NON-INVASIVE TESTING FOR CORONARY ARTERY DISEASE

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OBJECTIVES

Review current clinically relevant non-invasive testing modalities for detecting CAD

Coronary calcium scoring

Exercise stress testing

Stress echo

Stress nuclear

Coronary CT angiography

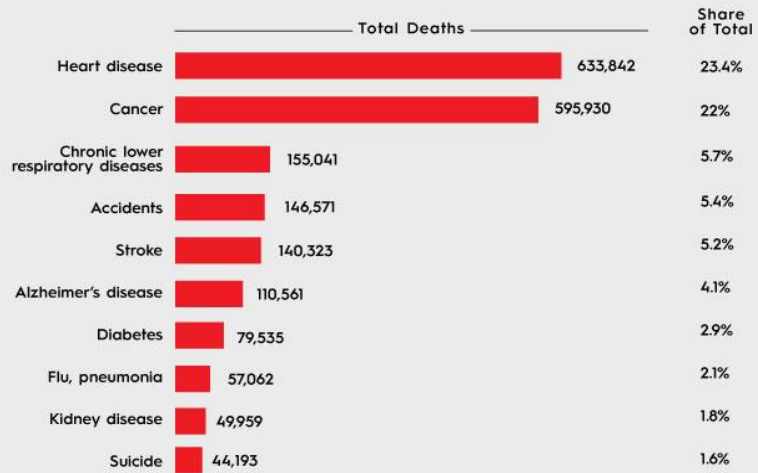Strengths, weaknesses, limitations, clinical quirks of each

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Leading Causes of Death
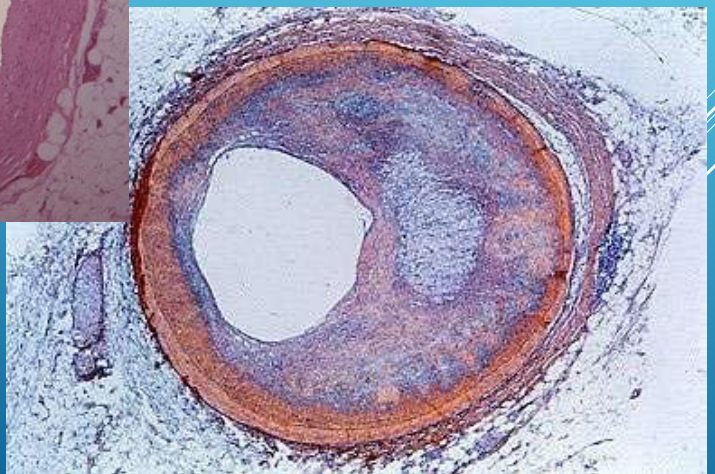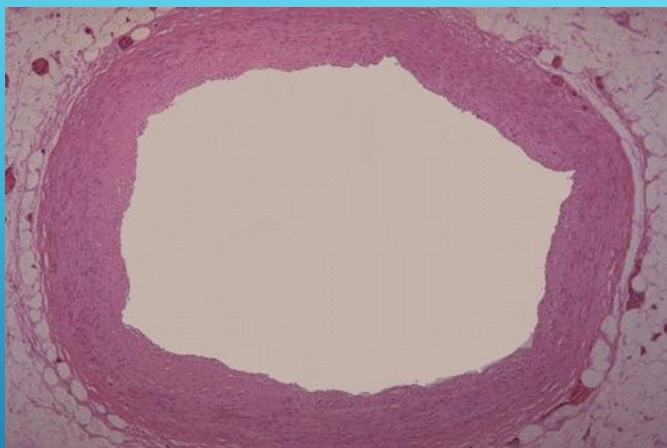By AMERICAN HEART ASSOCIATION NEWS

Heart disease continues to kill more Americans than any other cause, followed by stroke at No. 5, according to 2015 federal data.

	Total Deaths	Share of Total
Heart disease	633,842	23.4%
Cancer	595,930	22%
Chronic lower respiratory diseases	155,041	5.7%
Accidents	146,571	5.4%
Stroke	140,323	5.2%
Alzheimer's disease	110,561	4.1%
Diabetes	79,535	2.9%
Flu, pneumonia	57,062	2.1%
Kidney disease	49,959	1.8%
Suicide	44,193	1.6%

Source: Centers for Disease Control and Prevention

Published Dec. 8, 2016

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Britannica.com

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Atherosclerotic Plaque Development

Stary Classification of Atherosclerotic Plaques

I   II   III   IV   V$_{a,b,c}$ VI$_{a,b,c}$

Normal Early Lipid rich Internal rupture Calcified shell Calcified plaque Vulnerable Rupture Thrombus Myocardial infarction Obstructive

Fatty streaks White blood cells Calcium
Red blood cells
Lipid rich plaque Scar
White blood cells Platelets and fibrin

Inflammation and calcification

Scar development with calcification

This process in many stages of development can be seen in multiple places in the coronary system and is consistent with the known diffuse nature of CAD

heartsofjersey.org

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ACCF/AHA/ASE/ASNC/HFSA/HRS/SCAI/SCCT/SCMR/ STS 2013 Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease
A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons
Michael J. Wolk, Steven R. Bailey, John U. Doherty, Pamela S. Douglas, Robert C. Hendel, Christopher M. Kramer, James K. Min, Manesh R. Patel, Lisa Rosenbaum, Leslee J. Shaw, Raymond F. Stainback and Joseph M. Allen

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WHICH TEST FOR WHICH PERSON?

Pretest Probability

　History and Physical Exam!!!

