Triage of Acute Chest Pain in ED

서울아산병원
강준원

Risk stratification of acute chest pain using clinical parameters

RISK STRATIFICATION

Stable	Typical	Atypical	non-Anginal		
JACC 2006	Very low	Low	Intermediate	High	
AJM 1997		Low	Intermediate	High	
Unstable AHA Likeli		Low	Intermediate	High	
AHA Risk		Low	Intermediate	High	
TIMI					

GRACE	Total Risk score		Mortality Risk	
PURSUIT	Mortality only score		30-day	
	Mortality or infarction		30-day	

Tatum	Very Low	Low	Intermediate	High	Very high

Table A. Pretest Probability of CAD by Age, Sex, and Symptoms

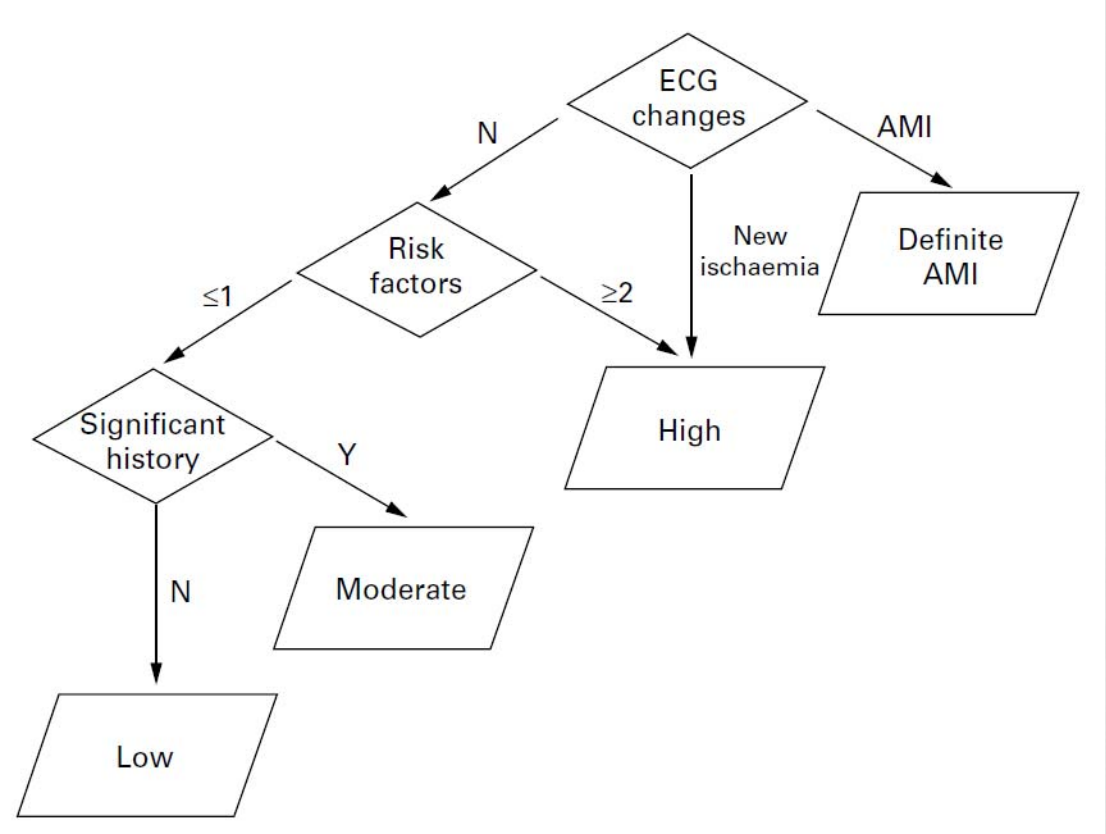
Age	Sex	Typical/Definite Angina Pectoris	Atypical/Probable Angina Pectoris	Nonanginal Chest Pain	Asymptomatic
<39	Men	Intermediate	Intermediate	Low	Very low
	Women	Intermediate	Very low	Very low	Very low
40–49	Men	High	Intermediate	Intermediate	Low
	Women	Intermediate	Low	Very low	Very low
50–59	Men	High	Intermediate	Intermediate	Low
	Women	Intermediate	Intermediate	Low	Very low
>60	Men	High	Intermediate	Intermediate	Low
	Women	High	Intermediate	Intermediate	Low

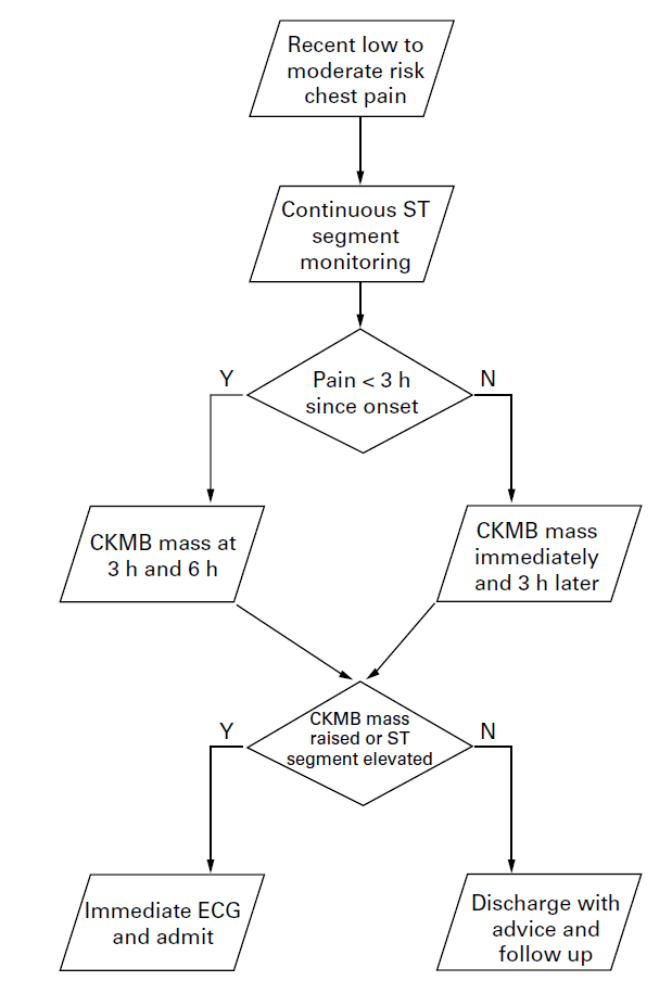
TABLE 45–2 Likelihood that Signs and Symptoms Represent an Acute Coronary Syndrome

Feature	High Likelihood (any of the following)	Intermediate Likelihood (absence of high-likelihood features and presence of any of the following)	Low Likelihood (absence of high- or intermediate-likelihood features but may have any of the following)
History	• Chest or left arm pain or discomfort as chief symptom reproducing prior documented angina • Known history of coronary artery disease, including myocardial infarction	• Chest or left arm pain or discomfort as chief symptom • Age >70 years • Male sex • Diabetes mellitus	• Probable ischemic symptoms in absence of any of the intermediate likelihood characteristics • Recent cocaine use
Examination	• Transient mitral regurgitation, hypotension, diaphoresis, pulmonary edema, or rales	• Extracardiac vascular disease	• Chest discomfort reproduced by palpation
Electrocardiogram	• New, or presumably new, transient ST-segment deviation (≥0.05 mV) or T-wave inversion (≥0.2 mV) with symptoms	• Fixed Q waves • Abnormal ST segments or T waves not documented to be new	• T-wave flattening or inversion in leads with dominant R waves • Normal ECG
Cardiac markers	Elevated cardiac TnI, TnT, or CK-MB	Normal	Normal

From Fleet RP, Dupuis G, Marchand A, et al: ACC/AHA 2002 guideline update for the management of patients with unstable angina and non–ST-segment elevation myocardial infarction: Summary article. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on the Management of Patients With Unstable Angina). Circulation 106:1893, 2002.

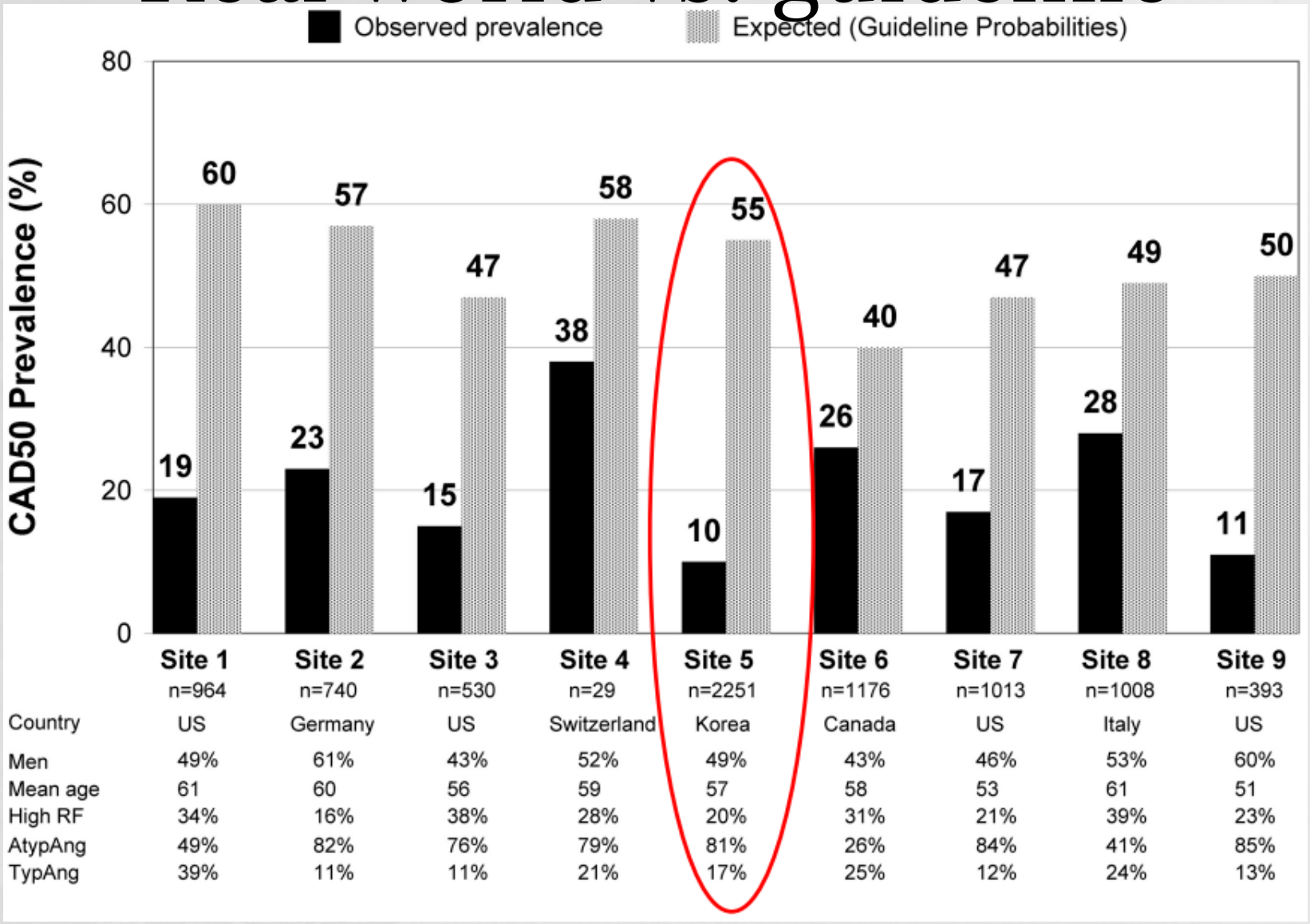
Recommended triage flow using clinical parameters





