Canada Life™
Reinsurance

Cardiac Testing in The Insurance Applicant

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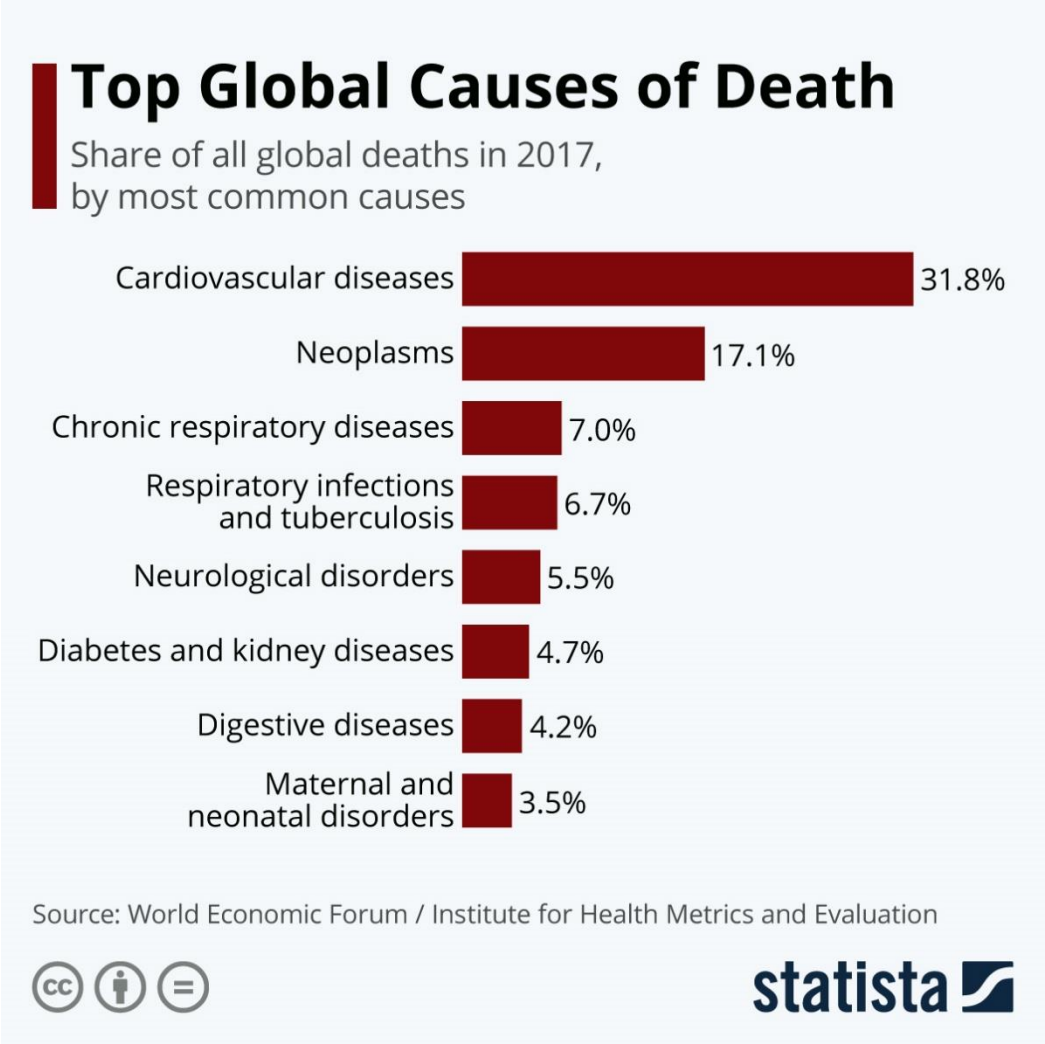
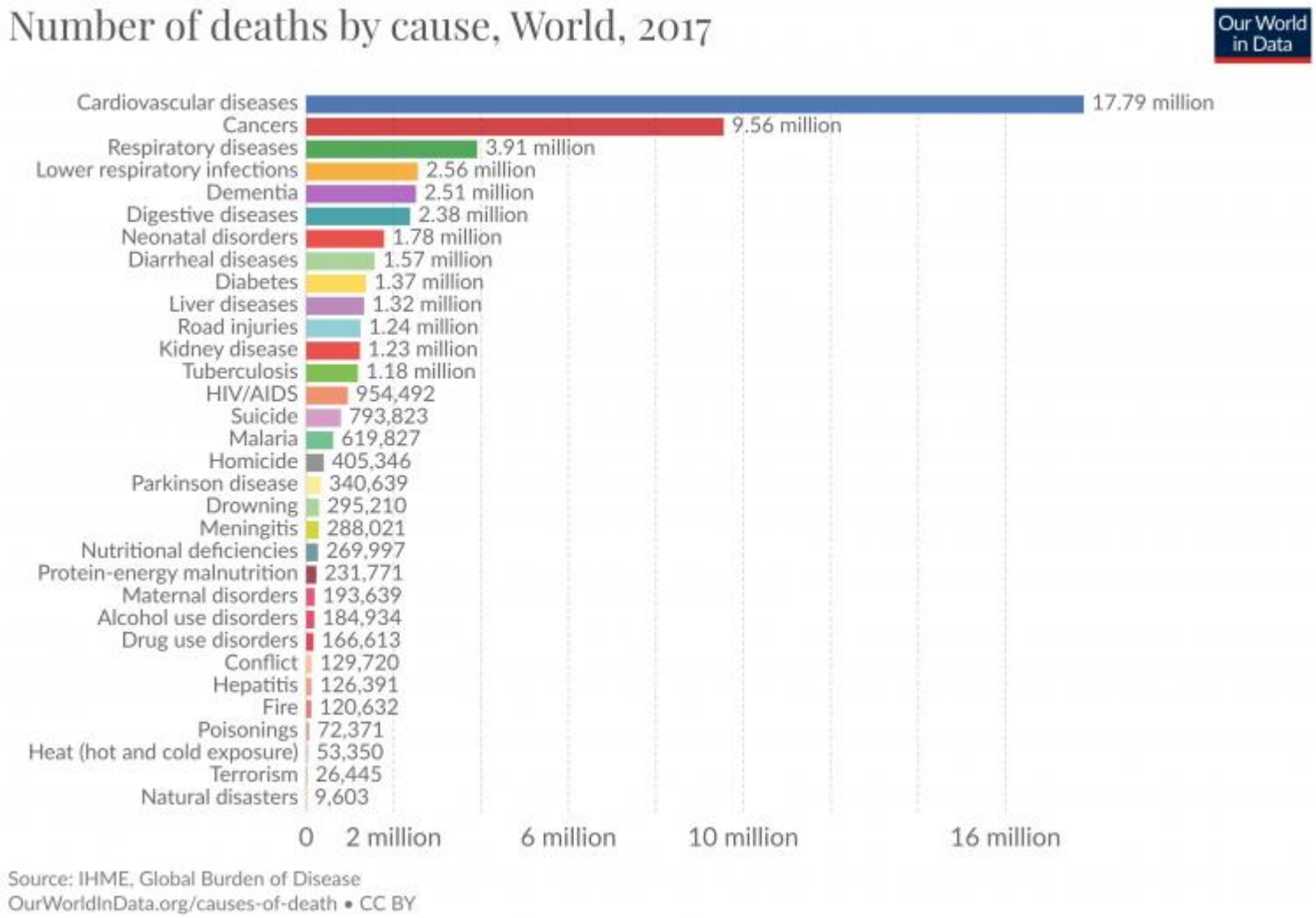
Canada Life Reinsurance
Toronto, Canada
October, 2020

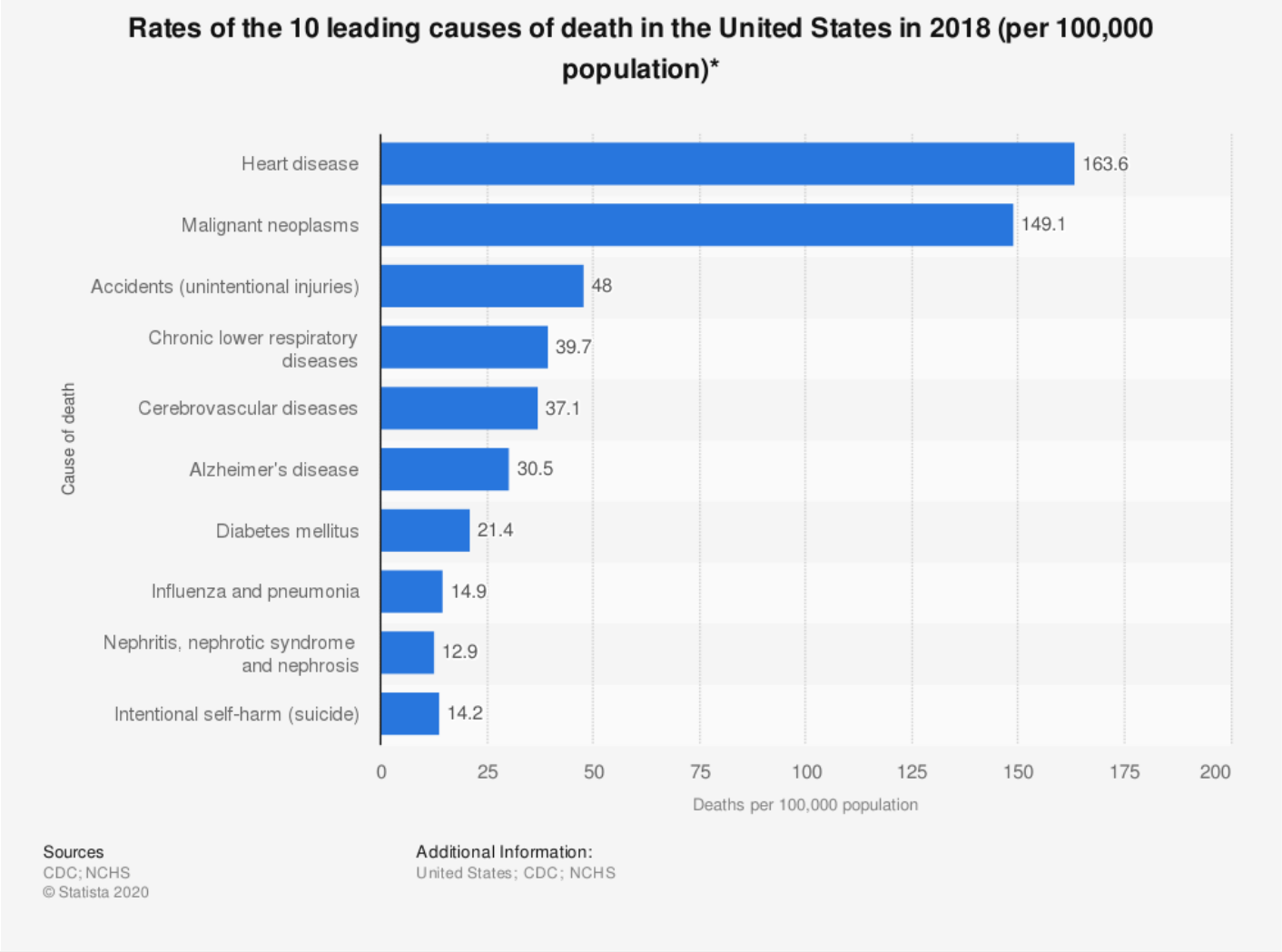
Leading Global Causes of Death - 2017



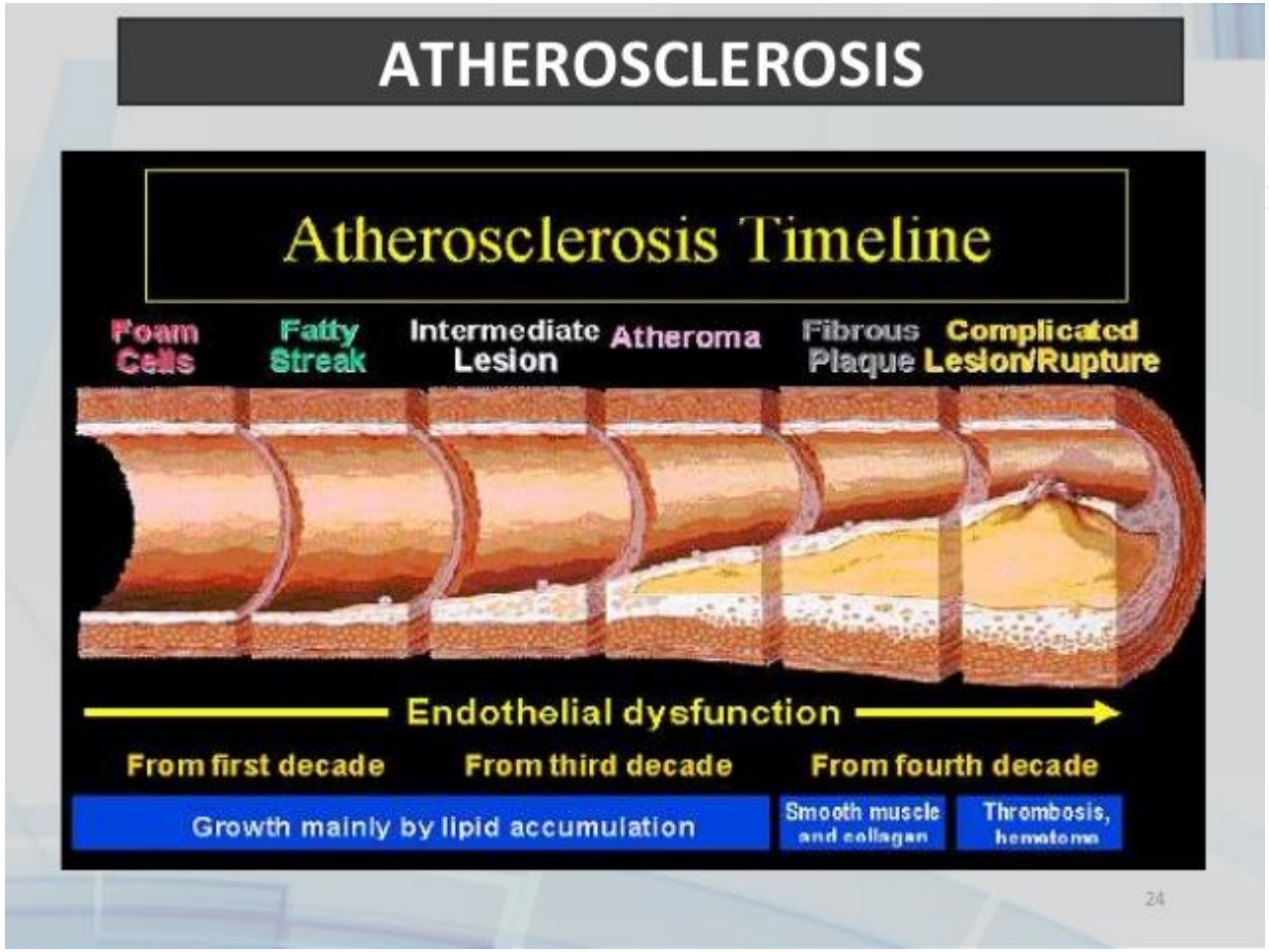
Leading Causes of Death Worldwide, 2017



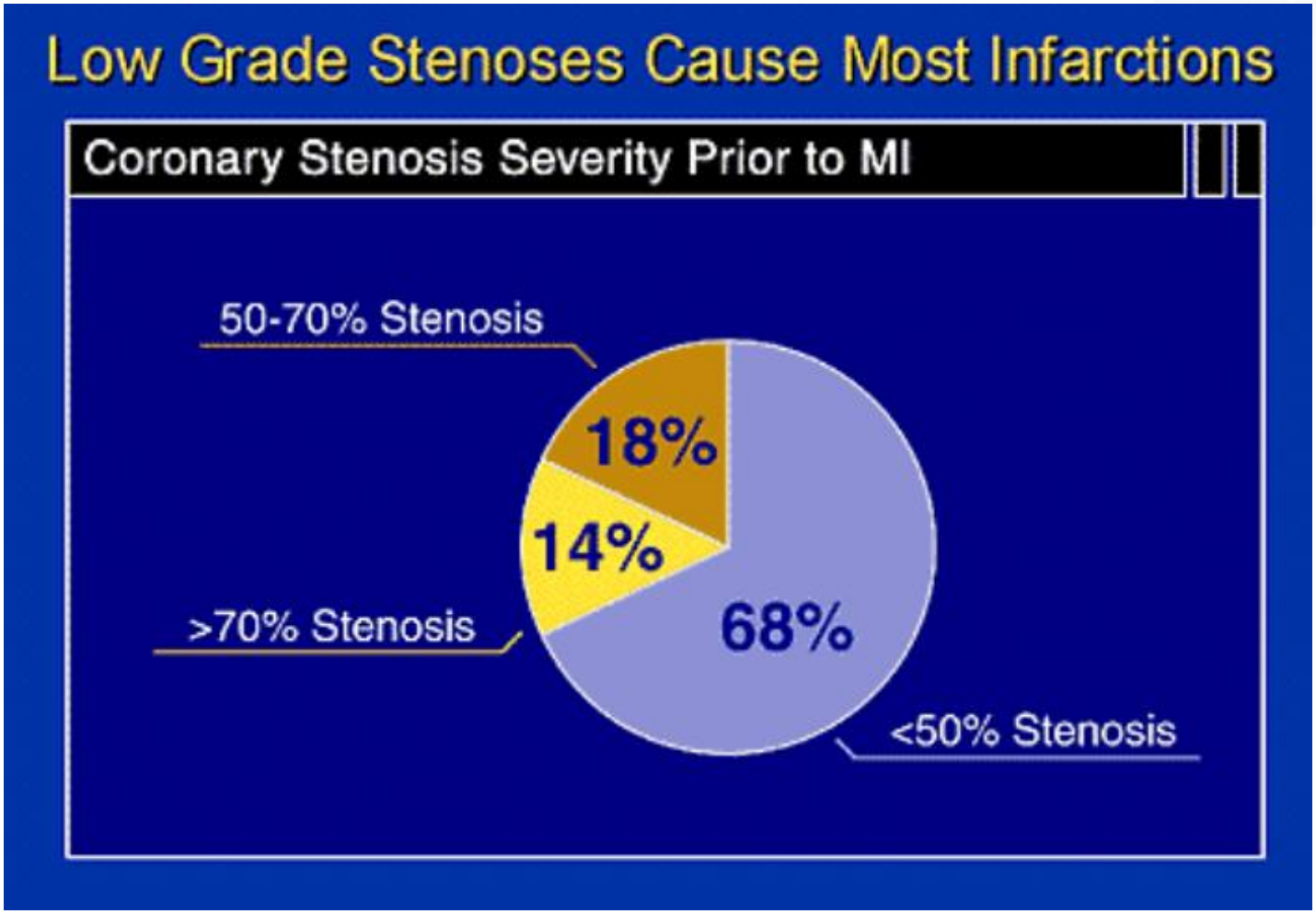
Leading Causes of Death in US - 2018



Atherosclerosis – Timeline



Atherosclerosis – Timeline



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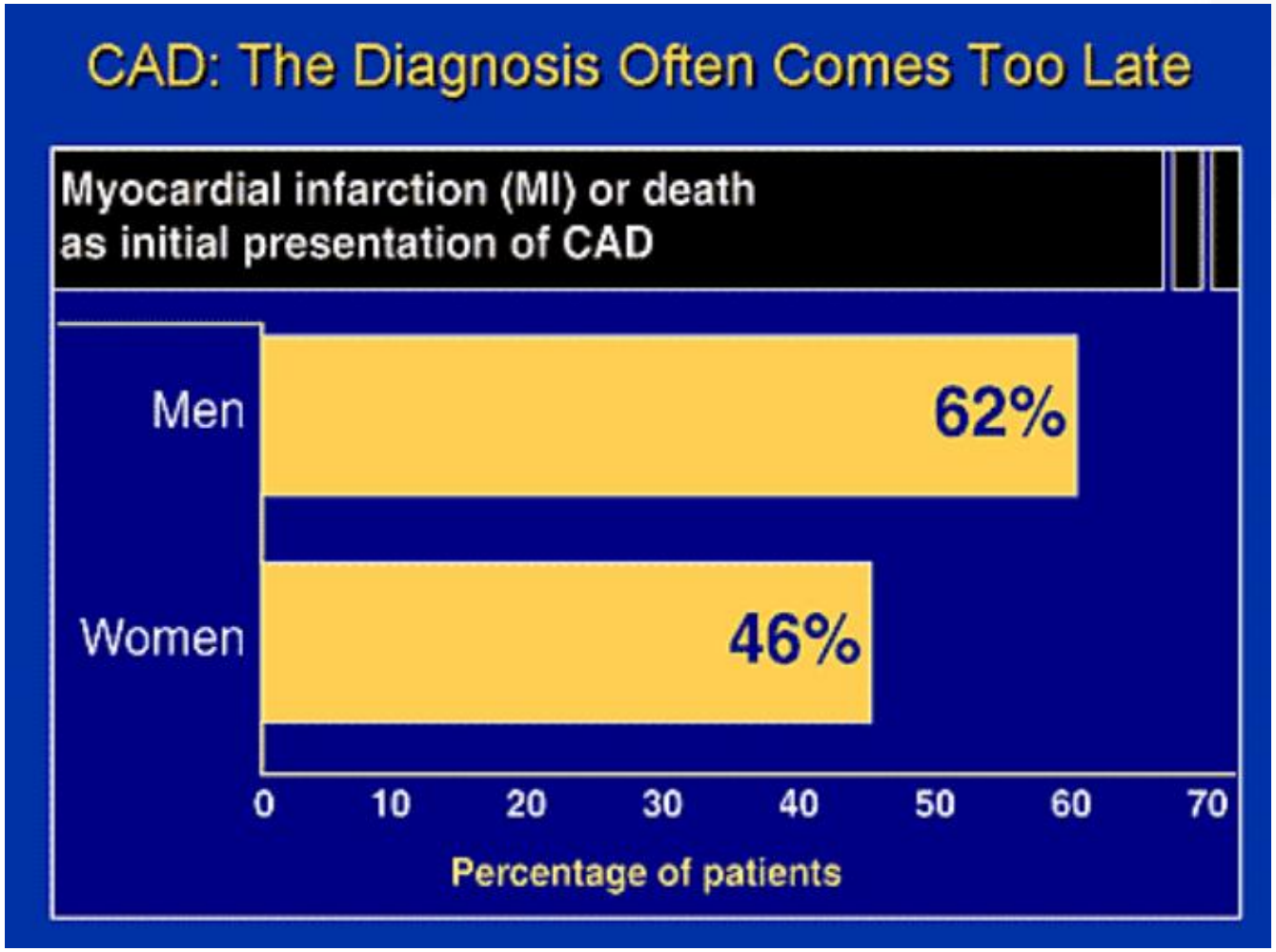