Baseline EKG

Baseline medications

Ability to walk

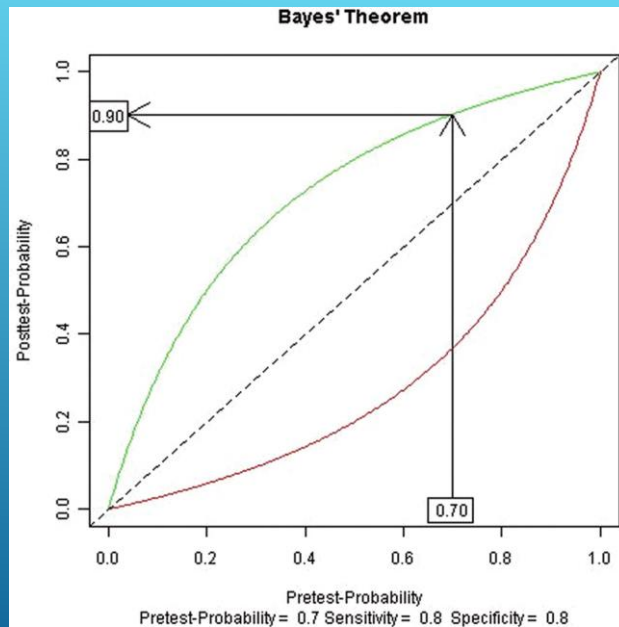History of prior non-invasive testing

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Pre Test Probability of Coronary Disease by Symptoms, Gender and Age

Age	Gender	Typical/Definite Angina Pectoris	Atypical/Probable Angina Pectoris	Non-Anginal Chest Pain	Asymptomatic
30-39	Males	Intermediate	Intermediate	low (<10%)	Very low (<5%)
30-39	Females	Intermediate	Very Low (<5%)	Very low	Very low
40-49	Males	High (>90%)	Intermediate	Intermediate	low
40-49	Females	Intermediate	Low	Very low	Very low
50-59	Males	High (>90%)	Intermediate	Intermediate	Low
50-59	Females	Intermediate	Intermediate	Low	Very low
60-69	Males	High	Intermediate	Intermediate	Low
60-69	Females	High	Intermediate	Intermediate	Low
High = >90%		Intermediate = 10-90% Very Low = <5%		Low = <10%	

image.slidesharecnd.com

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Bayes' Theorem

Pretest-Probability = 0.7 Sensitivity = 0.8 Specificity = 0.8

ebm.bmj.com

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NONINVASIVE TESTING FOR CAD

Asymptomatic Patients

Coronary Calcium Scoring

Symptomatic Patients

Exercise Stress Testing

Stress Echo

Stress Nuclear Perfusion Imaging

Coronary CT Angiography

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CORONARY CALCIUM SCORING

Risk stratification tool in asymptomatic patients with intermediate risk by traditional risk factor evaluation

Low cost

Low radiation

Can be diagnostic for CAD in a previously undiagnosed and asymptomatic patient

Can change goals for risk factor modification if abnormal

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prweb.com

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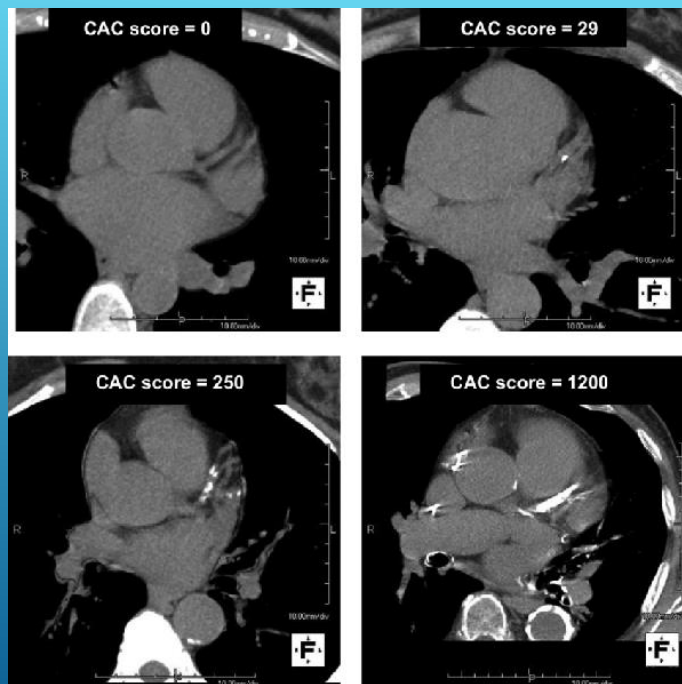
clevelandclinic.org

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dicardiology.com

	LAD	LCX	RCA	Total Coronaries	Aorta
Score	1760.15	3534.09	1800.28	7094.52	570.88
#ROI's	32	48	23	103	17
AreaSq (sq.mm.)	666.52	1344.85	680.92	2692.29	225.25