Emerg Med J 2001;18;6-10

Real world vs. guideline



Circulation. 2011;124:2423-2432.

Limitations of clinical triage

- Missed diagnoses and inappropriate discharge still ranged up to 8%.
- Time-consuming and expensive.

Circ J 2011;75:246-252

CT in acute chest pain

- CTA can rapidly and definitely exclude CAD as the cause of acute chest pain.
- Immediate CTA reduces length of stay and cost of care without increasing risk.

JACC 2007:49:863-871

- MDCT as a first diagnostic approach to acute chest pain:

  - can reduce the unnecessary admission

  - possibly reduces the length of hospital stay in patients with clinically low and intermediate risk of CAD.

Am Heart J 2008;156:375-83

Correlation with clinical triage

(N=73)

RISK STRATIFICATION	CLASSIFICATION	CT FINDINGS : Significant lesion			
		유		무	
AHA LIKE	HIGH	7	26.9%	19	73.1%
	INTEMEDIATE	8	17.8%	37	82.2%
	LOW	0	0.0%	2	100.0%
AHA RISK	0	0	0.0%	2	100.0%
	HIGH	8	27.6%	21	72.4%
	INTEMEDIATE	5	15.6%	27	84.4%
	LOW	2	20.0%	8	80.0%
TATUM	HIGH	1	100.0%	0	0.0%
	INTERMEDIATE	7	25.9%	20	74.1%
	LOW	6	14.3%	36	85.7%
	VERY LOW	1	33.3%	2	66.7%
TIMI	4	0	0.0%	1	100.0%
	3	4	66.7%	2	33.3%
	2	4	28.6%	10	71.4%
	1	6	19.4%	25	80.6%
	0	1	4.8%	20	95.2%
GRACE	1%	11	19.0%	47	81.0%
	10%	0	0.0%	1	100.0%
	5%	15	20.8%	57	79.2%
PURSUIT MORTALITY	5%	0	0.0%	1	100.0%
	3%	4	28.6%	10	71.4%
PURSUIT HARD CHD MORTALITY	25%	0	0.0%	1	100.0%
	20%	1	100.0%	0	0.0%
	17%	0	0.0%	2	100.0%
	13%	1	25.0%	3	75.0%
	10%	1	33.3%	2	66.7%
	9%	5	22.7%	17	77.3%
	8%	1	8.3%	11	91.7%
	6%	6	35.3%	11	64.7%
	5%	0	0.0%	11	100.0%

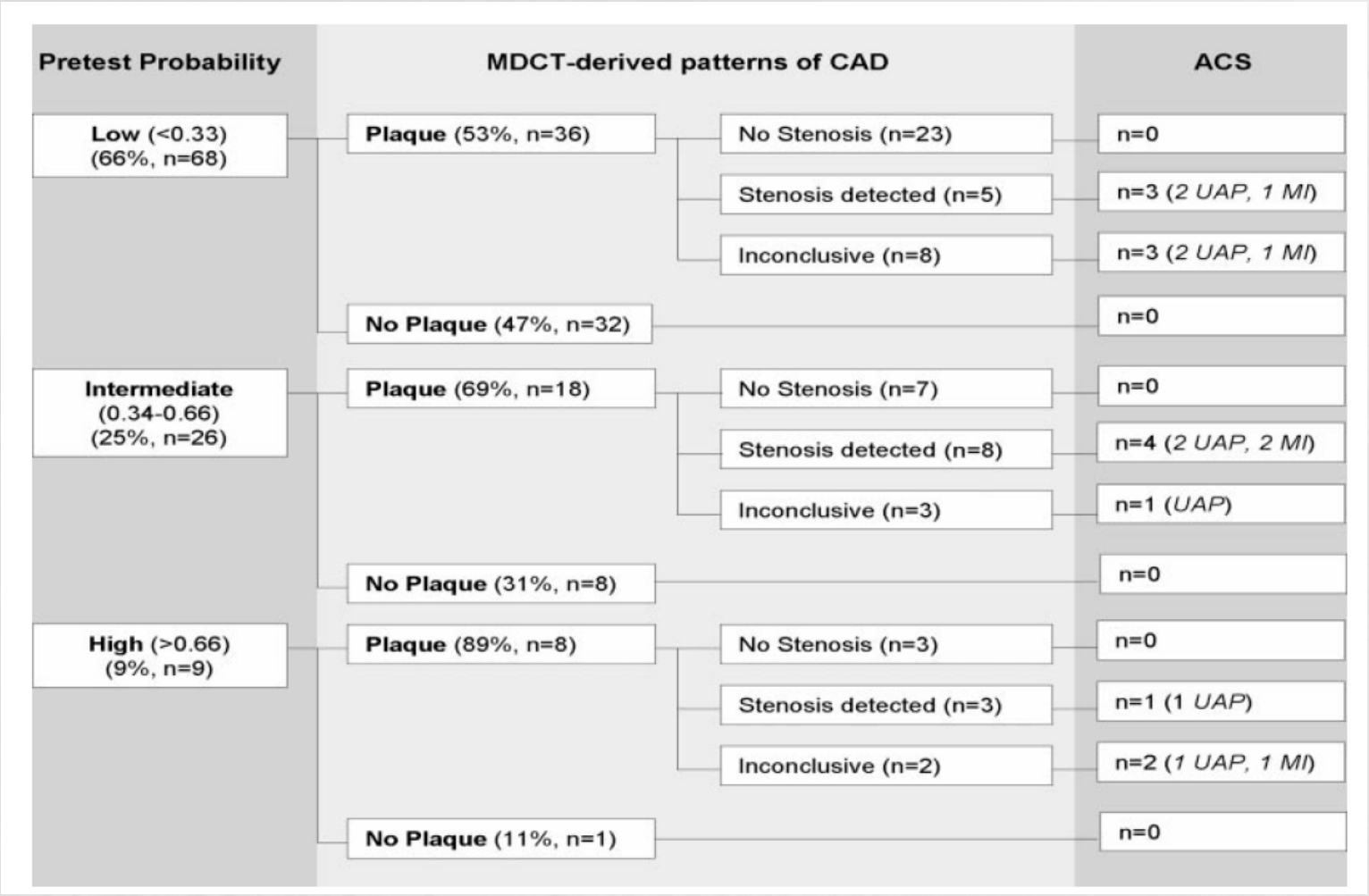
AMC data (Unpublished)

Accuracy of CT as a diagnostic triage tool with chest pain to ER

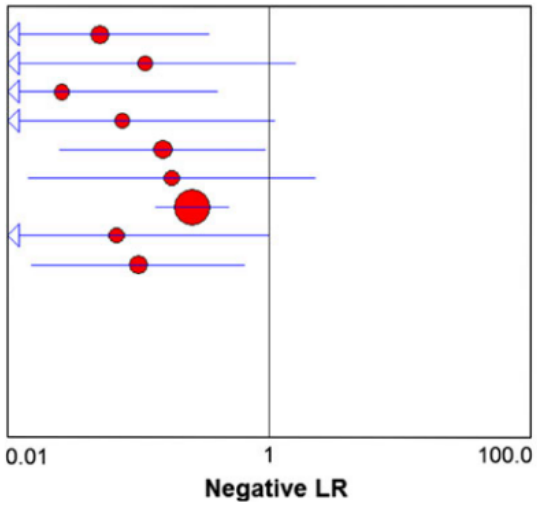
Table 4. Test performance characteristics of CTA in the included studies