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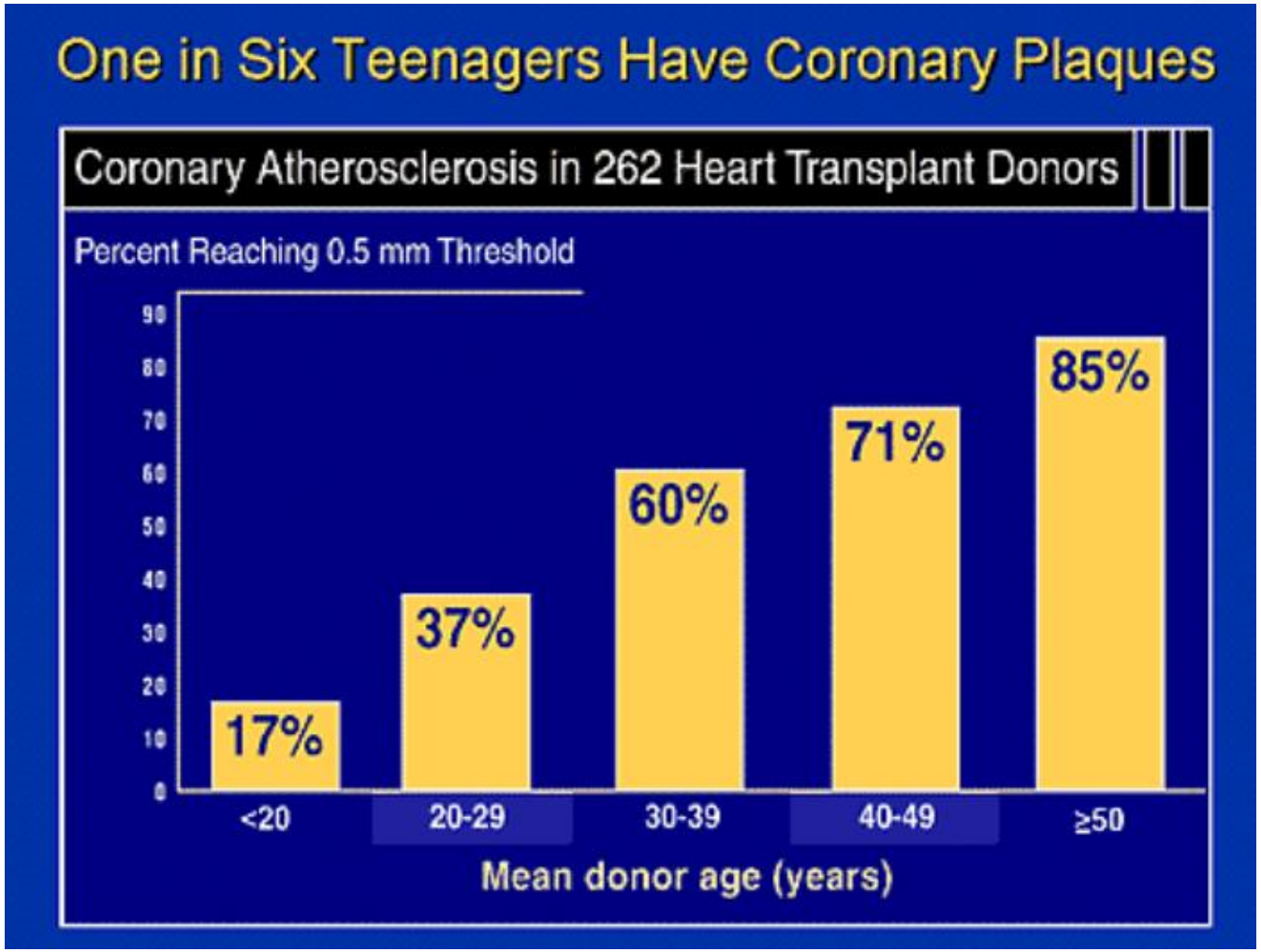
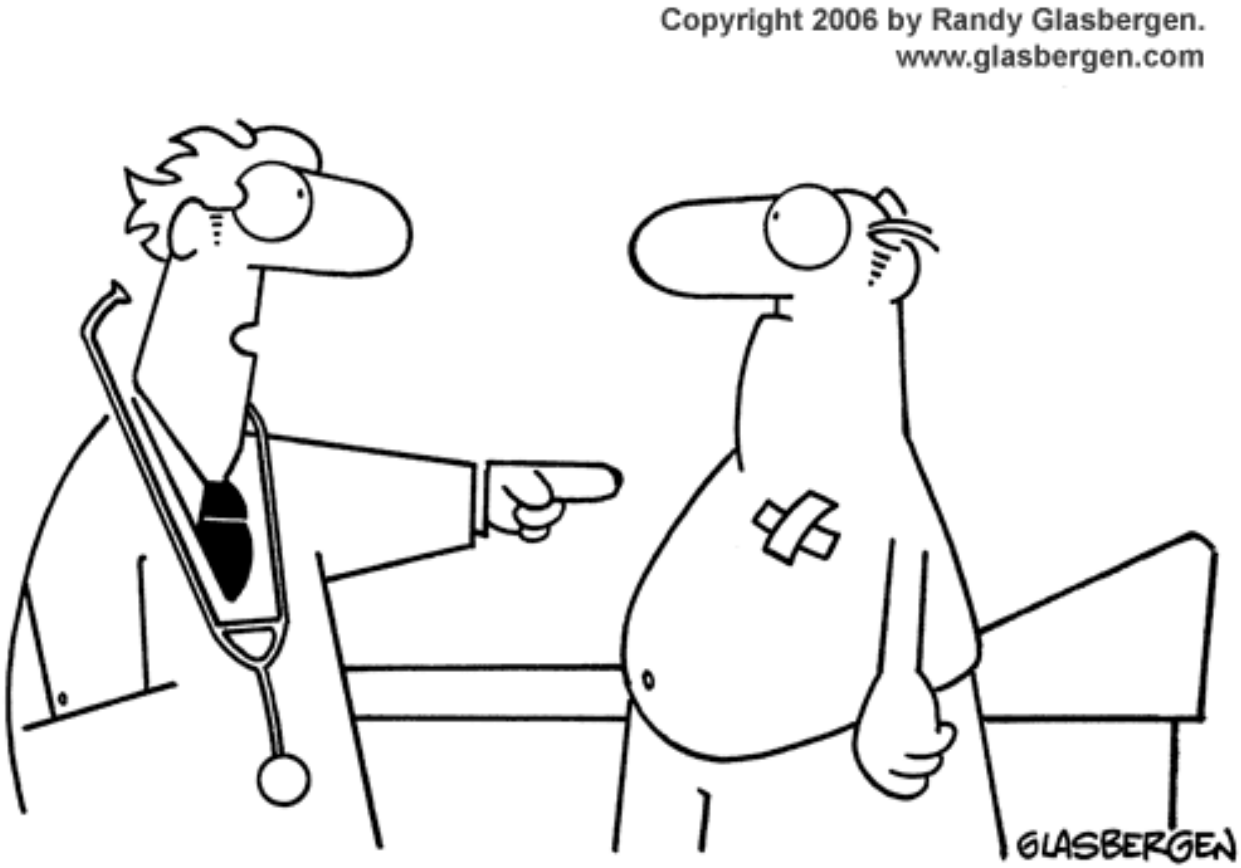
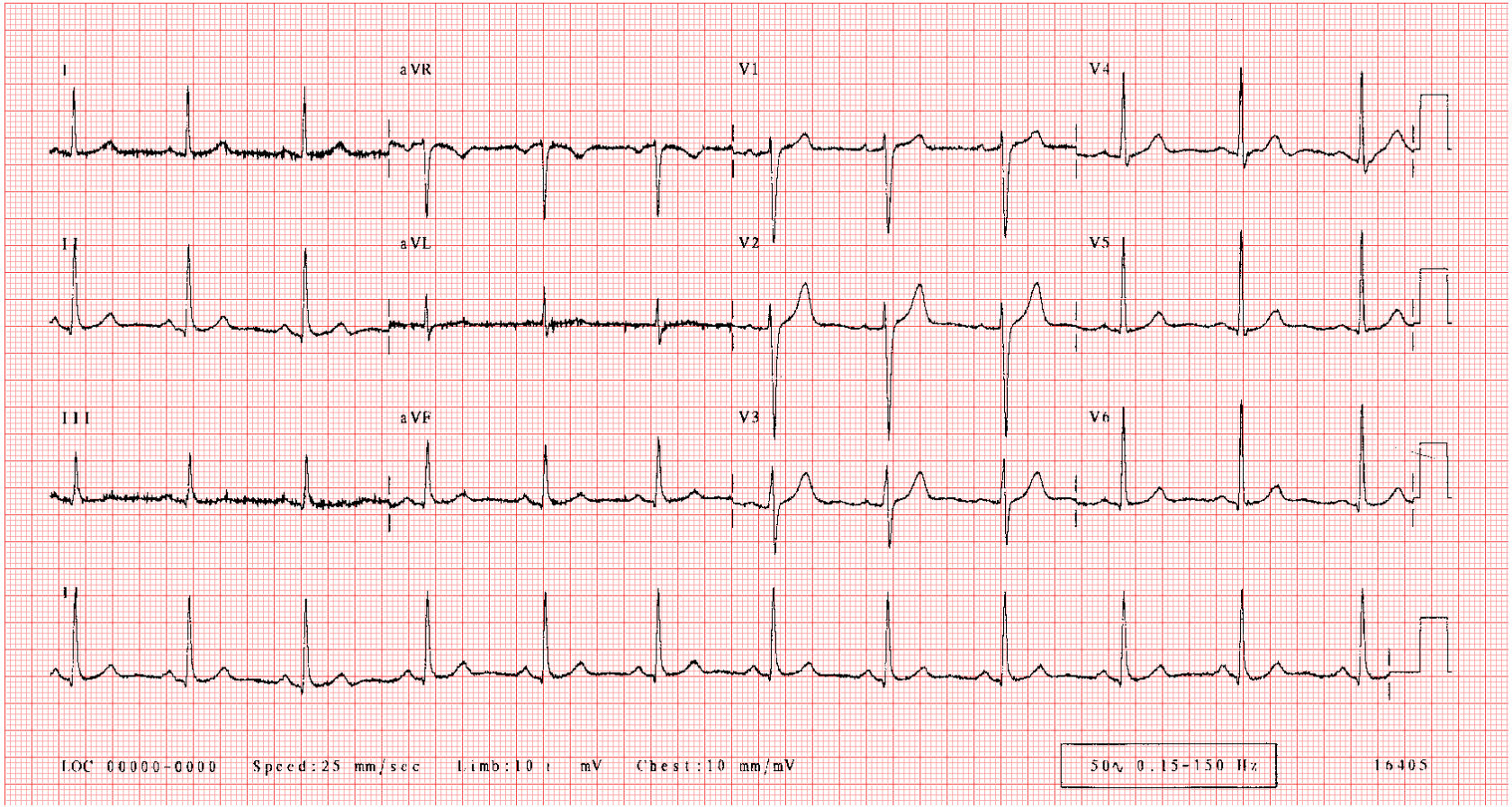


Cardiac Testing



"Whenever your cholesterol gets too high, a sensor will send out a signal that automatically locks the kitchen door and turns on your treadmill."

Normal ECG


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
IOC 00000-0000
Speed:25 mm/sec
Limb:10 mV
Chest:10 mm/mV
50~ 0.15-150 Hz
16405

