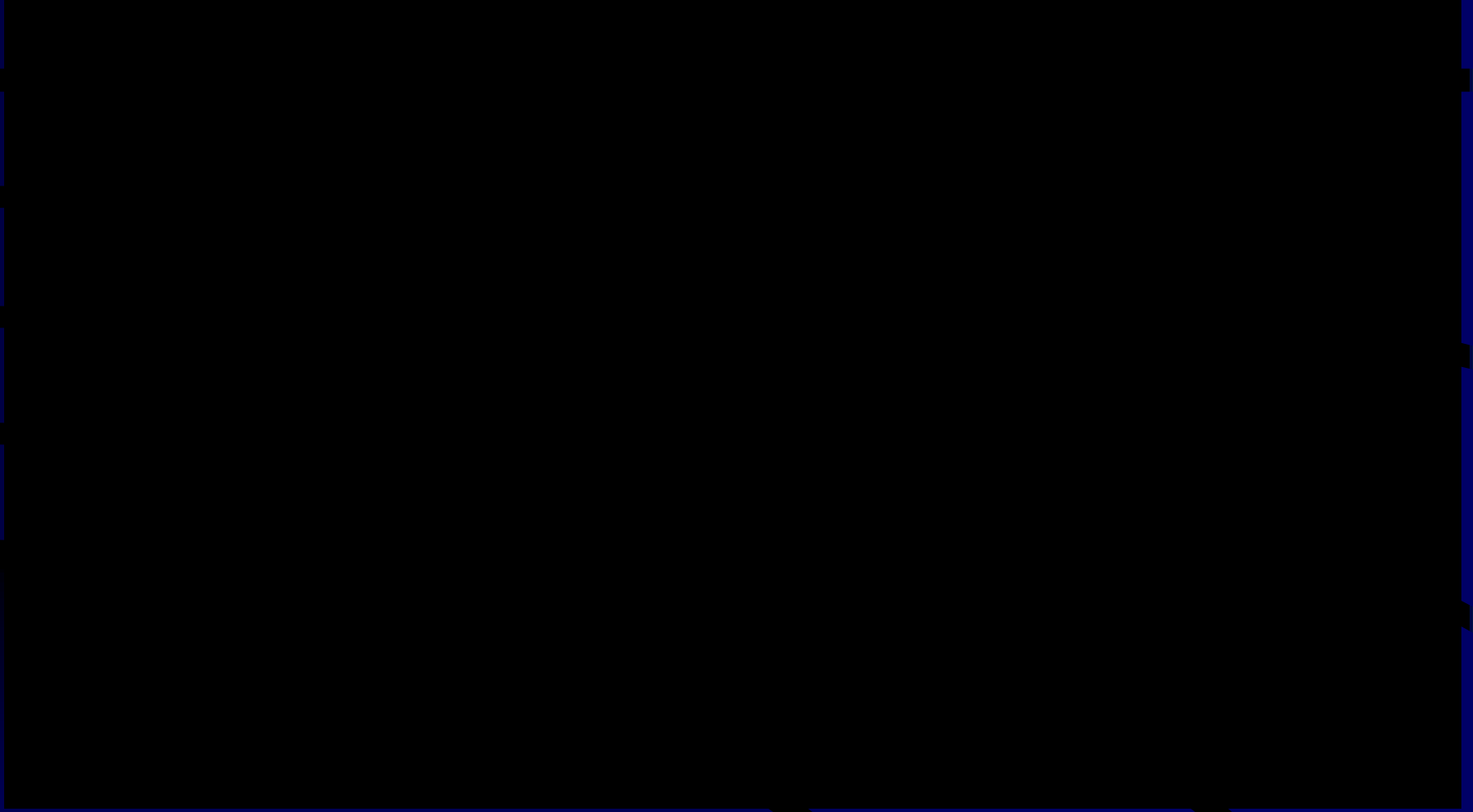
# IMPROVING DIAGNOSIS IN HEALTH CARE

QUALITY CHASM SERIES

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*The National Academies of*  
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# Institute of Medicine





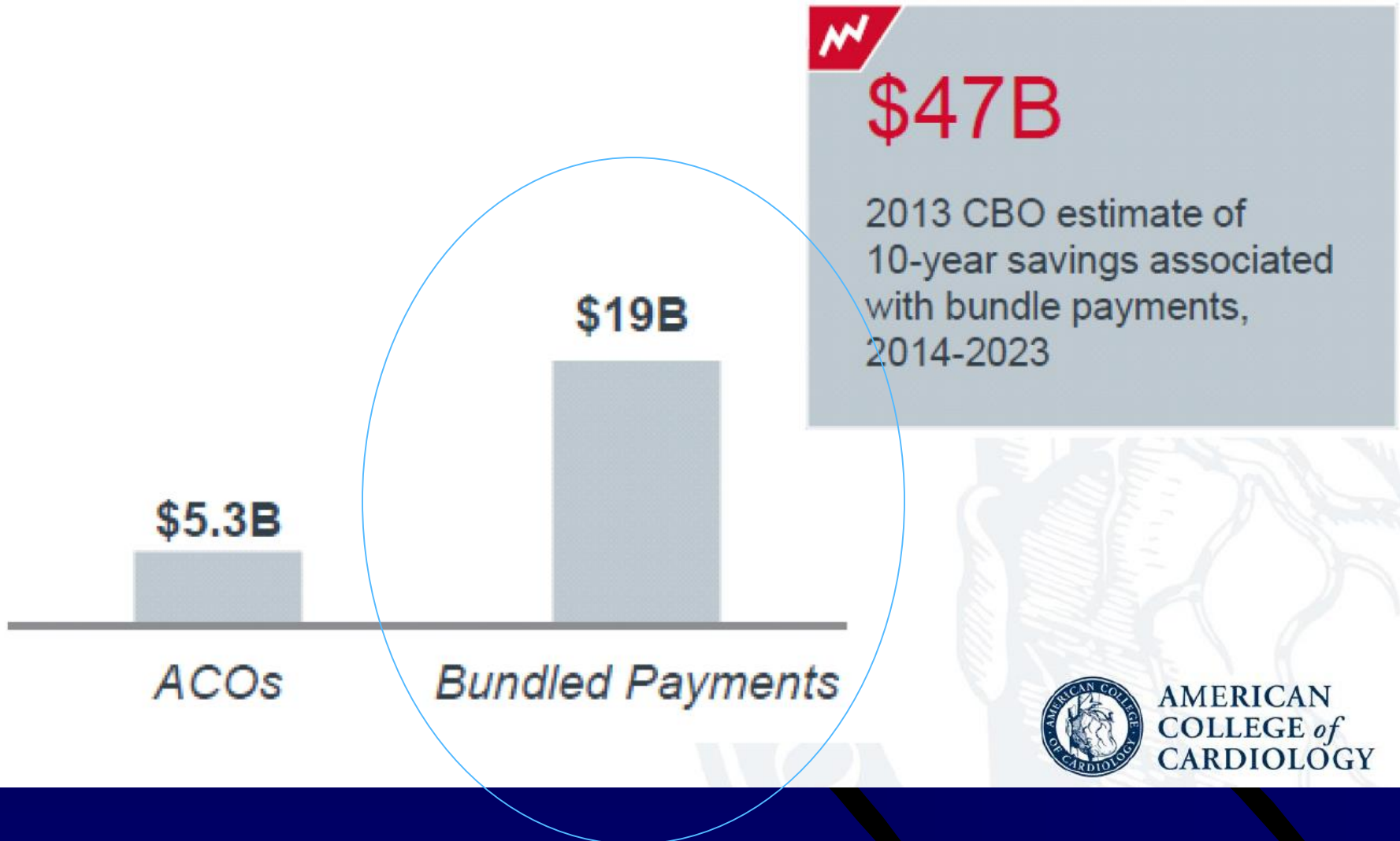
7 million Chest Pain patients present to U.S. Emergency Departments yearly (National Hospital Medical Care Survey), with benign to life-threatening causes, costing \$6 billion.

# BPCI Cardiac Episodes

- Acute Myocardial Infarction
- Percutaneous Coronary Intervention
- Coronary Artery Bypass Graft
- Cardiac Arrhythmia
- Cardiac Defibrillator
- Cardiac Valve
- Congestive Heart Failure
- Chest pain
- Major Cardiovascular Procedure
- Pacemaker
- Pacemaker device replacement or revision
- AICD generator or lead revision



# Bundled Payments Savings Potential

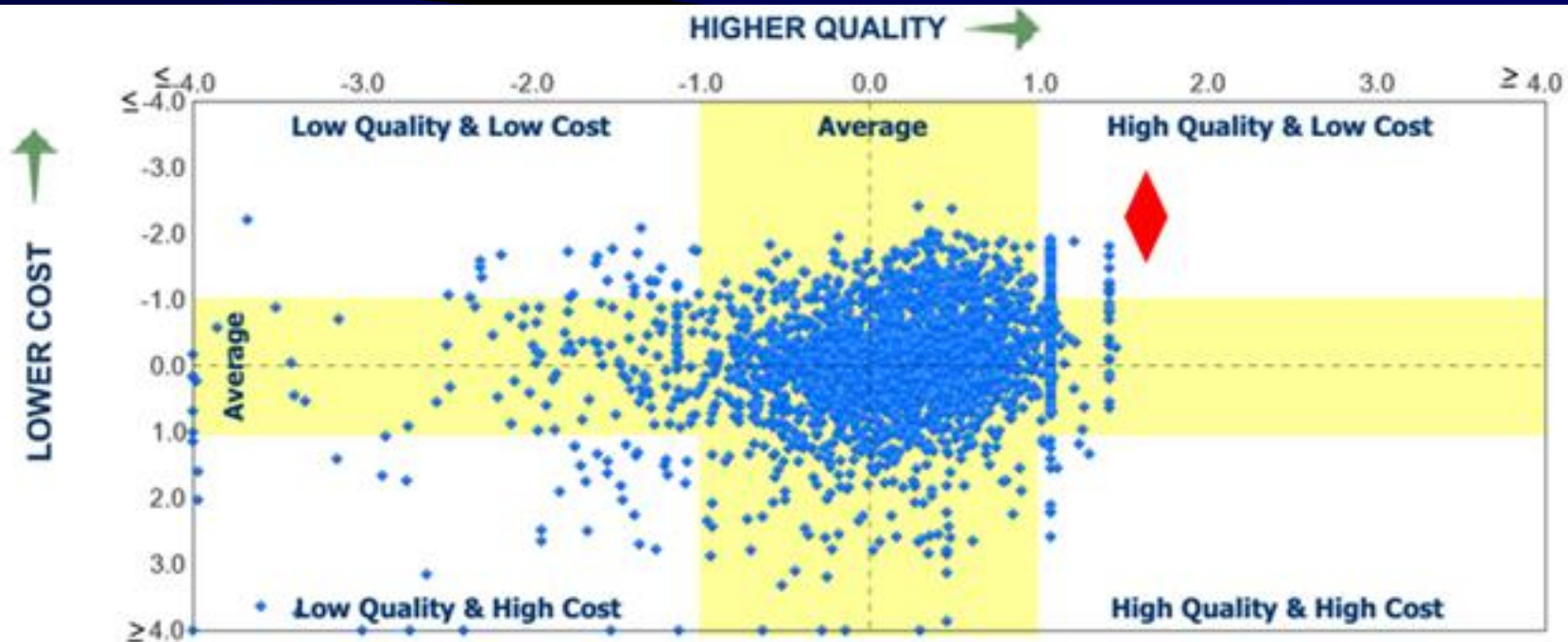




# CMS Physician Compare Public-reported Data

## ?new iteration of incentives and punishments

- CMS physician spend per beneficiary to be publically reported, as well hospitals.
- “2017 MIPS scores will be public and posted on 'Physician Compare' on the CMS website as a result of MACRA. Performance will be ranked against peers.
- Non participation will give you the lowest possible score.



Note: The scatter plot reflects the performance of a representative sample of your peers.

# Chest Pain is a high risk Chief Complaint

Current consensus is to exclude life-threatening causes of chest pain to less than 1% uncertainty (99% NPV), do it cost-effectively, efficiently and noninvasively when possible.

Many clinicians do not want to evaluate chest pain.

# Epidemiology of chest pain reflects selection bias

Diagnosis	Primary Care: USA	Primary Care: Europe	Emergency Department
Musculoskeletal conditions	36%	29%	7%
Gastrointestinal disease	19%	10%	3%
Serious Cardiovascular disease (Infarction, Unstable Angina, PE, HF)	16%	13%	54%
Stable CAD	10%	8%	13%
Unstable CAD	1.5%		13%
Psychosocial or Psychiatric disease	8%	17%	9%
Pulmonary disease (Pneumonia, Pneumothorax, Lung Cancer)	5%	20%	12%
Non-specific chest pain	16%	11%	15%

➤ *J Fam Pract.* 1994 Apr;38(4):345-52.