Year	Authors	N	CTA sensitivity	CTA specificity	CTA positive predictive value	CTA negative predictive value
2005	Sato et al[24]	31	21/22 (96%)	8/9 (89%)	21/22 (96%)	8/9 (89%)
2006	Hoffmann et al[29]	40	5/5 (100%)	26/35 (74%)	5/14 (36%)	26/26 (100%)
2007	Rubinshtein et al[9]	58	20/20 (100%)	35/38 (92%)	20/23 (87%)	35/35 (100%)
2007	Goldstein et al[22]	99	8/8 (100%)	67/91 (74%)	8/32 (25%)	67/67 (100%)
2007	Gallagher et al[25]	85	6/7 (86%)	72/78 (92%)	6/12 (50%)	72/73 (99%)
2007	Hollander et al[23]	54	2/2 (100%)	48/52 (92%)	2/6 (33%)	48/48 (100%)
2009	Hoffmann et al[27]	368	24/31 (77%)	293/337 (87%)	24/68 (35%)	293/300 (98%)
2009	Hollander et al[30]	562	7/7 (100%)	508/555 (91%)	7/54 (13%)	508/508 (100%)
2009	Ueno et al[26]	36	11/12 (92%)	20/24 (83%)	11/15 (73%)	20/21 (95%)
			95% (95% CI 88-100)	**87% (95% CI 83-92)**		

J Nucl Cardiol 2012 Feb 10. [Epub ahead of print]



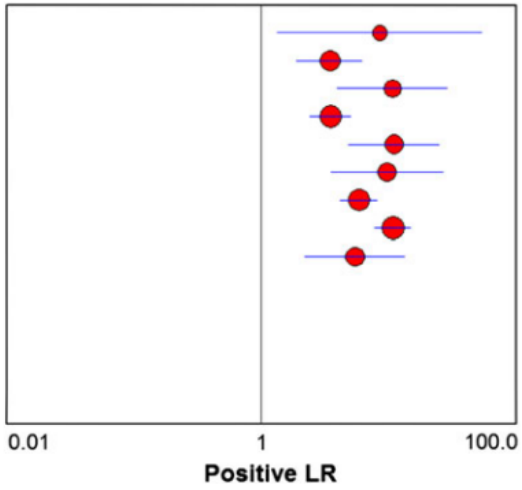
Conclusions—Noninvasive assessment of coronary artery disease by MDCT has good performance characteristics for ruling out ACS in subjects presenting with possible myocardial ischemia to the emergency department and may be useful for improving early triage. (***Circulation*. 2006;114:2251-2260.**)



	Negative LR (95% CI
Sato. Y	0.05 (0.01 - 0.35)
Hoffmann. U	0.11 (0.01 - 1.62)
Rubinshtein. R	0.03 (0.00 - 0.41)
Goldstein. JA	0.08 (0.01 - 1.12)
Gallagher. MJ	0.15 (0.03 - 0.95)
Hollander. JE	0.18 (0.01 - 2.29)
Hoffmann. U	0.26 (0.14 - 0.50)
Hollander. JE	0.07 (0.00 - 1.00)
Uneno. K	0.10 (0.02 - 0.66)

Negative likelihood ratio 0.06 (95% CI 0-0.14)

Figure 4. Forest plot of negative likelihood ratios. The summary estimate for the negative likelihood ratio was derived from the bivariate estimates of sensitivity and specificity.



	Positive LR (95% CI)
Sato. Y	8.59 (1.35 - 54.64)
Hoffmann. U	3.47 (1.91 - 6.31)
Rubinshtein. R	10.88 (3.99 - 29.62)
Goldstein. JA	3.55 (2.44 - 5.16)
Gallagher. MJ	11.14 (4.88 - 25.45)
Hollander. JE	9.81 (3.54 - 27.18)
Hoffmann. U	5.93 (4.24 - 8.29)
Hollander. JE	10.97 (7.92 - 15.20)
Uneno. K	5.50 (2.21 - 13.67)

Positive likelihood ratio 7.4 (95% CI 4.8-10)

Figure 5. Forest plot of positive likelihood ratios. The summary estimate for the positive likelihood ratio was derived from the bivariate estimates of sensitivity and specificity.

J Nucl Cardiol 2012 Feb 10. [Epub ahead of print]

Cost-effectiveness of CT

CT-STAT trial: 699 pts with low-risk acute chest pain randomized to coronary CTA or nuclear stress imaging as initial screen.

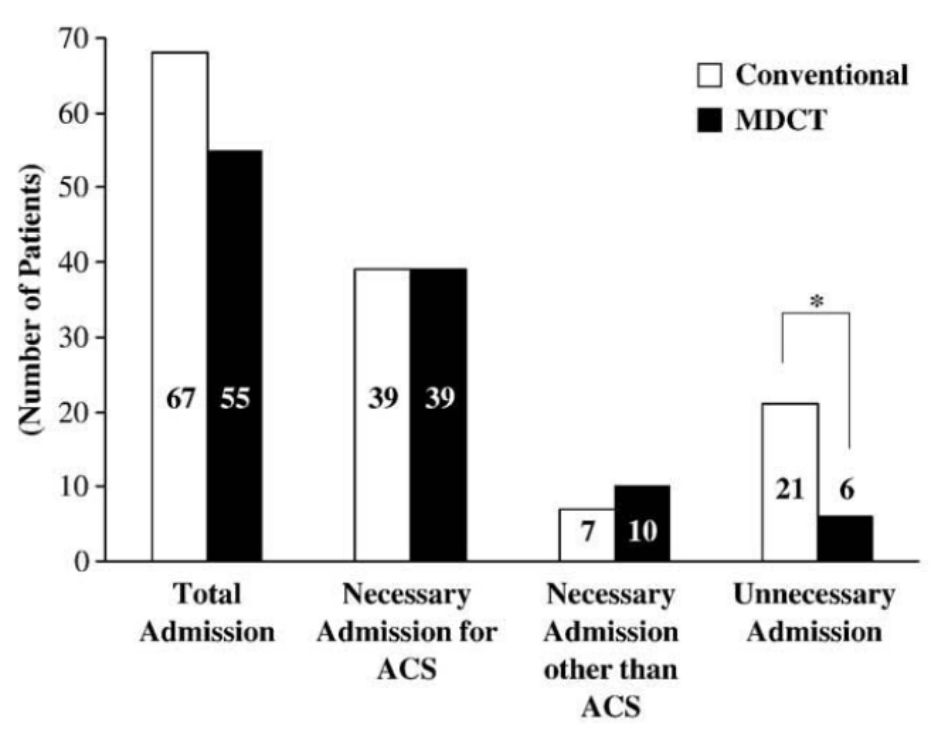
6-Month Follow-up	CTA (n = 361)	Stress Imaging (n = 338)	*P* Value
Time to Diagnosis, hrs	2.9	6.2	< 0.0001
Emergency Dept Costs	$2,137	$3,458	< 0.0001
MACE	0.8%	0.4%	0.29

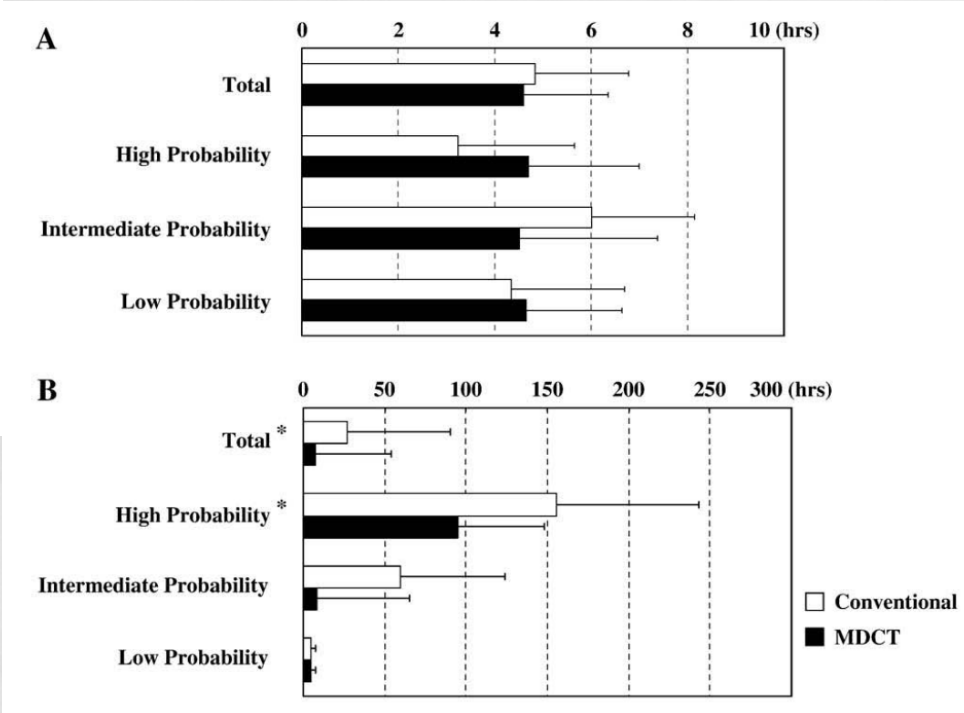
CTA also resulted in similar negative prediction values for significant CAD, referrals for invasive angiography, and subsequent revascularizations.

Conclusion: Using coronary CTA as a screening tool for low-risk pts with chest pain in the ED achieves lower costs and quicker diagnoses without sacrificing safety or accuracy.