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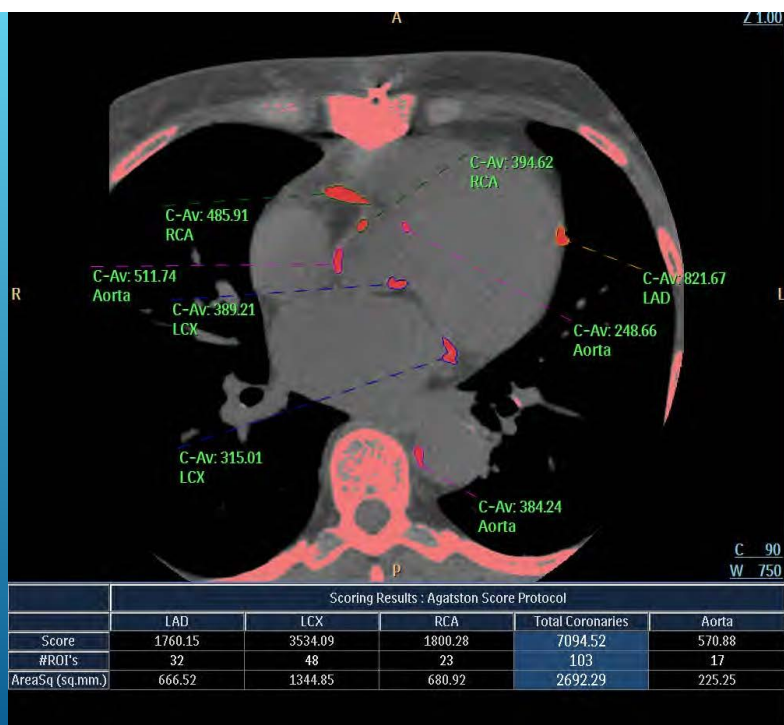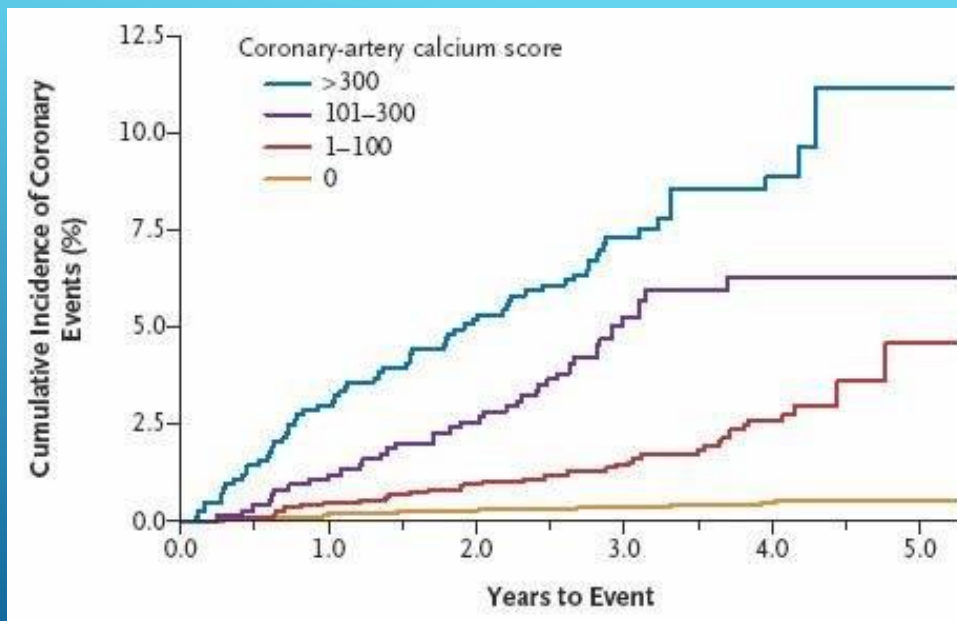
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CORONARY CALCIUM SCORING

Does not tell you anything about degree of active ischemia or degree of stenosis, only presence/absence of underlying CAD and the volume of plaque

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SYMPTOMATIC PATIENTS OR ASYMPTOMATIC PATIENTS WITH HIGH RISK CLINICAL FINDINGS

Non-invasive
 Functional
 Anatomic
Invasive

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FUNCTIONAL TESTING FOR CAD

Stress testing
 Stress EKG
 Stress echo
 Stress SPECT/PET
 Stress MRI

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CONTRAINDICATIONS TO STRESS TESTING

Acute MI within 2 days
Pharmacologic Nuclear stress
Unstable angina
Uncontrolled arrhythmia
VT, Atrial fibrillation, etc
Severe symptomatic aortic stenosis
Decompensated CHF
Active Endocarditis/Myocarditis/Pericarditis
Acute aortic dissection
Acute PE
Acute noncardiac conditions that are not stable

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Sensitivity and Specificity of Non-invasive Tests for the Diagnosis of CAD*

Diagnostic Test	Sensitivity % (range)	Specificity % (range)	# Studies	# Patients
TMT	68	77	132	24,027
Planar MPI	79 (70-94)	73 (43-97)	6	510
SPECT	88 (73-98)	77 (53-96)	8	628
Stress echo	76 (40-100)	88 (80-95)	10	1174

* NEJM Vol. 344, No. 24 June 14, 2004

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Treadmill Stress Test

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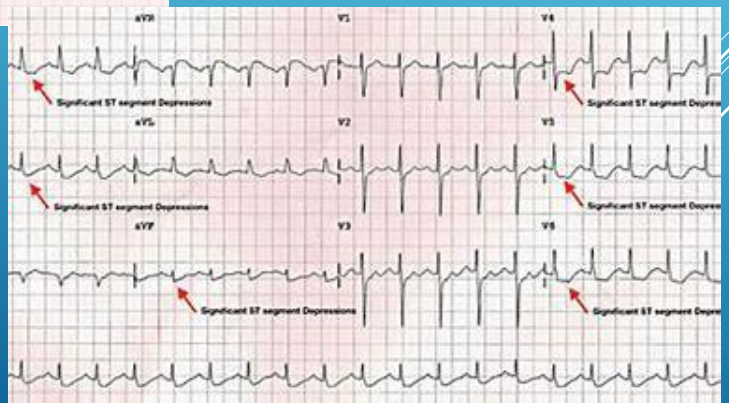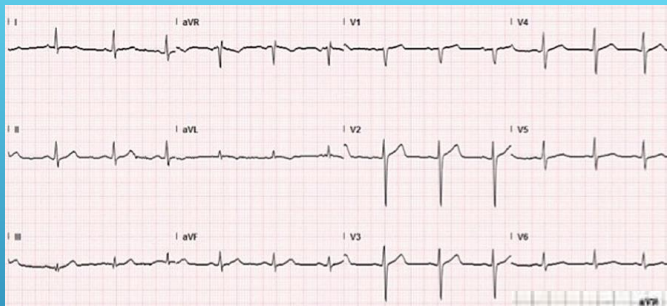
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Determining Duke Treadmill Score (DTS)

$$DTS = \text{Exercise time}^* - (5 \times \text{ST deviation}^\dagger) - (4 \times \text{exercise angina}^{\dagger\dagger})$$