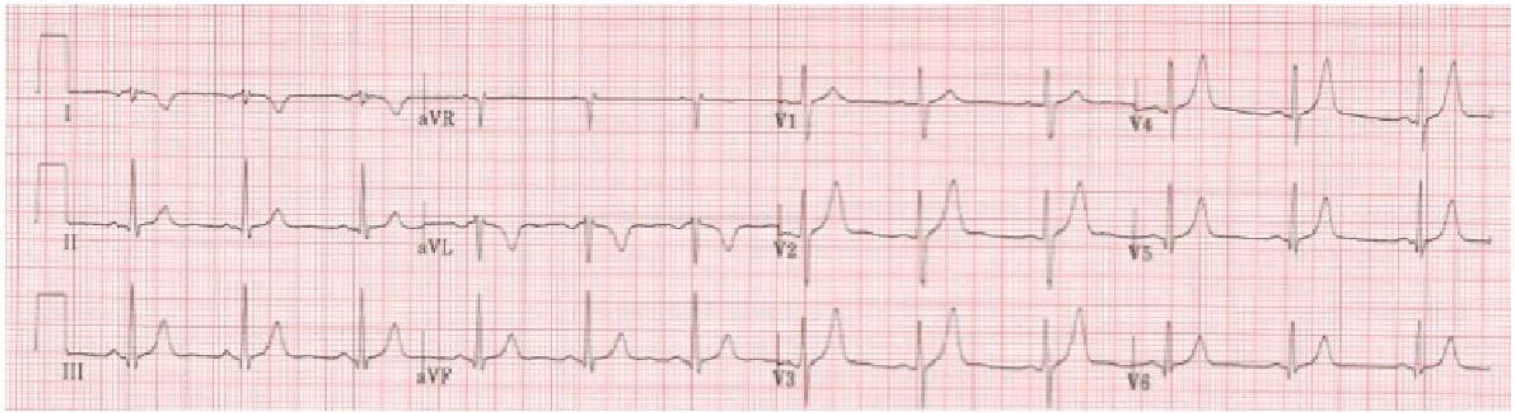
ECG – Lead Placement

ECG – Technical Issues

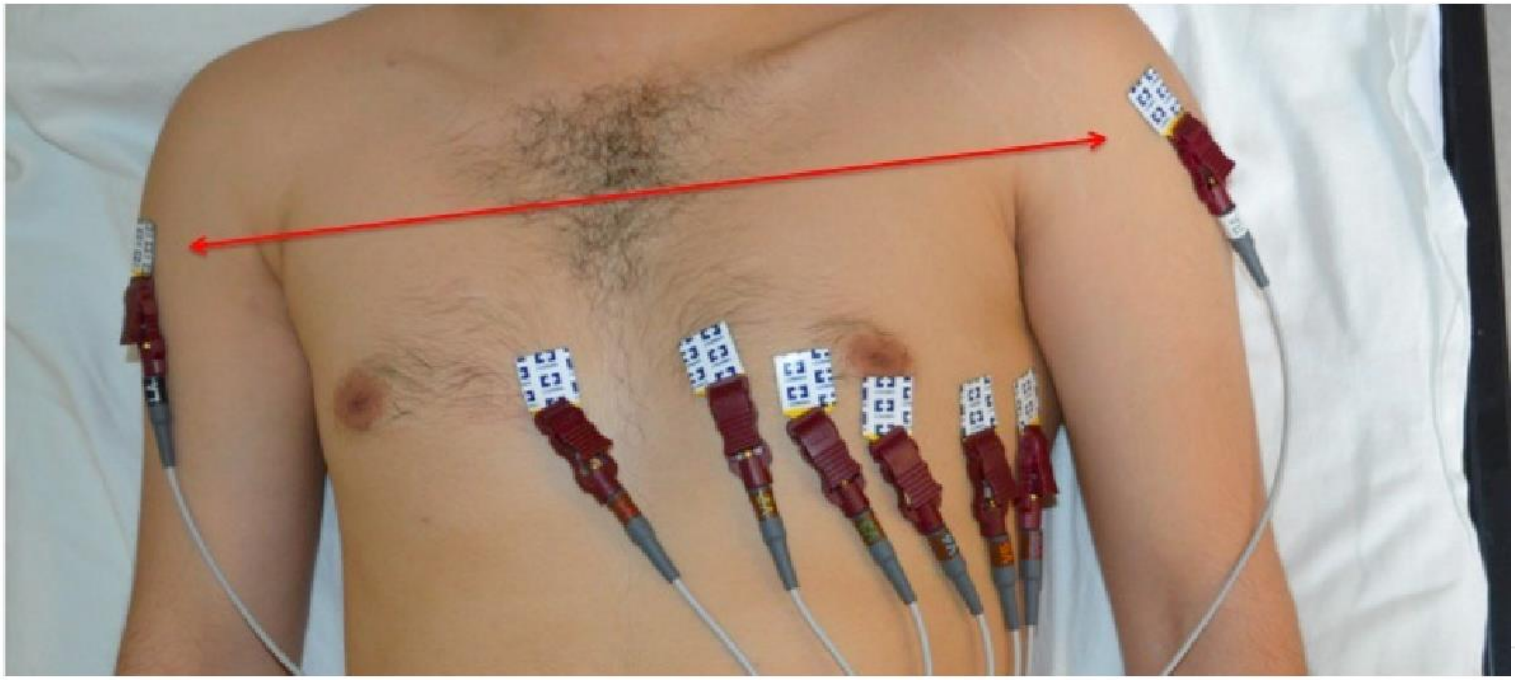
ECG – Technical Issues

ECG Technical Error – Lead Misplacement

A



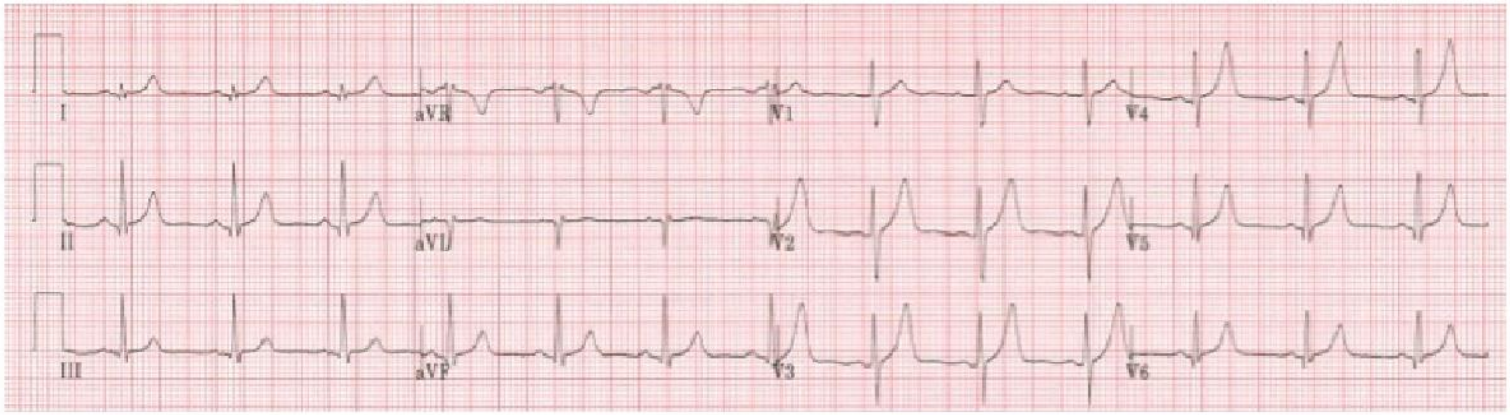
B



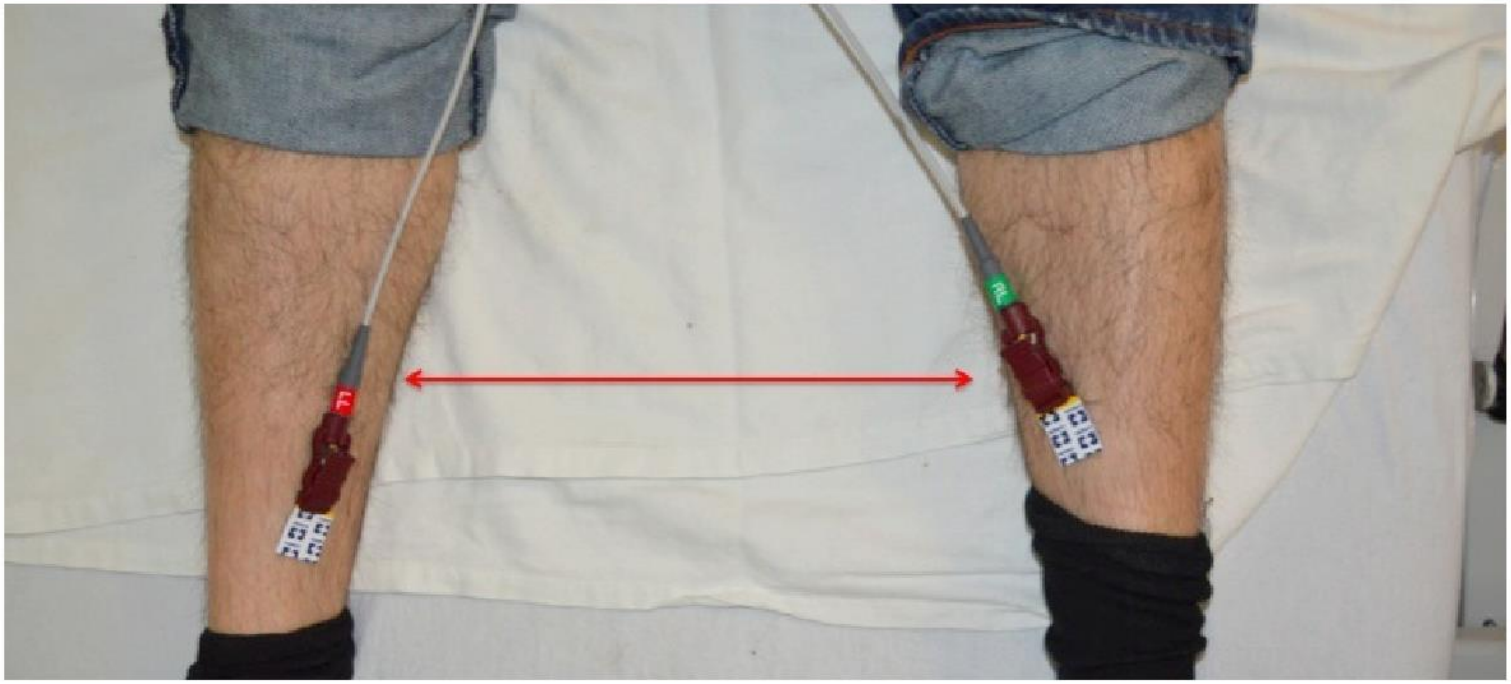
ECG Technical Error – Lead Misplacement

and right leg.

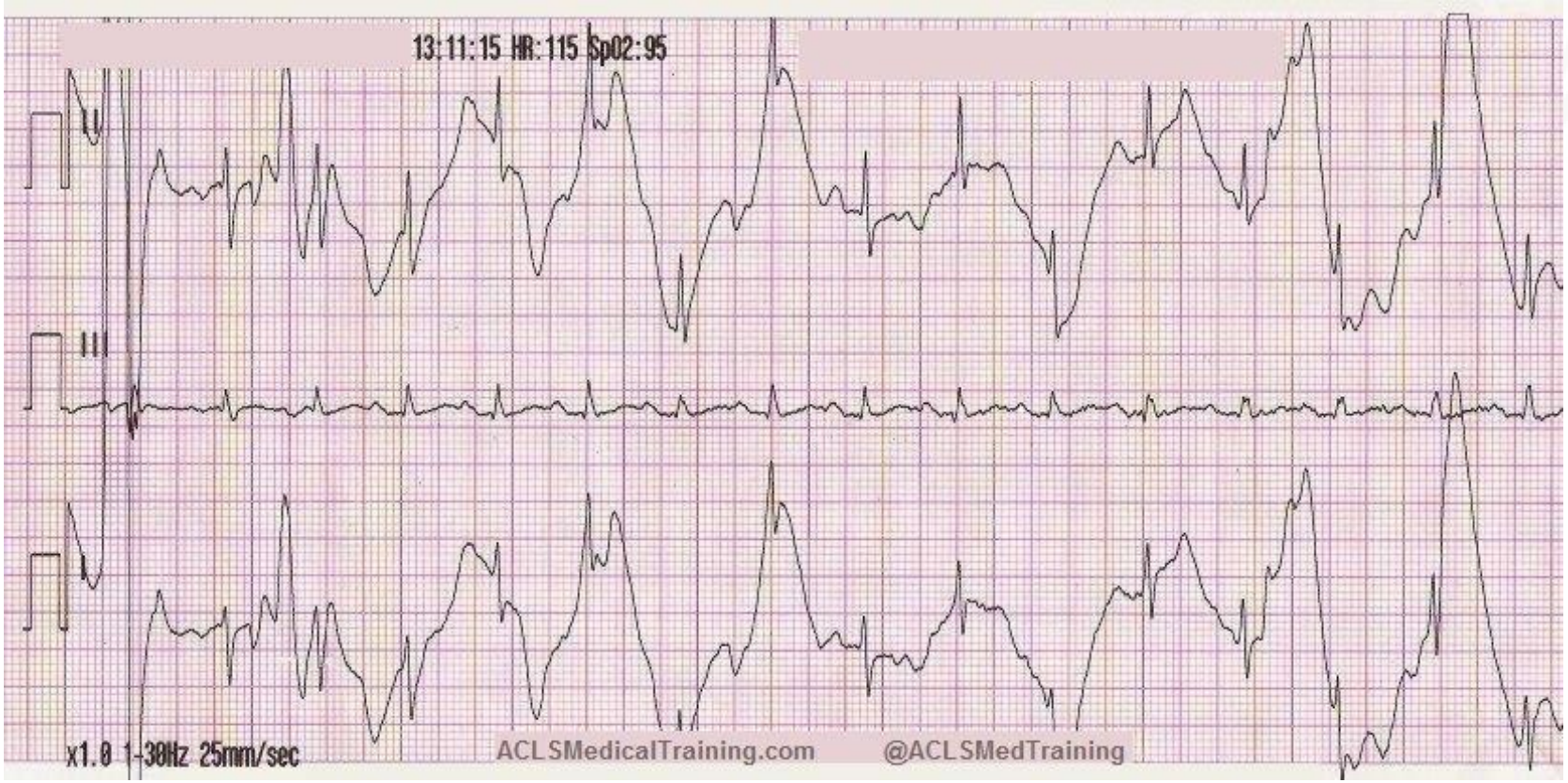
A



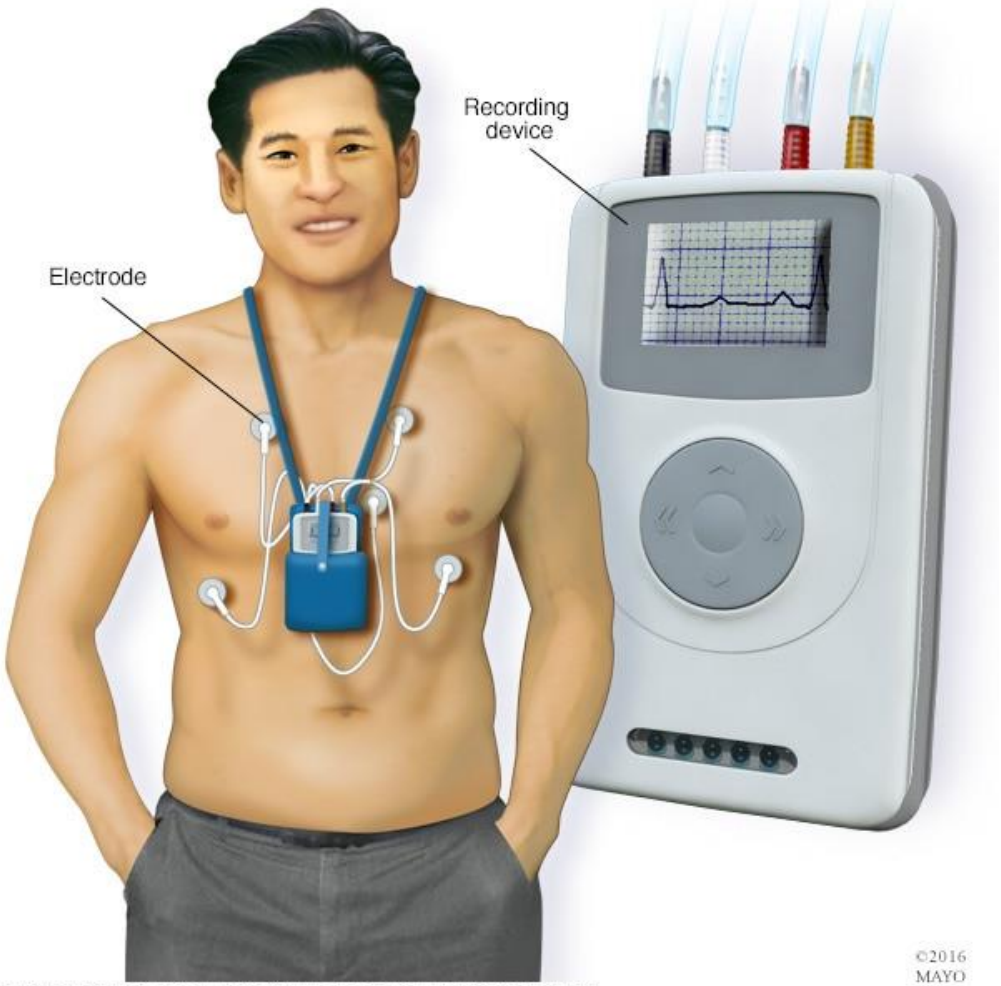
B



ECG Artifact



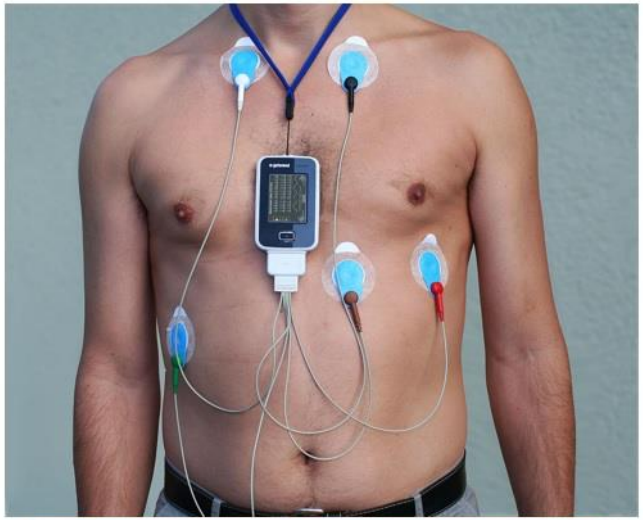
Holter Monitor



Holter Monitor – 24 to 48 hours

Holter Monitor – new technologies

Holter monitoring is now easier than ever before!



Traditional Holter

HealthWatch myPatch Holter

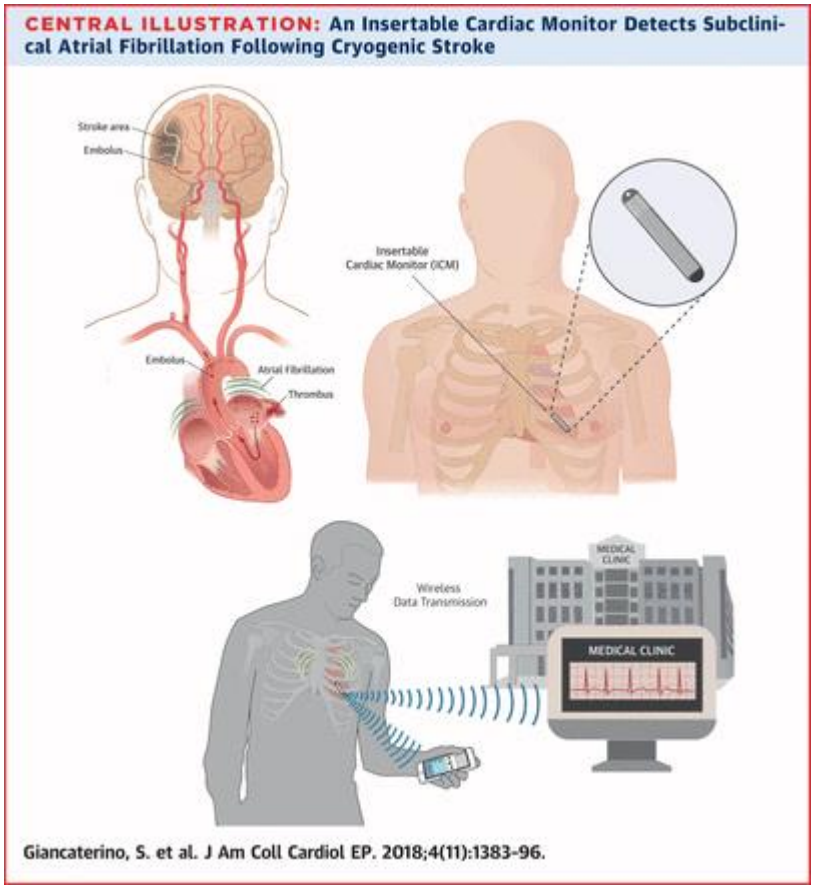
Holter Monitor – new technologies

There's a PERFECT SIZE for everyone!

Adult | Pediatric | Neonate

Insertable Cardiac Monitors (ICMs) – Implantable Loop Recorder

- Small, subcutaneously implanted devices
- Continuous ambulatory monitoring
- Lifespan up to 3 year



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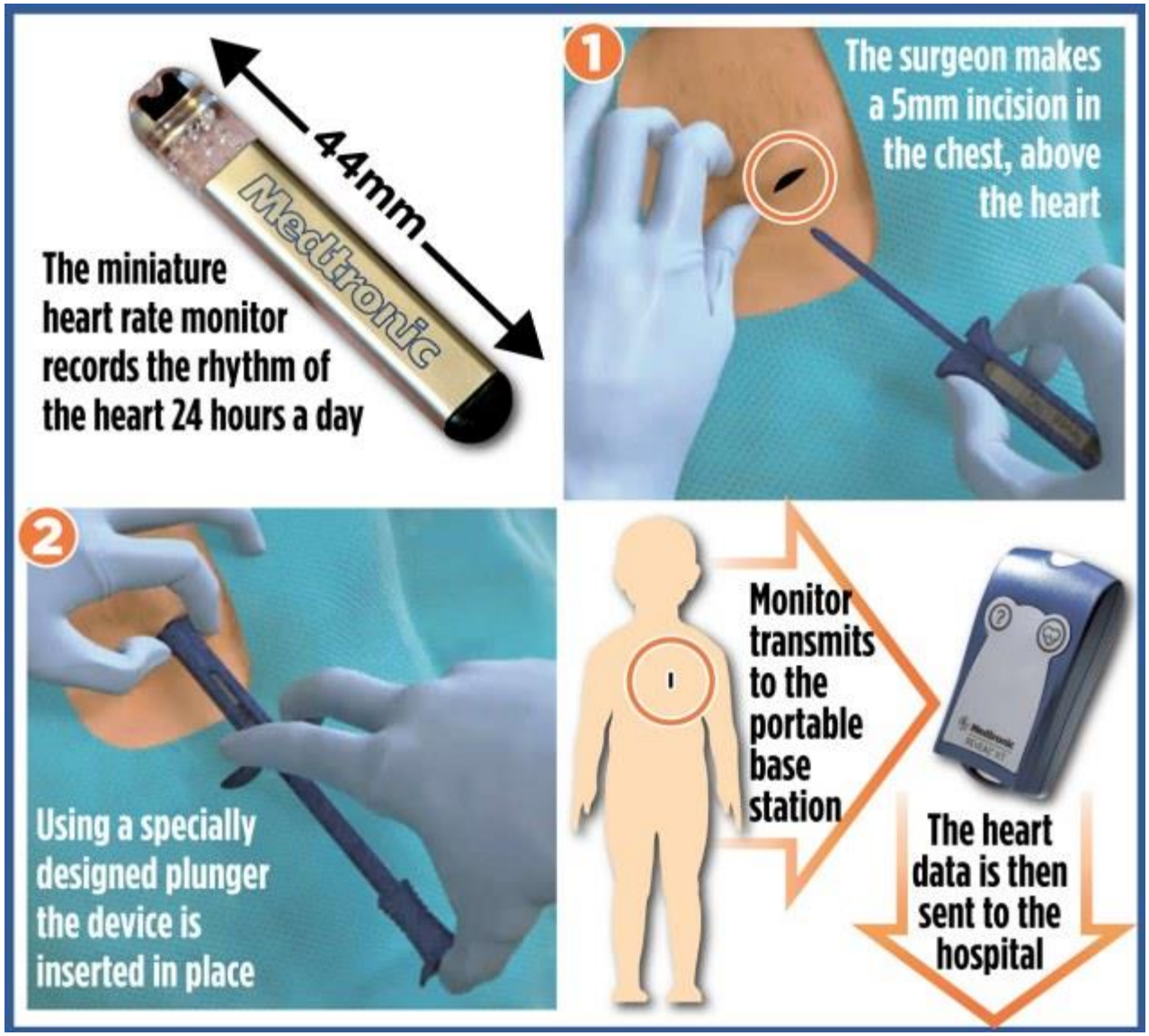
Insertable Cardiac Monitors (ICMs)