J Am Coll Cardiol 2011;58:1414–22

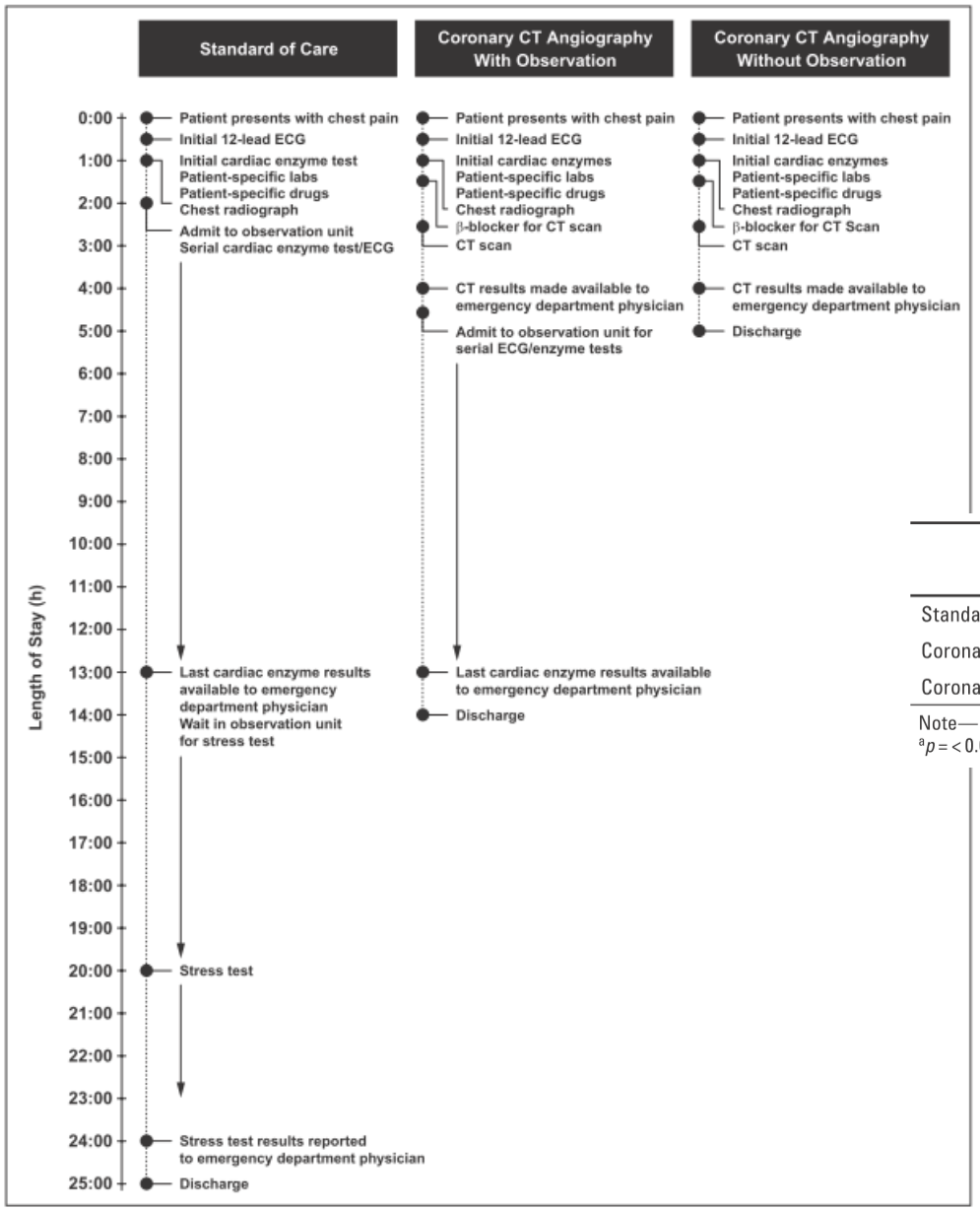
- 266 patients in ED





Significant decrease in unnecessary admission, total adm. hours

Am Heart J 2008;156:375-83



Analysis of Workups	Emergency Department	
	Length of Stay (h)	Charges (U.S. $)
Standard of care	25.4 ± 6.3	7,597 ± 2,216
Coronary CTA with observation	14.3 ± 5.0[a]	6,153 ± 1,196[a]
Coronary CTA without observation	5.0[a]	4,251 ± 420[a]

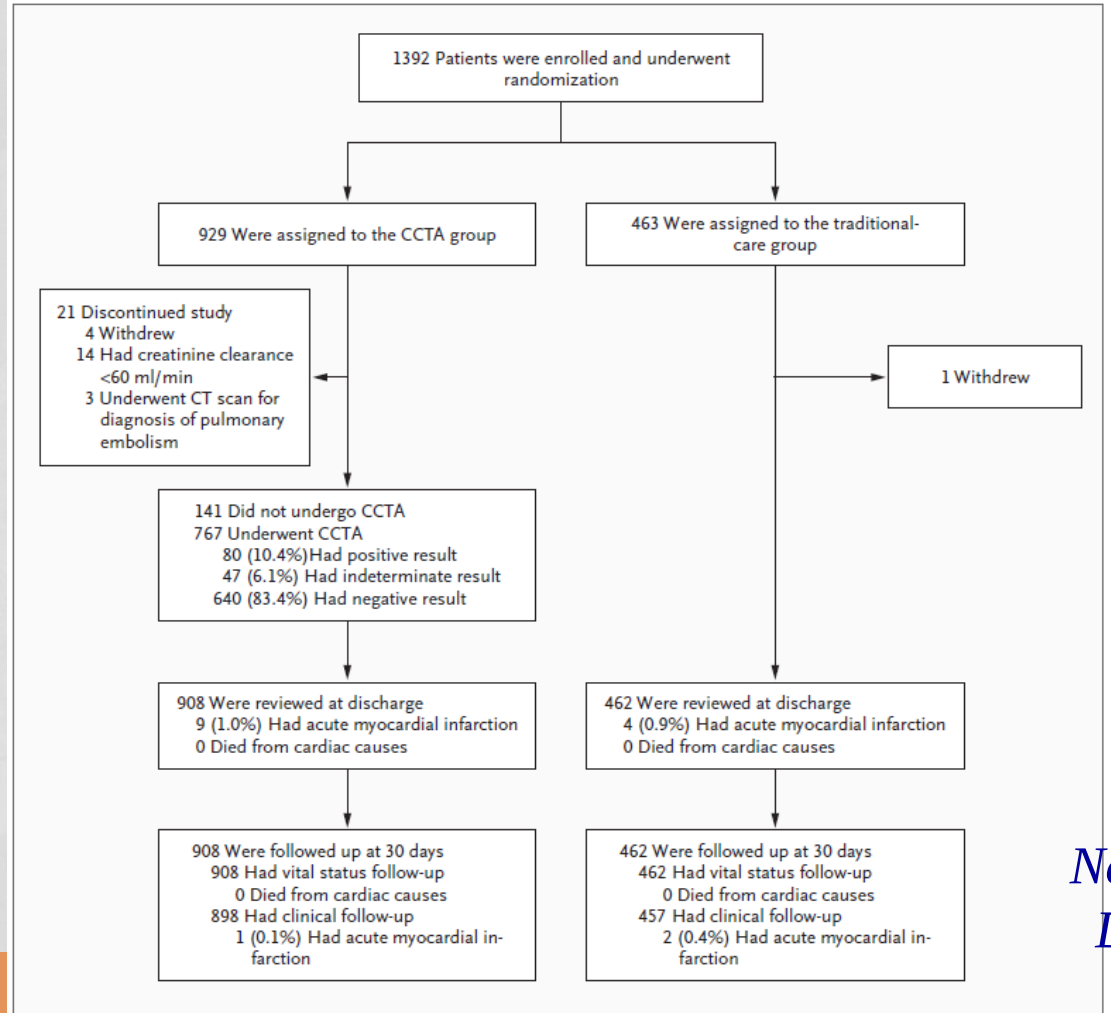
Note—Data are mean ± SD.
[a] $p = < 0.001$ when compared to standard of care.

Significant decrease in Stay and Charges in acute CP with low-risk patients

AJR 2009;193:150-154

ORIGINAL ARTICLE

CT Angiography for Safe Discharge of Patients with Possible Acute Coronary Syndromes



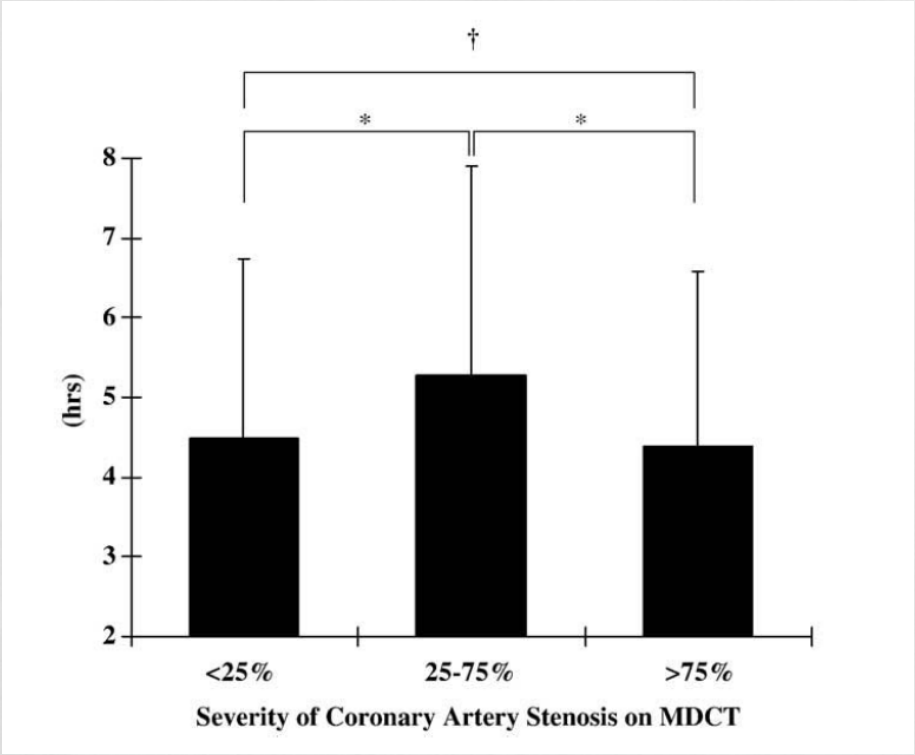
New Engl J Med 2012 March 26, DOI 10.1056/NEJMoa1201163

- CCTA group
  - Higher rate of discharge from the emergency department (49.6% vs. 22.7%; difference, 26.8 percent-age points; 95% CI, 21.4 to 32.2)
  - Shorter length of stay (median, 18.0 hours vs. 24.8 hours; P<0.001)
  - Higher rate of detection of coronary disease (9.0% vs. 3.5%; difference, 5.6 percentage points; 95% CI, 0 to 11.2).
- CCTA-based strategy for low-to-intermediate-risk
  - Safe, expedited discharge from the emergency department of many patients who would otherwise be admitted.

