



Dr Chris Ellis

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Auckland

Saturday, June 10, 2017

11:30 - 12:00 ECGs for Nurses, and The Basics of CT Heart Scanning

ECGs for Nurses, and the Basics of CT Heart Scanning

Dr Chris Ellis

Cardiologist

Greenlane CVS Services,
Auckland City Hospital
& Auckland Heart Group

NZMA Rotorua 2017 CME

10 June 2017: 11.30



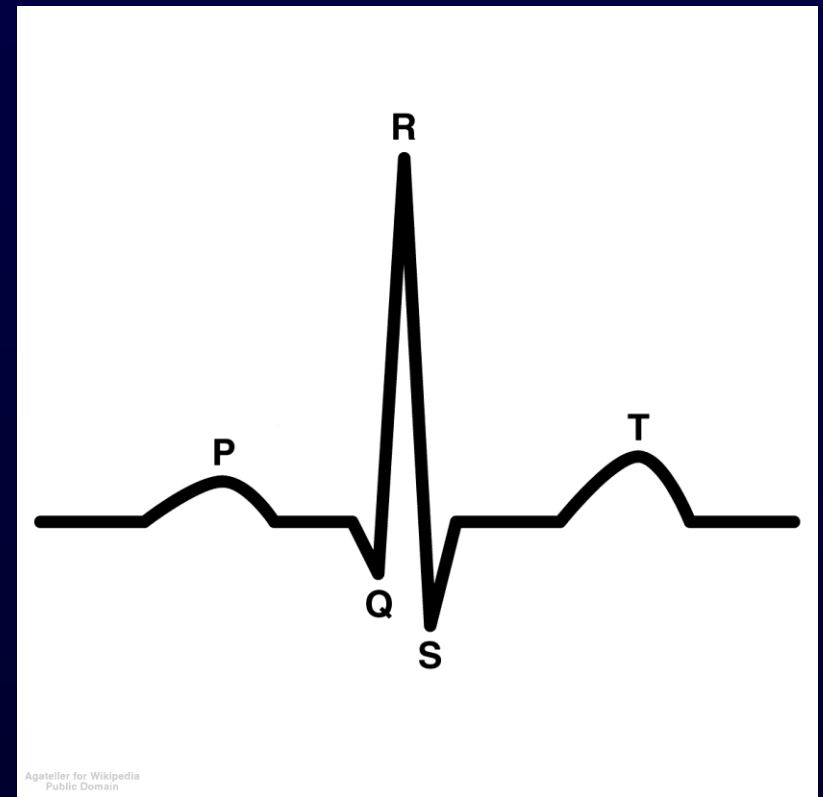
ECGs for Nurses



Heart Disease: The Central Role of the ECG

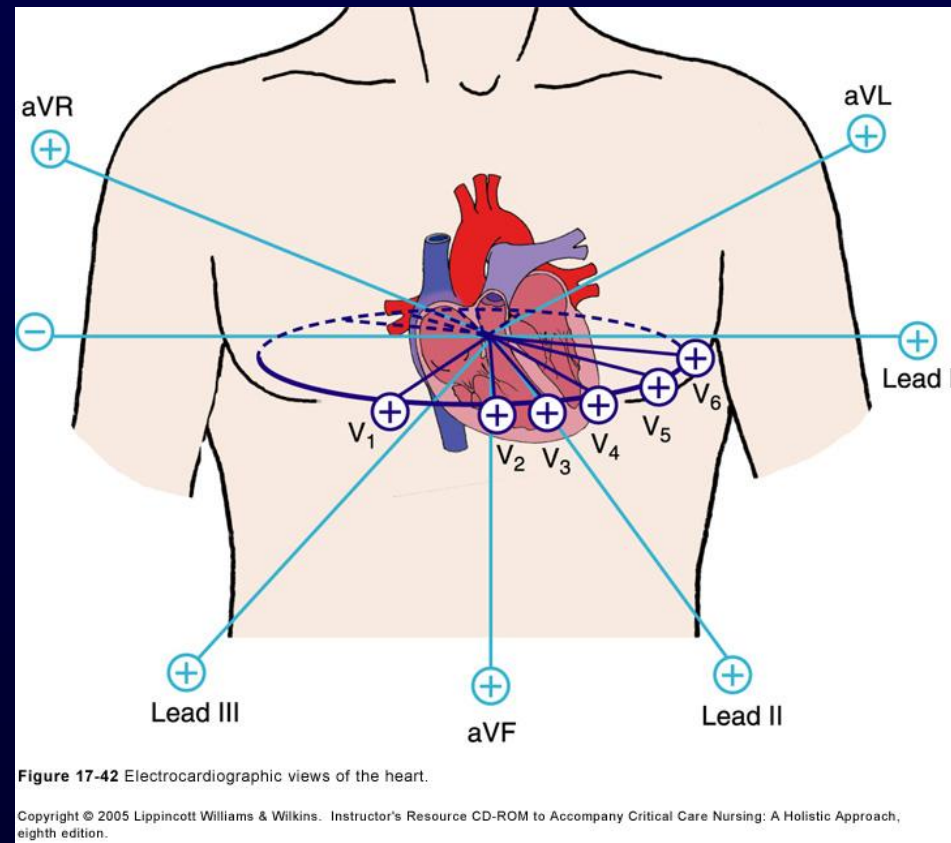
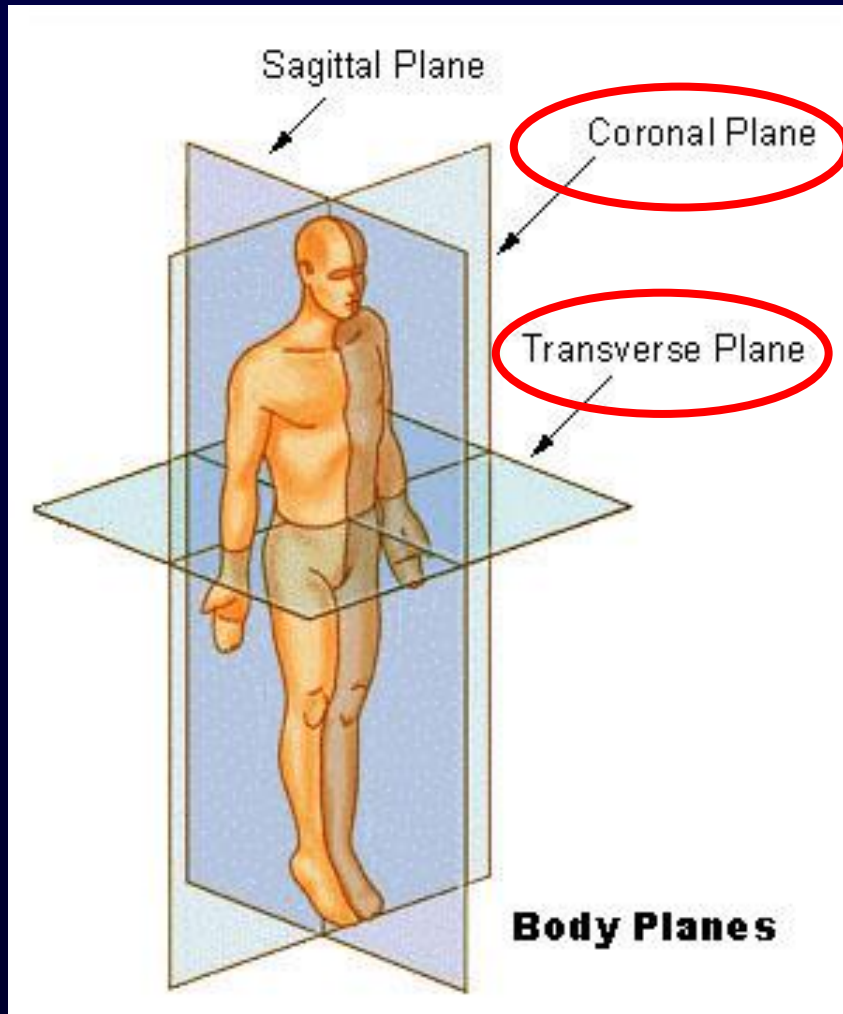
Community Assessment:

- History, Examination
- ECG
- Blood tests, Chest X-Ray



ECG: Standard leads in Coronal Plane

Chest Leads in Transverse Plane



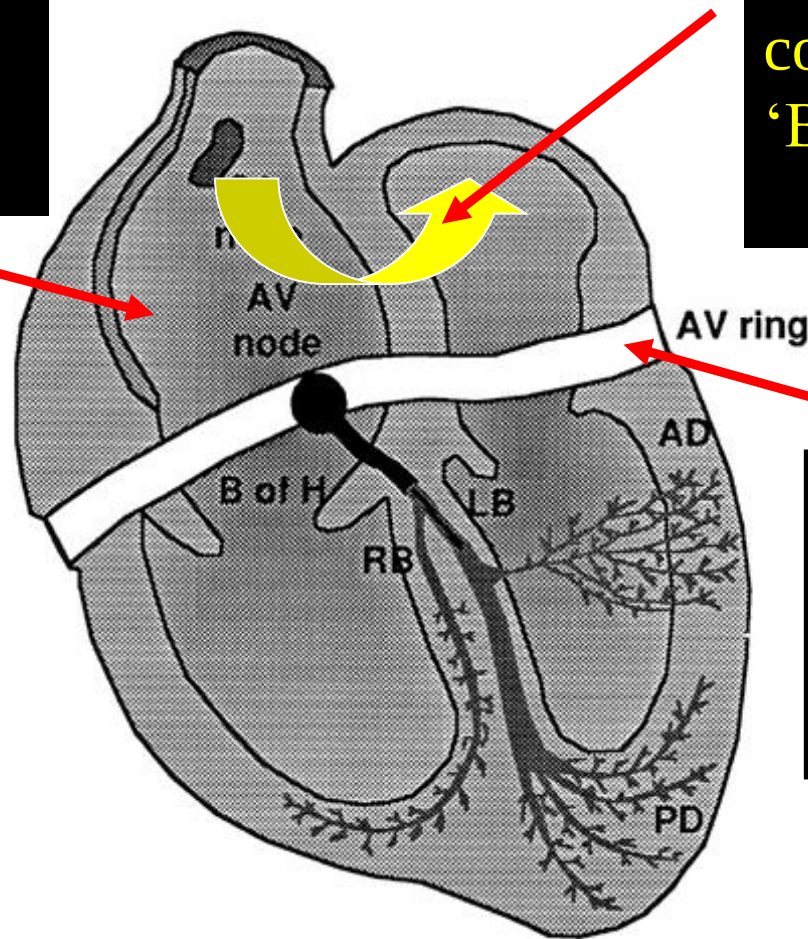
ECG: The Basics

- Electrical ‘depolarisation’ precedes muscle contraction
 - Skin electrodes can detect this electrical activity
- Atrial muscle mass is small
 - Electrical current is small
 - P wave is small
- Left ventricular muscle mass is more than RV muscle mass
 - The QRS complex is dominated by the LV current
 - QRS is large
- T wave records ‘repolarisation’ of muscle mass

Diagram of the Cardiac Conducting System

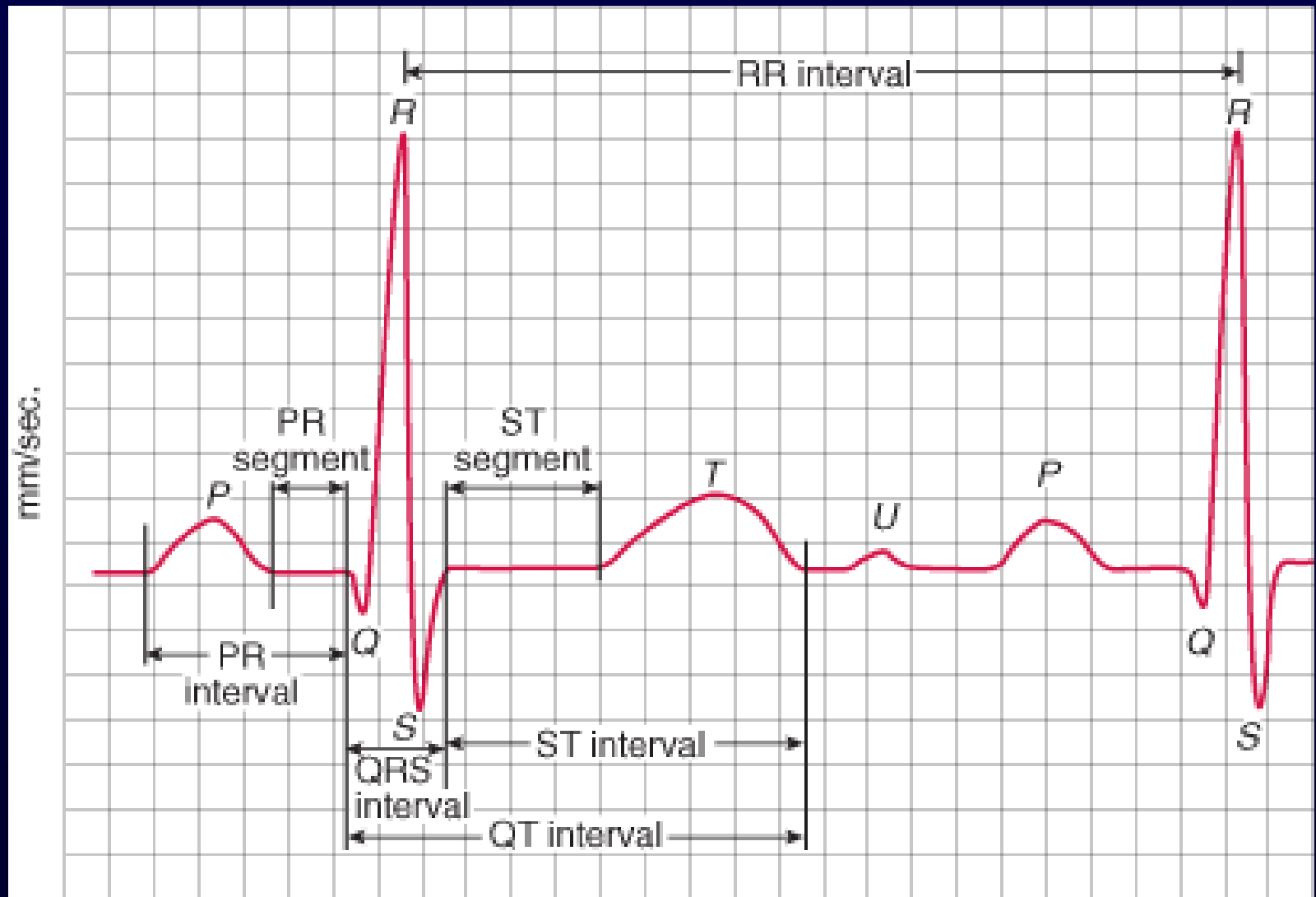
Cell to cell
conduction in
RA

RA to LA via
conduction tissue:
'Bachmann's bundle'