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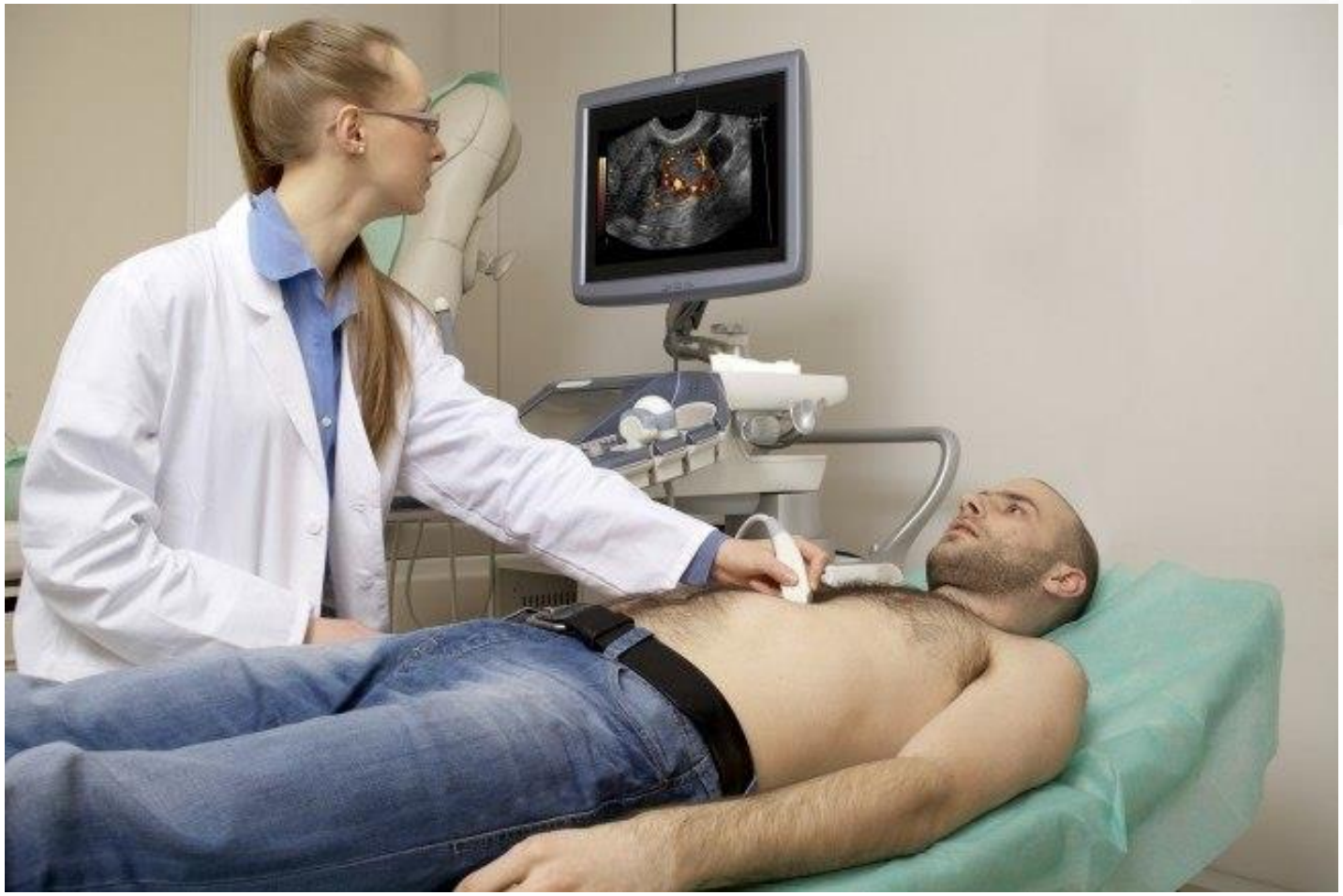
Diagnosing an Arrhythmia

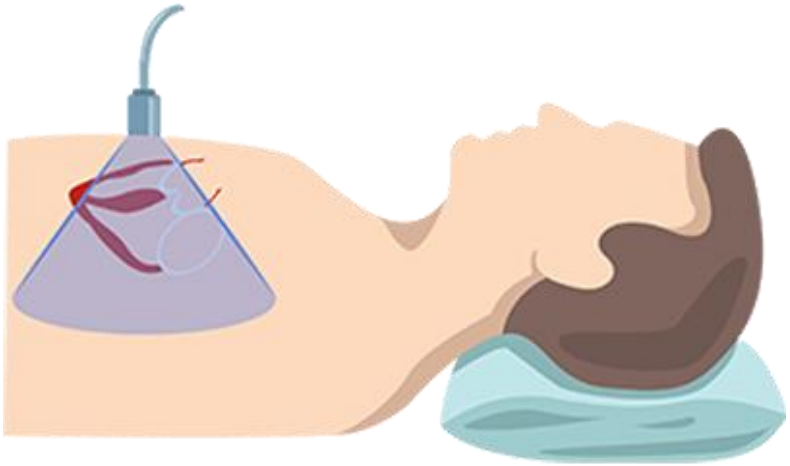
Device type	Holter monitoring 	External loop recorders 	Implantable loop recorders 
Frequency of symptoms	Daily, near-daily	Weekly	Rare (almost monthly)
Recording time	24 hours, 48 hours or one week	Up to four weeks	Up to three years
Availability and cost	Usually available in primary and secondary care. Less expensive	Available only in specialised cardiac centres. More expensive than Holter monitoring	Available only in specialised cardiac centres More expensive compared with other monitoring strategies
Patient convenience/ practicality	Non-invasive. No action needed from the patient	Non-invasive. Patients need to activate the recorder when symptoms occur	Minimally invasive procedure
Use and limitations	Suitable for patients with frequent symptoms. Limited recording capacity	Higher likelihood of detecting arrhythmias due to prolonged monitoring as compared with Holter monitoring. Not suitable for syncope or in other conditions when patients cannot activate the device. ECG data can be transmitted continuously over wireless network to a remote monitoring system for evaluation	Minimally invasive procedure. Both automatic and patient activation methods supported

Echocardiogram - Resting

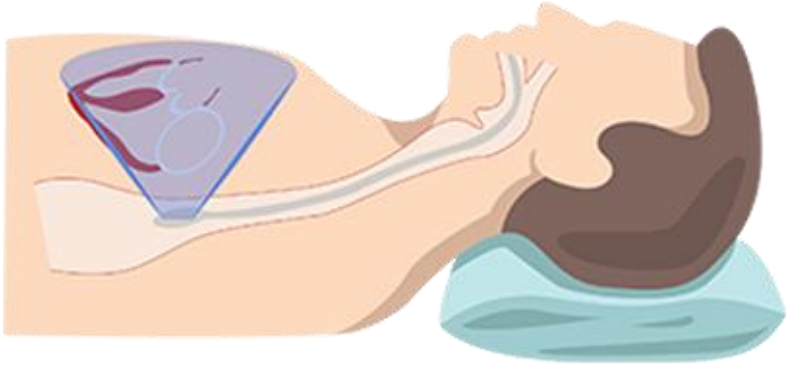


Resting Echocardiogram

Echo – Transthoracic (TTE) vs. Transesophageal (TEE)



Standard or Transthoracic Echo



Transesophageal Echo or TEE

Resting Echocardiogram

206-430 The Boardwalk, Waterloo, ON, N2T 0C1 Phone: 519-741-5252 Fax: 519-741- 5772

ECHOCARDIOGRAM REPORT

Test, John
DOB: 2/29/1958
OHIP#: 11111111 DF

Family MD: Dr.Giovanni Ranozzo
Referring MD: Dr.Giovanni Ranozzo
Date of Exam: February 26, 2016

Echo Impression	Left ventricular ejection fraction is greater than 55%. Apical anterior wall and apical septum are mildly hypokinetic. Mild left ventricular diastolic dysfunction with impaired relaxation pattern.
Reason for Test	Murmur
Study Quality	Good.
LV size and function	Normal left ventricular cavity size, wall thickness, regional wall motion, systolic function. Left ventricular ejection fraction is greater than 55%. Apical anterior wall and apical septum are mildly hypokinetic. Mild left ventricular diastolic dysfunction with impaired relaxation pattern.
RV,PA,PV	Normal right ventricular structure and function. Normal RVSP. Normal pulmonic valve structure and function with trivial/mild (physiologic) pulmonic regurgitation. Normal pulmonary artery.
LA,RA	Left atrium is normal. Right atrium is normal.
Aorta and AV	Normal aortic root, ascending aorta and aortic arch. No coarctation of the aorta. Moderate thickening of the aortic valve leaflets with no significant stenosis. Trivial (physiologic) aortic regurgitation.
MV and TV	Normal tricuspid valve structure and function. Trivial (physiologic) tricuspid regurgitation. Trivial to mild (physiologic) mitral regurgitation.
Miscellaneous	No evidence of an intracardiac shunt (ASD, VSD or PDA). No pericardial effusion.

Exercise Stress Test

Exercise Stress Test

Exercise Stress Test

Bruce Protocol

Stage	Minutes	% grade	km/h	MPH	METS
1	3	10	2.7	1.7	5
2	6	12	4.0	2.5	7
3	9	14	5.4	3.4	10
4	12	16	6.7	4.2	13
5	15	18	8.0	5.0	15
6	18	20	8.8	5.5	18
7	21	22	9.6	6.0	20

METs – Each Minute of Exercise Approx. 1 MET

What is MET?

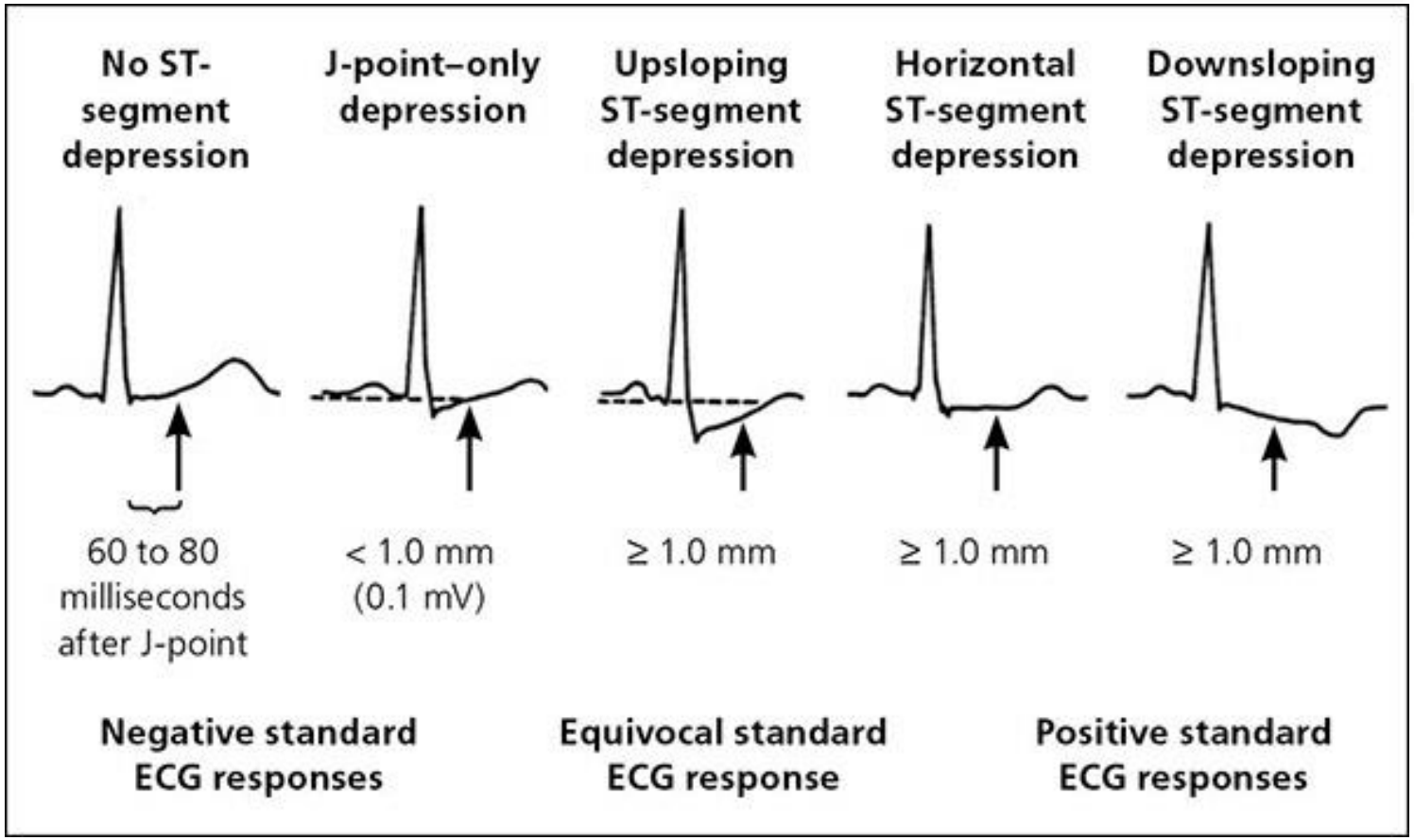
- Metabolic Equivalent Term
- 1 MET = 3.5 ml O2 per kilogram of body weight per minute
- Actually differs with thyroid status, post exercise, obesity, disease states
- By convention just divide ml O2/Kg/min by 3.5

$$\text{METs} = \frac{\text{Speed} \times [0.1 + (\text{Grade} \times 1.8)] + 3.5}{3.5}$$

Stress Test


"I'M AFRAID YOU FAILED YOUR STRESS TEST."
AAAARGH!
©2009 BALOOCARTOONS.COM

Stress Test – ST Depressions



Stress Test – The Report

STRESS TEST Bruce Protocol

Stage	Speed (mph)	Grade (%)	Time (min)	METS	BP (mmHg)	HR (bpm)	Comments
REST	1.2	0.0	06:23	1.9	130/ 86	72	Echo check by Dan - ok
STAGE 1	1.7	10.0	03:00	4.6	138/ 86	98	
STAGE 2	2.5	12.0	03:00	7.0	152/ 84	117	
STAGE 3	3.4	14.0	03:00	10.2	168/ 84	153	
STAGE 4	4.2	16.0	00:18	13.5	---/---	154	Stop exercise at 09:18
RECOVERY	0.0	0.0	01:00	1.0	162/ 62	123	
RECOVERY	0.0	0.0	02:00	1.0	152/ 68	102	
RECOVERY	0.0	0.0	03:00	1.0		95	
RECOVERY	0.0	0.0	04:00	1.0	150/ 72	91	
RECOVERY	0.0	0.0	05:00	1.0		86	
RECOVERY	0.0	0.0	06:00	1.0	140/ 78	88	
RECOVERY	0.0	0.0	06:20	1.0		86	

Stress Results

Stress Duration (min:sec): 09:18 METS: 10.1

Resting HR (bpm): 72 Resting BP (mmHg): 130 / 86 Max Predicted HR: 166 Target HR: 141

Peak HR (bpm): 155 Peak BP (mmHg): 168 / 84 % Max Predicted HR: 93 Double Product: 25041

Stress Summary: Normal, atypical symptoms with no ECG evidence for myocardial ischemia

BP Response: Normal blood pressure response during stress

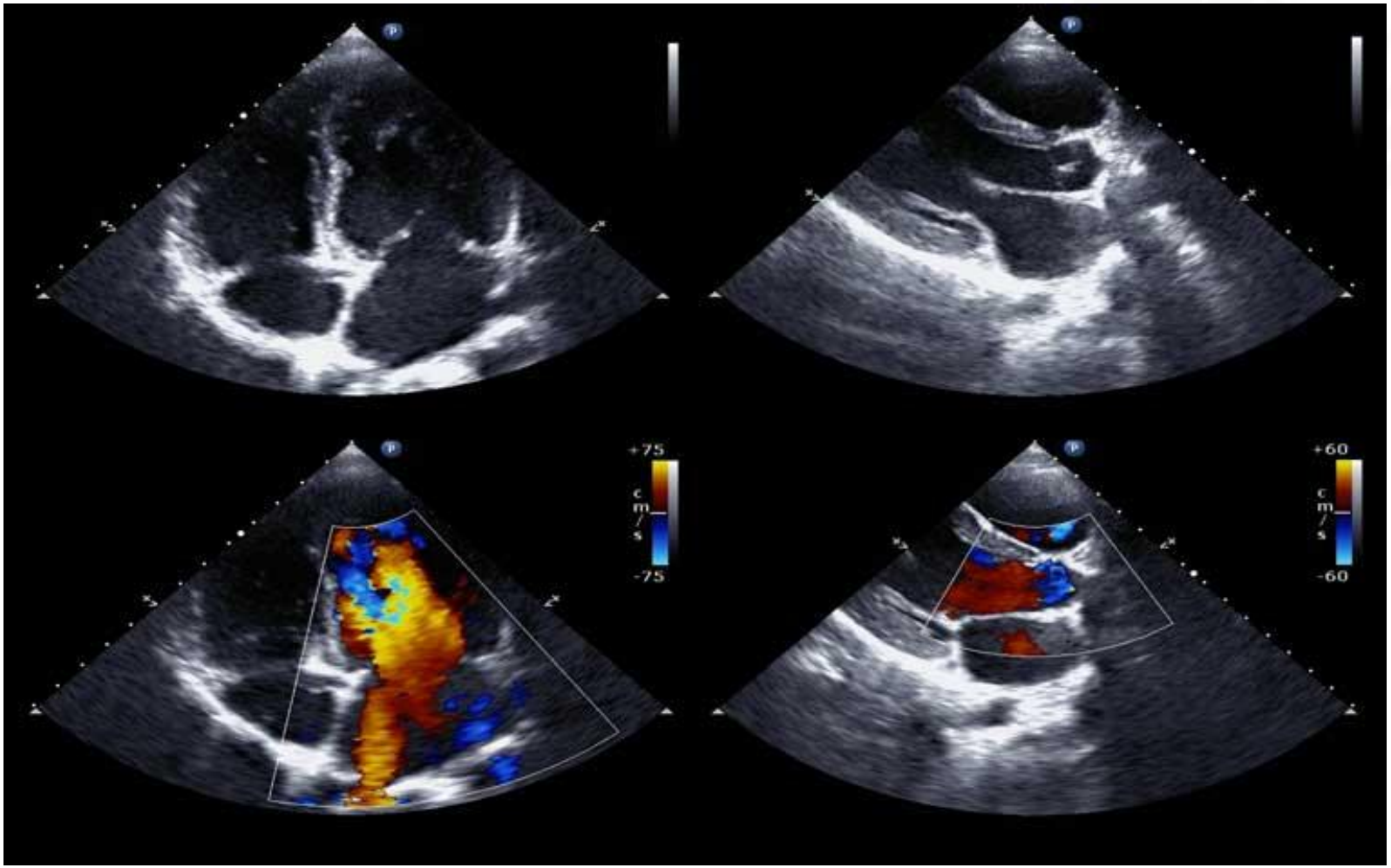
Reas. Termination: Fatigue

Stress Test – Double Product Calculation

- Product of SBP (Systolic BP) and PR (Pulse Rate) at Peak Exercise
- Index of Myocardial Oxygen Consumption = Myocardial Workload
- Previously used during exercise stress testing in pts with CAD – the attenuated increase in this index response to exercise predicted CV Mortality
- If Double Product (DP) >30,000 is achieved, ? lower chance of underlying CAD and CV events.
- Double Product <15000, low hemodynamic response, ? poorer outcomes
- DP significantly associated with all-cause and CVD mortality (preliminary data)