New Engl J Med 2012 March 26, DOI 10.1056/NEJMoa1201163

However…

- Limitation in intermediate stenosis on CT
  - Longer stay in ER compared with others



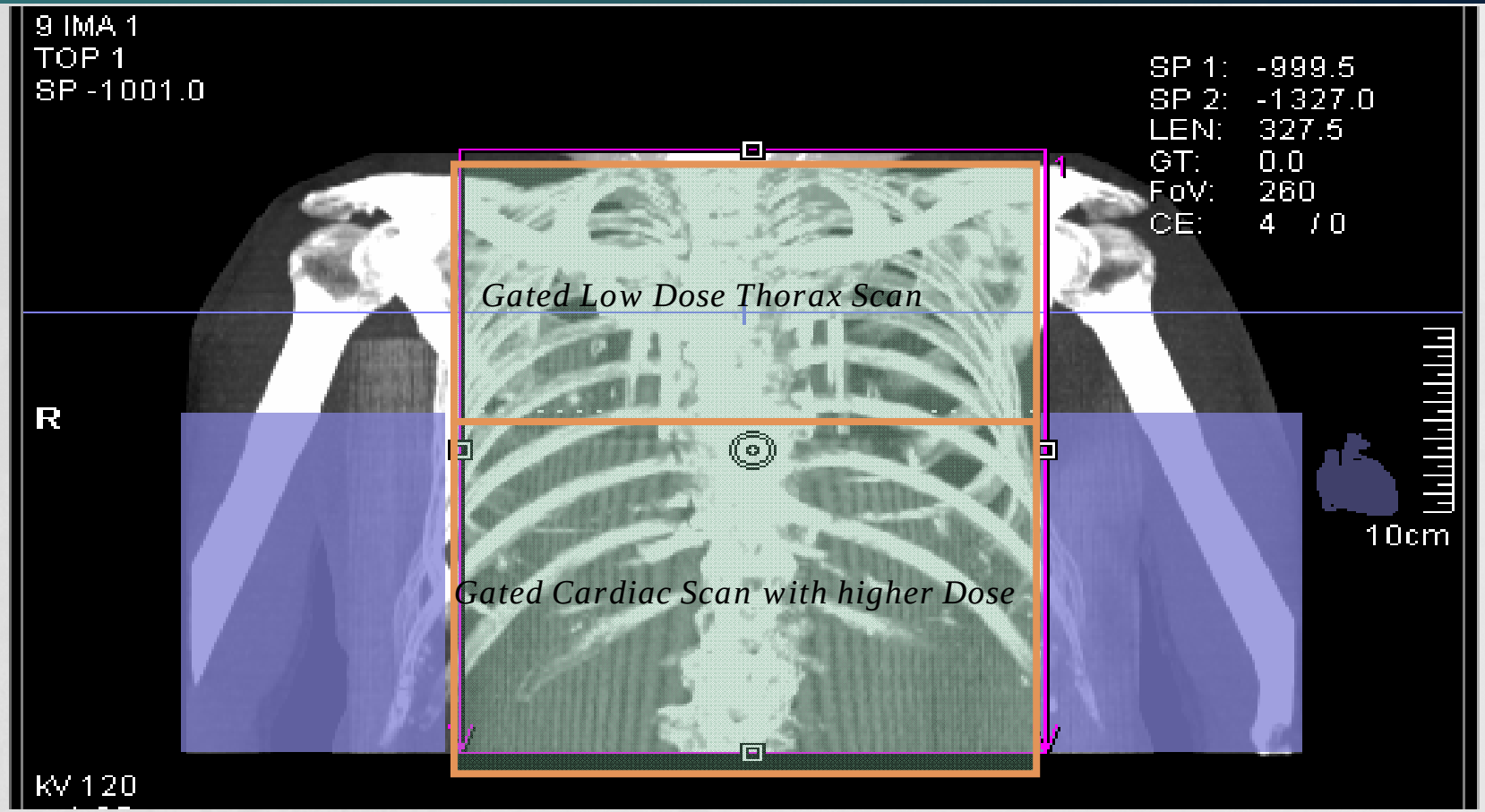
Am Heart J 2008;156:375-83

Limitations

- Availability of 64-slice CT
  - On-site device
  - Not already in use
- Availability of personnel
  - To modify heart rate
  - To supervision contrast administration
  - For interpretation
- Inability to receive β-blocker
  - Bronchoconstrictive lung disease (asthma, chronic obstructive pulmonary disease)
  - Allergy
  - Heart block
- Arrhythmia
  - Atrial fibrillation
  - Frequent supraventricular or ventricular ectopy
- Contrast related
  - Allergy
  - Uncontrolled hyperthyroidism
  - Receiving metformin
  - Renal insufficiency/failure
- Financial
  - Capital purchase
  - Ongoing staff requirements for 24/7/365 utilization
- Nondiagnostic examinations
  - Calcification
  - Stents
  - Bypass grafts
- Ionizing radiation

Circ Cardiovasc Imaging 2009;2;264-275

DSCT for "Triple Rule Out"



MDCT: Shows coronary, pulmonary arteries and aorta in one scan (10-15sec scan with one breath hold)

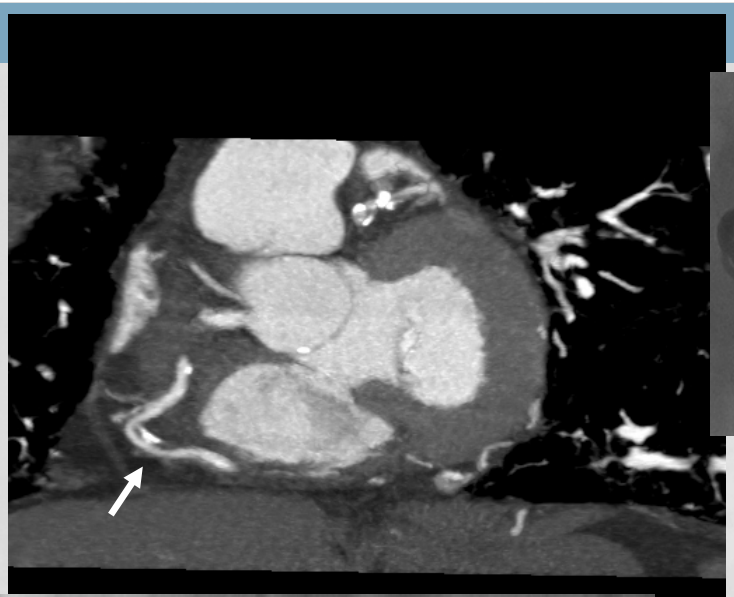
Coronary CT angiography in emergency department patients with acute chest pain: triple rule-out protocol versus dedicated coronary CT angiography

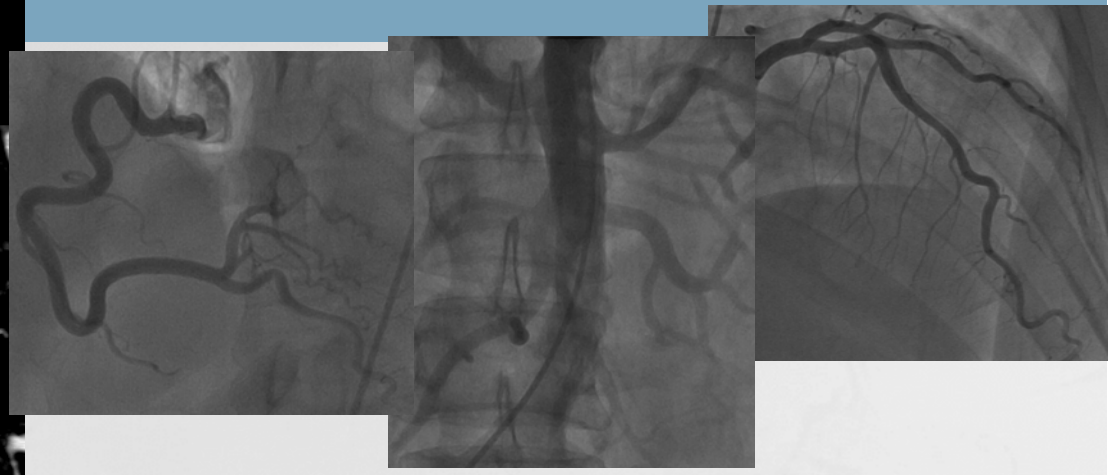
Table 1 Comparison of sample ED chest pain 64-Slice MDCT Protocols

Protocol	Dedicated CT angiography	Triple rule-out
Field of view	220	400
Thickness (mm)	0.625–0.9	0.625–0.9
Increment (mm)	Half of slice thickness	Half of slice thickness
Direction	Cephalad-caudal	Caudal-cephalad
Time (s)	9–10	15
Z axis coverage	Aortic root-cardiac base	Aortic arch-adrenal gland

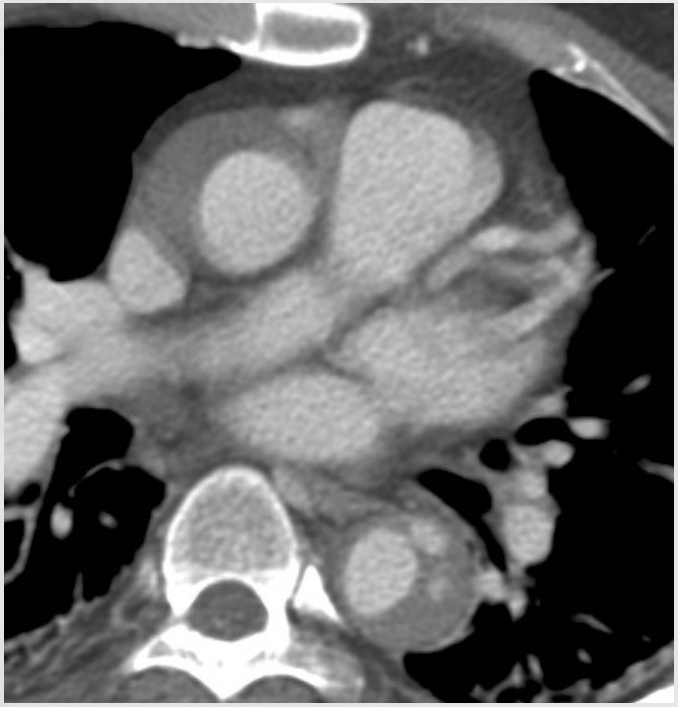
Conclusion

Coronary CT angiography is useful to evaluate ED patients with atypical chest pain who are at low to intermediate risk. With 64-slice MDCT technology, major life-threatening thoracic diseases (i.e., ACS, PE, and AAS) can be diagnosed using the "triple rule-out" protocol within a single breathhold. However, the increased radiation dose resulting from the extended volume coverage should be fully considered prior to performing this protocol. Therefore, in ED patients who have a low clinical suspicion of PE and AAS, especially younger patients, dedicated coronary CT angiography accompanied by methods to reduce radiation dose is recommended.