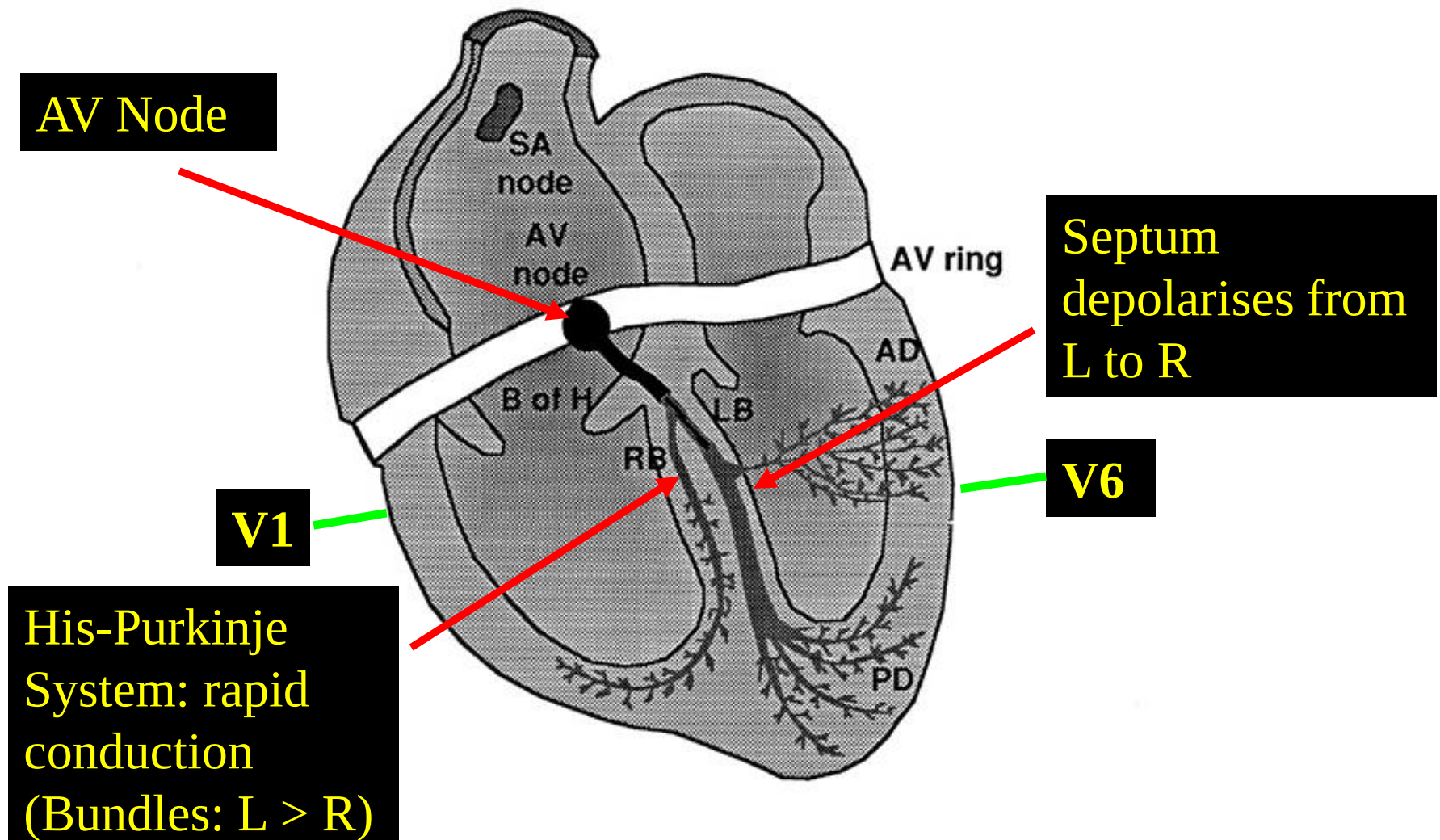
Fibrous ring
supporting TV &
MV is an electrical
insulator