➤ *Fam Pract* 2001;18: 586-589.

# Acute Cardiopulmonary symptoms

(chest pain, dysnea,)

**ACS**

STEMI  
NSTEMI  
Unstable Angina

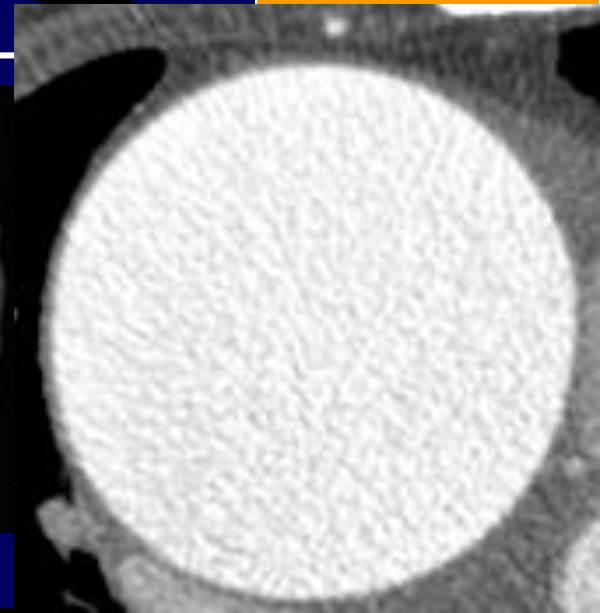
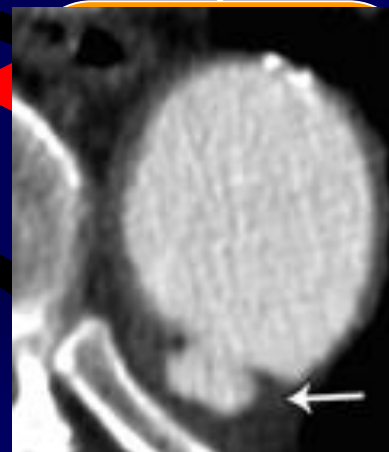
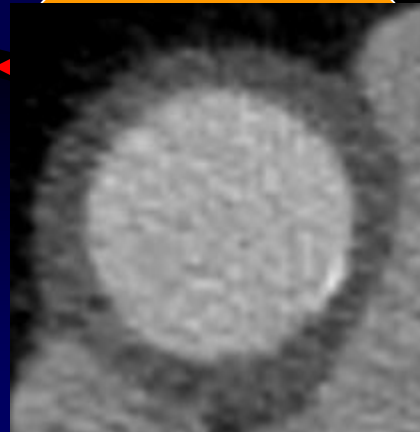
**AAS**

*Acute  
Aortic  
Syndromes*

**VTE**

Venothrombo-  
embolism

**Tamponade**  
**Esophageal  
Rupture**  
**Spontaneous  
tension PTX**





**FDA**

**WARNING**

# 2018 FDA Recommendation

Healthcare professionals should:

- **Avoid** prescribing fluoroquinolone antibiotics to patients who have an aortic aneurysm or are at risk for an aortic aneurysm, such as patients with peripheral atherosclerotic vascular diseases, **hypertension**, certain genetic conditions such as Marfan syndrome and Ehlers-Danlos syndrome, and elderly patients.
- Prescribe fluoroquinolones to these patients only when no other treatment options are available.
- Stop fluoroquinolone treatment immediately if a patient reports side effects suggestive of aortic aneurysm or **dissection**.

- For Life-threatening causes,
  - Consider the entire thorax and abdomen.
- Know characteristics of noninvasive tools in your region
- Exclude life-threatening causes to at least  $<5\%$  post test(s) probability of life-threatening disease (per IOM)  
or  $<1\%$  per the American College of Emergency Physicians
- Embrace the diagnostic timeout

# Outpatient Chest Pain

Up to **16%** of outpatient chest pain evaluations may never reach a definitive diagnosis.

**Before ordering a test elicit patient's fears** (false negative stress testing, invasive procedures), **expectations** (resume exercise with confidence), and **define a successful chest pain workup together:**



## *For a successful chest pain workup:*

- Plan what happens if we don't find heart or lung disease— it's not intellectually satisfying but the outcome is better
- Exclude life-threatening causes including CAD sufficiently that 'if you re-start exercising and feel chest discomfort, that you will have the confidence to push through'
  - This recommendation requires 100% NPV
- Plan to follow patients no matter what the tests show, to ask more questions and look for patterns that might suggest other diagnoses

If persistent chest discomfort, or evolution,  
then start evaluating for rare causes-

avoid 'zebra retreat'

Chest Pain evaluation is in rapid evolution due to

- Recent multi-center trial data evaluating event-free survival for *years* after randomizing patients to testing alternatives
- cost pressure, including diagnostic bundle payments
- background medico-legal pressure – high rate of claims from missed MI, Acute aortic syndromes, and PE – pushes for tests with high sensitivity and high NPV.

# Value and Limitations of Chest Pain History in the Evaluation of Patients With Suspected Acute Coronary Syndromes

Clifford J. Swap, MD, MS

John T. Nagurney, MD, MPH

**D**IFFERENTIATING ACUTE CORONARY syndromes (ACS) from benign causes of chest pain is critical because of the consequences of misdiagnosis in either direction. Despite diagnostic advances, missed acute myocardial infarction (AMI) and ACS remain problematic, with estimates ranging between 2% and 10%.<sup>1-3</sup> Conversely, a large proportion of patients with chest pain who are admitted do not turn out to have ACS.<sup>4</sup> This overtriage has enormous economic implications for the US health care system, estimated at \$8 billion in annual costs.<sup>7,8</sup>

Distinguishing whether a patient presenting with chest pain has ACS or a non-ACS problem is at best difficult. The differential diagnosis of chest pain is broad and includes many systems, such as pulmonary, musculoskeletal, gastrointestinal, dermatologic, psychiatric, and cardiovascular (including ACS and non-ACS).<sup>9,10</sup> In addition to ACS, this differential includes other immediately life-threatening diseases such as pulmonary embolism, tension pneumothorax, and aortic dissection, necessitating rapid diagnosis and treatments that are markedly different than those for ACS.

The tools most readily available to guide disposition of the patient with chest pain are the patient's age and sex, his-

**Context** The chest pain history, physical examination, determination of coronary artery disease (CAD) risk factors, and the initial electrocardiogram compose the information immediately available to clinicians to help determine the probability of acute myocardial infarction (AMI) or acute coronary syndrome (ACS) in patients with chest pain. However, conflicting data exist about the usefulness of the chest pain history and which components are most useful.

**Objective** To identify the elements of the chest pain history that may be most helpful to the clinician in identifying ACS in patients presenting with chest pain.

**Evidence Acquisition** MEDLINE and Ovid were searched from 1970 to September 2005 by using specific key words and Medical Subject Heading terms. Reference lists of these articles and current cardiology textbooks were also consulted.

**Evidence Synthesis** Certain chest pain characteristics decrease the likelihood of ACS or AMI, namely, pain that is stabbing, pleuritic, positional, or reproducible by palpation (likelihood ratios [LRs] 0.2-0.3). Conversely, chest pain that radiates to one shoulder or both shoulders or arms or is precipitated by exertion is associated with LRs (2.3-4.7) that increase the likelihood of ACS. The chest pain history itself has not proven to be a powerful enough predictive tool to obviate the need for at least some diagnostic testing. Combinations of elements of the chest pain history with other initially available information, such as a history of CAD, have identified certain groups that may be safe for discharge without further evaluation, but further study is needed before such a recommendation can be considered reasonable.

**Conclusion** 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 alone or in combination identify a group of patients that can be safely discharged without further diagnostic testing.

JAMA. 2005;294:2623-2629

www.jama.com

tory of coronary artery disease (CAD) or its risk factors, and the chest pain history. Usually, an initial 12-lead electrocardiogram (ECG) is added as well. In patients without significant ECG changes, risk factors for CAD have been shown to be poor predictors of AMI or ACS.<sup>4,11,12</sup> The initial 12-lead ECG has a sensitivity of only 20% to 60% for AMI,<sup>13-15</sup> and a single set of biochemical markers also has poor sensitivity.<sup>14-16</sup> Because none of these tools used alone

is a reliable predictor of ACS, the chest pain characteristics are usually used in conjunction with them to help determine disposition. Although this article dis-

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**Clinical Review Section Editor:** Michael S. Lauer, MD. We encourage authors to submit papers for consideration as a "Clinical Review." Please contact Michael S. Lauer, MD, at lauerm@ccf.org.

CME available online at  
[www.jama.com](http://www.jama.com)

# Only “typical” angina helps

## High likelihood of ACS:

- Chest pain with radiation to the arms or shoulders
- Chest pain associated with exertion, diaphoresis, nausea or vomiting.
- Chest pain described as pressure or similar to a previous MI.”

## Low likelihood of ACS:

- Pleuritic or positional.

# Important findings with chest pain

New diastolic murmur

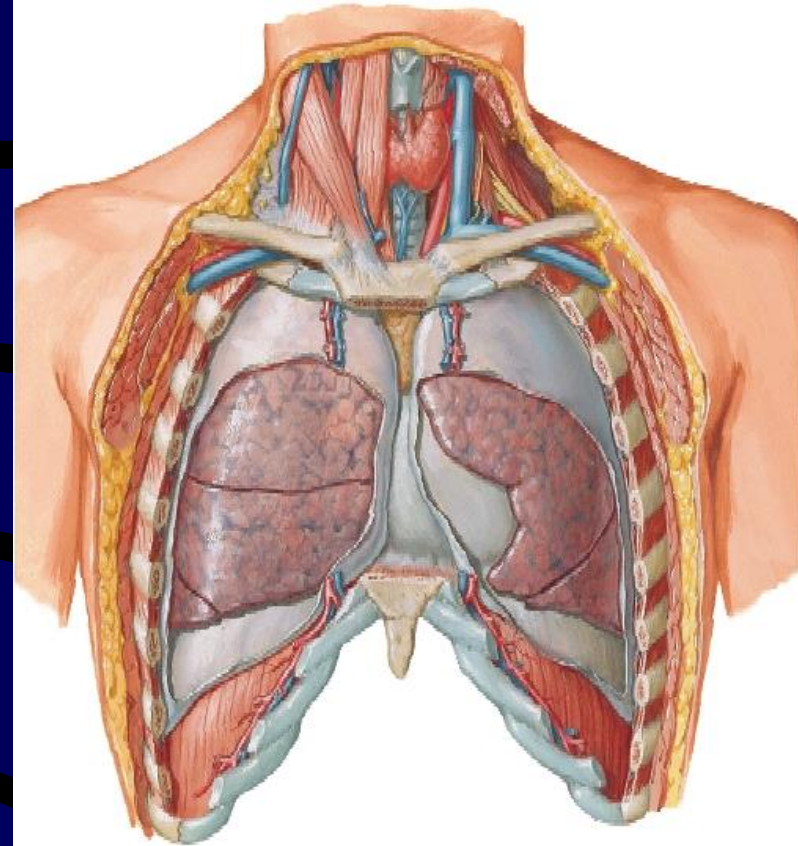
Late-peaking systolic murmur

**BP differential  
between the arms**

Diminished pulses

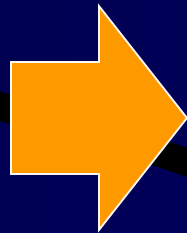
JVD and HJR

Chest-wall tenderness on  
palpation (markedly reduces  
ACS probability in low  
pretest probability settings)