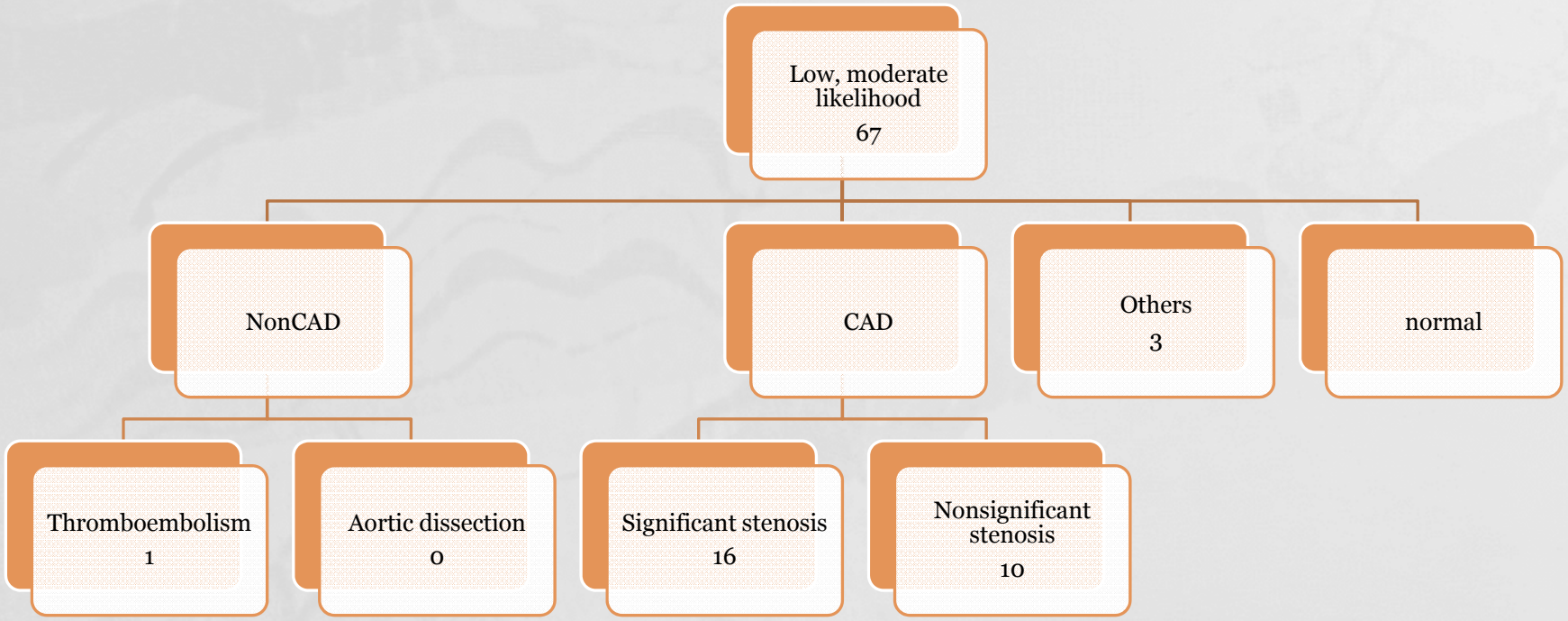


Significant stenosis at m-dRCA



Intramural hematoma and no CAD nor dissection

Acute chest pain with non-coronary origin



AMC data (Unpublished).

	Prevalence in the Cohort (n = 395) in %	Fraction of New Findings n (%)
Pulmonary Incidental Finding		
Noncalcified pulmonary nodule	94 (23.8%)	86/94 (91.5%)
Calcified pulmonary nodule	16 (4.1%)	14/16 (87.5%)
Pulmonary infiltrate	7 (1.8%)	3/7 (42.9%)
Emphysema	7 (1.8%)	4/7 (57.1%)
Atelectasis	5 (1.3%)	2/5 (40.0%)
Pleural effusion	3 (0.8%)	0/3 (0.0%)
Enlarged hilar or mediastinal lymph node	9 (2.3%)	5/9 (55.6%)
Pneumothorax	1 (0.3%)	1/1 (100.0%)
Abdominal Incidental Finding		
Liver cyst	26 (6.6%)	24/26 (92.3%)
Contrast-enhancing liver lesion	9 (2.3%)	8/9 (88.9%)
Fatty liver	1 (0.3%)	1/1 (100.0%)
Hiatus hernia	14 (3.5%)	12/14 (85.7%)
Contrast-enhancing splenic lesion	1 (0.3%)	1/1 (100.0%)
Gallstones	1 (0.3%)	1/1 (100.0%)
Aortic Incidental Finding		
Aneurysm	3 (0.8%)	3/3 (100.0%)
Dissection	1 (0.3%)	0/1 (0.0%)
Penetrating aortic ulcer	1 (0.3%)	0/1 (0.0%)
Cardiac incidental finding		
Sinus of Valsalva aneurysm	1 (0.3%)	1/1 (100.0%)
Pericardial effusion	1 (0.3%)	1/1 (100.0%)
Other Incidental Finding		
Hemangioma of the spinal column	1 (0.3%)	1/1 (100.0%)
Thyroid mass	1 (0.3%)	1/1 (100.0%)
Chest wall mass	1 (0.3%)	1/1 (100.0%)
Hemangioma	1 (0.3%)	1/1 (100.0%)
Overall	215	171/215 (79.5%)

Am J Med 2009;122:543-549

Radiation dose

- Chest radiograph: 0.03-0.05 mSv
- Coronary Calcium Score Scan
  Male: 1.5-5.2 mSv
  Female: 1.8-6.2 mSv
- Coronary CT angiography (4-slice MDCT)
  Male: 6.7-10.9 mSv
  Female: 8.1-13.0 mSv
- Invasive Coronary angiography
  Male: 2.1 mSv
  Female: 2.5 mSv
- Radiation worker dose limits: 20 mSv/year
- Natural background: 2.5-3.0 mSv/year

- *64-slice MDCT coronary angiography : 15.4 mSv*
- *MIBI scan 11 mSv, Thallium scan 29 mSv*

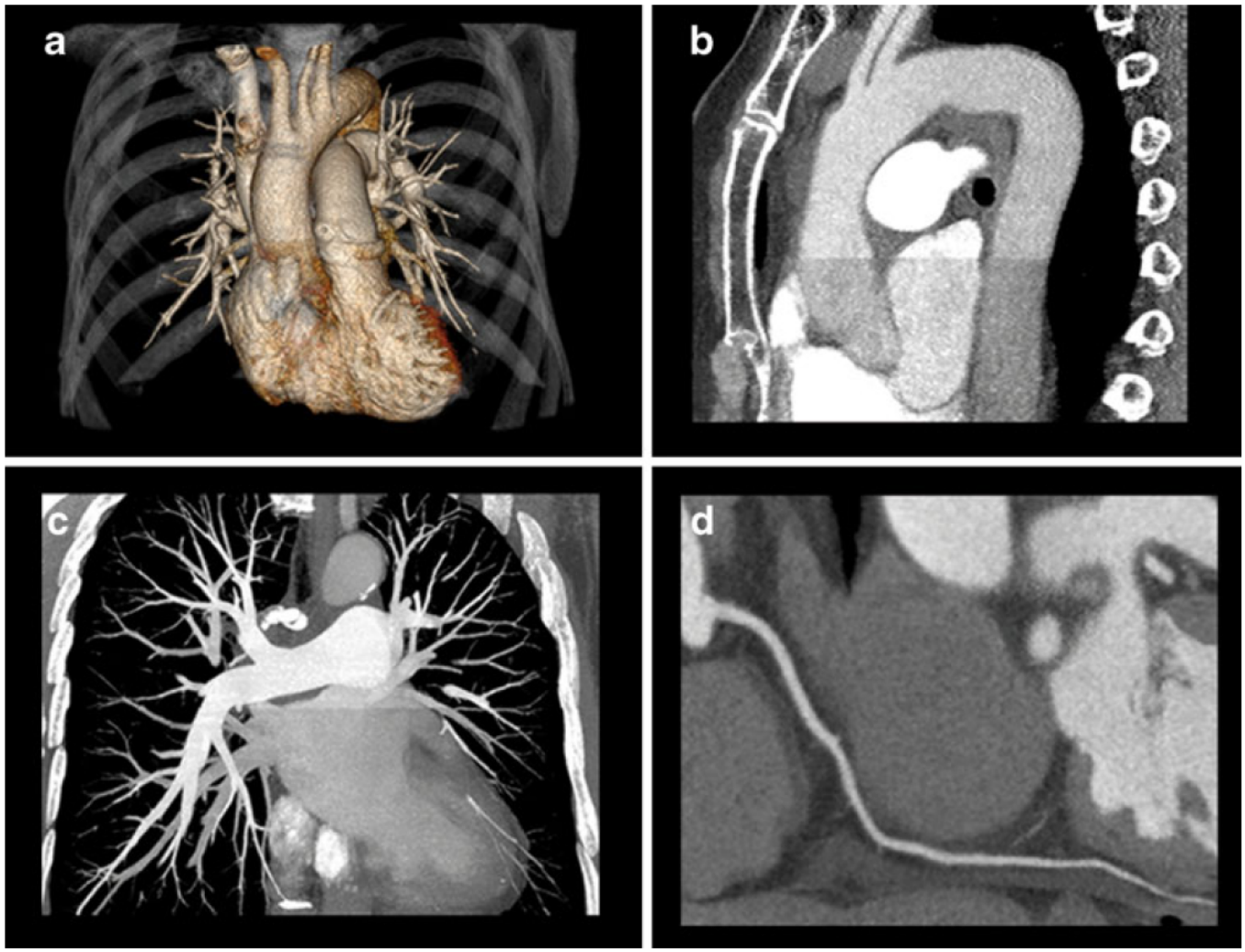
Radiology 2003;226:145-52

Radiation dose reduction

- ECG-pulsing (retrospective) or prospective gating
- Lowering tube voltage

→ **AMC coronary CT angiography : 4.7 ± 1.6 mSv**

- Wide detector or fast table speed CT
  - <1.0 mSv possible
  - Scan time less than 1 sec possible