* Exercise time in minutes

$\dagger$ ST deviation in millimeters

$\dagger\dagger$ Exercise angina: 0 = None

1 = Non limiting

2 = Exercise limiting

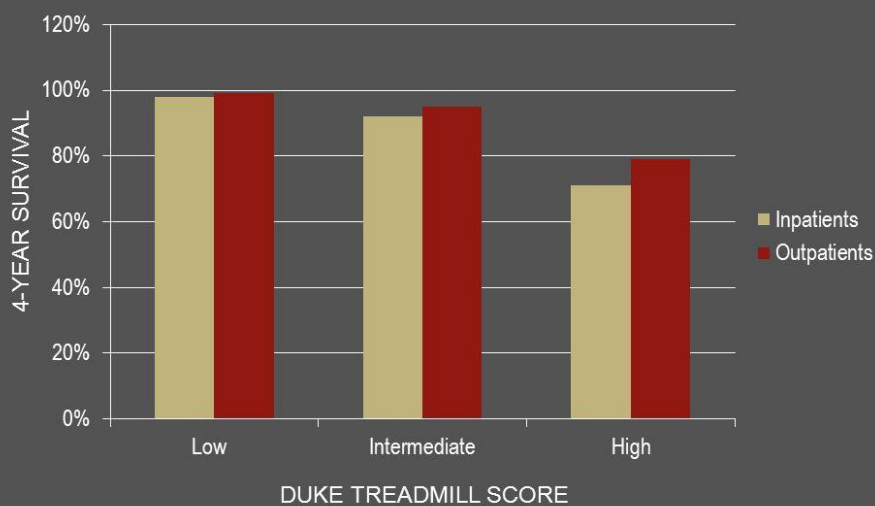Source: Cardiosource © 2008 by the American College of Cardiology Found...

- **Low Risk   >5**

- **Moderate Risk**
       -10 to +4

- **High Risk   < -10**

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DTS AND SURVIVAL

Adapted from: Mark DB, et al. N Engl J Med. 1991;325(12):849-53.

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STRESS ECHO

Exercise

Pharmacologic Stress

Dobutamine

No radiation

Lower cost

Quick and easy with right equipment and personnel

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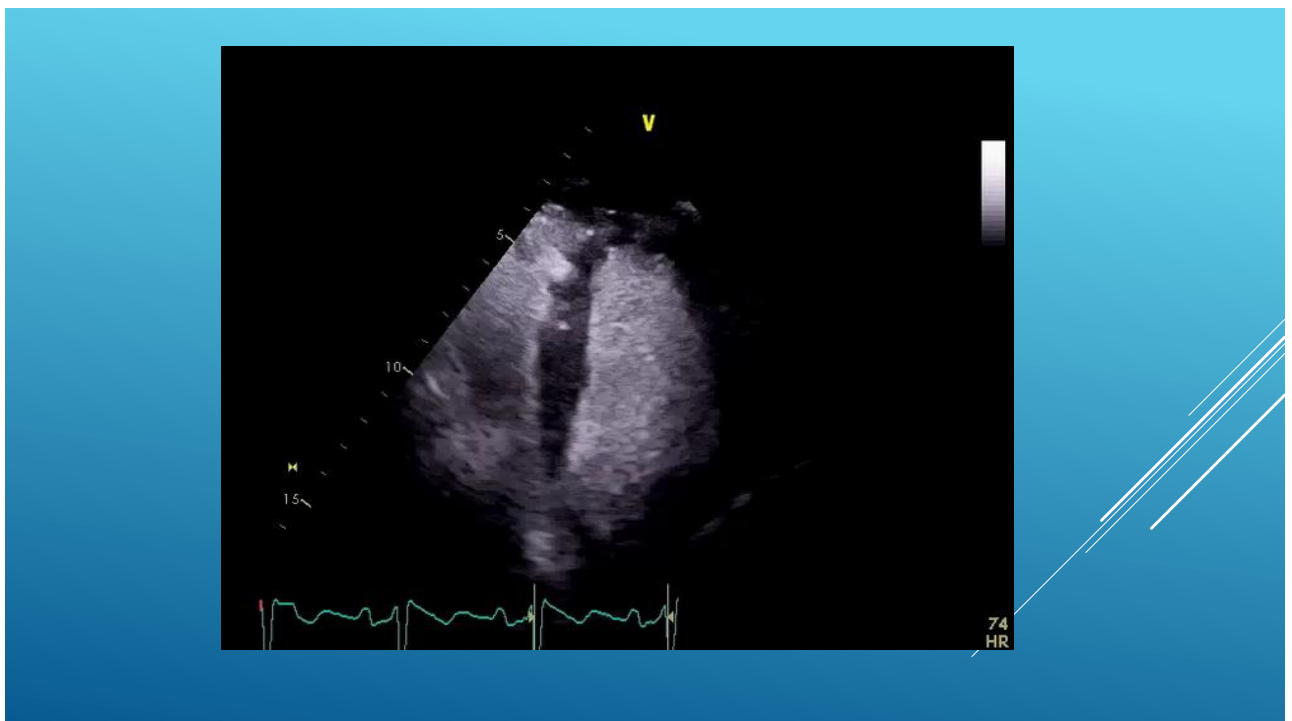
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STRESS NUCLEAR