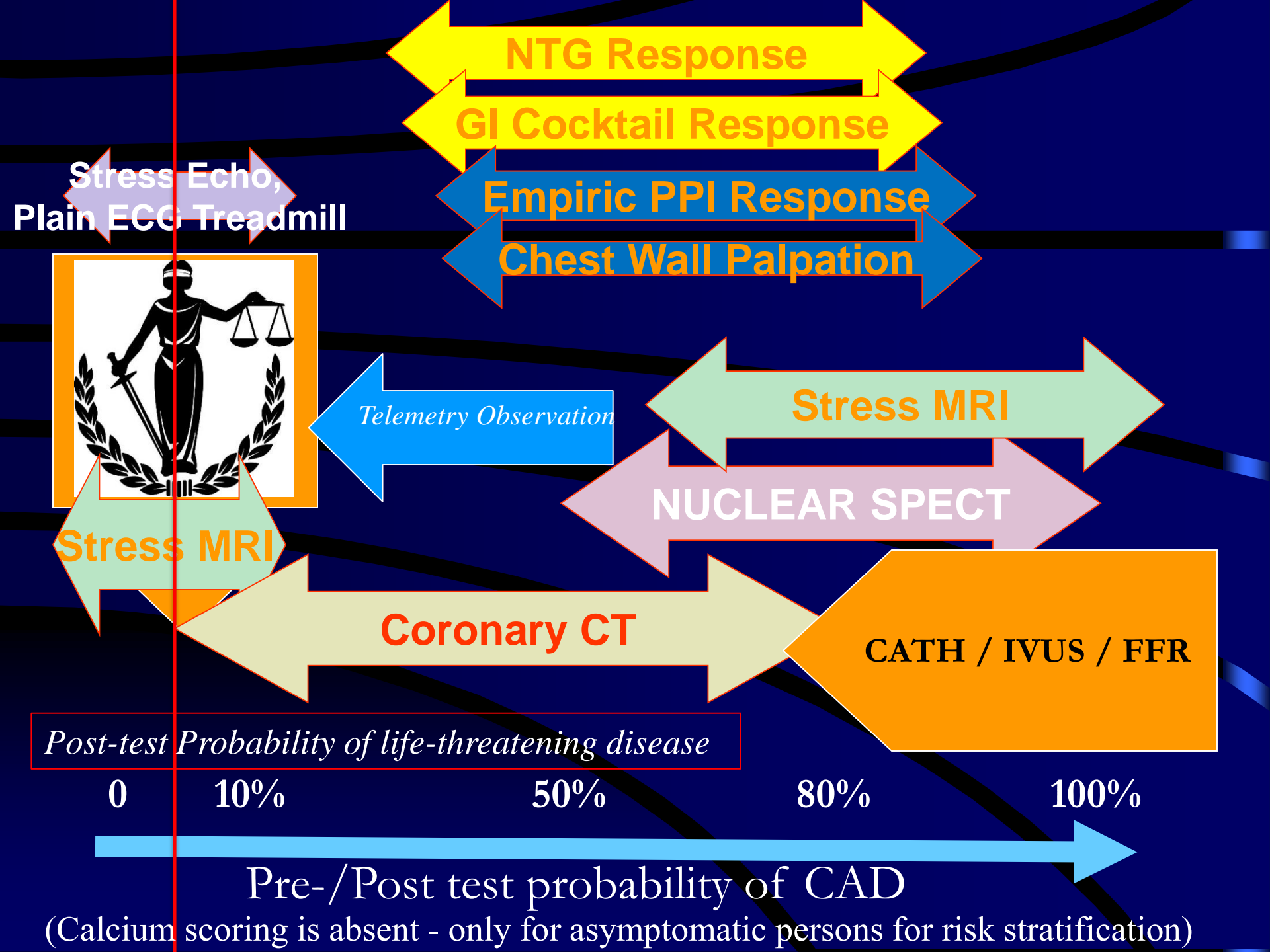


Tests become critically important  
to diagnosis and subsequent  
outcomes

Organize tools based on pre-test probability:  
after History, Risk Factors, Exam, EKG, CXR, and a cardiac  
enzyme, weigh the testing strategy sensitivity/NPV, renal  
and radiation risks if young, and ability to improve patient  
outcomes

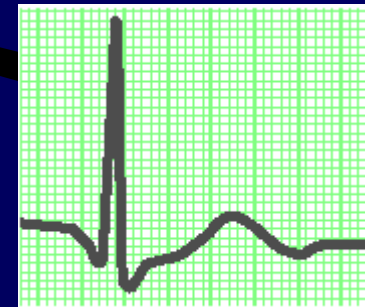






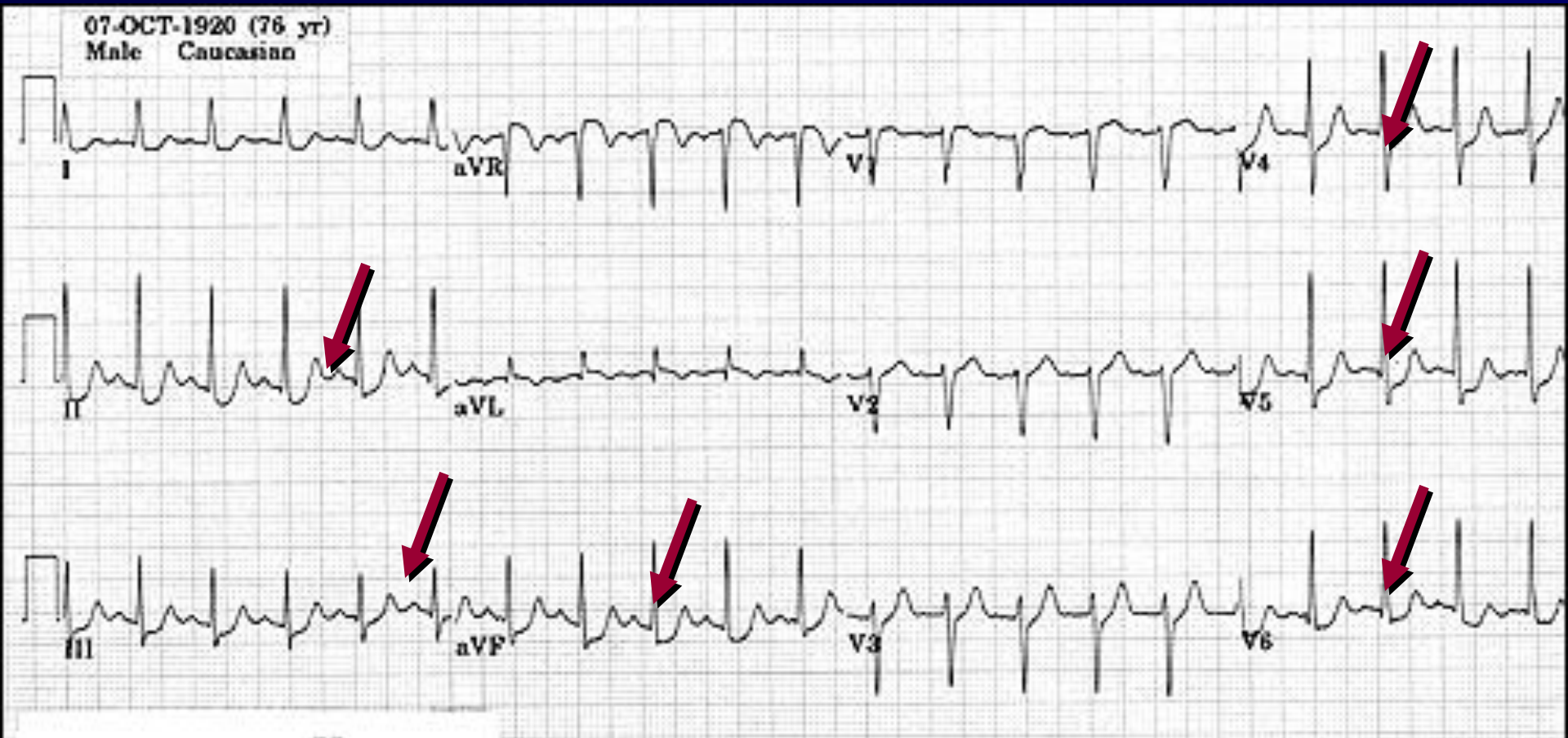
# Exercise Treadmill Test (ETT)

- Non-imaging stress test
- Bruce protocol
- Duke Treadmill Score (DTS)
  - $DTS = \text{exercise time} - (5 \times \text{max ST deviation in mm}) - (4 \times \text{treadmill angina index})$
  - Risk stratification
    - $< -10$ : High risk
    - $-10$  to  $+4$ : Intermediate risk
    - $\geq +5$ : Low risk
- Limitations<sup>1</sup>
  - False-positive and false-negative results

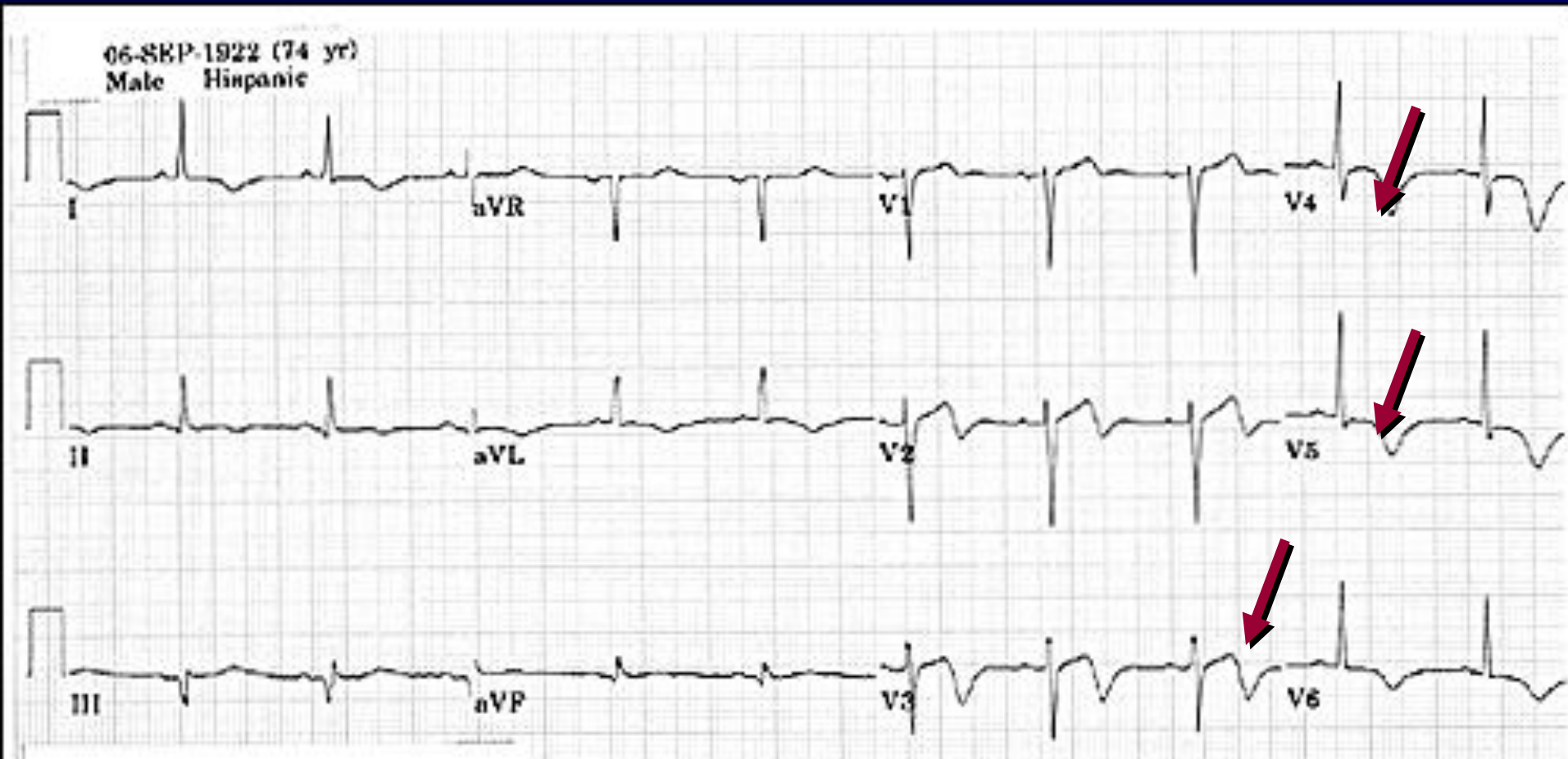


1. Gibbons RJ, et al. ACC/AHA 2002 guideline update for exercise testing. 2002. Available at [http://www.acc.org/clinical/guidelines/exercise/exercise\\_clean.pdf](http://www.acc.org/clinical/guidelines/exercise/exercise_clean.pdf).