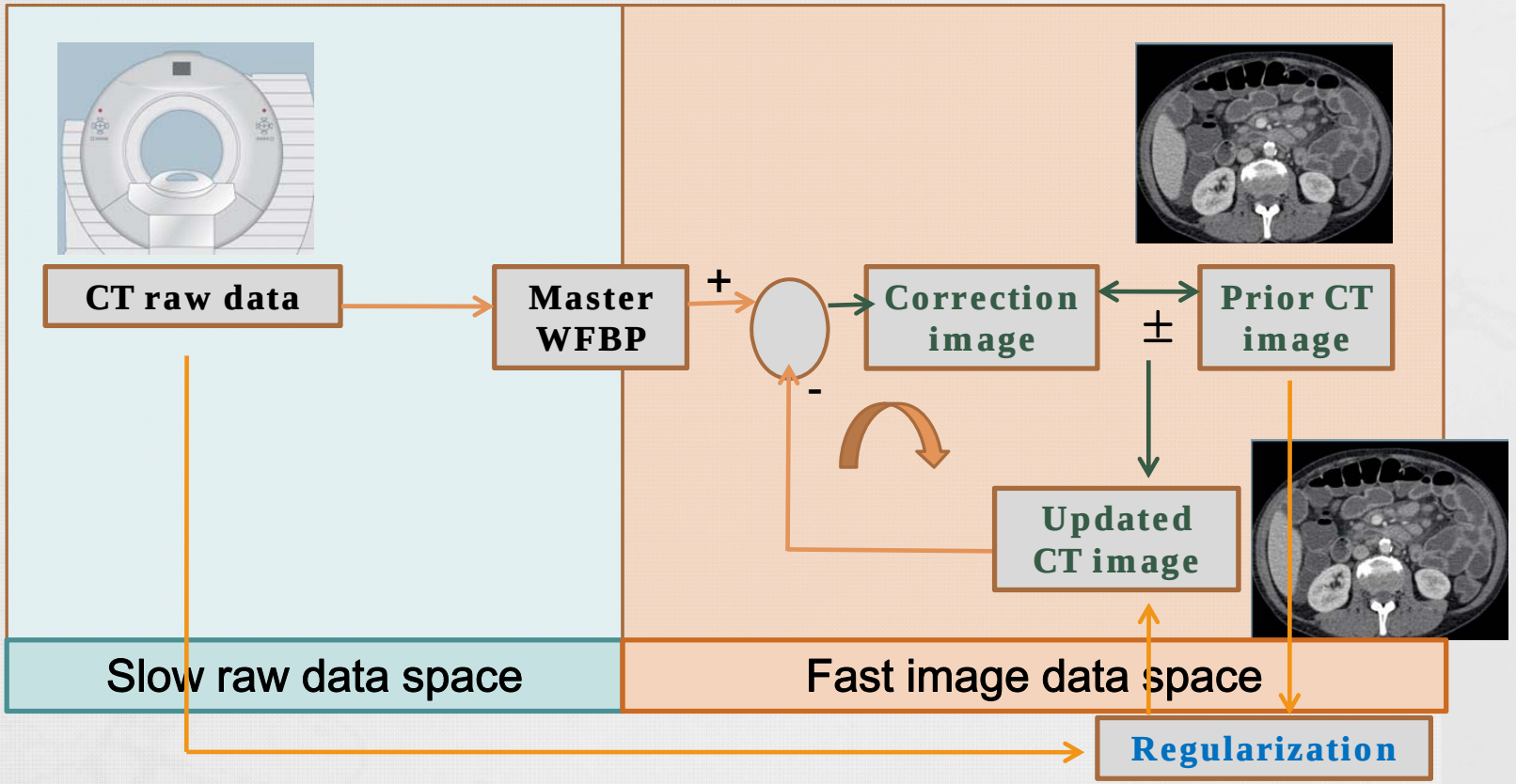


320 detector CT

- 2-slap
- 2.0 – 3.3 mSv
- Diagnostic quality in 96%

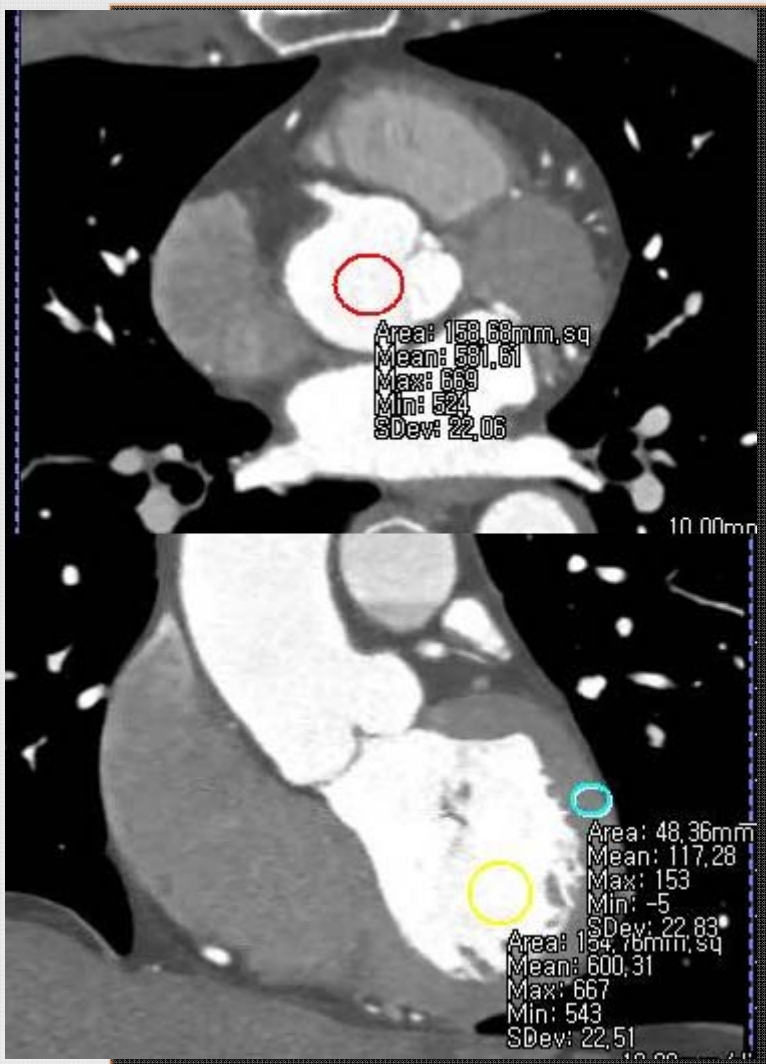
Eur Radiol 2011;21:1416–1423

Iterative reconstruction in image space (IRIS)



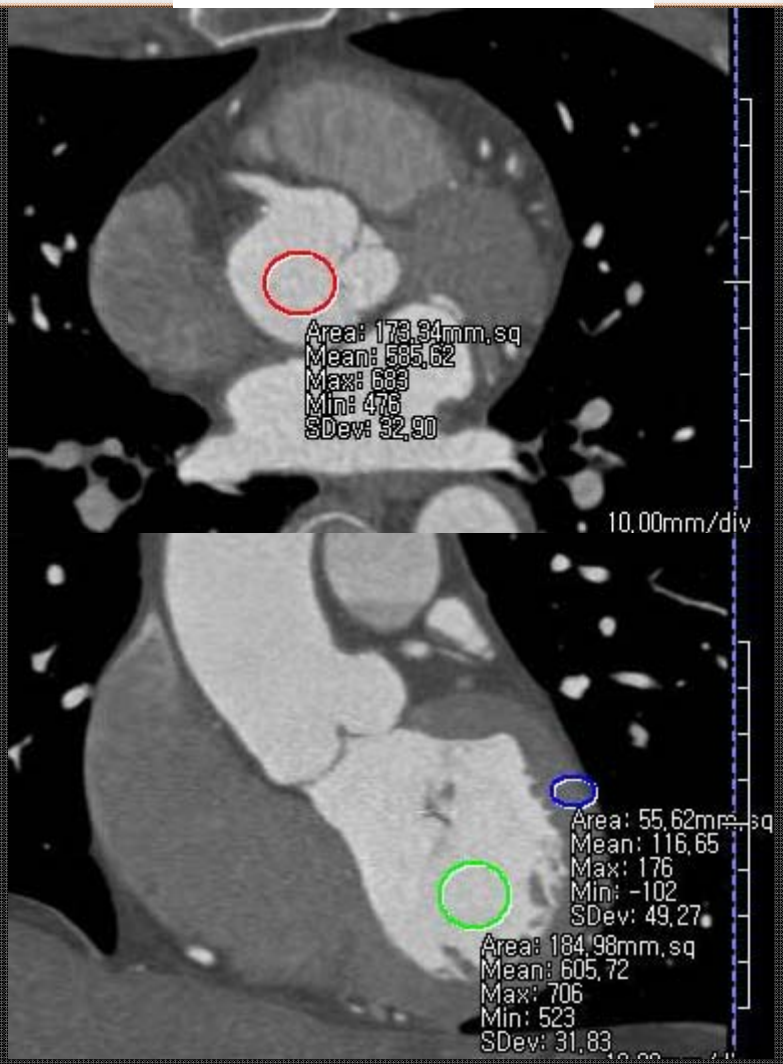
- Reduced image noise without loss of detail resolution
- Reduced radiation exposure