SPECT and PET tracers

Exercise

Pharmacologic stress

Dobutamine

Vasodilator (Regadenoson, Adenosine, Persantine)

Higher cost

More time consuming

More costly

Radiation

Useful in patients who cannot walk, cannot be titrated off rate lowering meds, or have baseline indecipherable EKGs (LBBB, LVH, WPW, marked baseline STT changes)

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STRESS NUCLEAR

Best studied stress imaging modality

Certainly the most quantitative

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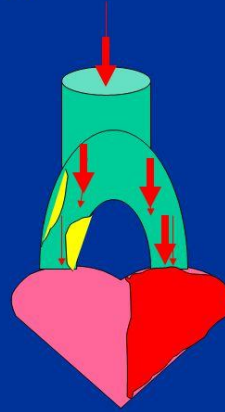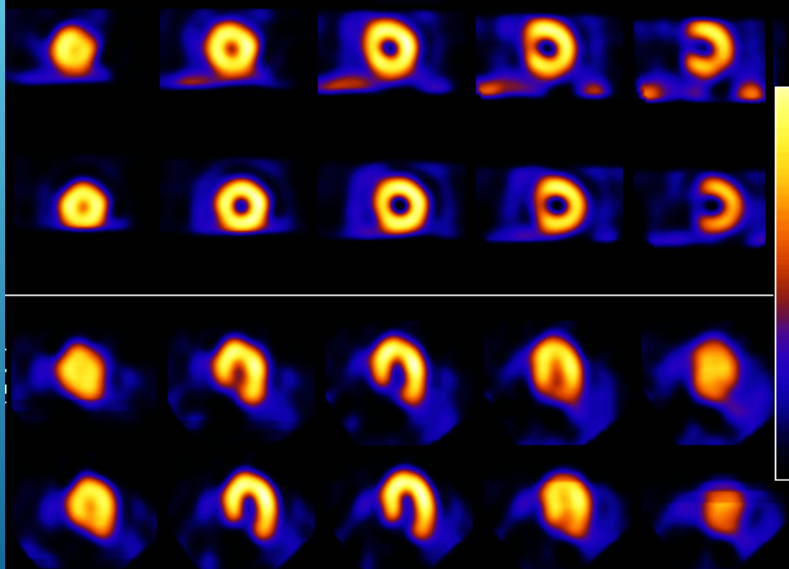
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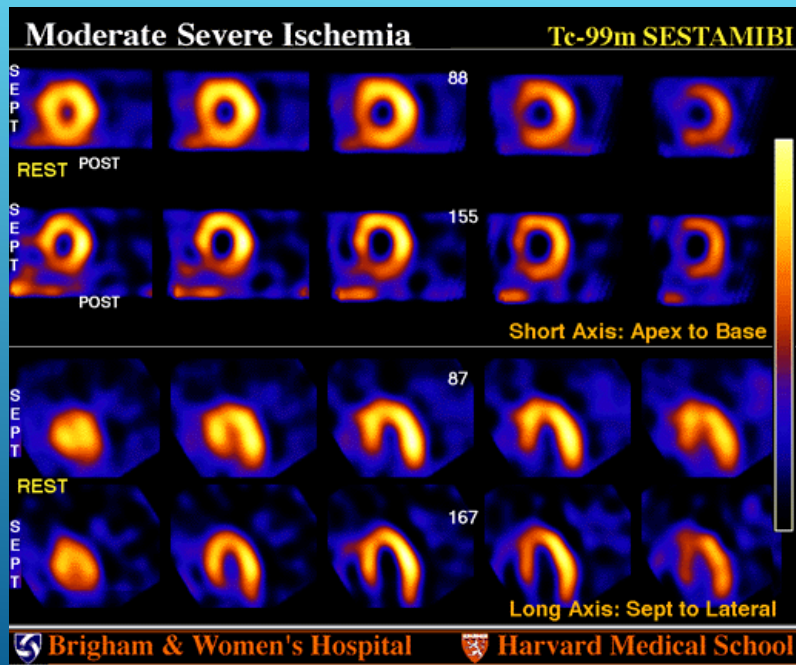
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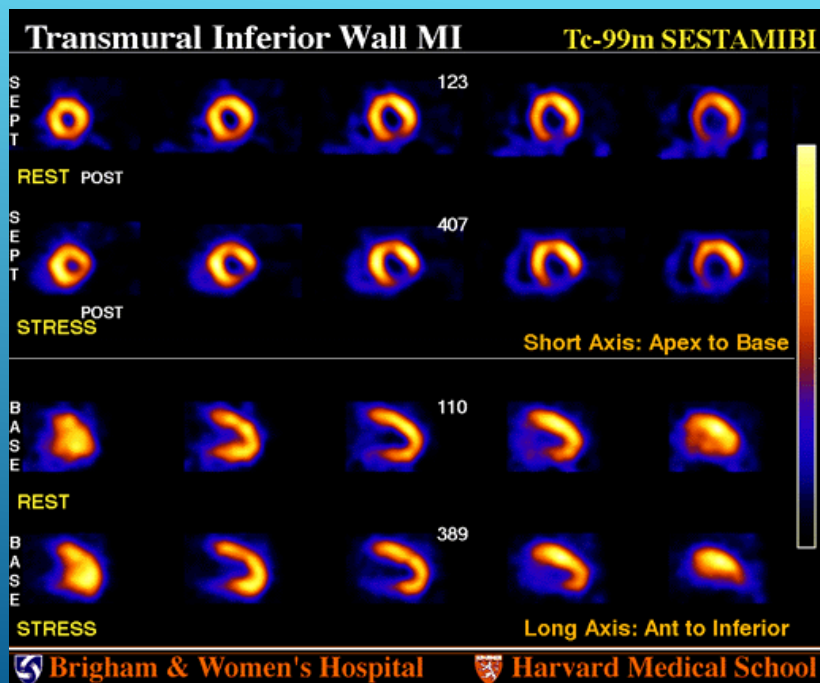
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ANATOMIC NON-INVASIVE EVALUATION