# ST Segment Depression



# Diffuse Anterolateral T Wave Abnormalities

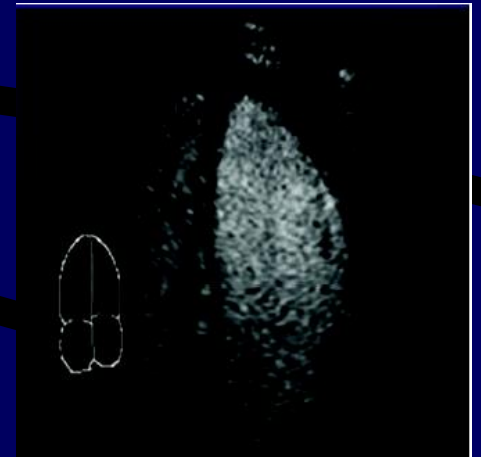


# Exercise Treadmill Testing

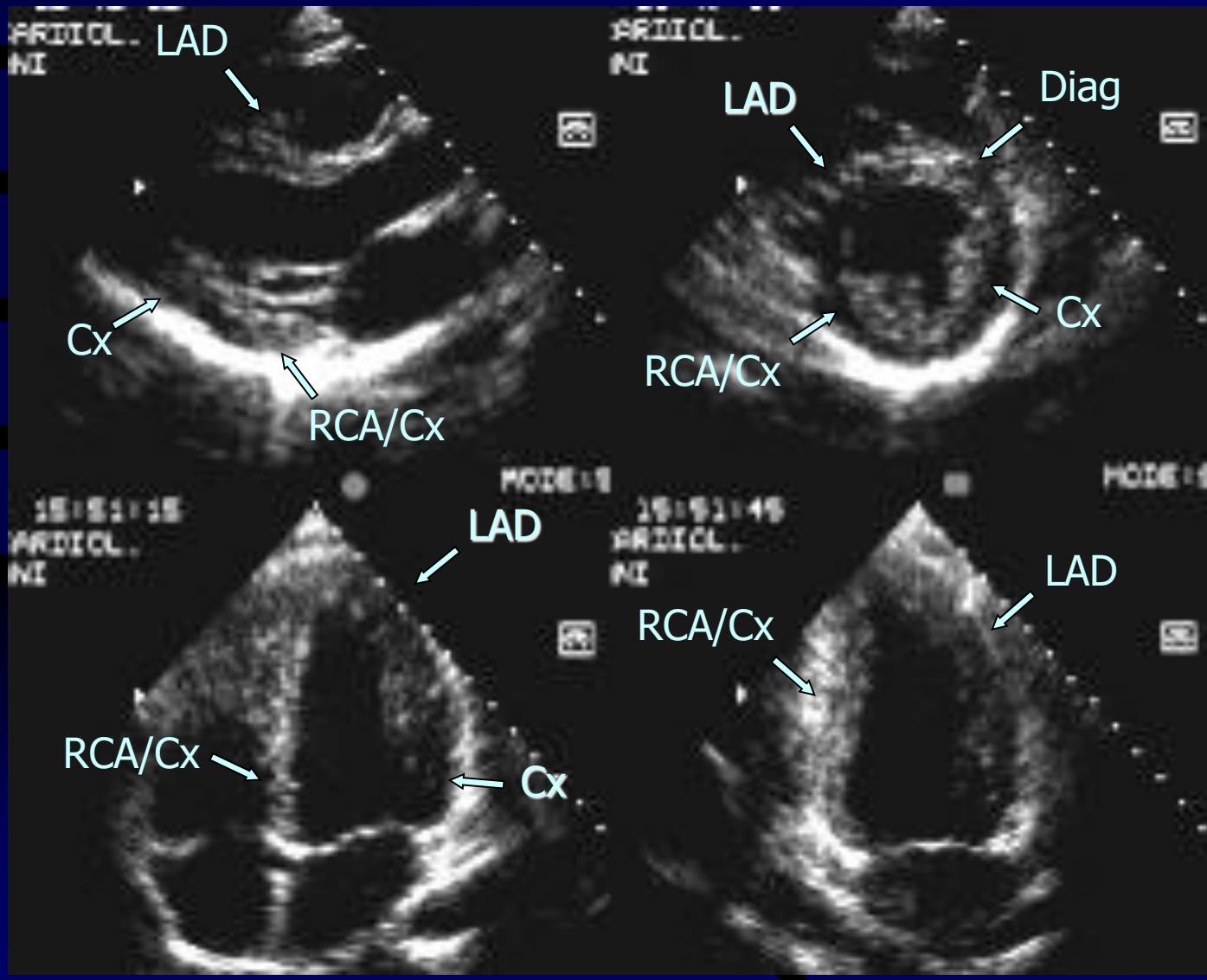
- Abnormal (Positive) Test
  - 39% incidence of cardiac events over 6.3 years
  - 89% of these events were occurrence of angina
- Normal (Negative) Test
  - 5.3% incidence of cardiac event over 6.3 years
  - 73% of these events were myocardial infarction or sudden death

# Echocardiography (stress echo)

- No ionizing radiation exposure
- Stress echo commonly performed with exercise or dobutamine



# Correlation of Coronary Arteries and Regional Wall Motion



## ACCURACY TO DETECT ischemia

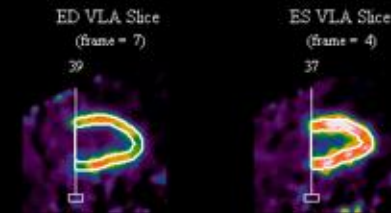
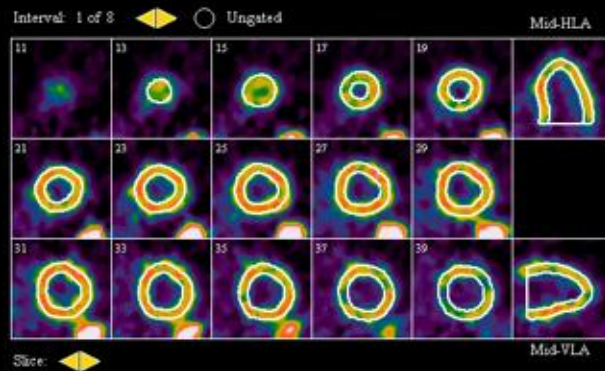
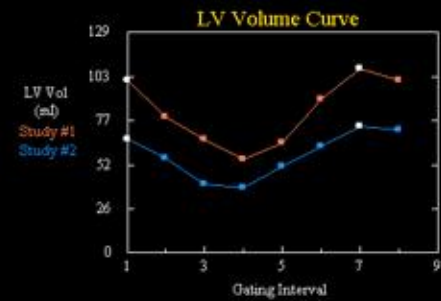
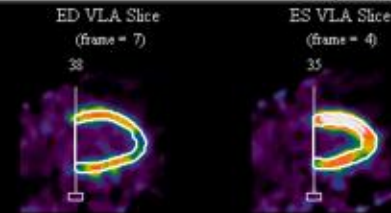
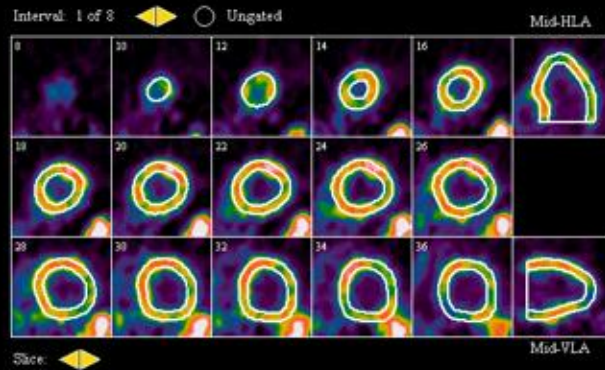
- Plain non-imaging exercise treadmill(ETT)
  - 60%
- ECHO
  - Stress - 75-80%
  - Specific but not sensitive



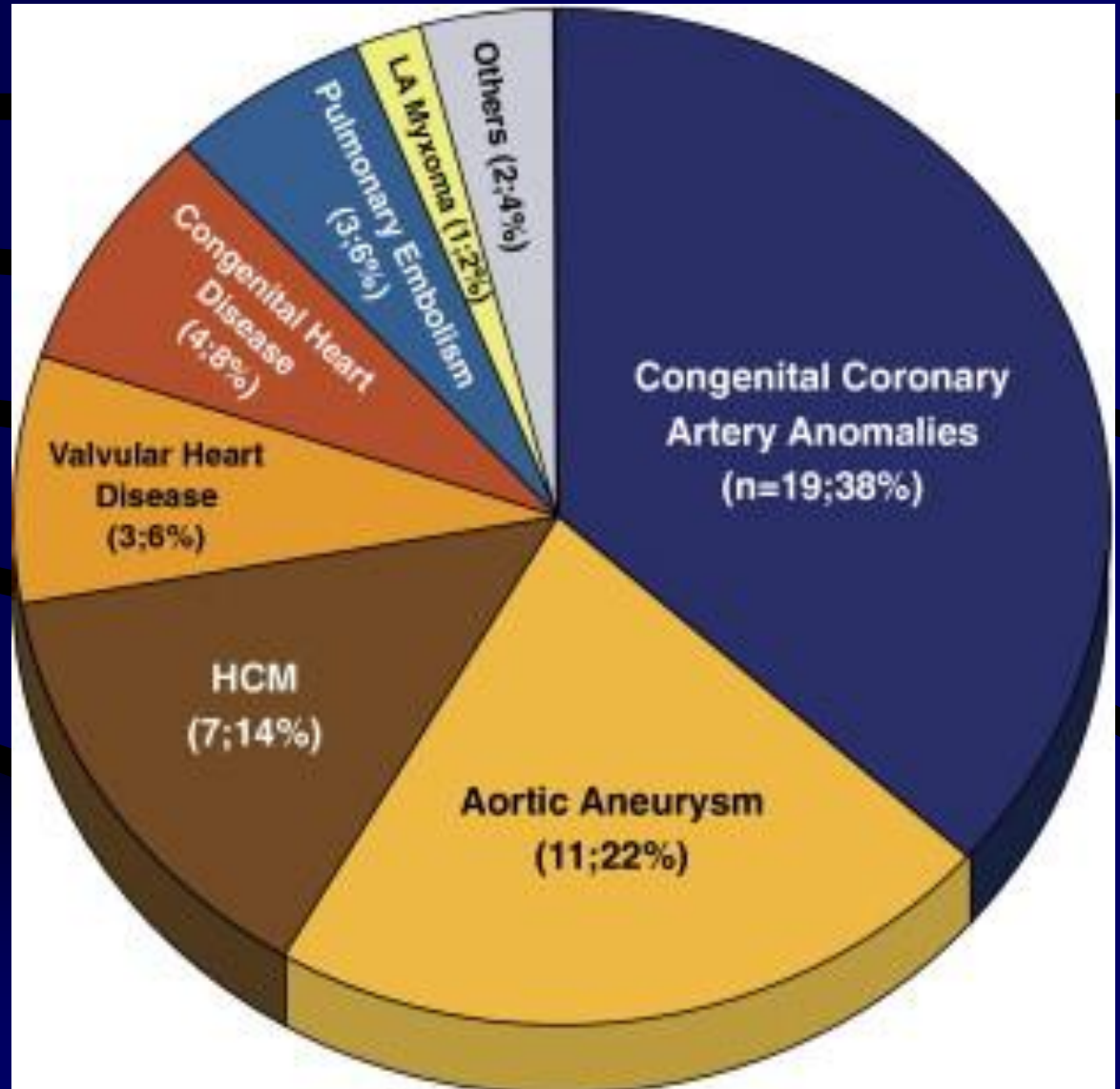
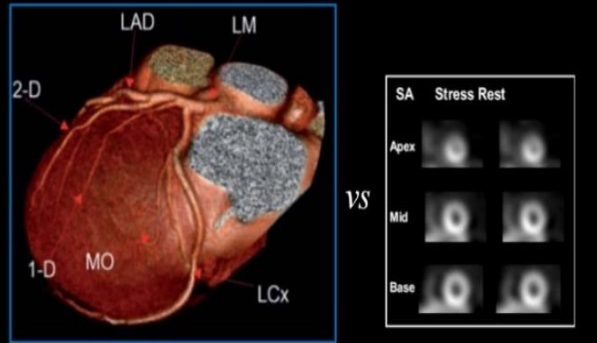
# Nuclear stress

**STRESS GATED C**  
 31-Jul-2007 10:27:52  
 Intervals: 8  
 Pharma: Rb<sup>82</sup> / <sup>18</sup>F<sup>82</sup>R  
 ED Vol: 107ml  
 ES Vol: 54ml  
 EF : 50 %  
 Mass: 124g, CO: 5.2 l/min  
 UgVol: 63 ml, TID: 1.47  
 SSS: 5  
 GSTR/SC/ALL