IRIS reconstruction



SNR: 26.36, Noise: 22.83, CNR: 21.16

FBP reconstruction

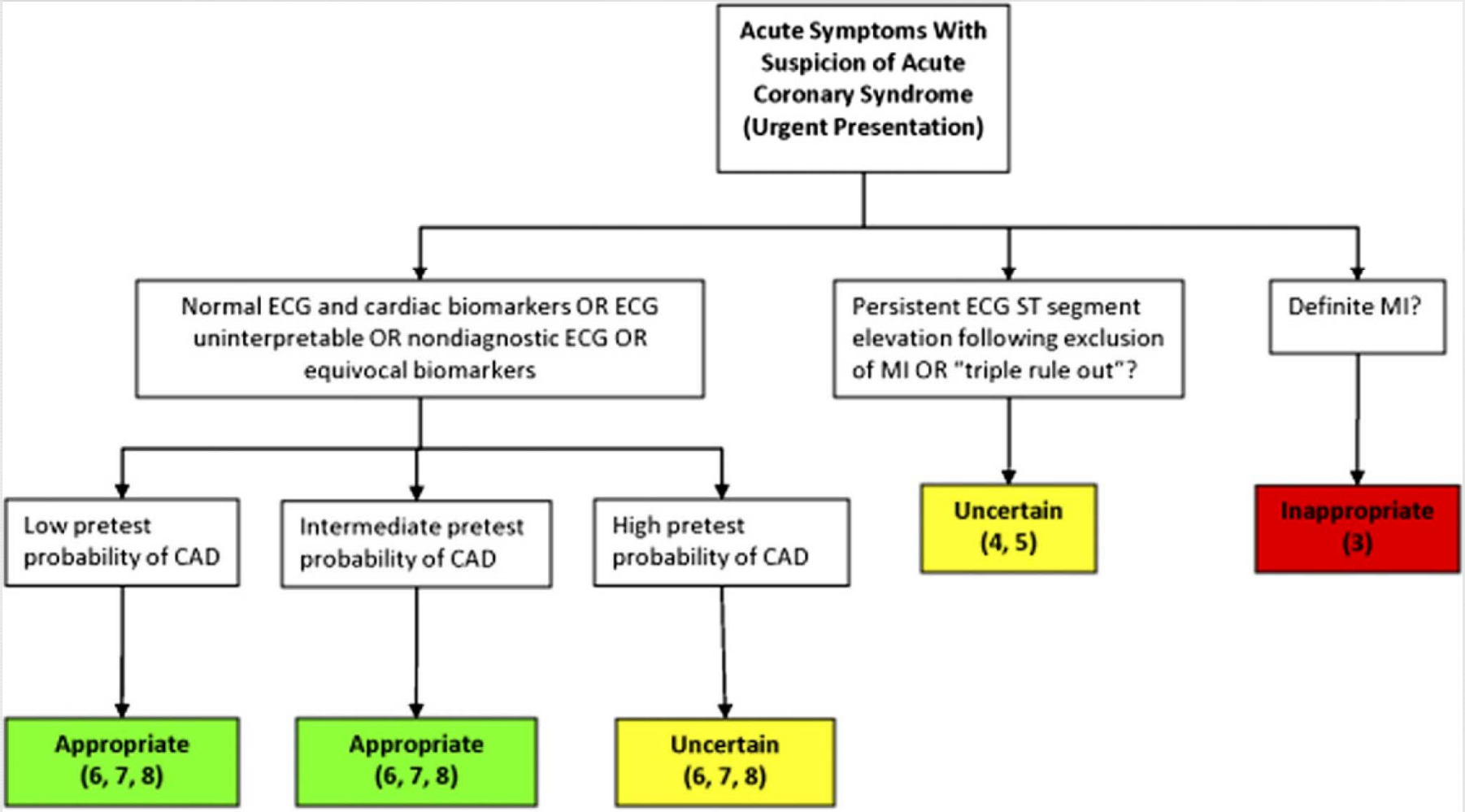


SNR: 17.8, Noise: 49.27, CNR: 9.92

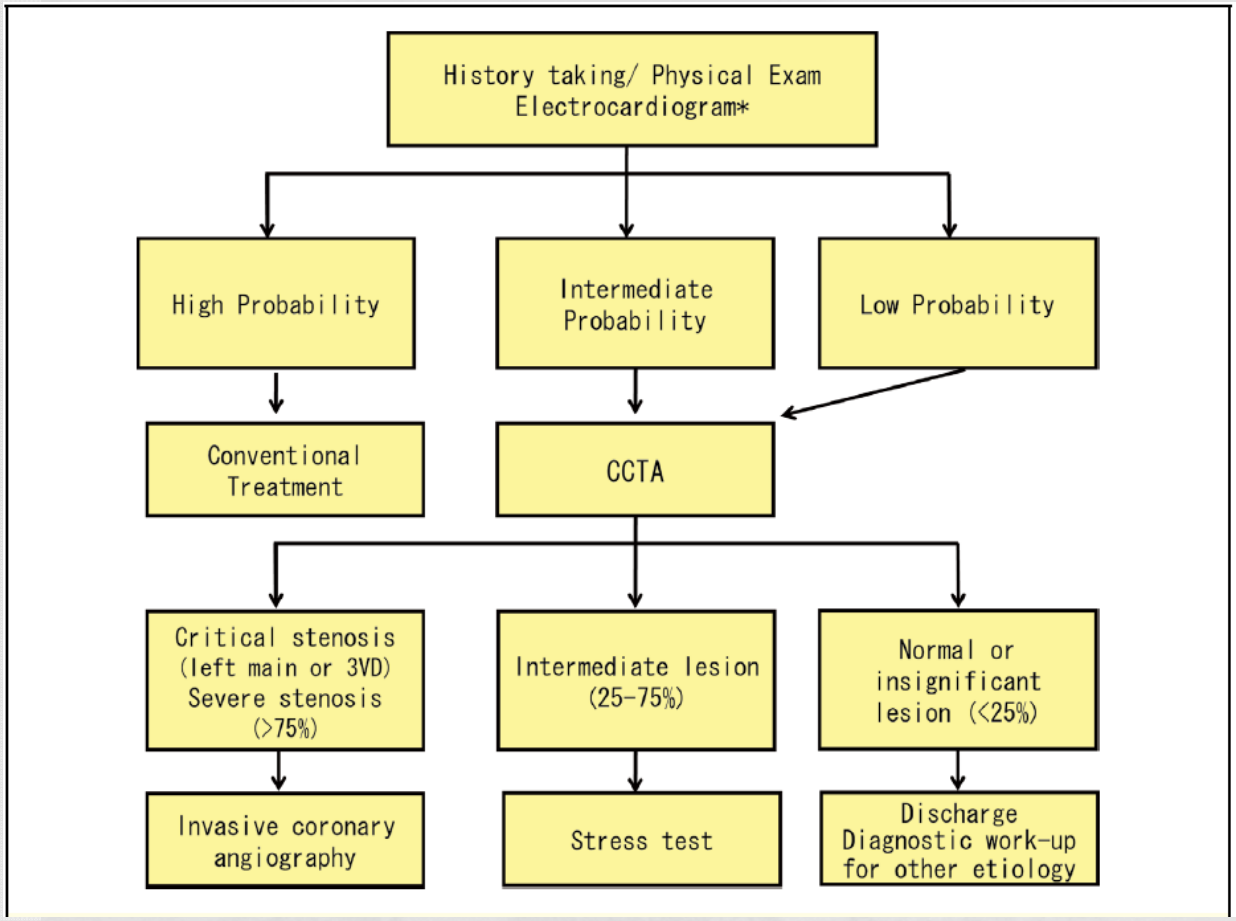
ACCF/SCCT/ACR/AHA/ASE/ASNC/NASCI/SCAI/SCMR 2010 Appropriate Use Criteria for Cardiac Computed Tomography

A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the Society of Cardiovascular Computed Tomography, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the American Society of Nuclear Cardiology, the North American Society for Cardiovascular Imaging, the Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance

Detection of CAD in Symptomatic Patients Without Known Heart Disease Symptomatic Acute Presentation Using CT



Triage guidelines



- Very high:

Typical chest pain with ECG changes consistent with AMI

- High:

Typical chest pain with ECG change of ST depression or T-wave inversion or with known CAD

- Intermediate:

Typical chest pain without diagnostic ECG changes and no known CAD

- Low:

Short duration of typical symptoms or prolonged atypical symptoms in patients without history of CAD and no diagnostic ECG changes

- Very low:

Atypical chest pain with an identifiable non-cardiac origin.

*Excluded very high or very low pretest probability of ACS

Circ J 2011;75:246-252

Conclusions

- **Acute chest pain of uncertain cause**

  ⇒ **prefer cardiac CT**

  (D/Dx pulmonary embolism, aortic dissection, and ACS ["triple rule out"])

- Typical angina & male ≥40 / female ≥60 ⇒ prefer CAG

- **Cardaic CT** was felt to be **appropriate** primarily for situations involving a **low or intermediate pretest probability** of obstructive CAD