Coronary CT Angiography

Higher Cost

Contrast

Radiation exposure

More technically difficult

Sinus, controlled Heart Rate, Cooperative, and able to hold their breath for 8-10 seconds

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Table 1 Diagnostic value of coronary CT angiography in coronary artery disease according to systematic reviews and meta-analyses

Type of CT scan	First author	No. of articles in the analysis	Patient-based sensitivity % [95% CI]	Patient-based specificity % [95% CI]
64-slice coronary CT angiography	Abdulla *et al*. 2007 (9)	27	97.5 [96-99]	91 [87.5-94]
	Stein *et al*. 2008 (10)	23	98 [96-98]	88 [85-89]
	Mowatt *et al*. 2008 (11)	28	99 [97-99]	89 [83-94]
	Sun *et al*. 2008 (7)	15	97 [94-99]	88 [79-97]
	Guo *et al*. 2011 (14)	24	98 [99-99]	87 [83-90]
	Salavati *et al*. 2012 (73)	25	99 [97-99]	89 [84-92]
Prospectively ECG-triggered coronary CT angiography	Von Ballmoos *et al*. 2011 (74)	16	100 [98-100]	89 [82-89]
	Sun *et al*. 2012 (75)	14	99 [98-100]	91 [88-94]
	Sun *et al*. 2012 (76)	22	97.7 [93.7-100]	92.1 [87.2-97]
	Sabarudin *et al*. 2013 (77)	23	98.3 [96-100]	90.5 [85.7-96]
320-slice coronary CT angiography	Gaudio *et al*. 2013 (79)	7	95.4 [88.8-98.2]	94.7 [89.1-97.5]
	Li *et al*. 2013 (80)	10	93 [91-95]	86 [82-89]
CT, computed tomography; ECG, electrocardiogram.				