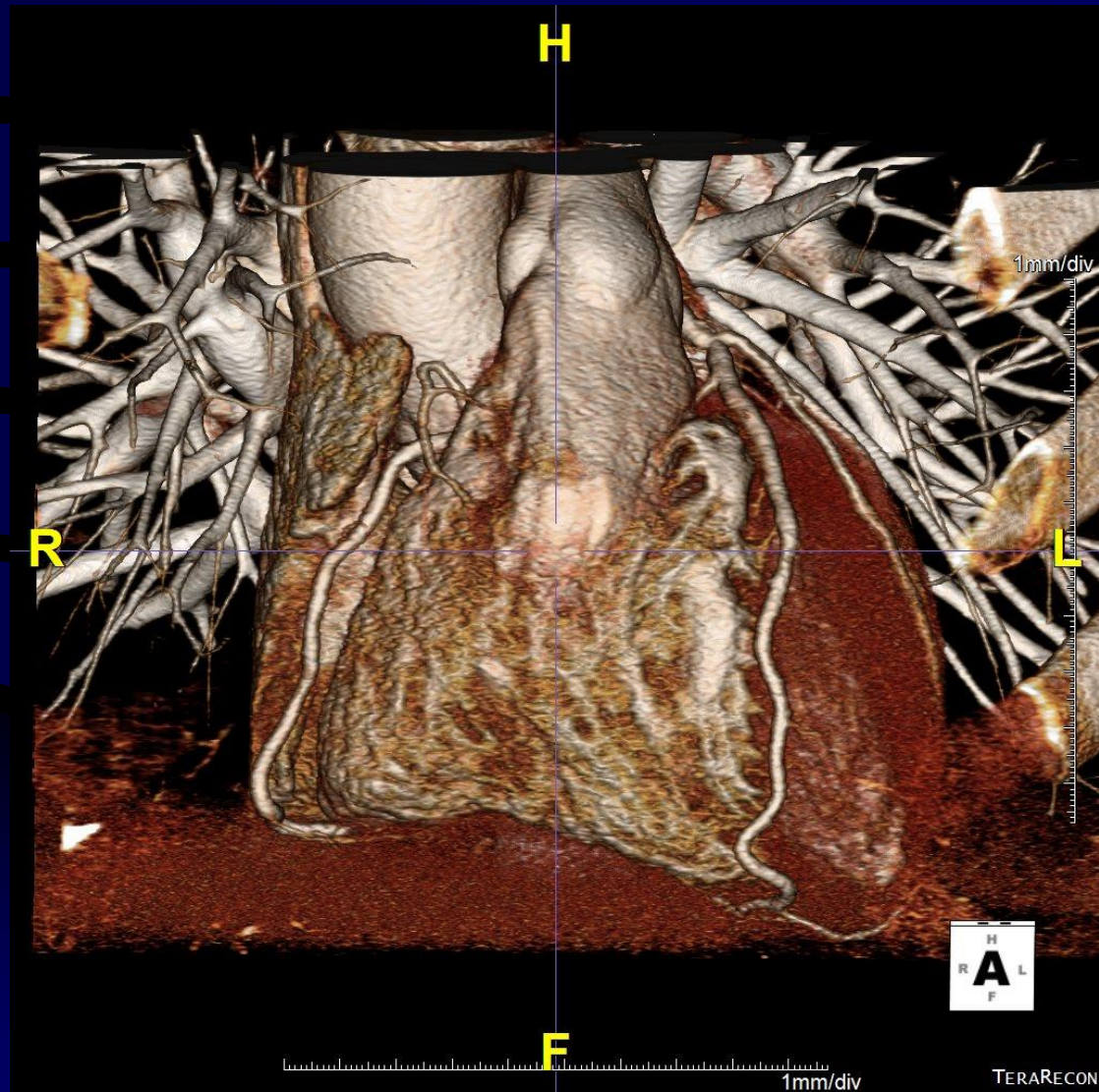
**REST GATED CT2**  
 31-Jul-2007 10:11:08  
 Intervals: 8  
 Pharma: Rb<sup>82</sup> / <sup>18</sup>F<sup>82</sup>R  
 ED Vol: 73ml  
 ES Vol: 37ml  
 EF : 49 %  
 Mass: 107g, CO: 2.4 l/min  
 UgVol: 43 ml, TID: N/A  
 SRS: 0  
 GRST/SC/ALL



# What's missed with stress testing?



# CT Heart and great vessels with contrast



# Normal Cardiac CT has 100 % NPV





Coronary CT has been well-studied in the ED setting, and recently in the outpatient setting, with over a long-term follow-up, in 14 high-quality randomized controlled trials and meta-analyses.

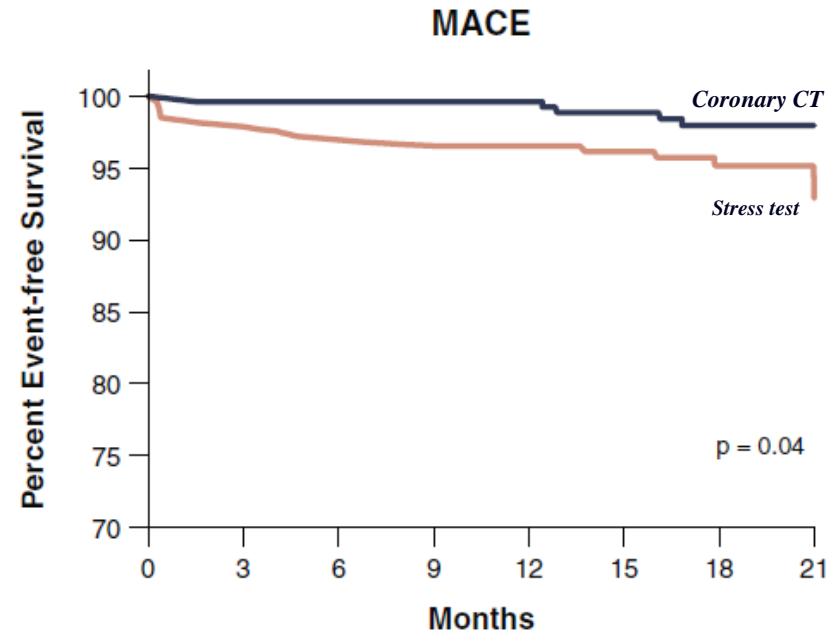
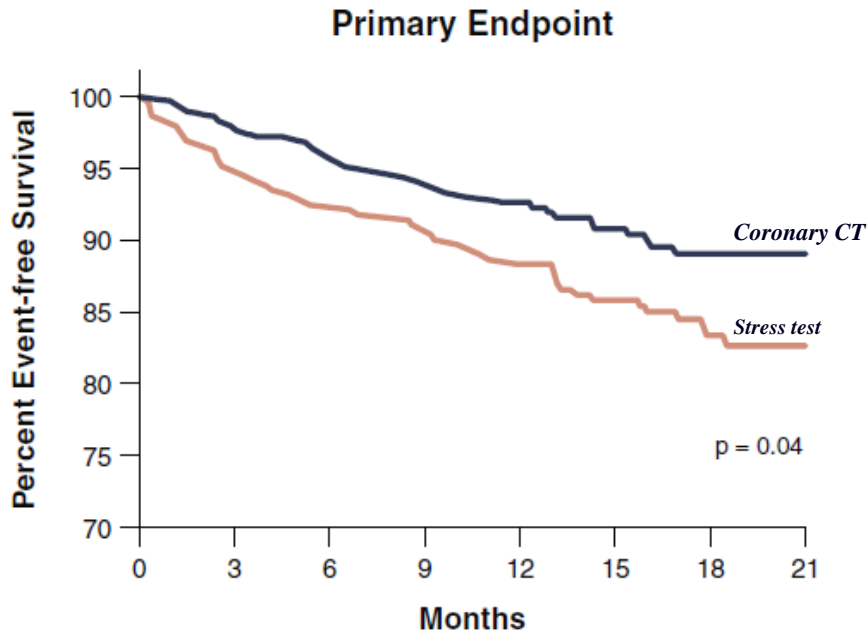
## Long-Term Clinical Impact of Coronary CT Angiography in Patients With Recent Acute-Onset Chest Pain



### The Randomized Controlled CATCH Trial

Jesper J. Linde, MD, PhD,\*† Jens D. Hove, MD, PhD,\*† Mathias Sørgaard, MD,† Henning Kelbæk, MD, DMSc,§  
Gorm B. Jensen, MD, DMSc,\* Jørgen T. Kühl, MD, PhD,† Louise Hindsø, MB,† Lars Køber, MD, DMSc,†  
Walter B. Nielsen, MD, PhD,\* Klaus F. Kofoed, MD, PhD, DMSc†||

# CATCH Study



Number of Patients at Risk

—	285	279	273	267	262	232	159	40
—	291	276	269	265	257	229	143	39

Number of Patients at Risk

—	285	284	283	283	282	254	173	37
—	291	285	283	282	281	256	160	44

— Coronary CTA-guided — Standard Care

*Composite endpoint: cardiac death, MI, hospitalization for unstable angina, late symptom-driven revascularization, & readmission for chest pain*



# Value of Cardiac CT in ED

	CT-STAT	ROMICAT2	ACRIN-PA	BEACON	CT-compare
	699	985	1370	500	562
Comparator	SPECT MPI	Usual care	Usual care	Usual care (hs-TnT)	XECG
ACS rate	1.8%	2.5%	1%	8%	4.2%
Cath rate	≈	≈	≈	≈	↑2x
Revascularization	≈	≈	≈	≈	≈
Hospital admission		↓40%	↓35%	≈	
Length of stay		↓25%	↓27%	≈	↓34%
Downstream testing				↓62%	
Costs	↓38% (ED)	≈ (hospital)		↓34%	↓19%
Adverse events	≈	≈	≈	≈	≈



ORIGINAL ARTICLE

## Coronary CT Angiography and 5-Year Risk of Myocardial Infarction

The SCOT-HEART Investigators\*

### ABSTRACT

#### BACKGROUND

Although coronary computed tomographic angiography (CTA) improves diagnostic certainty in the assessment of patients with stable chest pain, its effect on 5-year clinical outcomes is unknown.

#### METHODS

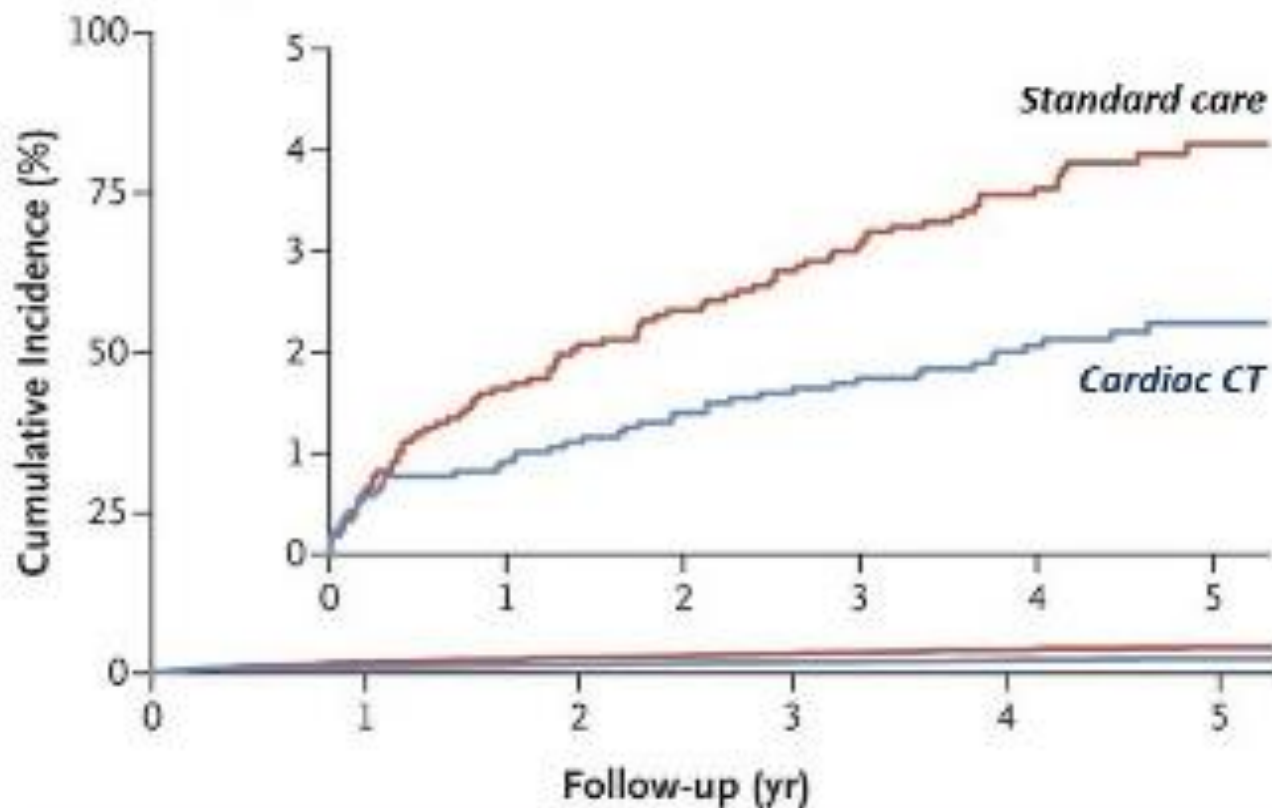
In an open-label, multicenter, parallel-group trial, we randomly assigned 4146 patients with stable chest pain who had been referred to a cardiology clinic for evaluation to standard care plus CTA (2073 patients) or to standard care alone (2073 patients). Investigations, treatments, and clinical outcomes were assessed over 3 to 7 years of follow-up. The primary end point was death from coronary heart disease or nonfatal myocardial infarction at 5 years.