Stress Echocardiogram – Stress Images

Stress Echocardiogram – Stress Images

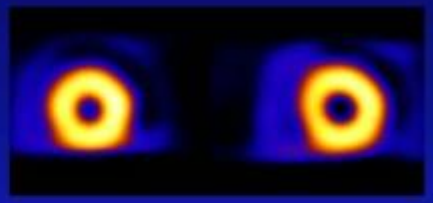


Nuclear Stress Test

Myocardial Perfusion Imaging

MYOCARDIAL PERFUSION IMAGING

- Tracers:
  - Thallium-201 (Tl-201)
  - Tc-99m MIBI (Cardiolyte)
  - Tc-99m tetrofosmin



- Principle: Myocardial perfusion of LV*
- Technique
  - Acquire rest & stress images
  - Stress: exercise or pharmacological tests

Exercise stress test --> increase sensitivity

Pharmacologic Stress Test (No Exercise)

PHARMACOLOGICAL STRESS TEST

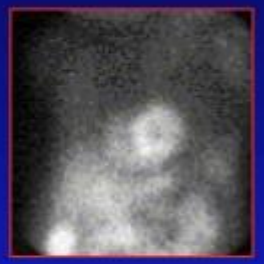
- Dipyridamole (Persantin)
- Dobutamine
- Adenosine

J SRIPRAPAPORN

Nuclear Study

MYOCARDIAL PERFUSION IMAGING

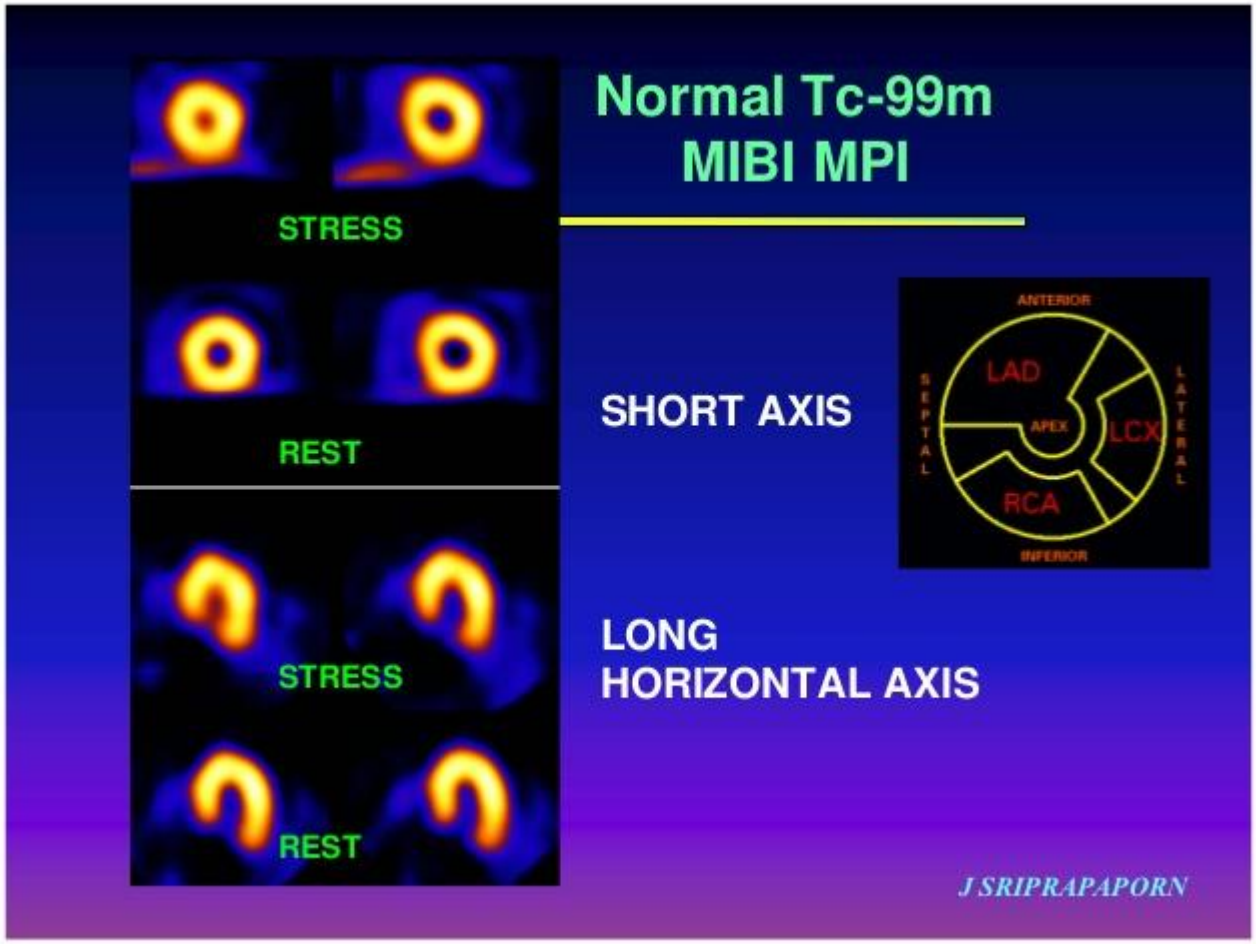
- Imaging techniques
  - Planar images: 2D
  - SPECT images*: 3D
    - short axis,
    - long axis-LH, LV
  - Gated SPECT: contractile function (LVEF)



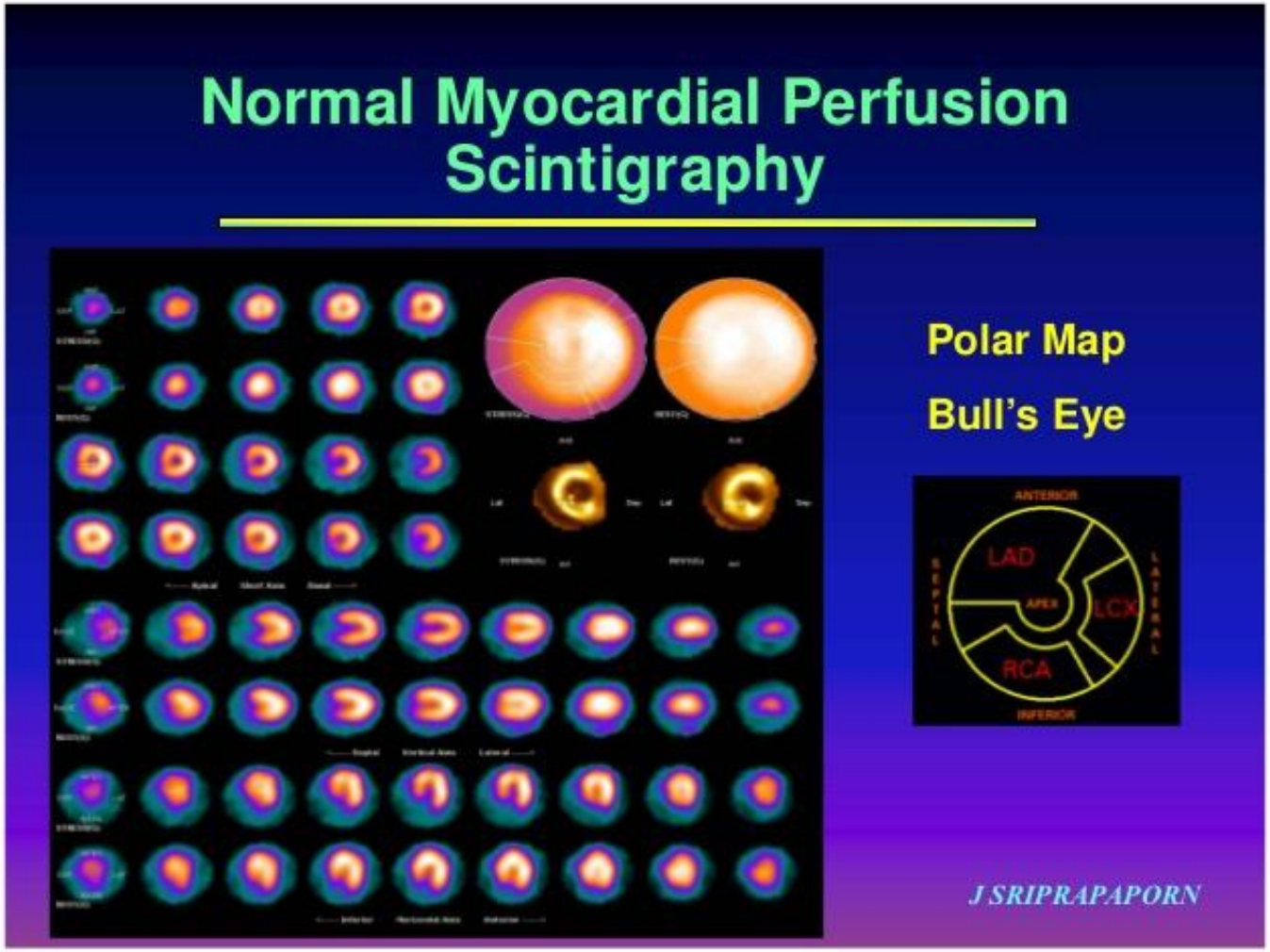
- Interpretation
  - Compare between rest & stress images
    - **Fixed perfusion defect: infarct**
    - **Transient perfusion defect: ischemia**

J SRIPRAPAPORN

Nuclear Study



Nuclear Study



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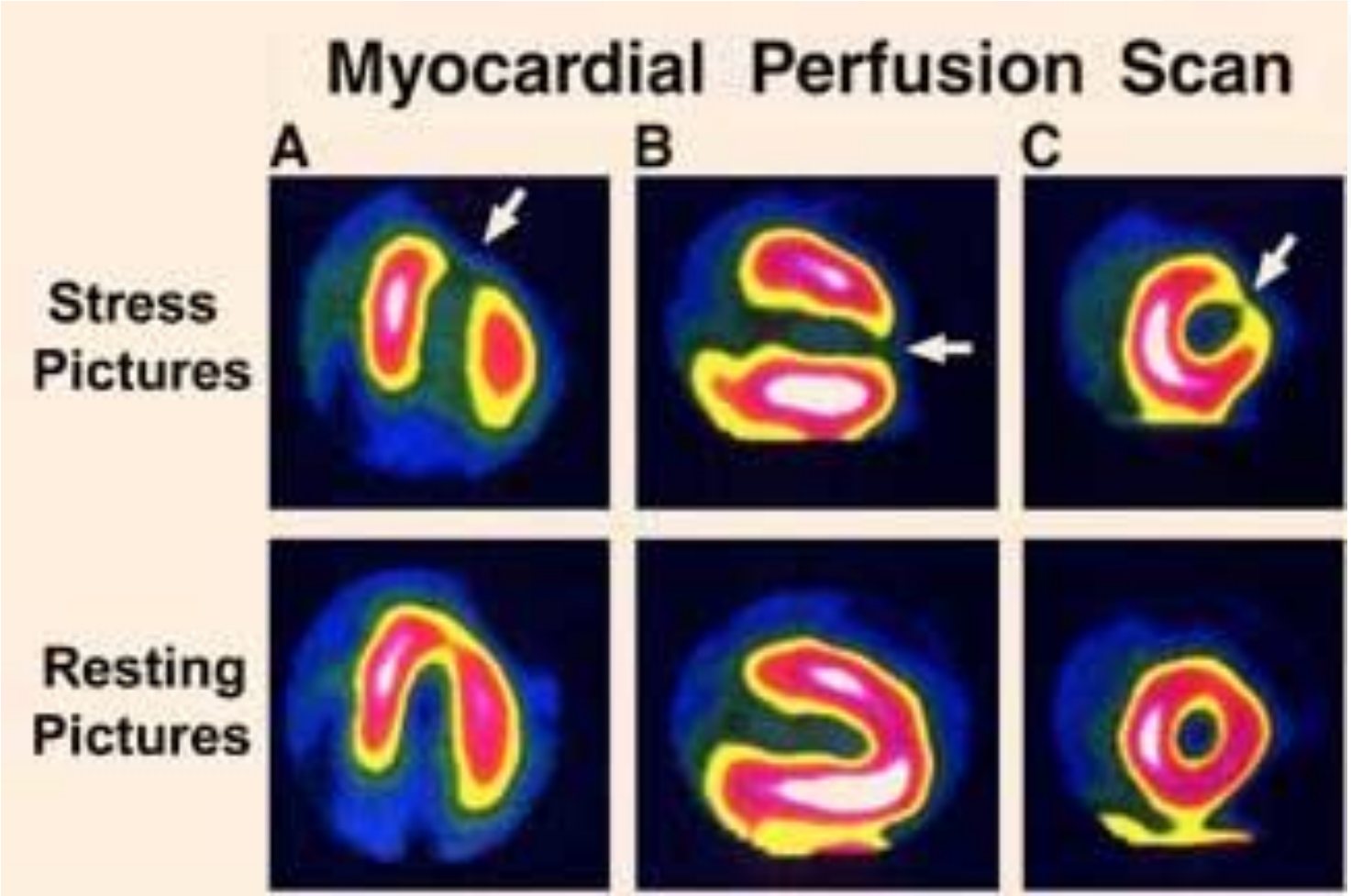
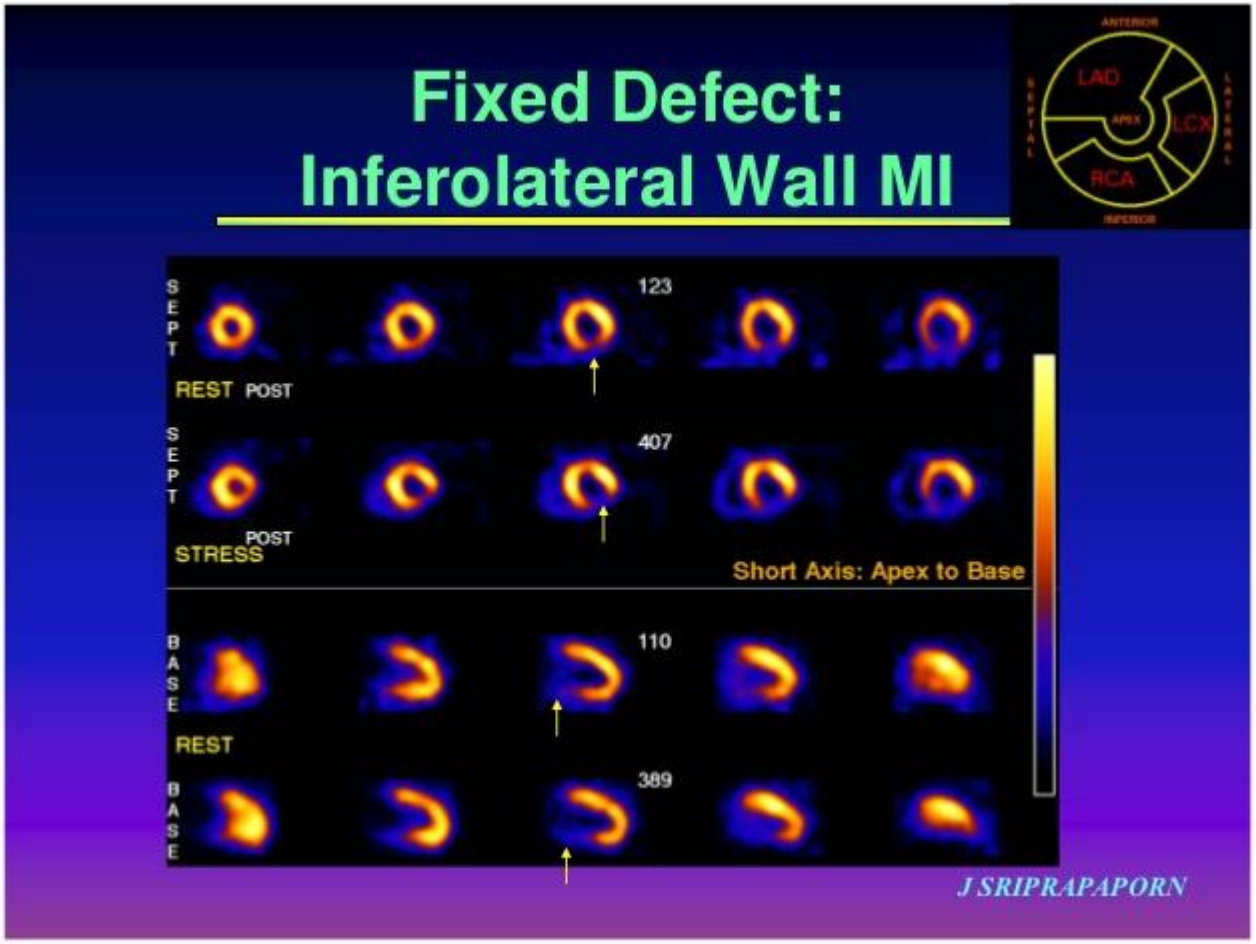
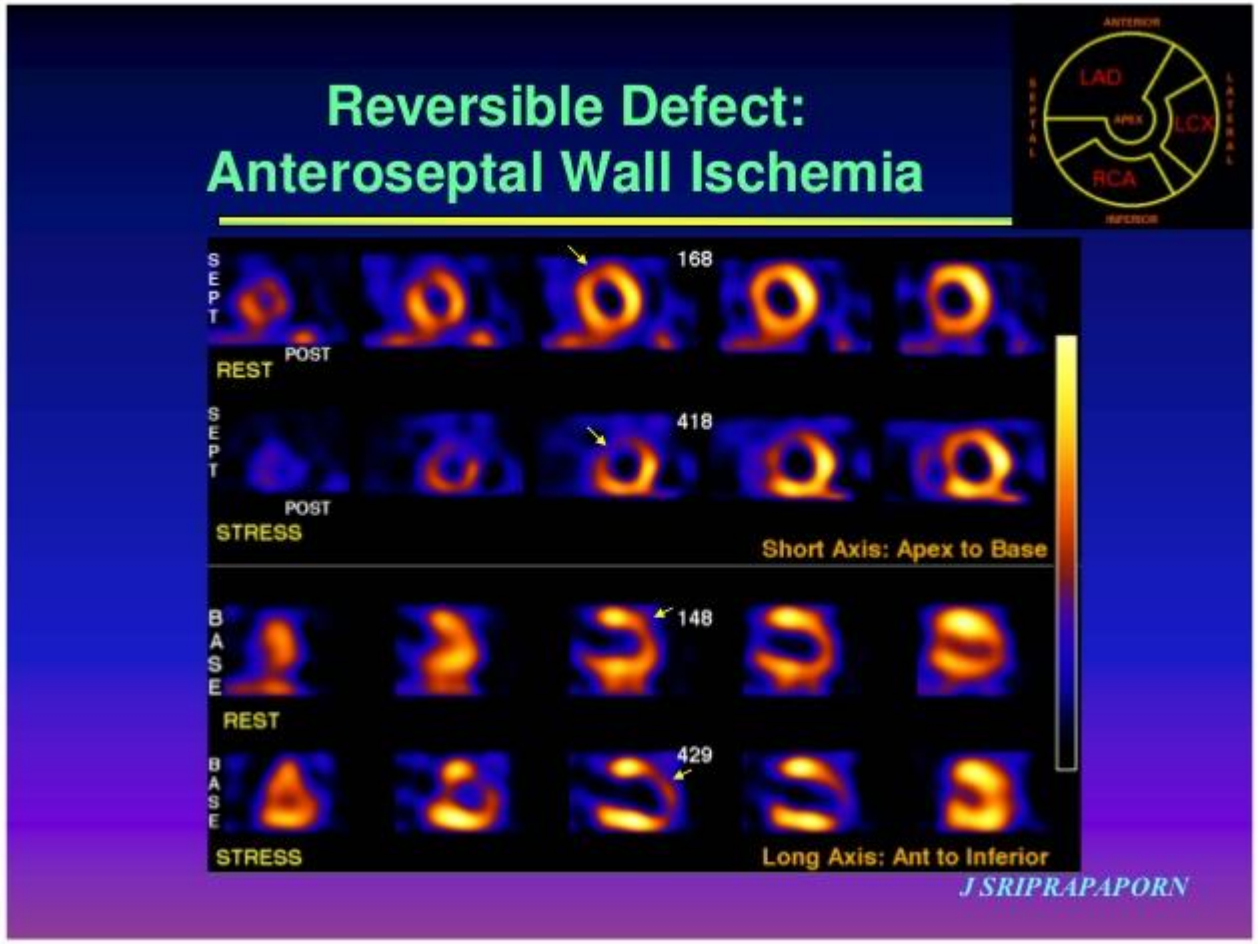