ECG: Standard Nomenclature

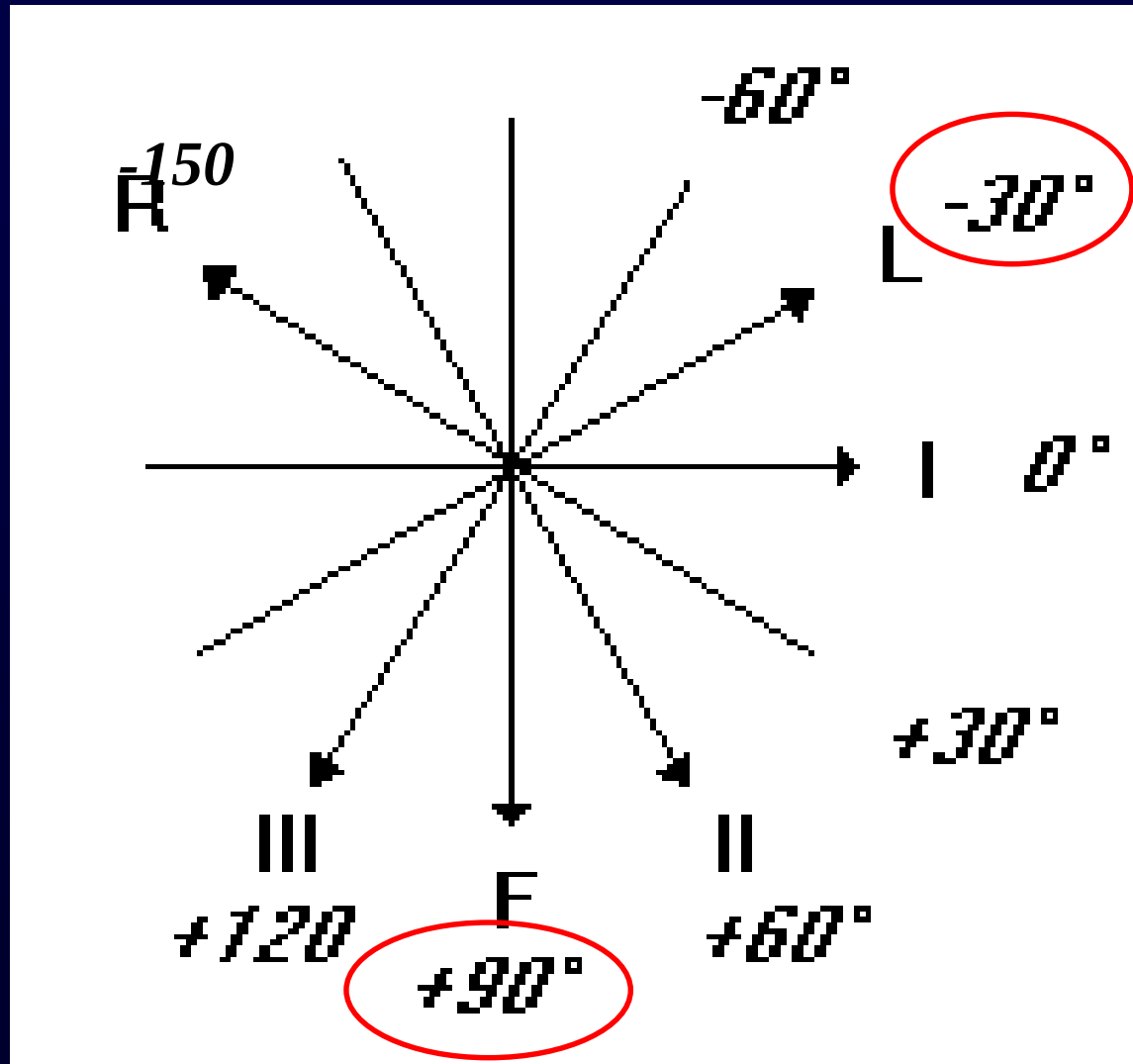


mm/mV 1 square = 0.04 sec/0.1mV

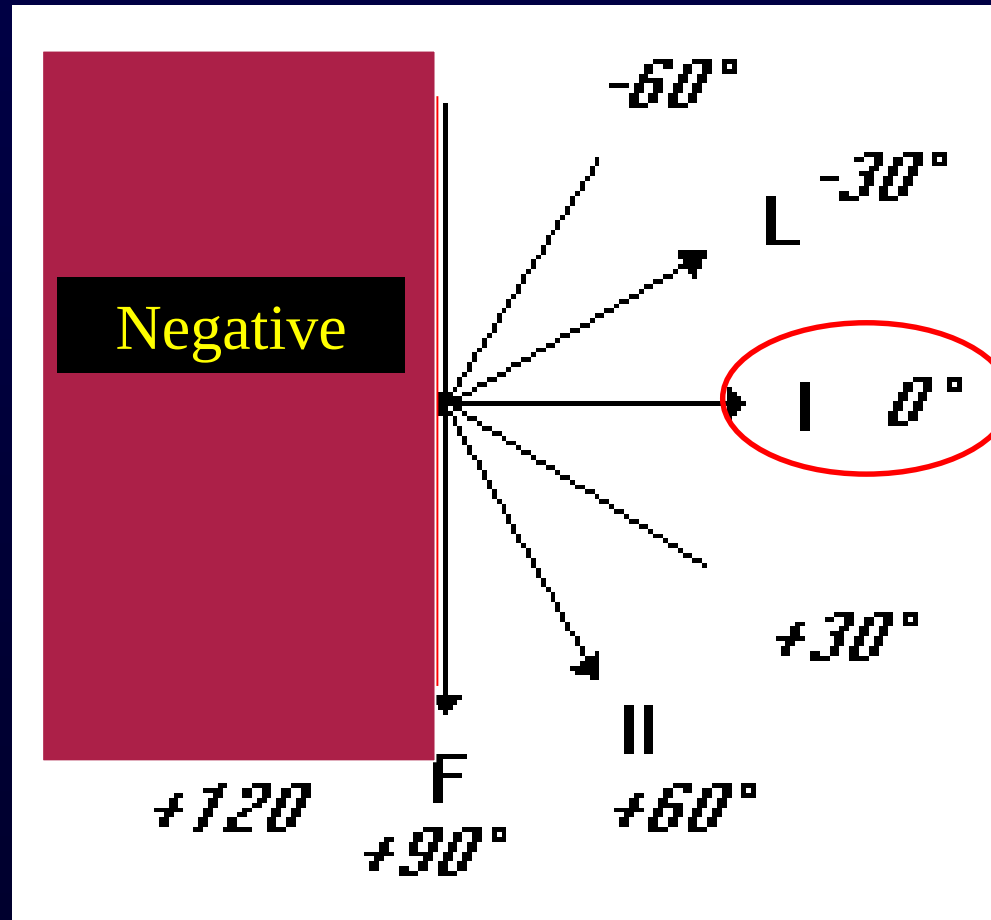
Diagram of the Cardiac Conducting System