#### RESULTS

The median duration of follow-up was 4.8 years, which yielded 20,254 patient-years of follow-up. The 5-year rate of the primary end point was lower in the CTA group than in the standard-care group (2.3% [48 patients] vs. 3.9% [81 patients]; hazard ratio, 0.59; 95% confidence interval [CI], 0.41 to 0.84;  $P=0.004$ ). Although the rates of invasive coronary angiography and coronary revascularization were higher in the CTA group than in the standard-care group in the first few months of follow-up, overall rates were similar at 5 years: invasive coronary angiography was performed in 491 patients in the CTA group and in 502 patients in the standard-care group (hazard ratio, 1.00; 95% CI, 0.88 to 1.13), and coronary revascularization was performed in 279 patients in the CTA group and in 267 in the standard-care group (hazard ratio, 1.07; 95% CI, 0.91 to 1.27). However, more preventive therapies were initiated in patients in the CTA group (odds ratio, 1.40; 95% CI, 1.19 to 1.65), as were more antianginal therapies (odds ratio, 1.27; 95% CI, 1.05 to 1.54). There were no significant between-group differences in the rates of cardiovascular or noncardiovascular deaths or deaths from any cause.

*NEJM Aug 2018*

# Death or MI after Coronary CT vs Stress Testing



**SCOT-HEART trial:** long-term impact in stable chest pain  
**1° outcome:** death from coronary heart disease or nonfatal MI

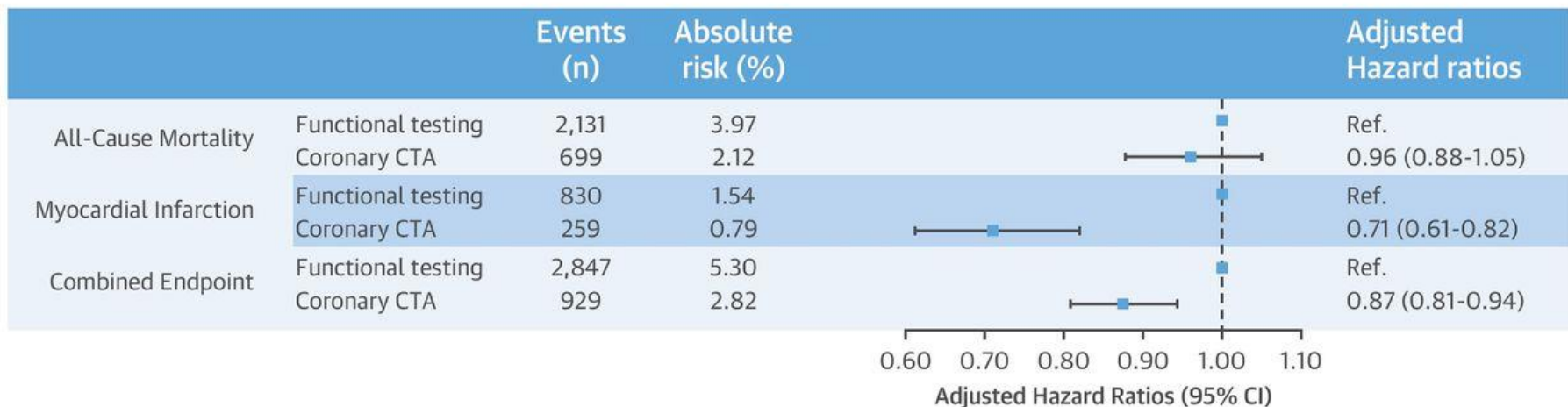
*NEJM*  
*Aug 2018*

# Danish Registry

86,705 patients underwent either stress testing or coronary CTA followed for 3.6 years.

Coronary CT lower risk of MI (hazard ratio: 0.71; 95% confidence interval: 0.61 to 0.82).

## CENTRAL ILLUSTRATION: Long-Term Risks of All-Cause Mortality and MI



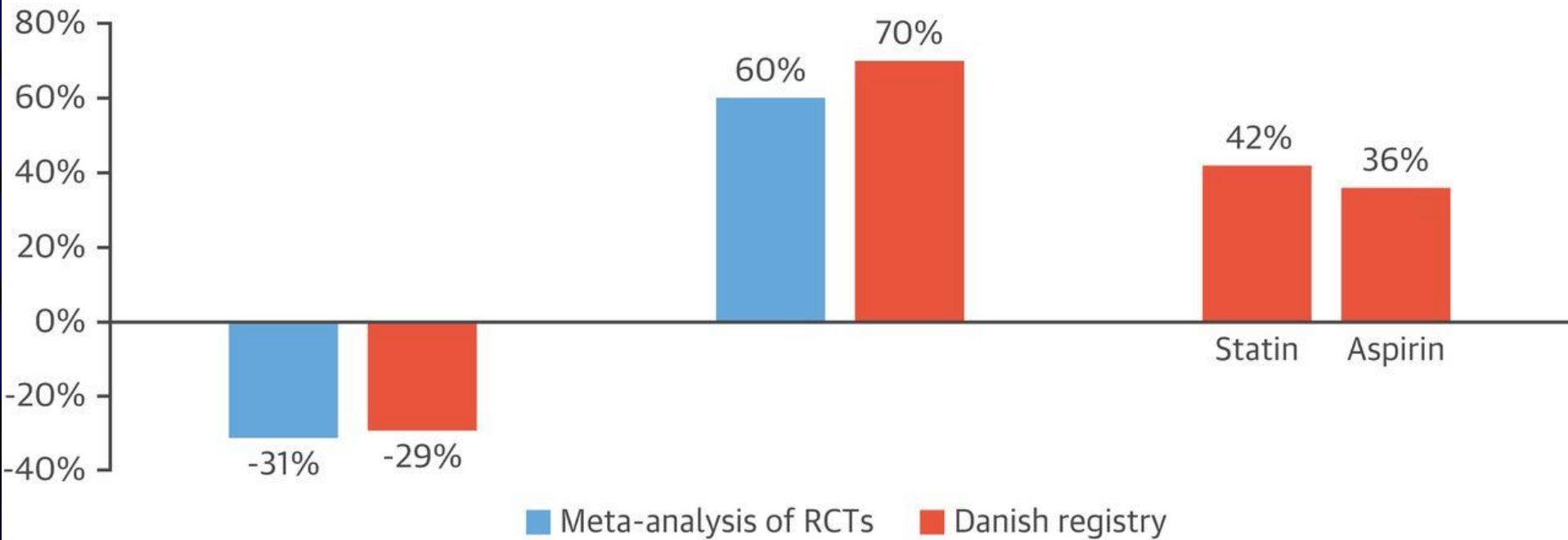
Jørgensen, M.E. et al. J Am Coll Cardiol. 2017;69(14):1761-70.

### Coronary CTA vs Functional Testing

↓ Myocardial Infarctions

↑ Coronary Revascularizations

↑ Preventive Therapies\*



# NIH

## PROMISE trial Economic Substudy: Estimation of Initial Chest Pain Testing Costs

<i>Dx Test</i>	<i>Mean Cost*</i>	<i>MD Fees**</i>	<i>Total</i>
<i>Coronary CTA</i>	\$285	\$119	\$404
<i>Echo w/ exercise stress</i>	\$428	\$86	\$ 514
<i>Echo w/ pharmacologic stress</i>	\$415	\$86	\$ 501
<i>ECG-only nonimaging stress</i>	\$137	\$37	\$174
<i>Nuclear w/ exercise stress</i>	\$829	\$117	\$ 946
<i>Nuclear w/ pharmacologic stress</i>	\$1015	\$117	\$ 1132

*\*based on costs in Premier database*

*\*\*based on Medicare Fee Schedule*

# U.K. National Institute for Health and Care Excellence (NICE) clinical guideline on 'Chest pain of recent onset'

- Coronary CT is the first line test before any consideration of invasive cath or stress testing.

“Coronary CT has almost 100% accuracy in excluding significant coronary artery disease and when compared with stress tests or invasive angiography and is the lowest cost, and can be delivered at low radiation dose.”



The challenge of national CT Coronary Angiography (CTCA) provision in response to NICE CG95 update 2016

# U.K. National Institute for Health and Care Excellence (NICE) clinical guideline on ‘Chest pain of recent onset’

“The evidence has brought new recommendations that propose Cardiac CT as the most clinically cost-effective diagnostic first line test for all patients presenting with chest pain.”



# System Solution

## ACC Rapid Chest Pain Pathway

### APPROPRIATE UTILIZATION OF CARDIOVASCULAR IMAGING

2015 ACR/ACC/AHA/AATS/ACEP/  
ASNC/NASCI/SAEM/SCCT/SCMR/  
SCPC/SNMMI/STR/STS **Appropriate  
Utilization of Cardiovascular Imaging  
in Emergency Department Patients  
With Chest Pain**



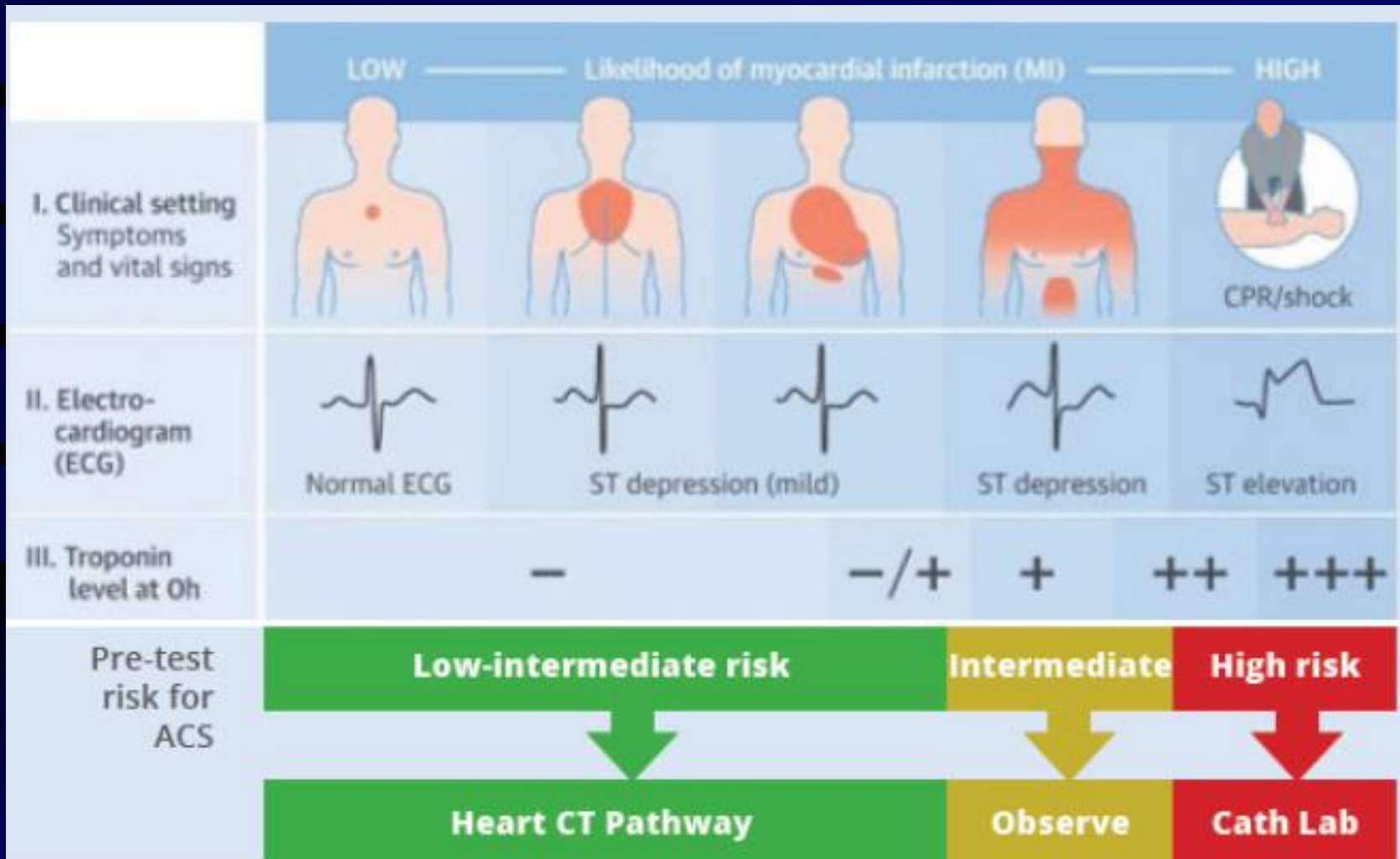
A Joint Document of the American College of Radiology Appropriateness Criteria Committee and  
the American College of Cardiology Appropriate Use Criteria Task Force

The American College of Cardiology endorsed Rapid Chest Pain Assessment by CT heart to time to diagnosis, unnecessary admissions, reduce total costs, and repeat evaluations for recurrent chest pain, with near zero undetected cases of ACS, with a 5 year 'warranty' for major adverse cardiac events after negative scans.