Zhonghua et al, QIMS Volume 4, Number 5, October 2014, 2223.
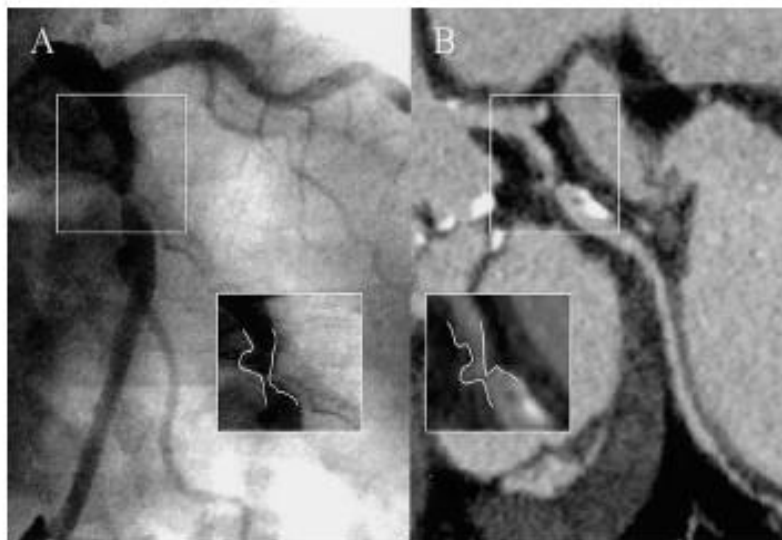
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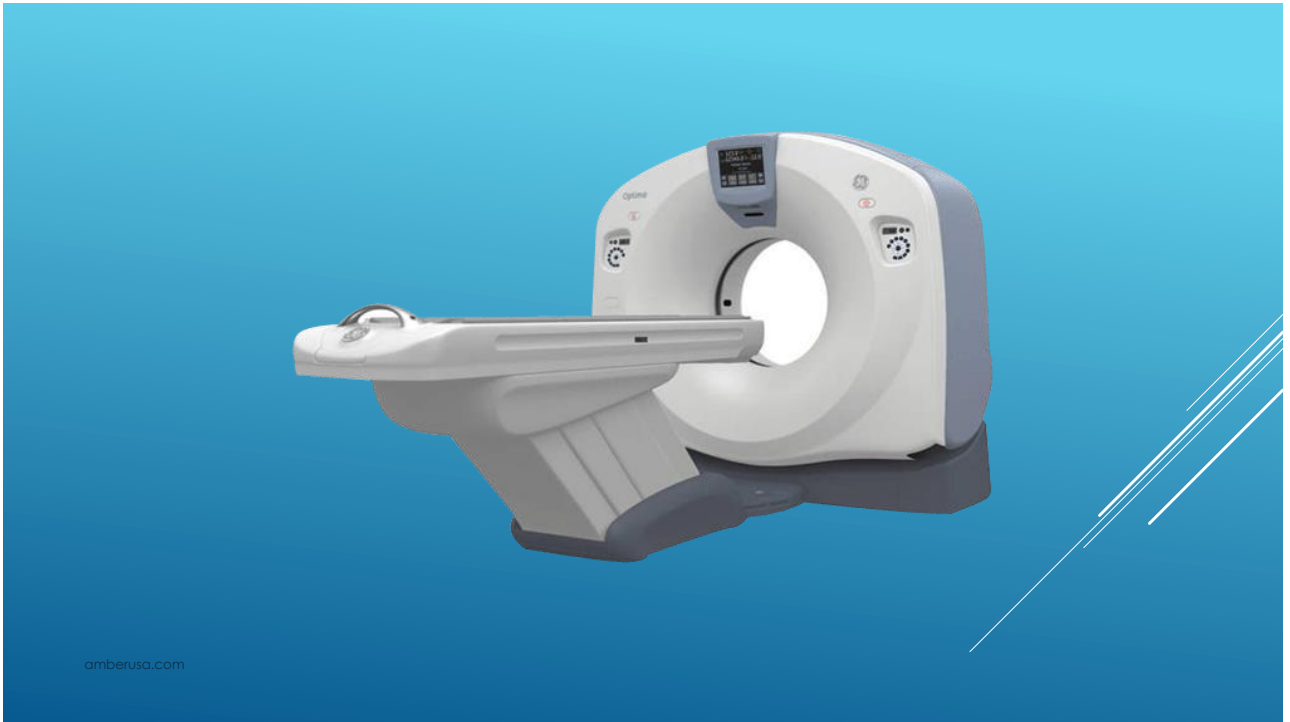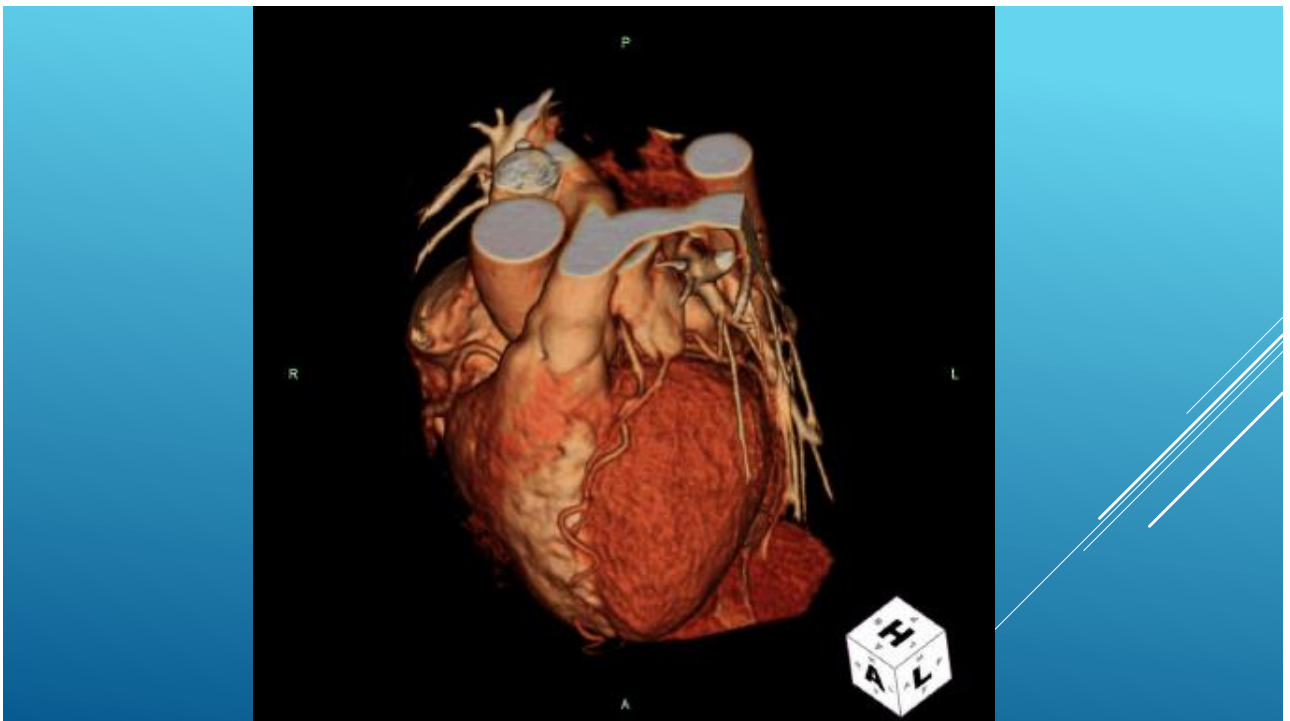
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Figure 2. Correlation of quantitative coronary angiography (QCA) and 64-slice computed tomography (CT) angiography: Visualization and quantification of a high-grade stenosis in the left circumflex artery. (Diameter in the reference section 3.1 mm on QCA, 3.0 mm on 64-slice CT; minimal diameter within the stenotic section 0.6 mm on QCA, 0.5 mm on 64-slice CT). (A) Invasive coronary angiogram of the left coronary artery (right anterior oblique projection). (B) Multiplanar reformatted projection of the left circumflex artery by 64-slice CT.