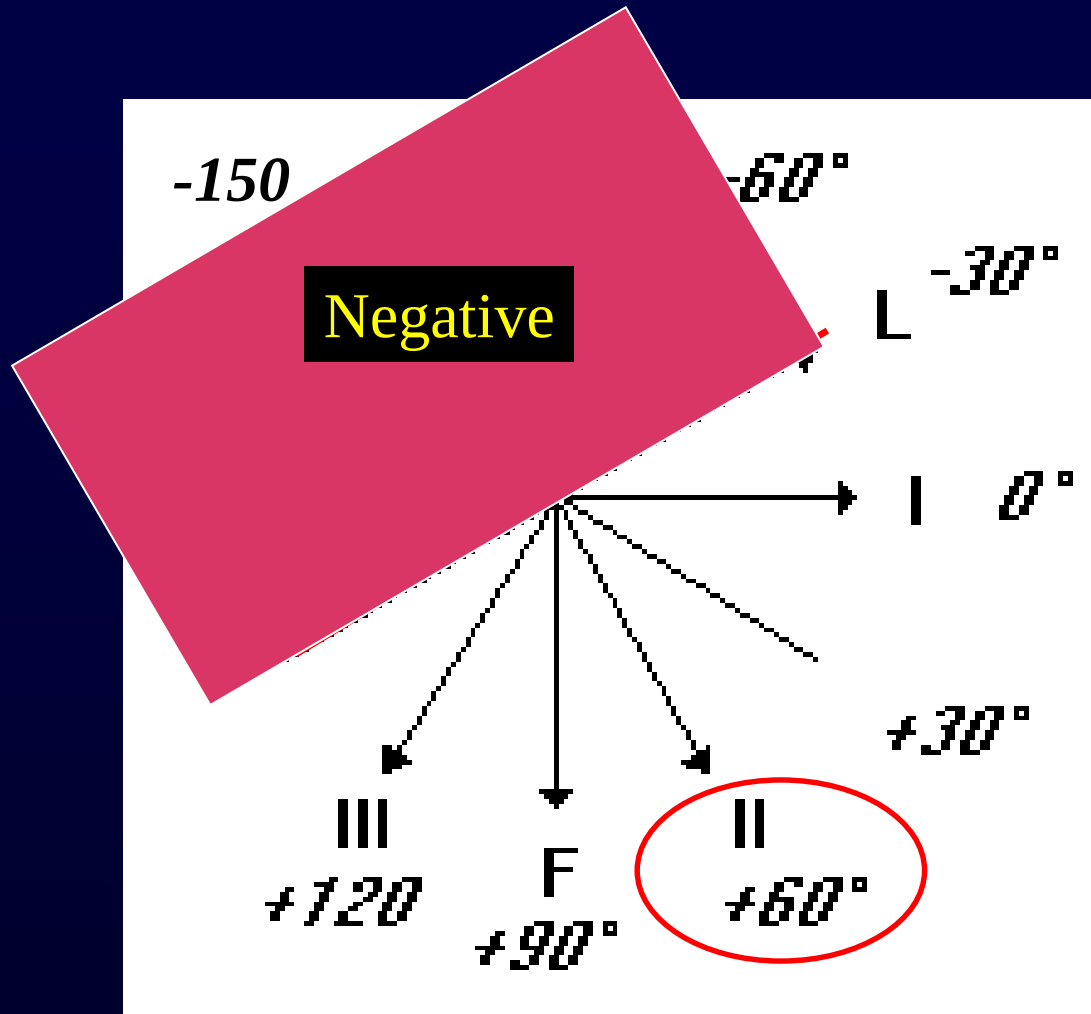
ECG: The Normal Axis



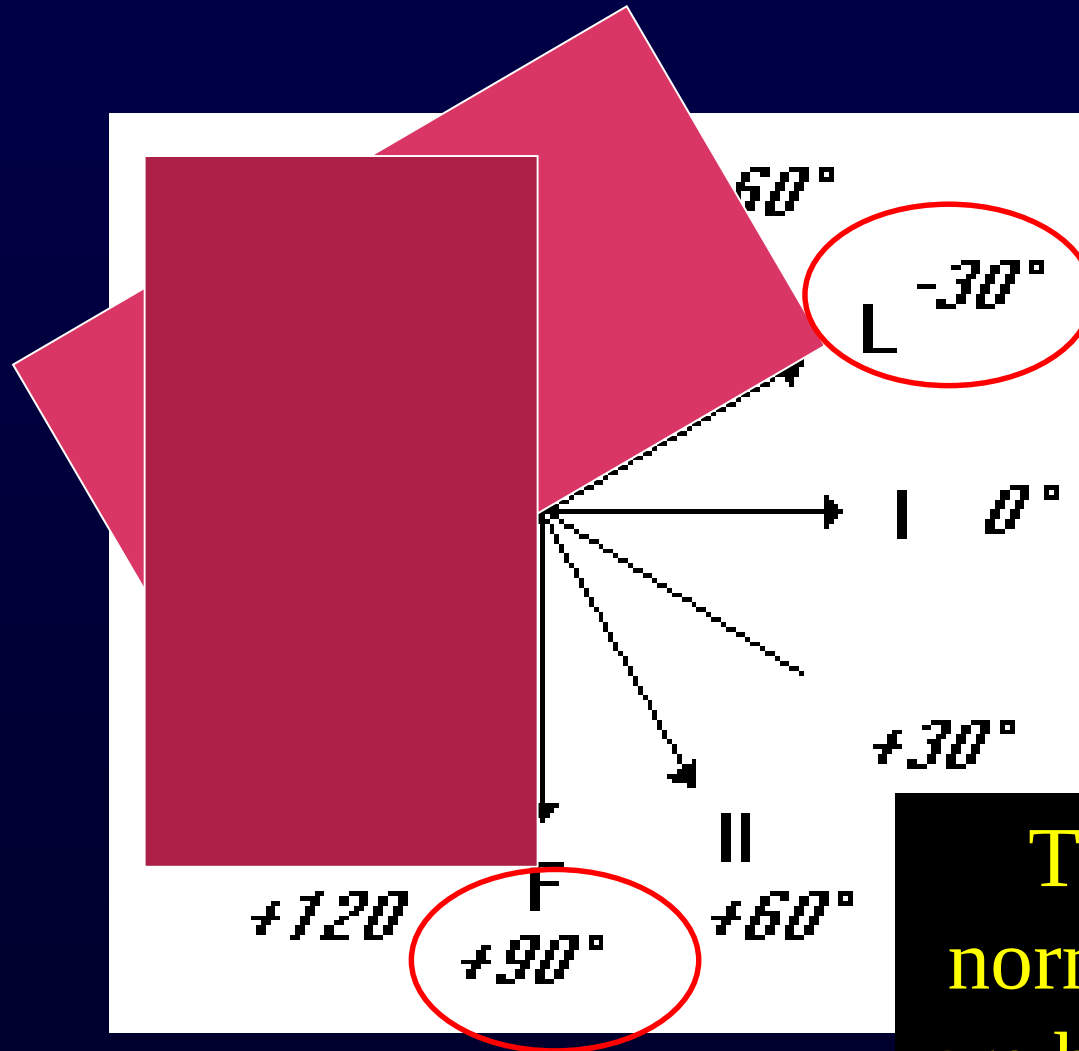
ECG: The Normal Axis (-30 to +90)



ECG: The Normal Axis (-30 to + 90)



ECG: The Normal Axis (-30 to + 90)



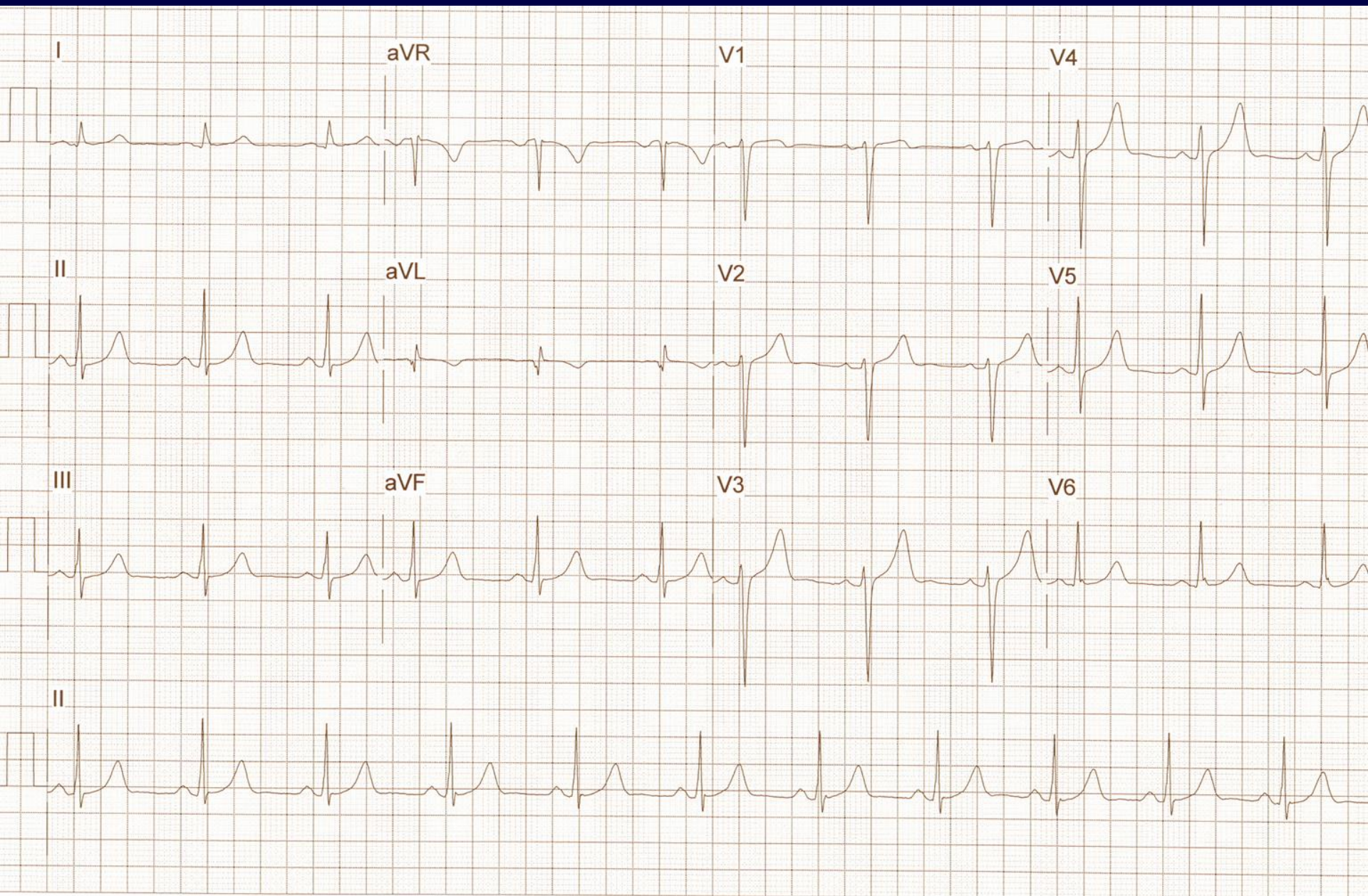
The axis is normal if 1 & 2 are both positive