# Green Pathway for Chest Discomfort

with or without moderate suspicion of PE or Aortic Syndrome



# How's it work?

Patients need only one troponin before the scan; *do not have to be NPO*

- Operates continuously through the night: sensitive, safe cardiac diagnosis
- Unlike stress testing, borderline troponin is not a contraindication given its safety

Normal aorta, pulmonary arteries, and LVEF. Proximal LAD and RCA 20-30% mixed density plaques.

Cardiologist Recommendation: ASA 81mg daily and atorvastatin 20mg or rosuvastatin 10mg, with no further testing.



Advanced Cardiovascular Imaging

Intermediate 50-60% stenosis of the dominant RCA.

Cardiologist Recommendation: ASA 325mg and atorvastatin 80mg or rosuvastatin 40mg, with consideration of antianginals if anginal quality pain is noted and ischemic testing for these territories would be reasonable. If symptoms are atypical for angina, could treat medically.

3D image post processing; computed tomographic angiography of coronary arteries (including native and anomalous coronary arteries, coronary bypass grafts), without quantitative evaluation of coronary calcium.

**Cardiovascular Findings**  
Coronary Angiography

\*PRELIMINARY section—Not FINALIZED

Extravascular mediastinal structures demonstrate no abnormality. Lung windows demonstrate no abnormality in the visualized lung fields. Bony structures are unremarkable.

1. No evidence of epicardial coronary artery disease
2. Unremarkable great vessels, systemic thoracic veins, and pulmonary veins.



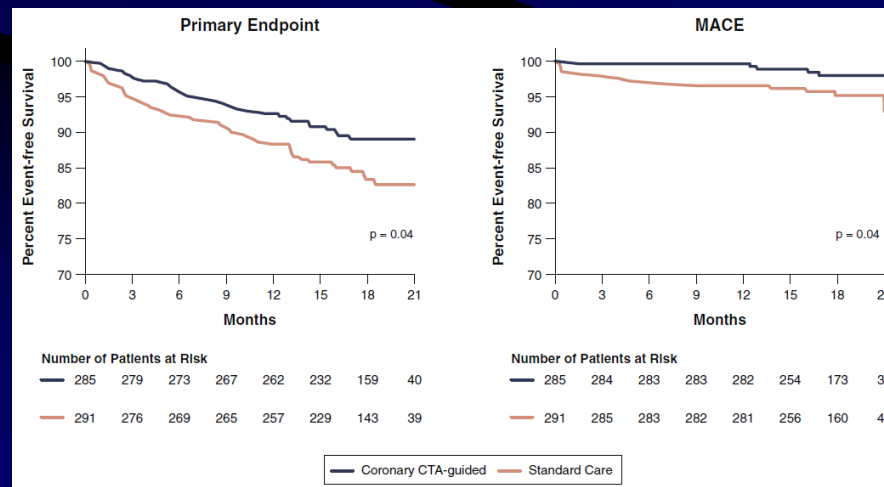
Normal Coronaries, LVEF, aorta and pulmonary arteries. Normal lungs.

Cardiologist Recommendation: No further testing. Return to full exercise, discontinue aspirin. Primary prevention.

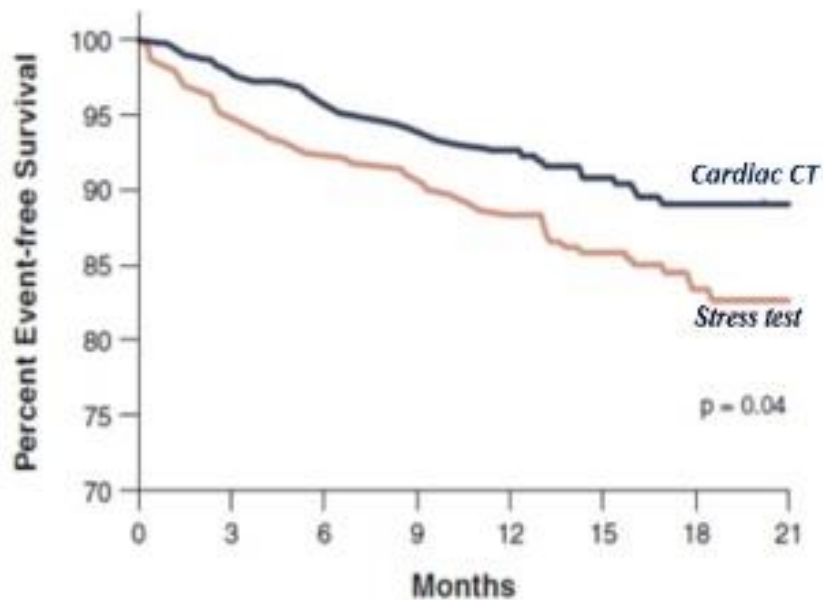
Thank you for this referral.

# Speeding test efficiency to bring down DRG spend

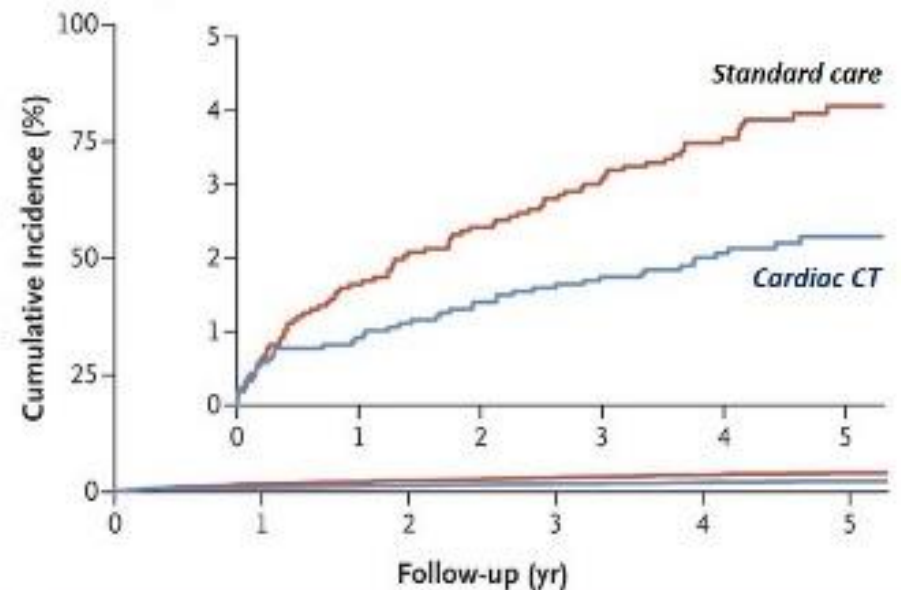
- **Syncope** workups taking days (current strategy of echo, stress, cardiology consultation) – both LVEF/RWMA and stress information can be combined in one cardiac CT presenting 0700-2300
- **Troponinemia (type II nstemi)** slows discharges (current strategy of echo, stress, cardiology consultation) for dysnea, syncope, anemia, asthma, dizziness, weakness
- **Sob/Dysnea** (CT PE then repeat CT coronary or stress and echo) – this current strategy is replaced by CT Triple rule out immediately
- Because coronary CT is a much more sensitive test than stress echo, **increase cath seen and increased PCI by 15-60%**, net neutral on Nuclear stress, improved patient survival b/c no false negative stress, adherence to meds, other diagnoses.



# Patient Survival with Coronary CT



**CATCH trial:** long-term impact in acute chest pain  
**1° outcome:** cardiac death, MI, hospitalization for unstable angina, and late symptom-driven revascularization



**SCOT-HEART trial:** long-term impact in stable chest pain  
**1° outcome:** death from coronary heart disease or nonfatal MI

How to Provide tests with few local  
imagers?

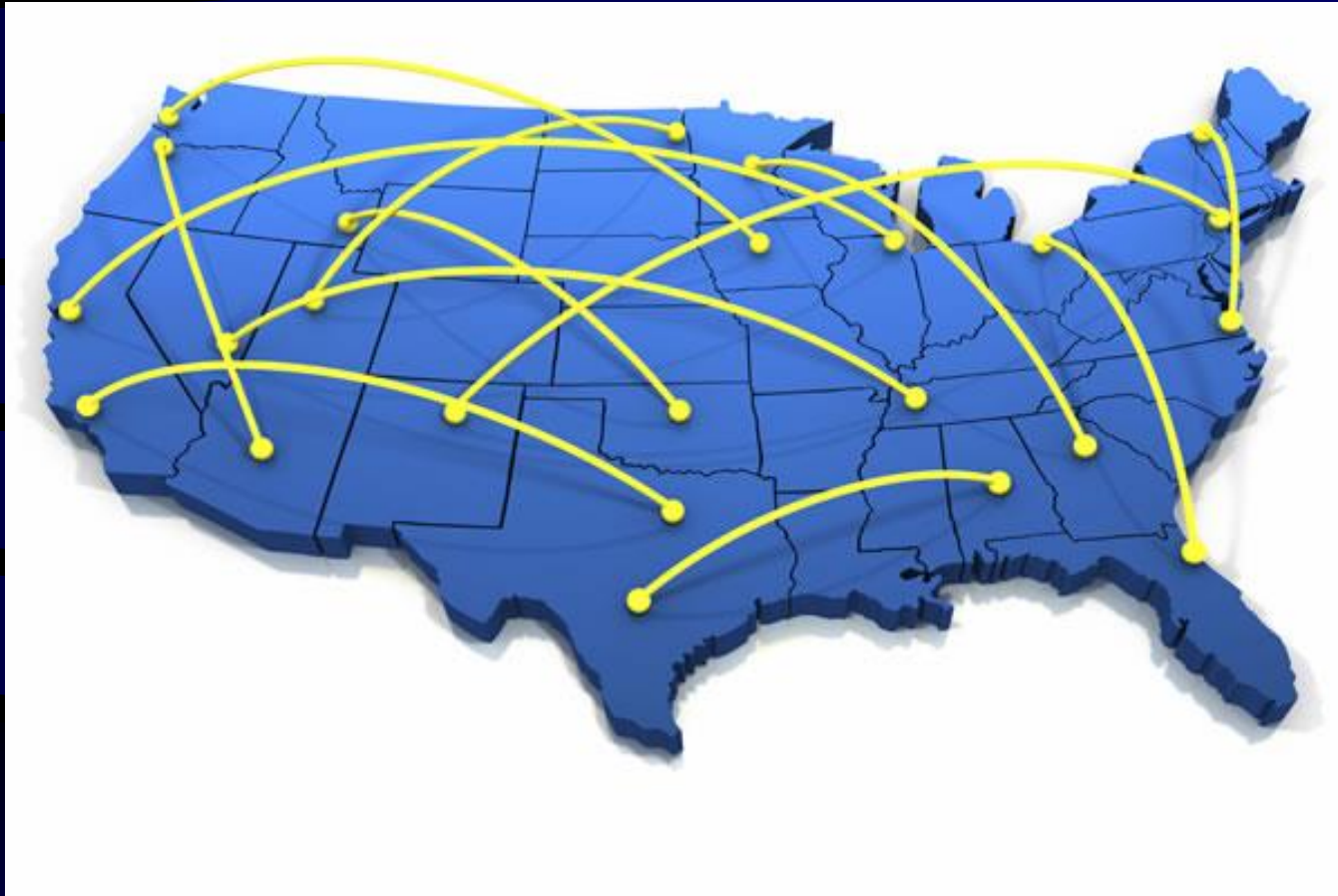
Unlock efficiencies by  
telecardiology



**American  
Heart  
Association®**

**life** is why™

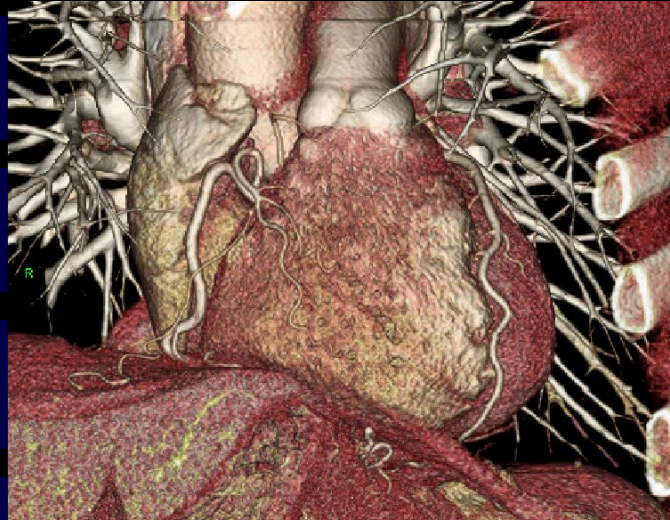
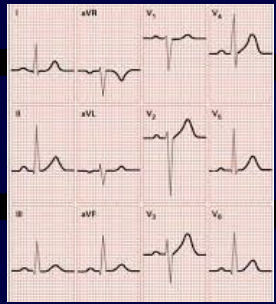
# Interstate Telecardiology