Nuclear Study



Nuclear Study



Cardiac Testing – Sensitivity and Specificity

Comparative Test Statistics on Diagnostic Accuracy in Women Using Contemporary Techniques

	Sensitivity (%)	Specificity (%)
Stress electrocardiography	61	70
Stress echocardiography	86	90
Nuclear (gated SPECT)	84	90

SPECT = Single Photon Emission Computed Tomography

Source: Cardiosource © 2008 by the American College of Cardiology Foundation

Cardiac MRI

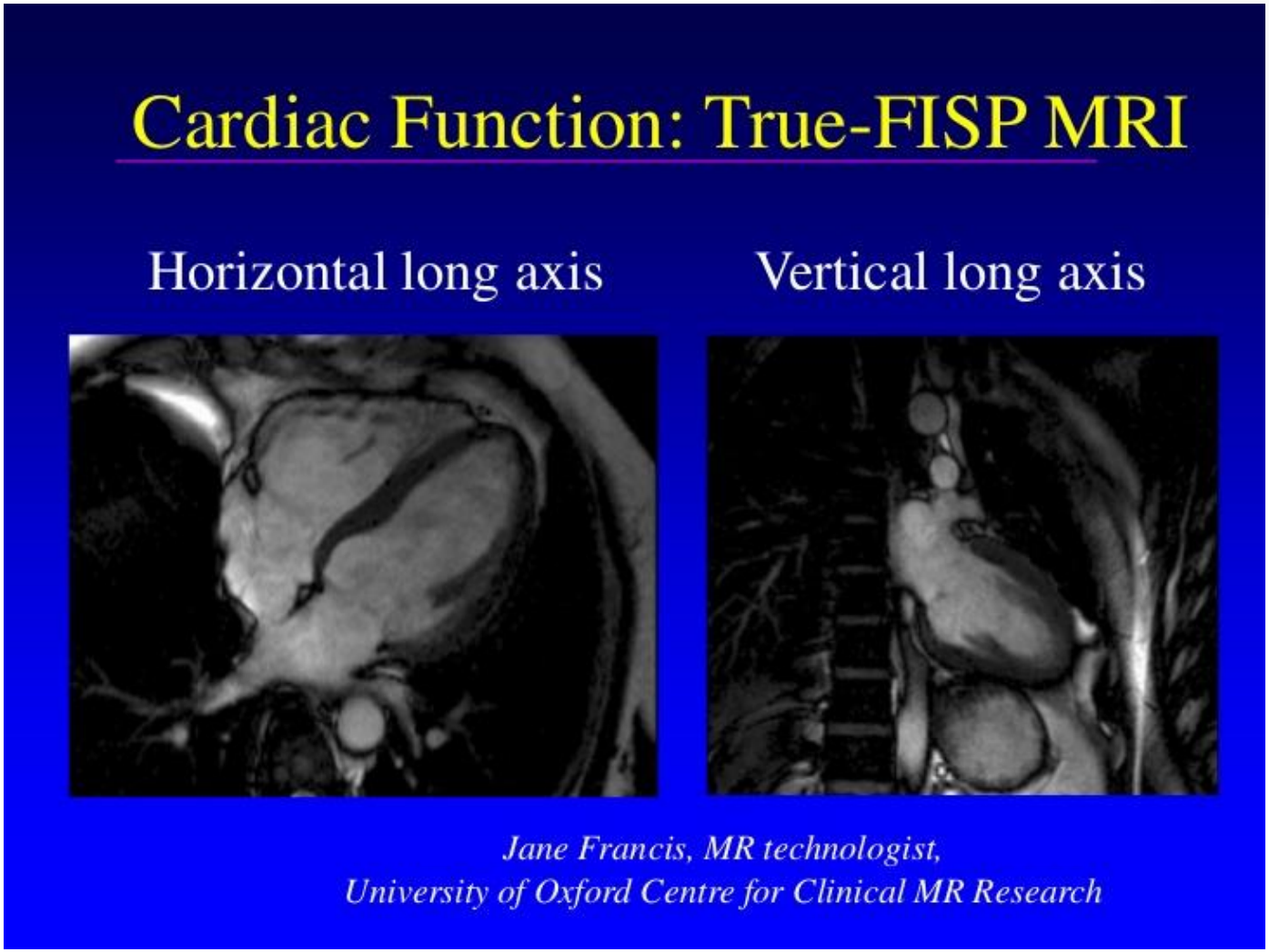
Cardiac MRI

The Comprehensive Cardiac MR (CMR)

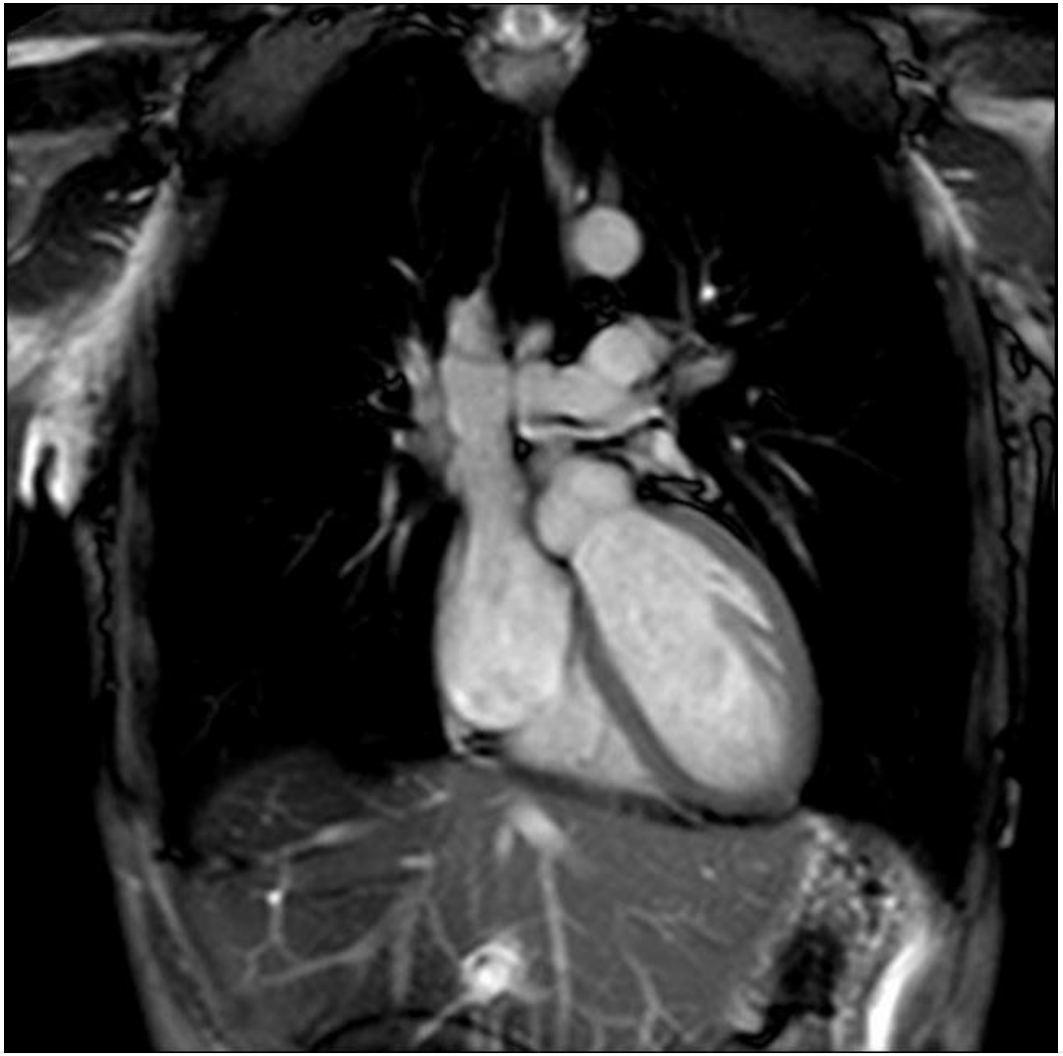
Goal: <30 min acquisition, <10 min post-processing

- Cardiac and great vessel anatomy
- Cardiac volumes and mass
- Global and regional contractile function
- Regional myocardial tissue perfusion
- Regional myocardial tissue characteristics: Viability, oedema, inflammation, fibrosis, metabolism
- Coronary artery lumen, wall anatomy, blood flow

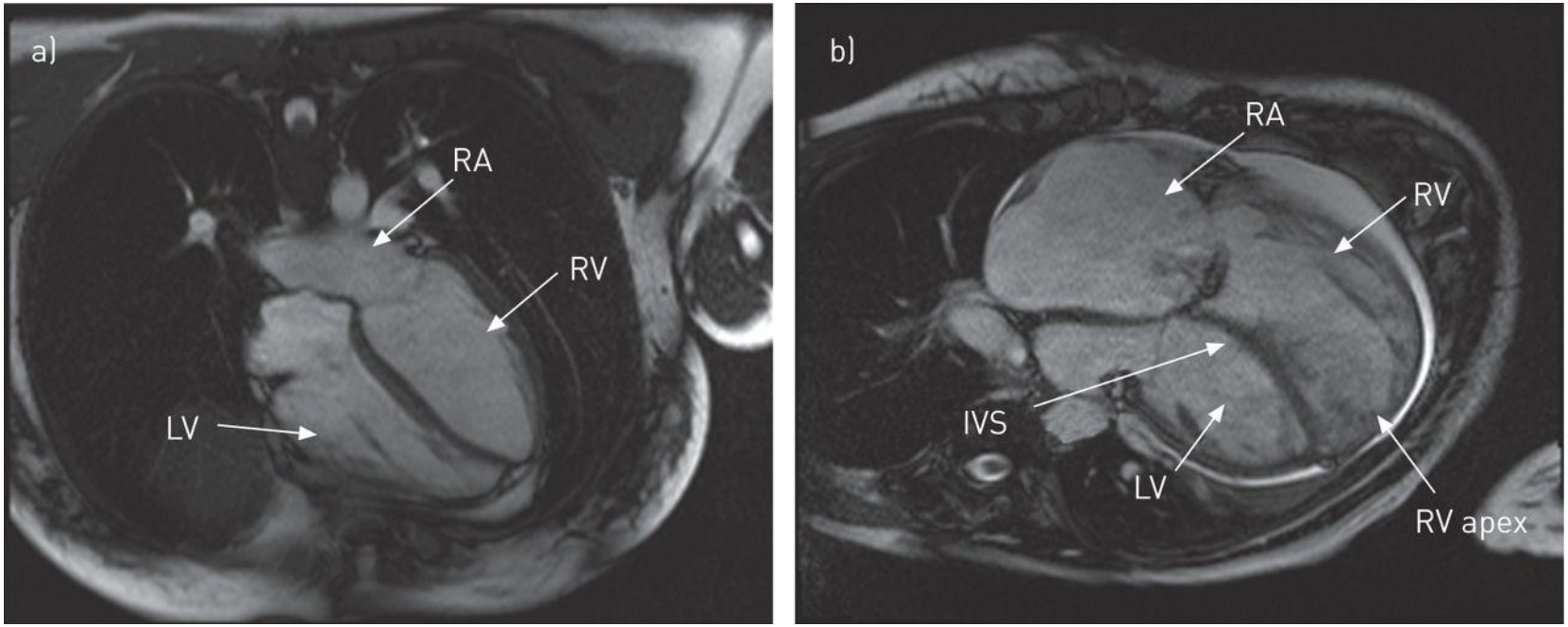
Cardiac MRI


Cardiac Function: True-FISP MRI
Horizontal long axis
Vertical long axis
Jane Francis, MR technologist,
University of Oxford Centre for Clinical MR Research

Cardiac MRI



Cardiac MRI



Cardiac MRI

Cardiac MRI

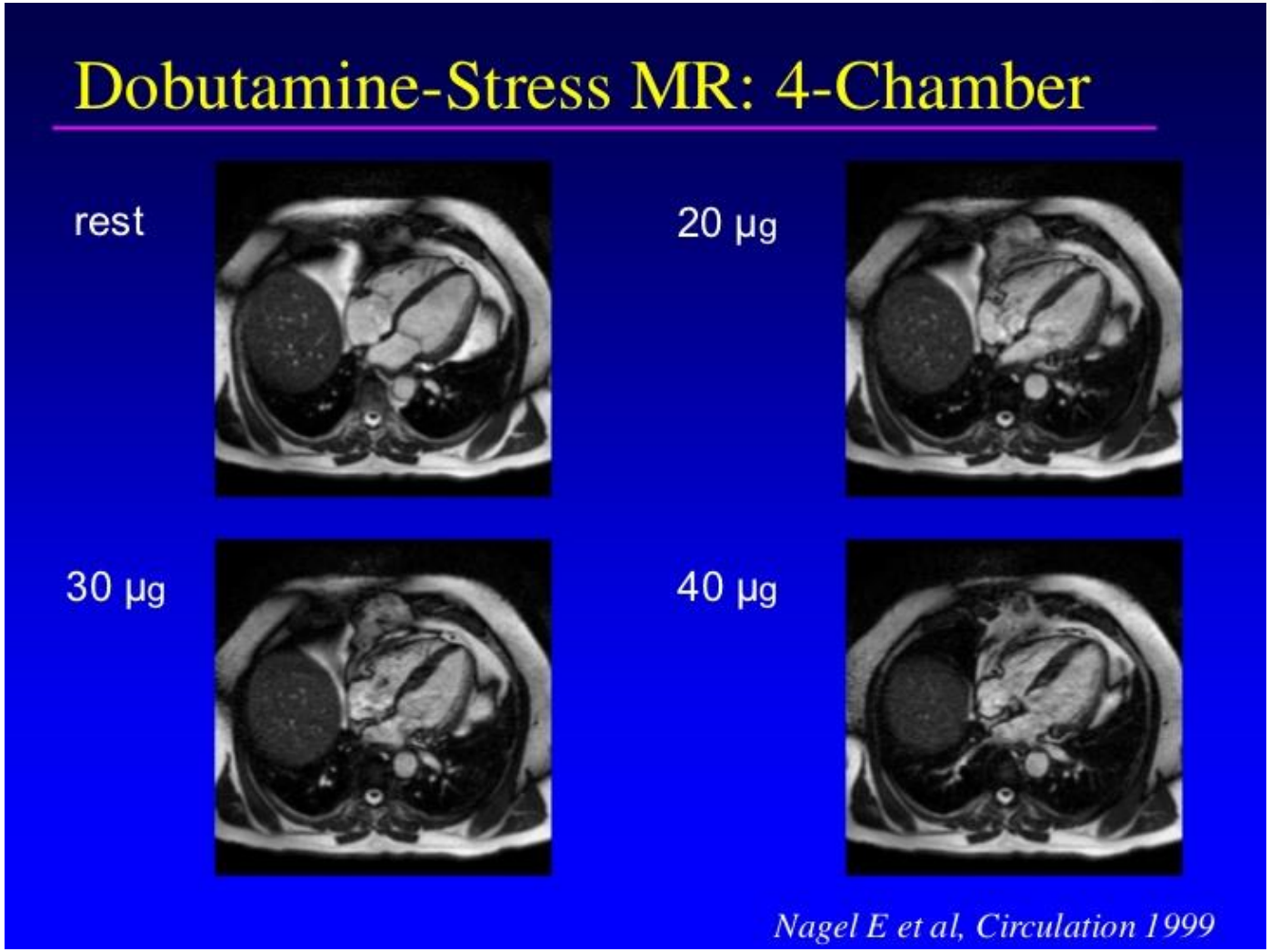
Regional Myocardial Perfusion

Nagel E el al. Circulation 2003

- Sensitivity 88%
- Specificity 90%
- Diagnostic accuracy 89%

Wolff SD et al, Circulation 2004
Giang TH et al, Eur Heart J 2004

Stress Cardiac MRI



Cardiac MRI - Contraindications

- Pacemakers &ICDS
- Intravascular coils,stents,filters(after 6-8wks)
- Prosthesis
- Occluder devices
- Ecg electrodes
- Cochlear implants
- Aneurysmal clips
- Foleys catheter(temp.. Sensors)

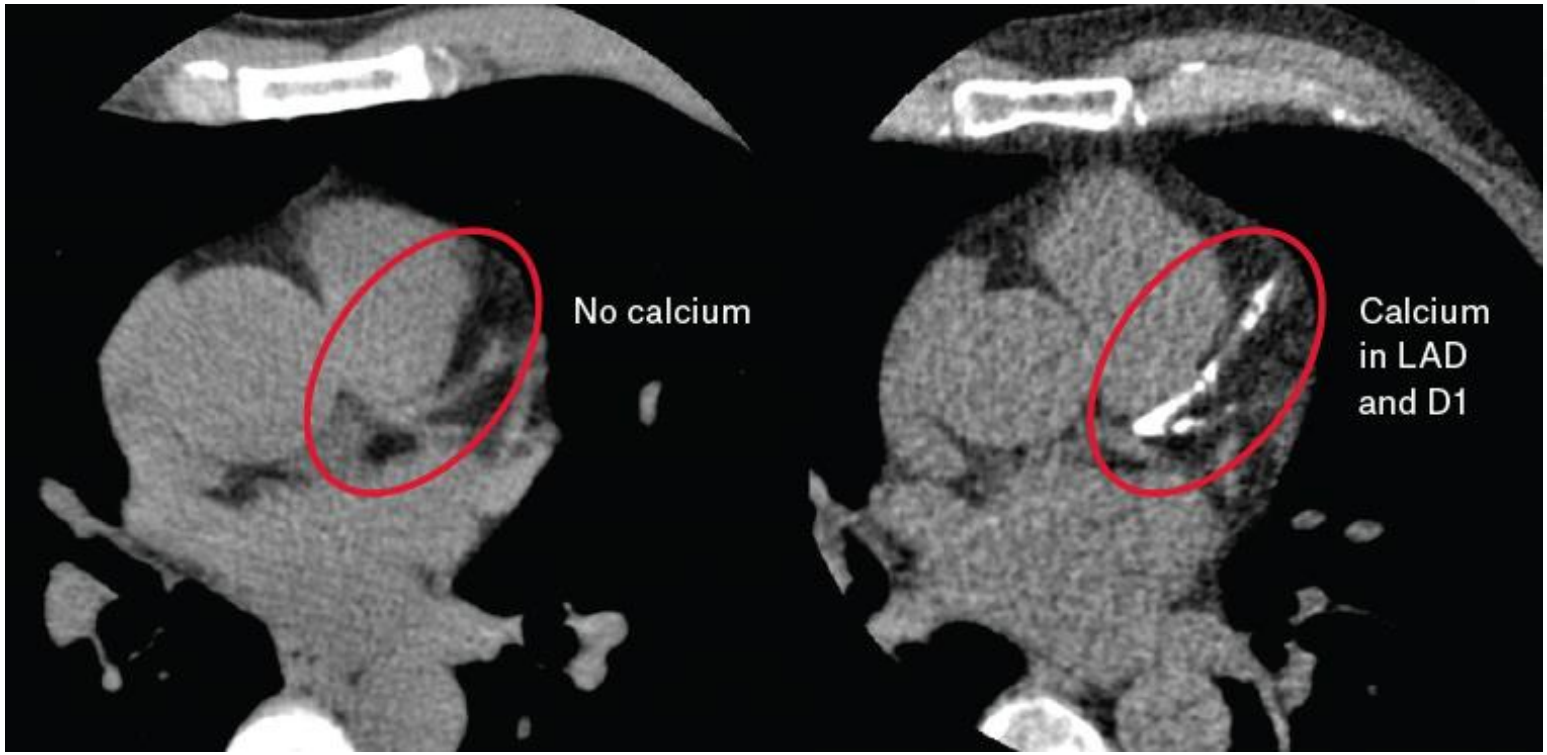
Coronary Artery Calcium (CAC)

- Detect Calcified Atherosclerotic Plaques Burden as a Surrogate Marker for Coronary Atherosclerosis
- Based on principle that atherosclerotic plaques are calcified - so called “hard plaque”
- Calcium is not found in the wall of a normal coronary artery
- Calcified Plaques can be quantified as CAC Score using a CT Scan
- CAC Score powerful marker for the presence and extent of CAD regardless of symptoms
- CAC Score strong determinant of heart attack in people with multiple risk facts
- Dyslipidemia is the principal driver of CAC Score
- Those with high LDL-C are 7 times more likely to have elevated CAC Scored compared to those with low LDL-C (<70 mg/dl)
- At any given age, non-white have approx. half the CAC scores of white; women have approx. half the calcium score of men

CAC Score

- Large prospective studies of asymptomatic individuals have shown that calcium score predicts important CV outcomes, including coronary events, MI and all-cause mortality
- While high scores associated with elevated CV risk, the absence of coronary calcium is a negative risk marker than confers a favorable prognosis.
- Meta-analysis of 71,595 asymptomatic individuals: CV event rate in those with CAC of zero was 0.47% over 50 months of follow-up, compared with 4.14% in those with a positive calcium score
- Studies assessing all-cause mortality reported similarly low event rates of <0.1% annually.
- Negative predictive value of zero CAC greatest in those at intermediate risk by traditional risk calculators.
- Power of zero CAC is limited in high-risk individuals who remain at greater CV risk despite CAC=0
- Many vulnerable plaques that produce heart attack get calcified at a late stage of the atherosclerotic process

Calcium Scoring



Calcium Scoring

Advantages of Coronary calcium scoring

- Gives an idea of whether CAD is present, despite a lack of symptoms or is likely to develop in next few years develop in next few years.
- Non invasive and less time consuming.
- No contrast required needed.
- The examination can suggests the presence of CAD even when the coronary arteries are <50% narrowed.