ECG Case 1



ECG Case 1

Normal

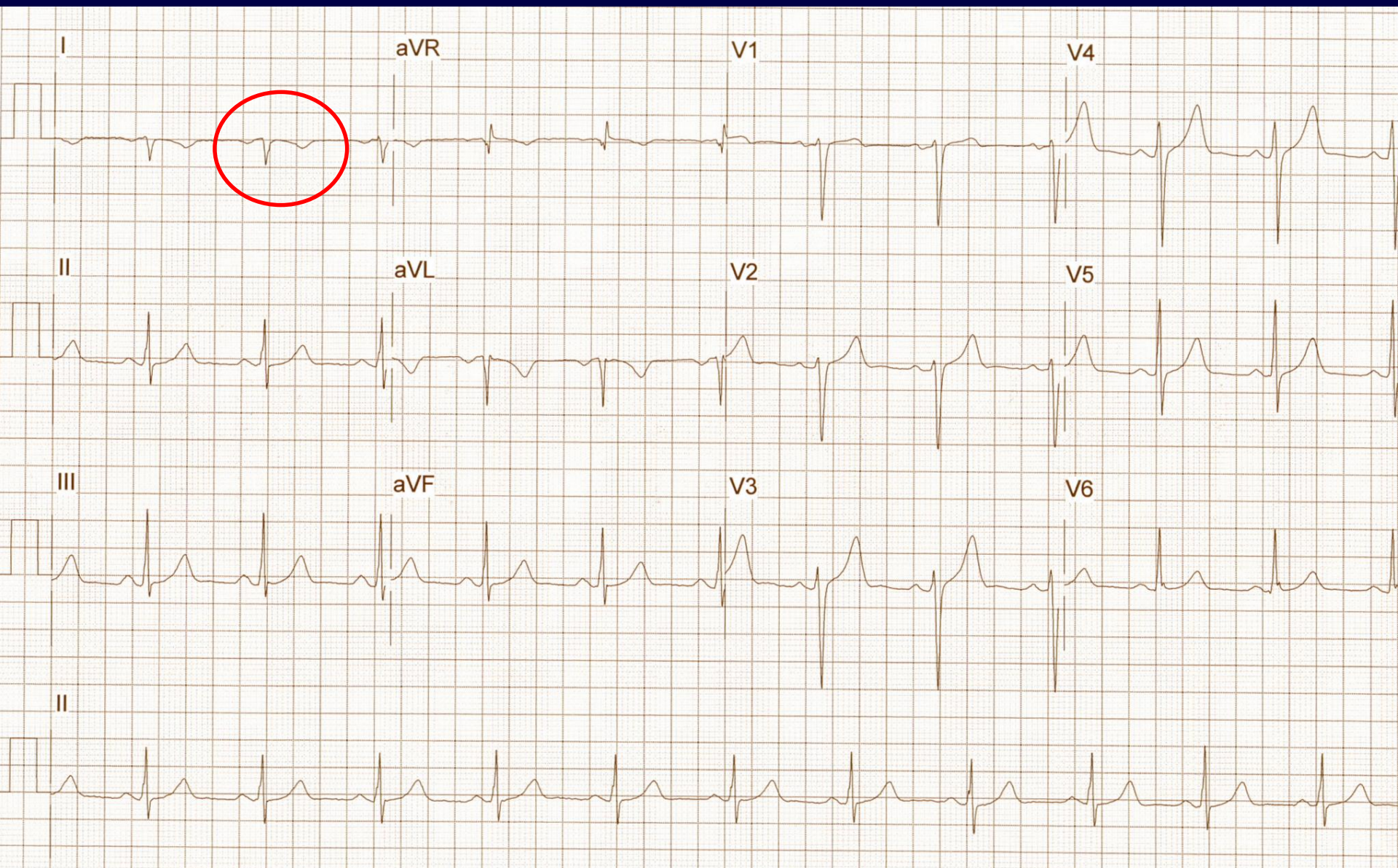


ECG Case 2



**"You have a rare condition called 'good health'.
Frankly, I'm not sure how to treat it."**

ECG Case 2

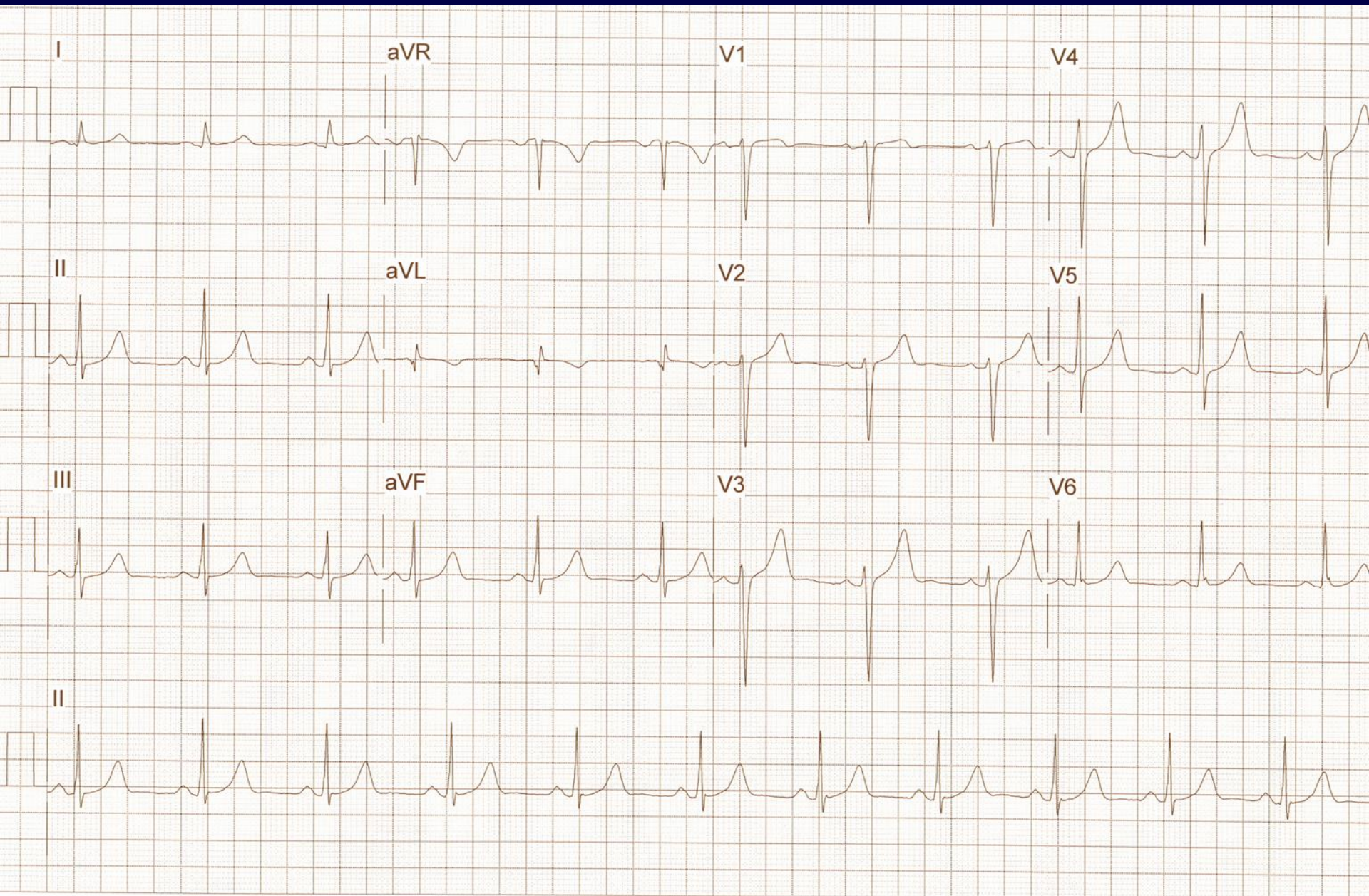


ECG 2: Crossed Arm Leads!

- 1 is upside down
- 2 & 3 transposed
- AVR & AVL transposed
- AVF & Chest leads unchanged



Normal ECG