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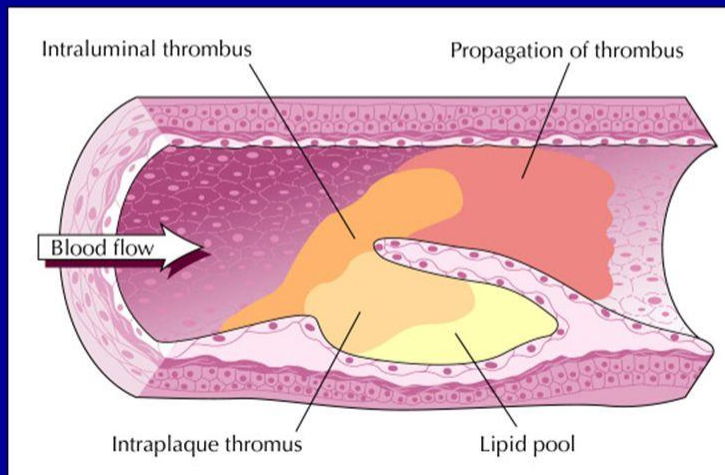SVG to LAD
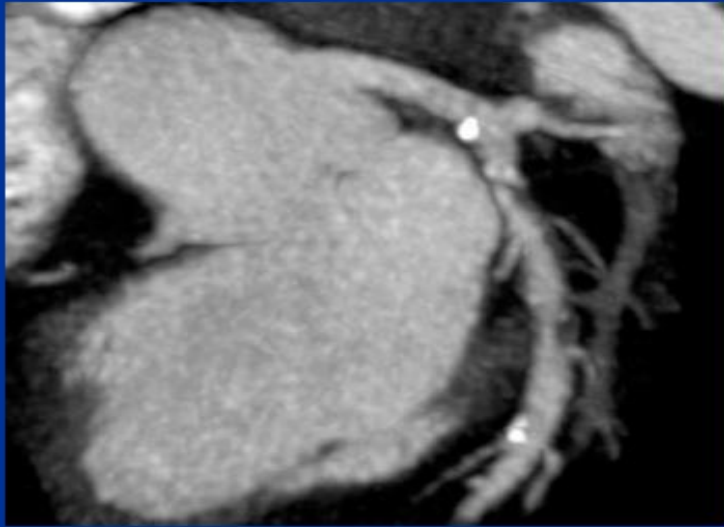
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THE FUTURE: PLAQUE IMAGING

Vulnerabe Plaque
   CTA – most accepted currently
   MRA
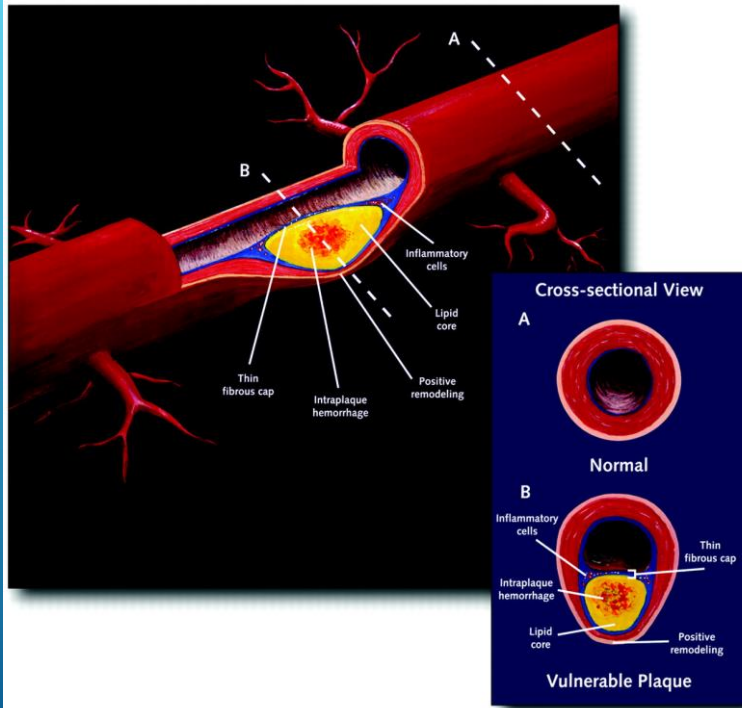   Nuclear

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Vulnerable plaque: from plaque to thrombus

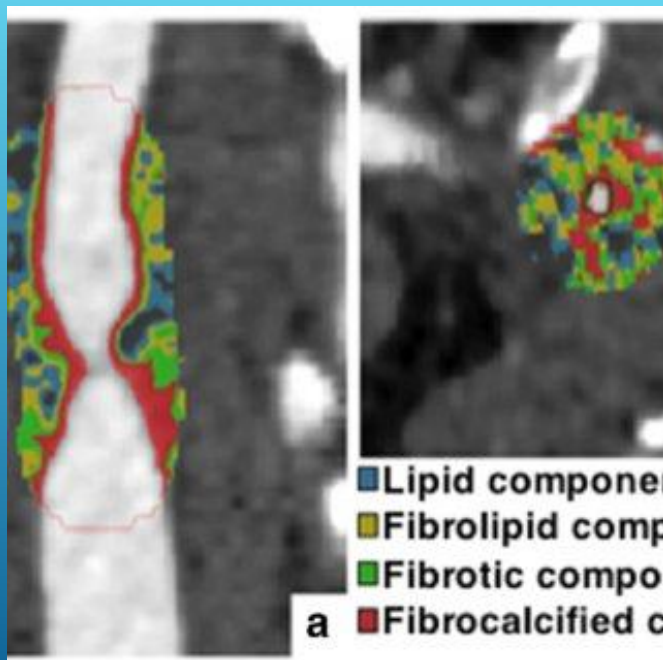
Intraluminal thrombus
Propagation of thrombus
Blood flow
Intraplaque thromus
Lipid pool
slideshare.n

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annals.org

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researchgate.net

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CONCLUSIONS

CAD is an enormous public health issue

Noninvasive testing preferable when feasible to limit procedural risk and cost

Numerous options for noninvasive testing based on patient history and symptoms

    Asymptomatic

    Symptomatic

    Functional

    Anatomic

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