94

Calcium Scoring

Methods

- Quantitative calcium scores are calculated according to the method described by Agatston et al .

Calcium score= density score x volume

- CAC scores are typically reported for each major coronary artery (left main, left anterior descending, circumflex, right coronary artery) separately

- The total score is achieved by adding up each of the scores for all the slices

Calcium Scoring

WHAT DOES THE CALCIUM SCORE REPRESENT

- Detection of any degree of coronary calcium on CT indicates that CAD is present
- It provides a quantitative estimation of plaque burden. Higher the score the larger the plaque burden & higher the subsequent cardiac events.
- Score of zero indicates unlikely chance of CAD, does not eliminate the possibility.

Calcium Scoring

CALCIUM SCORING GUIDELINES

CALCIUM SCORES	IMPLICATION	RISK OF CORONARY ARTERY DISEASE
0	No identifiable plaque	Very low, less than 5%
1 – 10	Minimal identifiable plaque	Very unlikely, less than 10%
11 – 100	Definite, at least mild atherosclerotic plaque	Mild or minimal coronary narrowing likely
101 - 400	Definite, at least moderate plaque	Mild coronary artery disease highly likely, significant narrowing possible
401 or higher	Extensive atherosclerotic plaque	High likelihood of at least one significant coronary narrowing

Calcium Scoring and Risk of MI

Table 1. Interpretation of coronary calcium score[3]		
Calcium score	Interpretation	Risk of myocardial infarction/stroke at 10 years
0	Very low risk	<1%
1–100	Low risk	<10%
101–400	Moderate risk	10–20%
101–400 and >75th percentile	Moderately high risk	15–20%
>400	High risk	>20%

Calcium Scoring

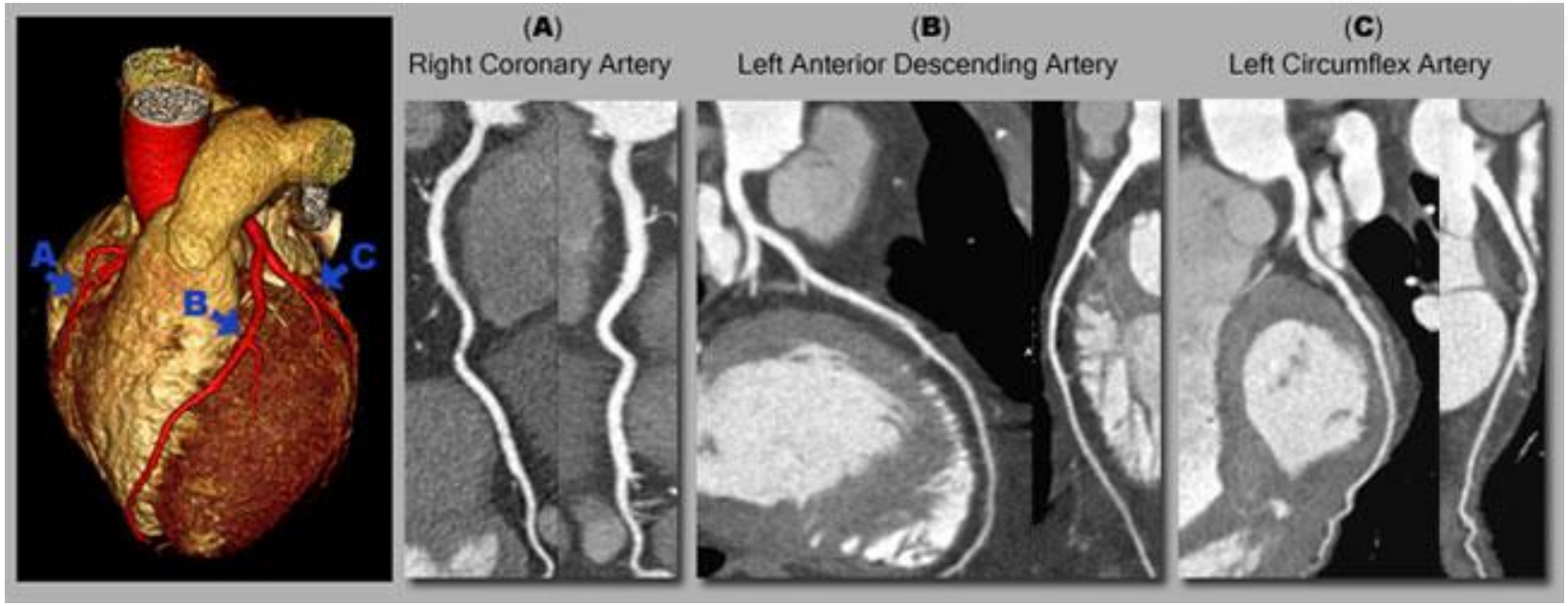
LIMITATIONS

- Not all calcium deposits mean there is a blockade and not all blocked arteries contain calcium.
- The earliest form of CAD soft plaque, cannot be detected by cardiac CT.
- A high heart rate interferes with the test.
- Men <35 yrs and women <40 yrs are not likely to benefit from cardiac CT for calcium scoring unless there is risk factors such as diabetes or a strong family history of heart disease.

95

Coronary CT Angiogram

Coronary CT Angiogram



Coronary CT Angiogram

INDICATION

- Screening high risk patients
- Evaluation of chest pain
- Post procedural study
  - Post CABG
  - Post stent
- Dilated Cardiomyopathy
- Non-cardiac surgery evaluation

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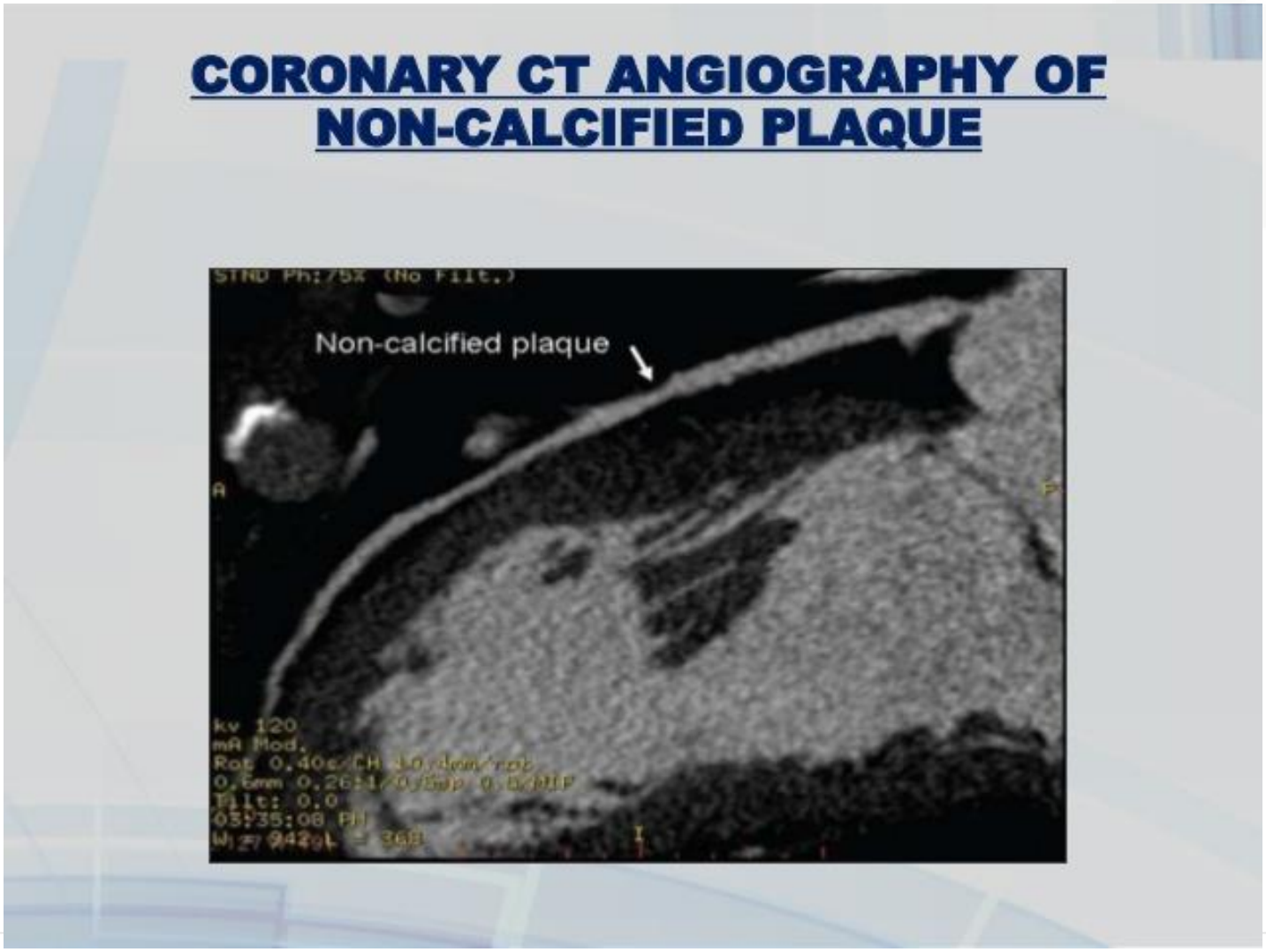
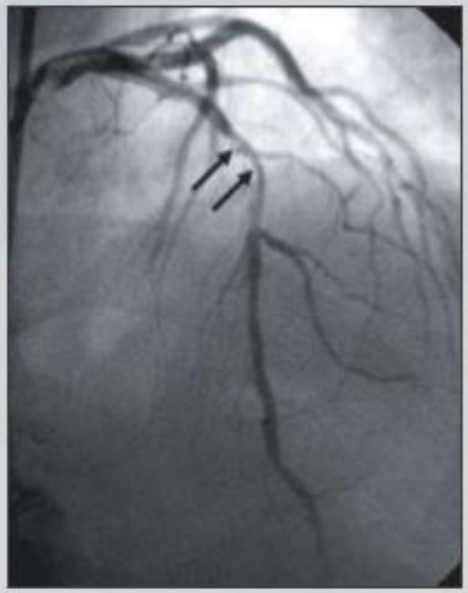
Coronary CT Angiogram



Coronary CT Angiogram

CORONARY CT ANGIOGRAPHY OF CALCIFIED PLAQUES



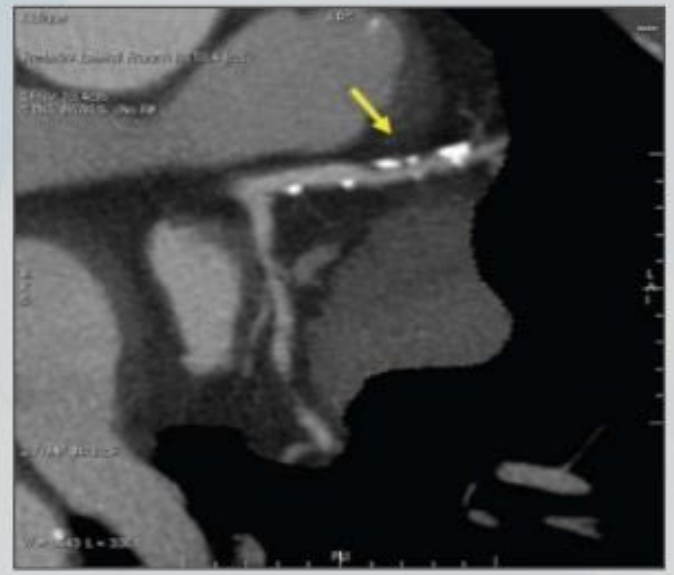
A significant stenosis of
LAD is confirmed on coronary angiography

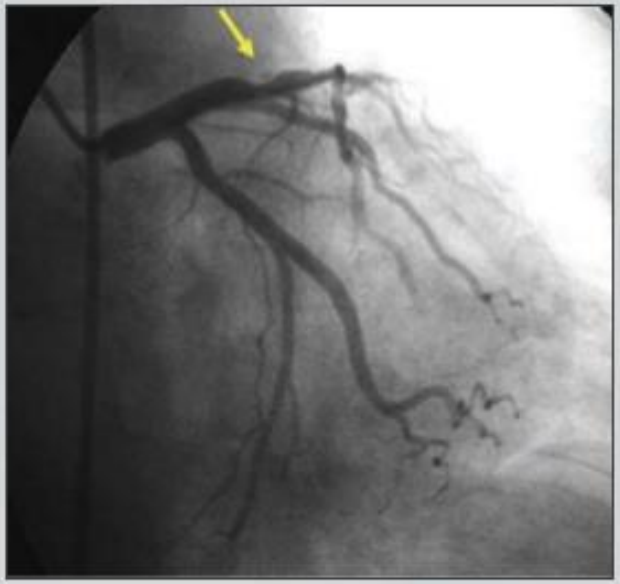
Extensive calcified plaques are noticed in the proximal and middle segments of left anterior descending (LAD) on curved multiplanar reformatted

Extensive calcified plaques are noticed in volume rendering images

Coronary CT Angiogram

CORONARY CT ANGIOGRAPHY OF MIXED PLAQUES





Coronary CT angiography of mixed plaques. Mixed plaques are observed in the proximal segment of the left anterior descending (LAD) artery with > 50% stenosis (a, arrow). Coronary angiography confirms the significant stenosis of the LAD (b, arrow).

Coronary CT Angiogram

GRADING

- 0 Normal: Absence of plaque and no luminal stenosis
- 1 Minimal: Plaque with <25% stenosis
- 2 Mild: 23%-49% stenosis
- 3 Moderate: 50%-69% stenosis
- 4 Severe: 70%-99% stenosis
- 5 Occluded

Raff GL, Abidov A, Achenbach S, et al: SCCT guidelines for the interpretation and reporting of coronary computed tomographic angiography. J Cardiovasc Comput Tomogr 3:122, 2009.

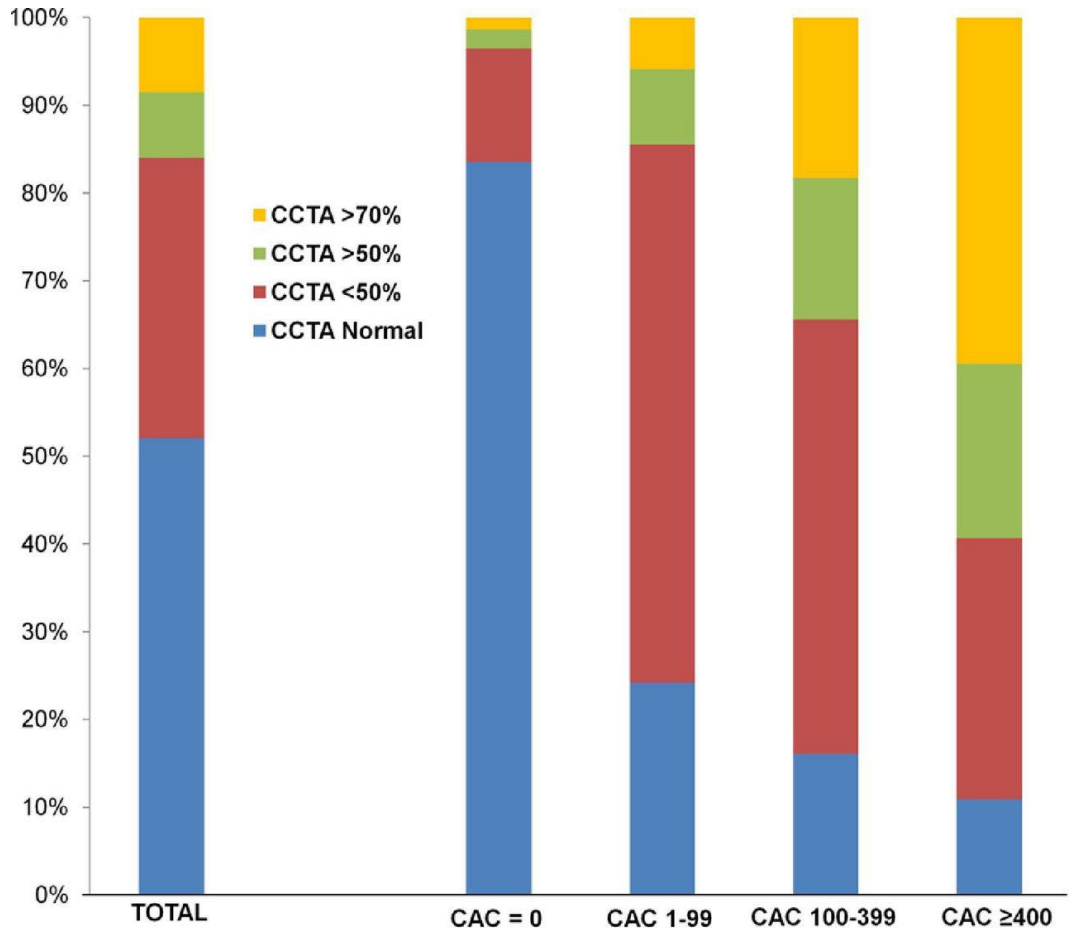
Coronary CT Angiogram

Limitations of CT coronary angio

- Rapid (>80 bpm) and irregular heart rate.
- High calcium scores (>800-1000)
- Presence of stents
- Contrast requirements
- small vessels (<1.5 mm) and collaterals
- Obese and uncooperative patients
- Radiation exposure

Coronary Artery Stenosis on CCTA

- Journal of the American College of Cardiology, Dec/11; more than 10,000 symptomatic patients; mean age 57