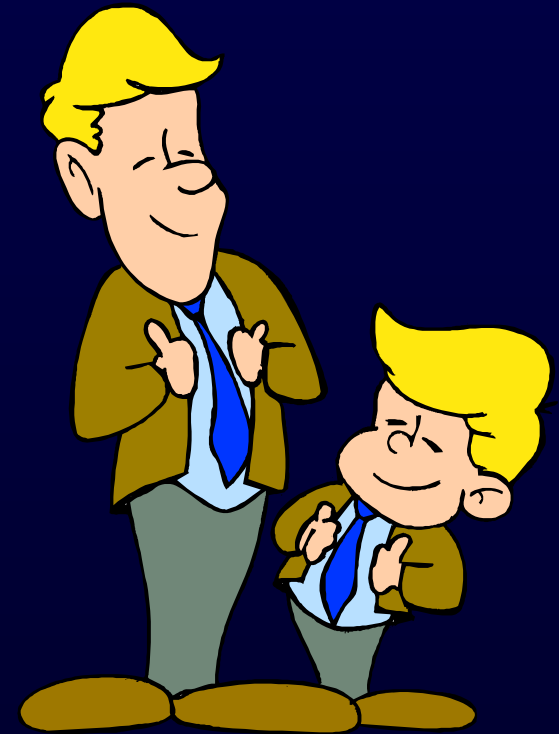


The Basics of CT Calcium Score Tests and CVS Risk

Who is at High Risk?



Atherosclerosis: Is Poorly Understood A Highly Complex Ageing of the Arteries



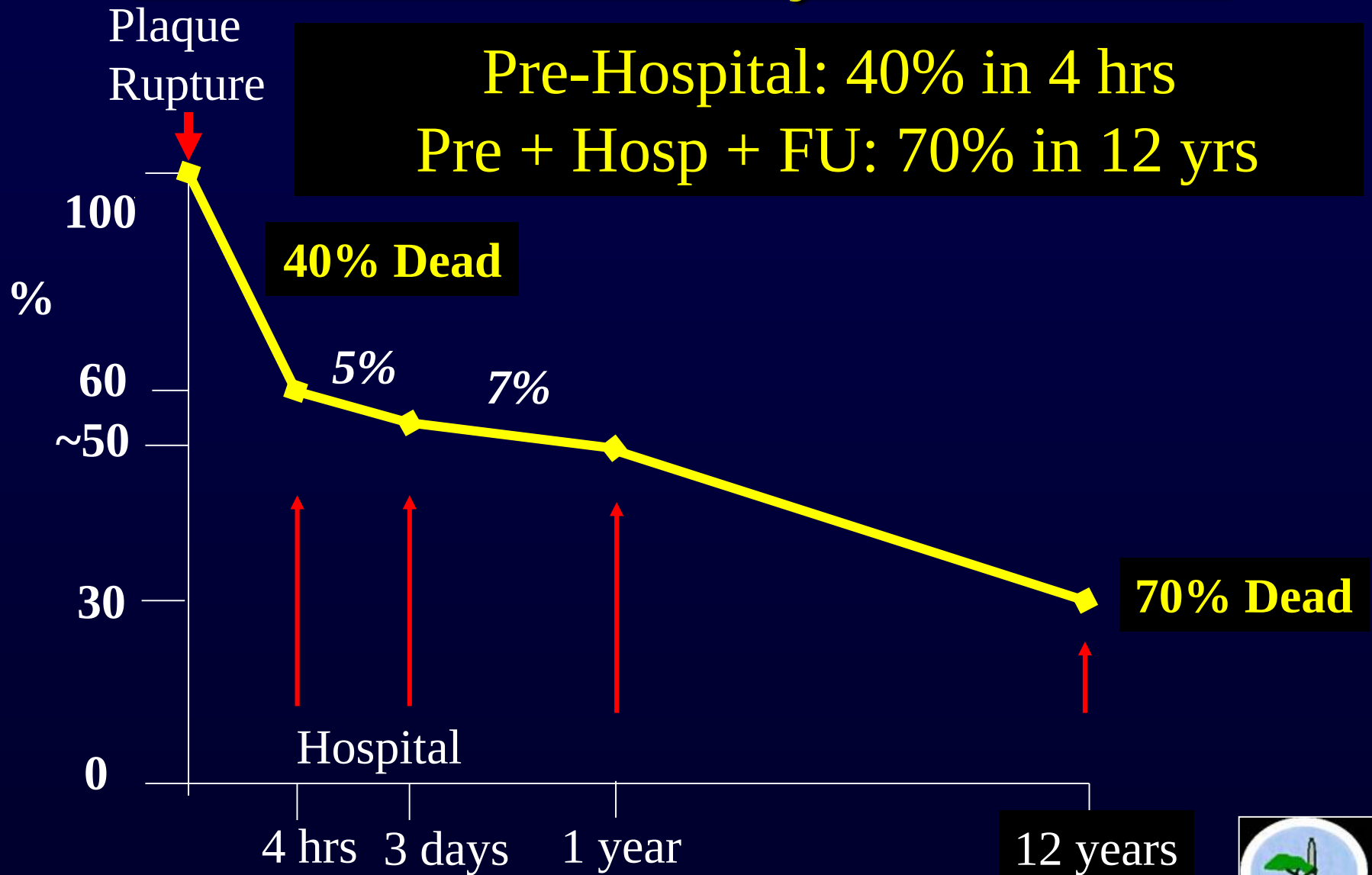
It is driven by *Lifestyle* and *Genetic* factors

Plaque Rupture/Erosion Causing Acute Arterial Thrombus: Well Understood Mechanism of Harm