Cardiologists and cardiac radiologists, across time zones, collaborating for accurate, cost-effective, and rapid diagnostics

# National Physician Portal

Connected by Cloud-Based 3D Software and a smartphone application

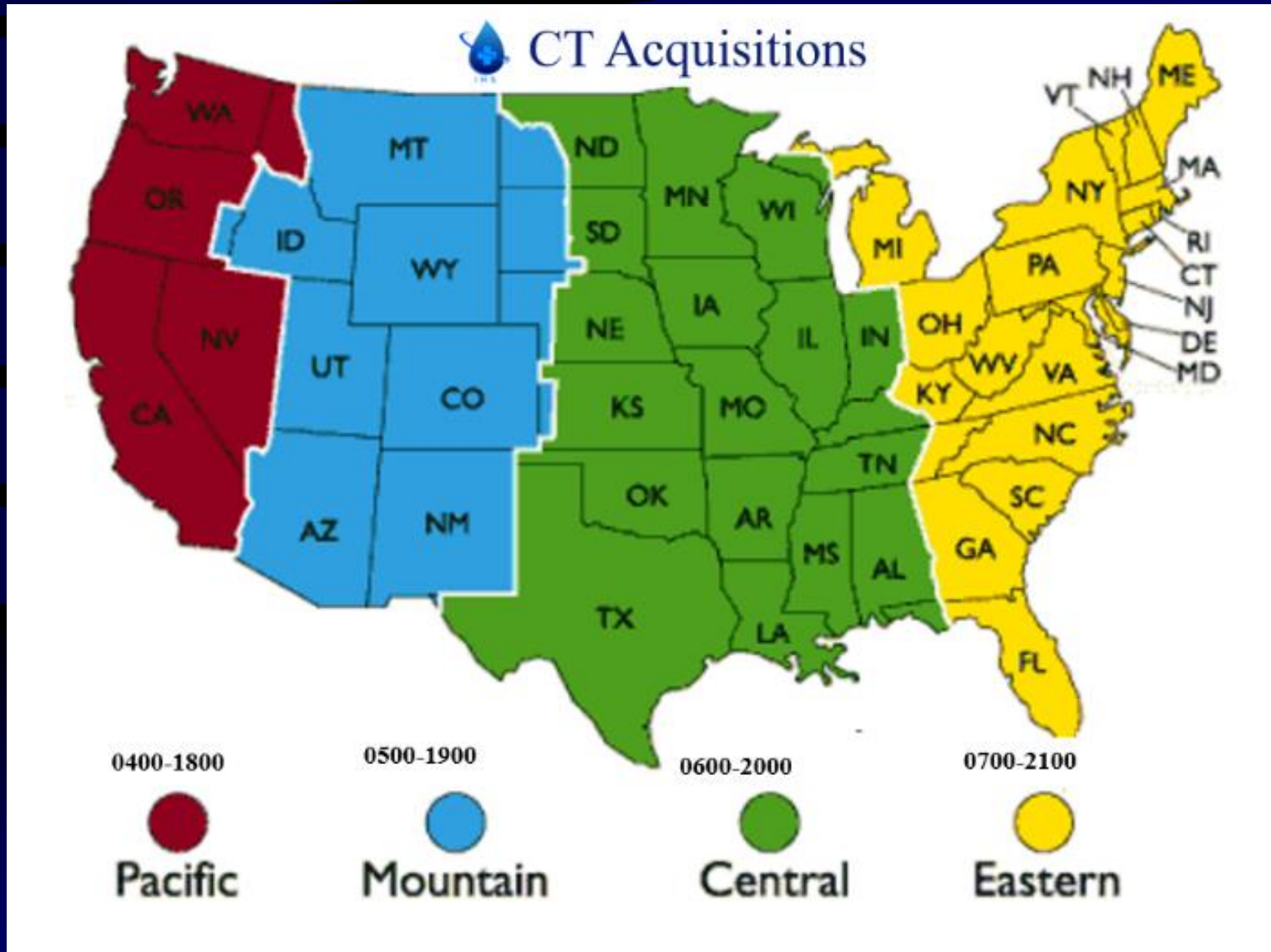


Inter-state practice of medicine by physician colleagues

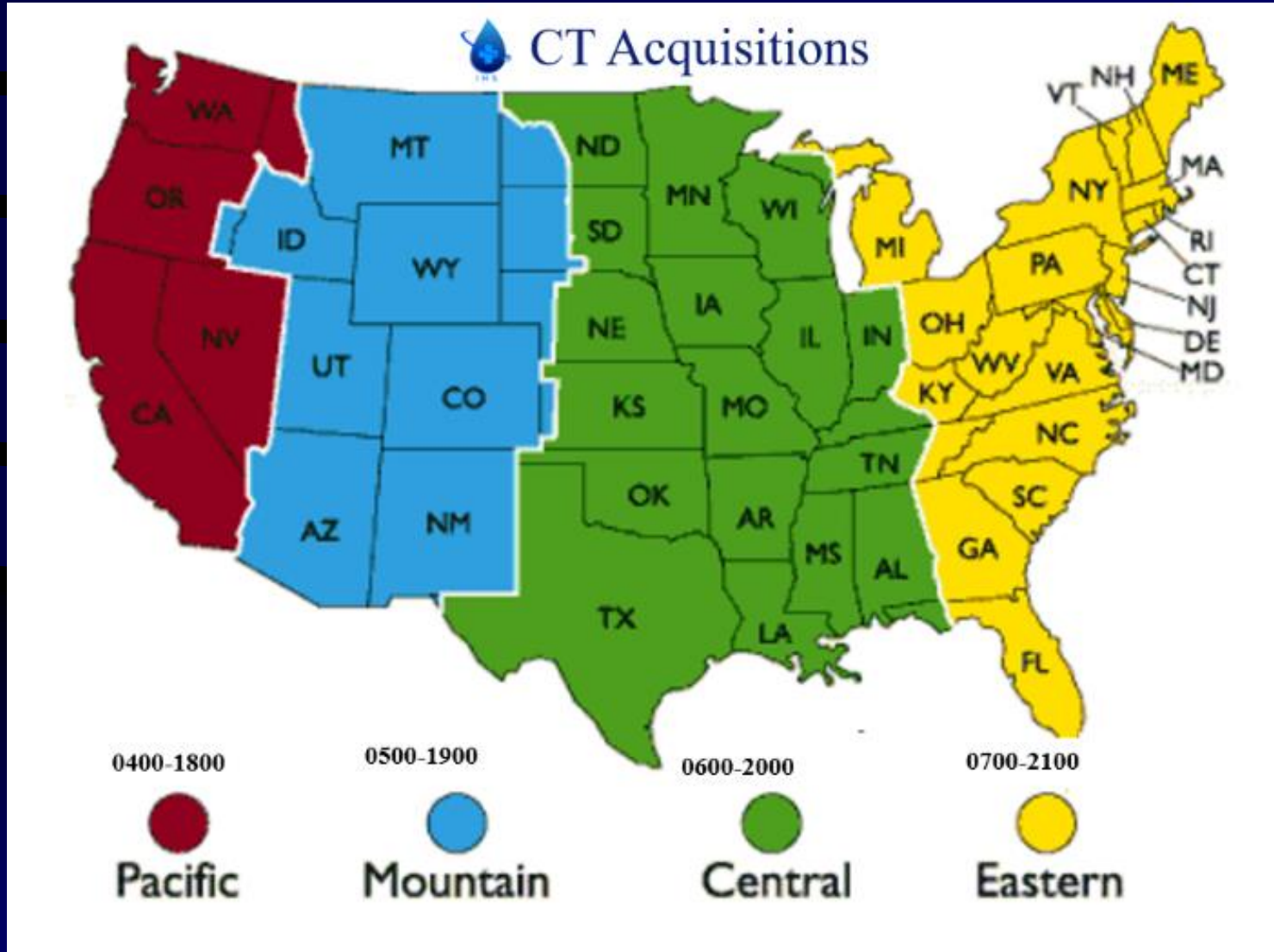
Providing EKG quality assurance then coronary CT with as needed clinical decision support to hospitals, free-standing Eds, and imaging centers



# Mon-Fri 0700-2300

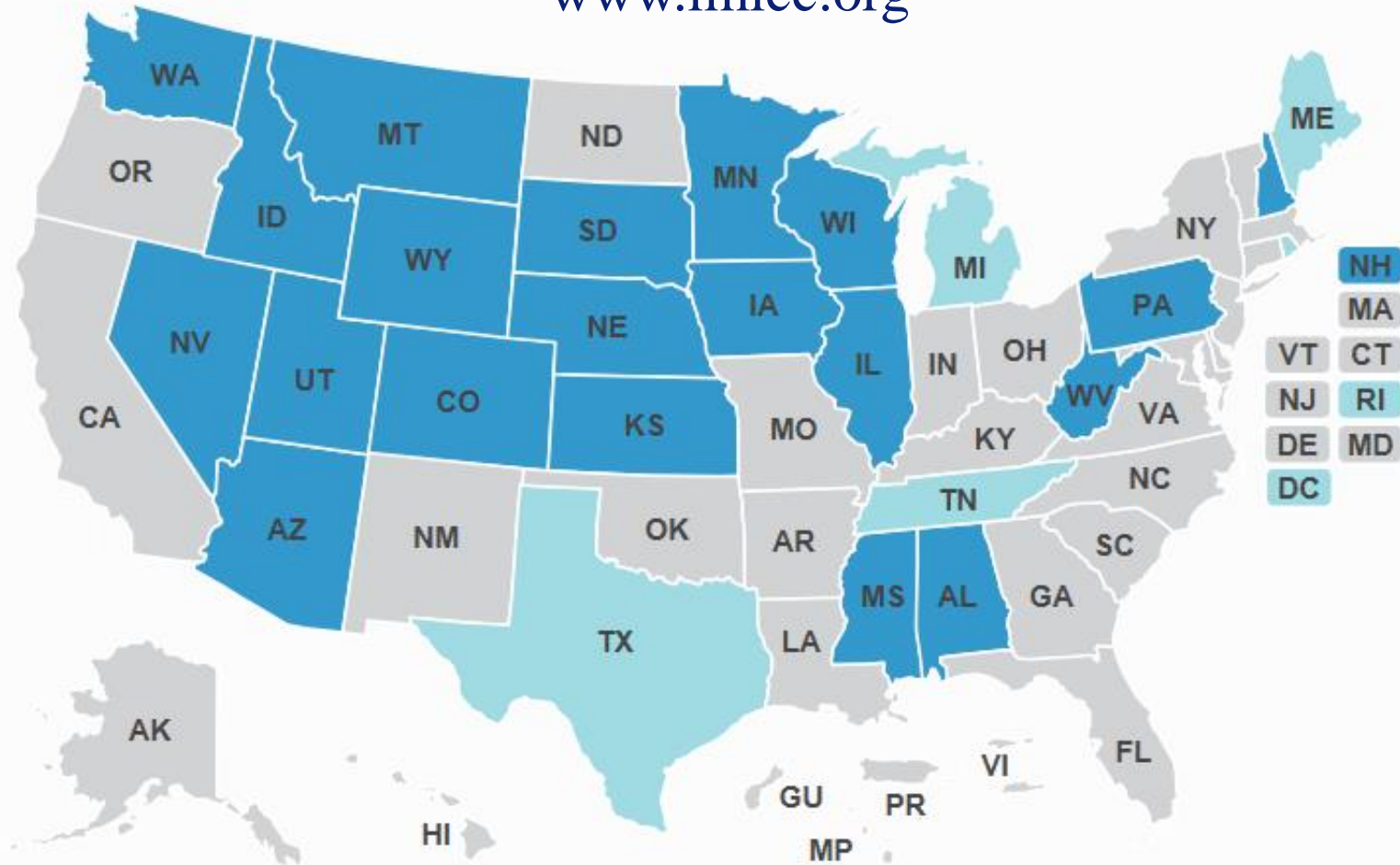




Weekends 0700-1700 plus Mon-Fri 0700-2300



# Interstate Medical Licensure Compact- 2017

[www.imlcc.org](http://www.imlcc.org)



 = Compact legislation enacted  
 = Compact legislation introduced

# Microhospitals and free-standing EDs, required to stay open 24/7



Emergency Departments in the United States