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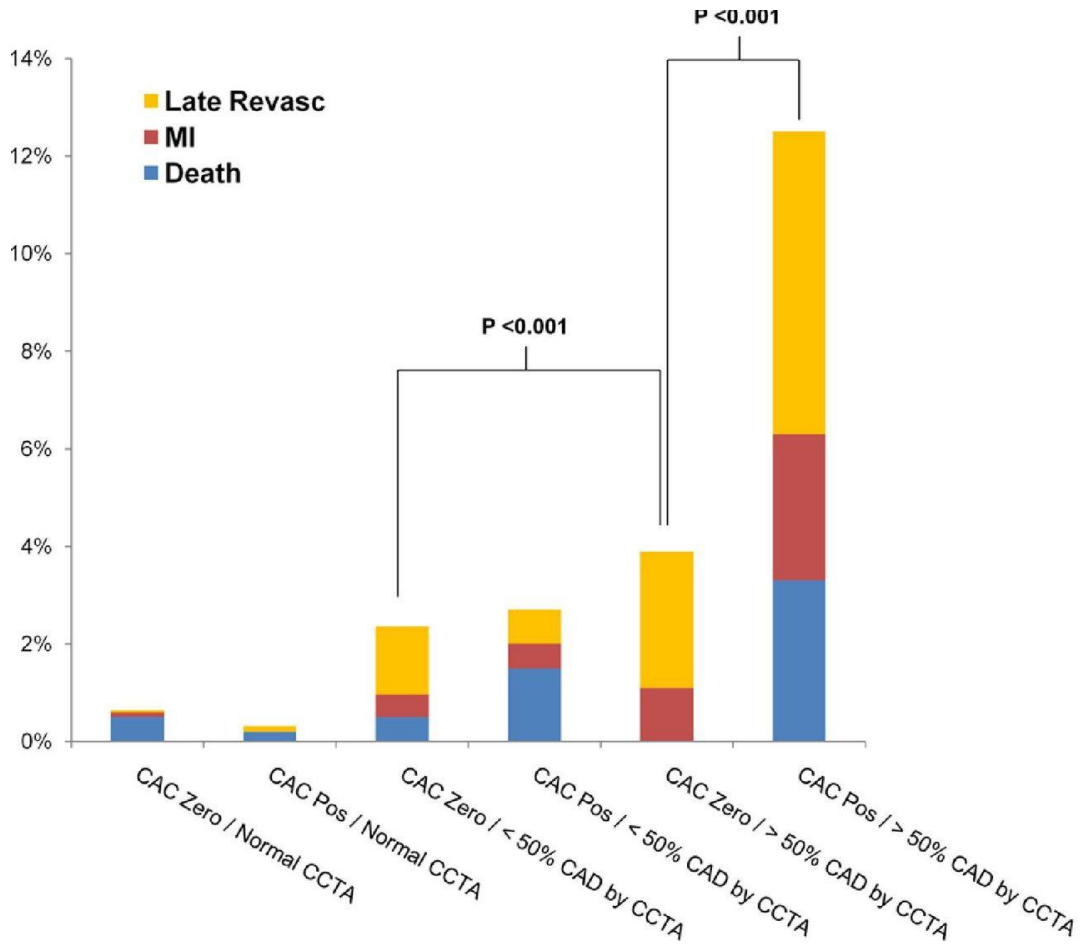
Major Adverse Events Stratified by CAC Score and Stenosis

- Journal of the American College of Cardiology, Dec/11; more than 10,000 symptomatic patients; mean age 57



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Cardiac Testing – Sensitivity and Specificity

Type of Stress Testing	Studies, n	Patients, n	Sensitivity, %	Specificity, %
Meta-analysis of standard stress ECG testing	147	24 047	68	77
Excluding MI patients	41	11 691	67	74
Perfusion scintigraphy	2	28 751	89	80
Exercise echocardiography	58	5000	85	79
Nonexercise stress tests				
Pharmacological stress scintigraphy	11	<1000	85	91
Dobutamine echocardiography	5	<1000	88	84
EBCT (from O'Rourke et al[23])	16	3683	91	49
EBCT (from Nallamothu et al[24])	9	1662	92	51

Adapted from O'Rourke et al.[23]

Coronary Angiography – An Accidental Discovery

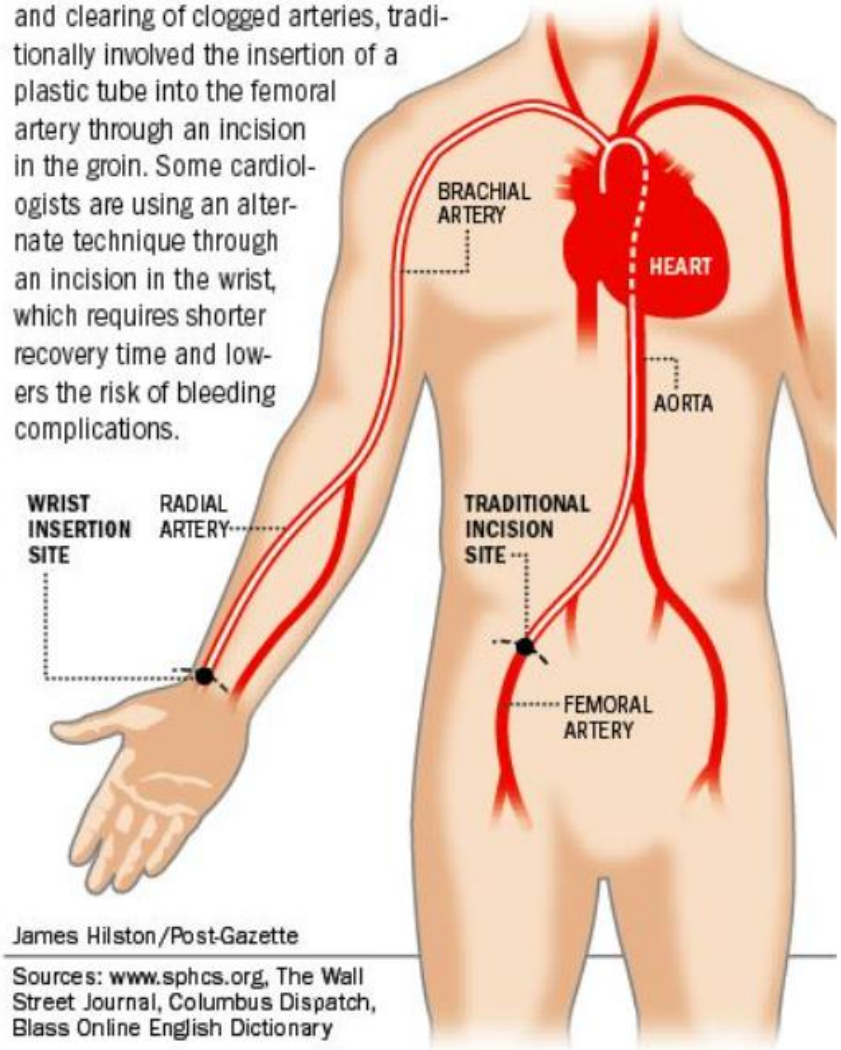
Oct. 30, 1958: Medical Oops Leads to First Coronary Angiogram

First Coronary Angriogram – The Discovery

- In the basement lab of an Ohio hospital, a cardiologist, Dr. F. Mason Sones Jr, accidentally injected a large amount of dye into the coronary vessels of patient during a routine imaging test
- Sones was attempting to look at the heart valves of a 26 year old man with RA
- The procedure required injecting 40-50ml of contrast dye into the pt's aorta
- As the dye was to be injected, the tib of the tube flipped into the right coronary artery
- To his surprise, the dye did not cause a fatal heart spasm
- Conventional wisdom at the time held that injecting contrast into the coronary arteries would cause a fatal ventricular fibrillation
- Over the next few years, Sones and colleagues at the Cleveland Clinic developed the technique of cardiac catheterization
- By 1967, Sones had performed more than 8200 coronary catheterizations
- He is known as the Father of Modern Cardiac Imaging
- After Sones' death in 1985, Dr. Rene Favaloro of Argentina, the first surgeon to perform coronary artery bypass surgery, said *"without the work of Dr. Mason Sones Jr – the most important contributor to modern cardiology – all our efforts in myocardial revascularization would have been fruitless"*

Coronary Angiography – The Gold Standard

Cardiac catheterization, the detection and clearing of clogged arteries, traditionally involved the insertion of a plastic tube into the femoral artery through an incision in the groin. Some cardiologists are using an alternate technique through an incision in the wrist, which requires shorter recovery time and lowers the risk of bleeding complications.

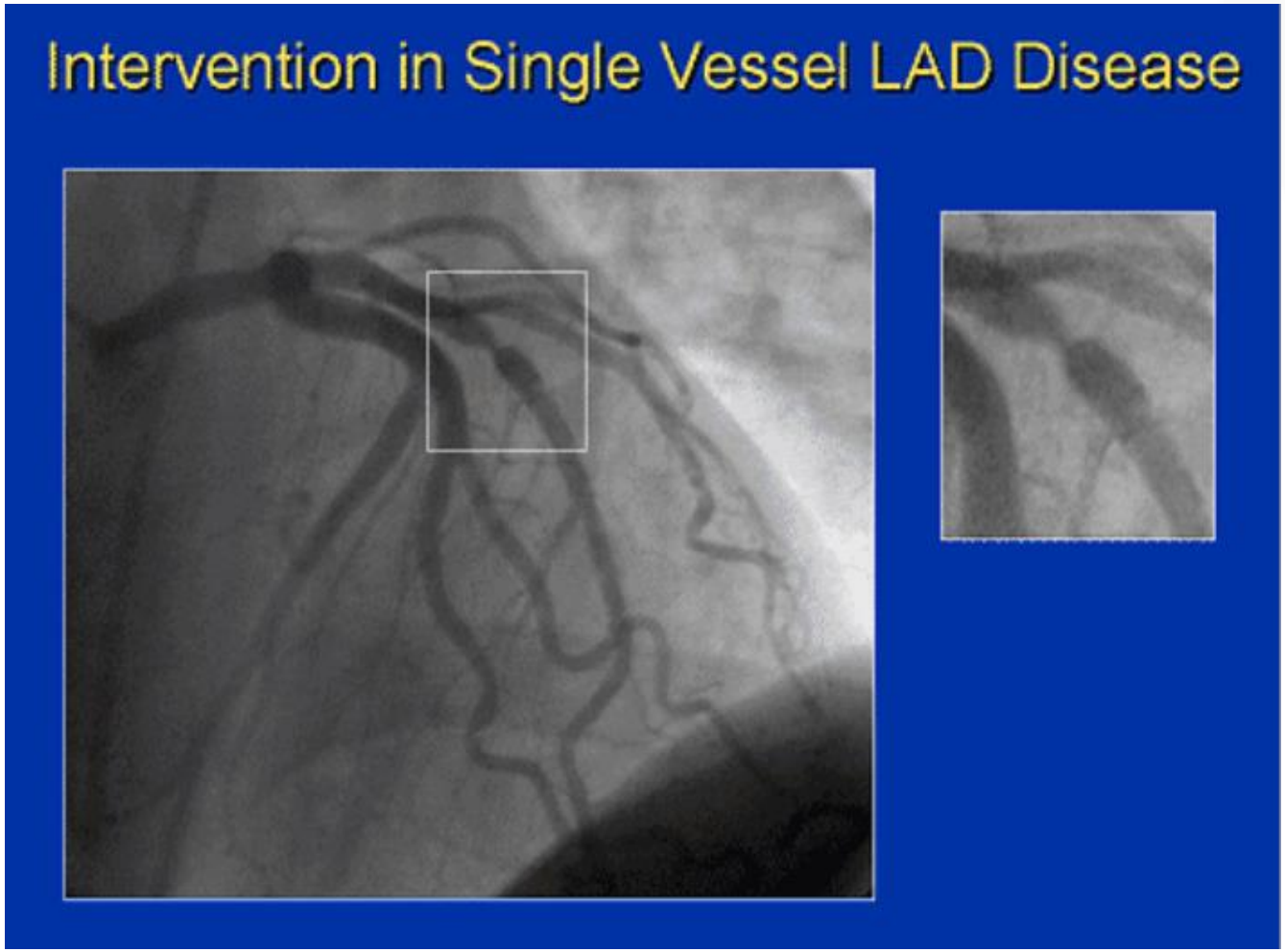


James Hilston/Post-Gazette

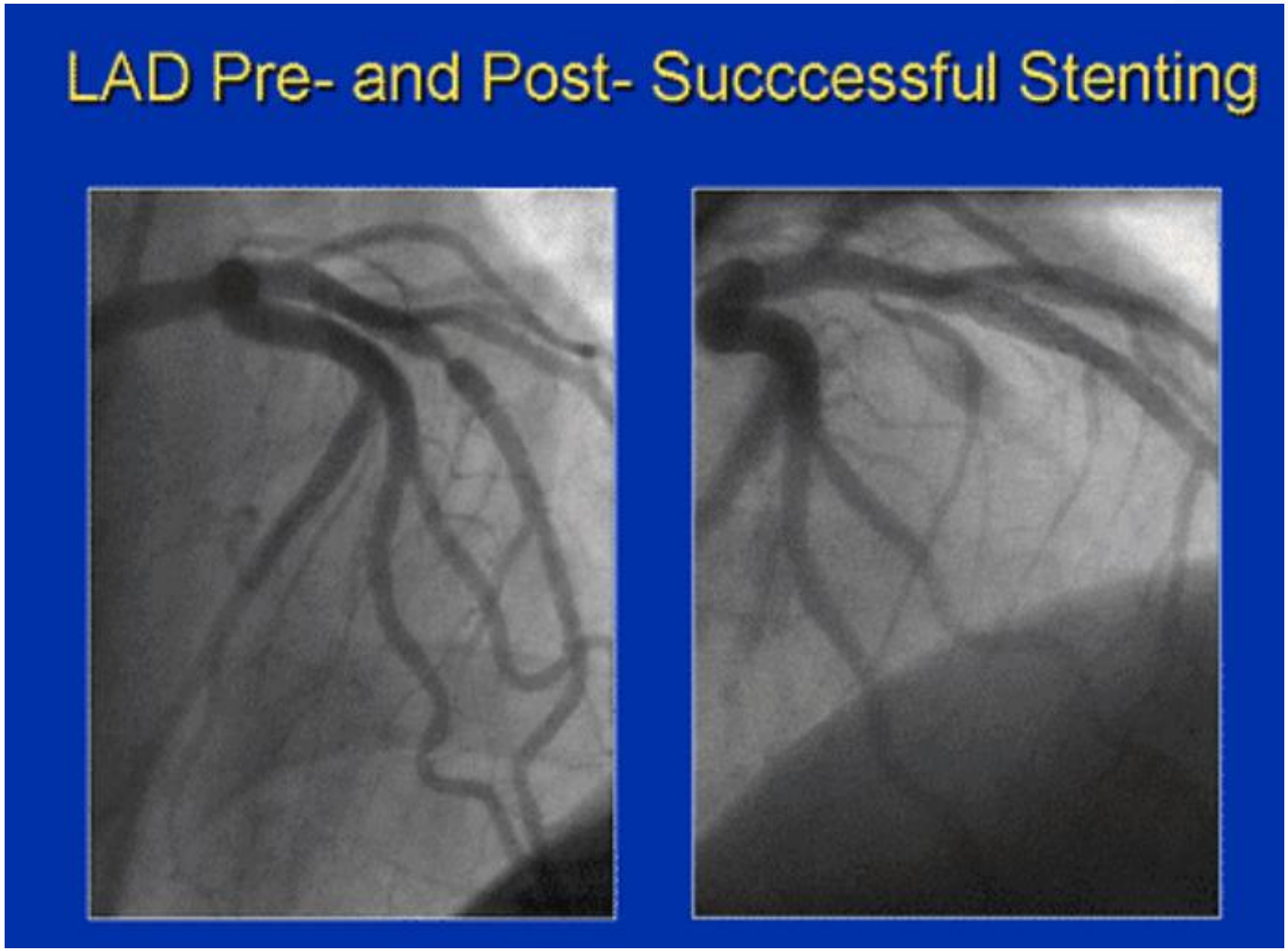
Sources: www.sphcs.org, The Wall Street Journal, Columbus Dispatch, Blass Online English Dictionary

Coronary Angiography – The Gold Standard

Coronary Angiography – The Gold Standard



Coronary Angiography – The Gold Standard



Coronary Angiography – Contraindications

Contraindications:

- Coagulopathy
- Active bleeding
- Malignant hypertension
- Acute or chronic renal failure
- Severe anemia (Hb < 10gm/dl of blood)
- Electrolyte imbalance
- Fever
- Active systemic infection
- Uncontrolled rhythm disturbances (arrhythmias)
- Uncompensated heart failure
- Transient Ischemic attack
- Patient unable to cooperate or does not desire procedure

Coronary Angiography – Complications

Complication:

Life threatening complications are rare (~1 in 1000) but more common in patients with serious disease, eg. Left main stem disease, aortic or peripheral vascular disease.

Major complications:

1. MI
2. Stroke
3. Renal failure
4. Aortic or coronary dissection
5. Cardiac rupture
6. Air embolism
7. Arrythmia
8. Peripheral vascular damage

ADAM

Coronary Angiography – Complications

Contrast nephropathy(CIN):

- Radiocontrast media can lead to a usually reversible form of acute kidney injury (formerly called ARF) that begins soon after the contrast is administered . In most cases, there are no permanent sequelae, but there is some evidence that its development is associated with adverse outcomes.

- Contrast-mediated nephropathy (CIN) was defined by an absolute increase of serum creatinine ≥0.5 mg/dL or a relative increase of ≥25% measured 2 to 5 days after the procedure. (AHA)

Coronary Angiography – Final Thoughts

- You can put a stent in the coronary artery but unless you treat the systemic disease that caused the disease to develop, you will NOT change the outcome.
- The intervention will not treat the underlying arterial plaque
- The intervention will treat the 1% of the plaque the angiographer can see; it will not treat the 99% of the plaque the angiographer cannot see
- A number of studies have shown that Optimal Medical Therapy (OMT) – consisting of diuretics, beta-blockers, CCBs, nitrates, and aggressive control of BP and Cholesterol – can be just as effective as PCI in treating some forms of CAD
- The landmark **COURAGE** study – Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation): NEJM 2007, 2287 adults with stable CAD, provided either OMT or a combination of PCI and OMT. At the end of the 5 yr study, those with OMT no greater risk of heart attack or death those offered PCI/OMT. PCI was no better at relieving angina symptoms than OMT.

Coronary Angiography – Final Thoughts

- Follow-up study in 2015: when PCI used in people with stable CAD, the procedure undermined its own benefits in three ways:
  - PCI tends to injure the artery wall and increase the risk of secondary obstruction. 21% of the PCI group required another stent within 6 months; 60% of the treated vessels required re-stenting
  - PCI associated with greater risk of post-op bleeding, heart attack and stoke in those with stable CAD compared to no treatment
  - People who undergo PCI tend to return to dietary habits that likely contributed to their CAD in the first place

Coronary Angiography – Final Thoughts

- Benefits of PCI:
  - **STEMI** – the blockage is usually severe and more likely to cause significant heart damage; If PCI performed within 12 to 72 hours of symptom onset, can reduce extent and severity of damage
    - 2015 study from France showed the PCI within 24 hour of a STEMI translates to a 5 yr survival rate of 85% compared to only 59% in those who receive no treatment
  - **NSTEMI** – the blockage is partial and temporary
    - 2018 study of 6,747 adults with NSTEMI, early PCI reduced risk of death during the first 28 days by as much as 58% c/w delayed treatment.
    - *2016 Cochrane review concluded that the use of PCI in pts with NSTEMI lowers the risk of heart attack over the next 3-5 years BUT doubles the risk of heart attack during or soon after the procedure*
  - **Unstable Angina/Acute Coronary Syndrome** – partial obstruction of coronary artery causes chest pain and other symptoms

Cardiac Testing - Final Thoughts

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Final Thoughts – Lifestyle Changes are Difficult

ALL YOU HAVE TO DO IS CHANGE EVERYTHING ABOUT THE WAY YOU LIVE.

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Thank you!

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Questions

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