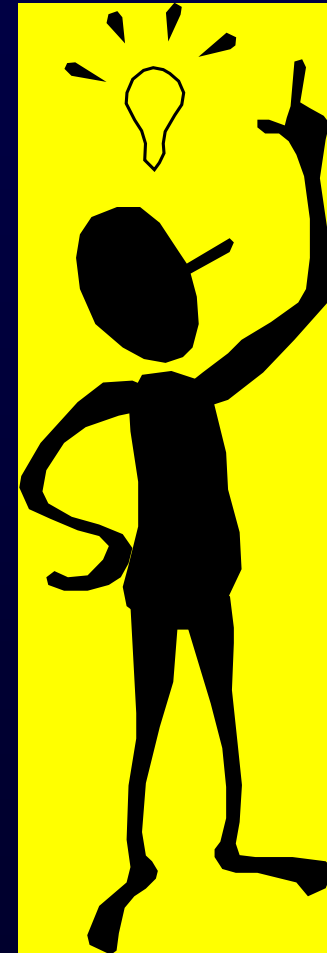
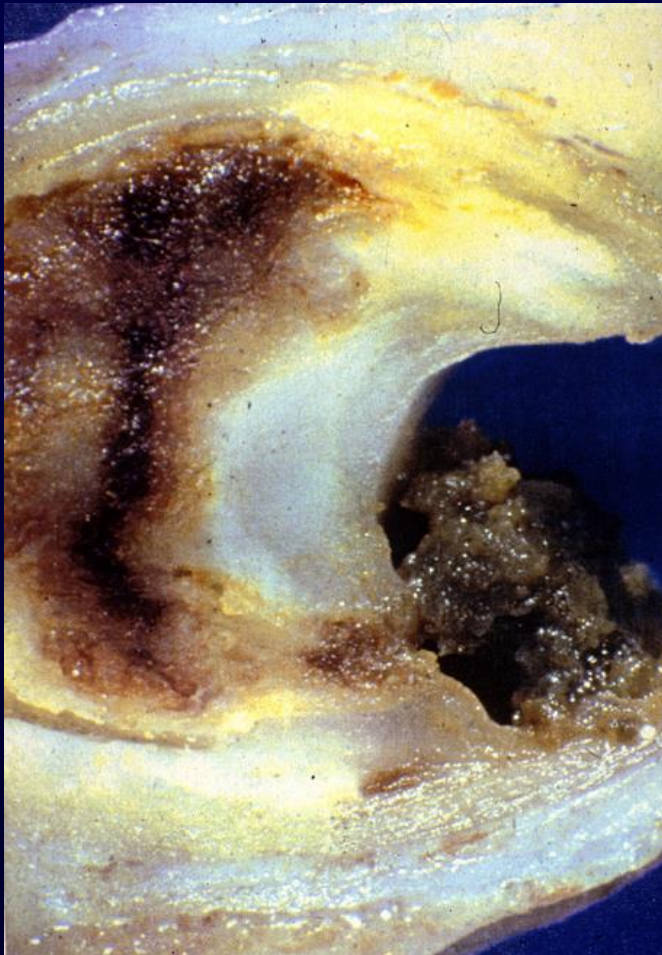
- Coronary artery
 - STEMI/NSTEMI/UAP
- Carotid or Cerebral artery
 - Stroke/TIA



What is the Mortality After a MI?



A Ruptured Plaque in a Coronary Artery is Very Serious



Atherosclerosis: A Complex Ageing/Disease Process: *How Have we Assessed CVS Risk in New Zealand?*



Patient Risk Assessment: Methods

- Epidemiology Based
 - Risk Factors
 - Complex Equation

VS

- Imaging Based
 - Look for Atheroma



Patient Risk Assessment: Methods

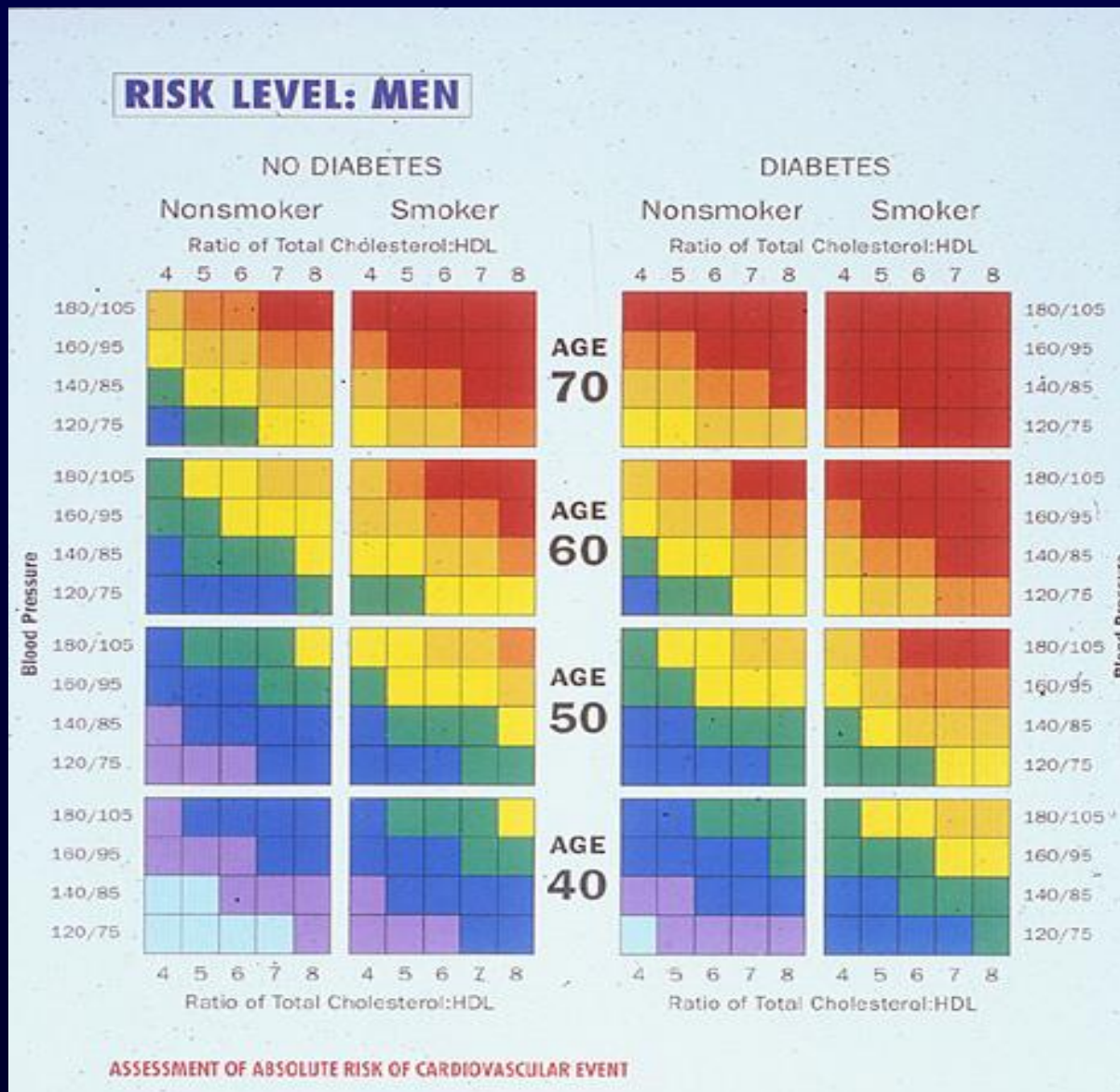
- Epidemiology Based
 - Risk Factors
 - Complex Equation

VS

- Imaging Based
 - Look for Atheroma

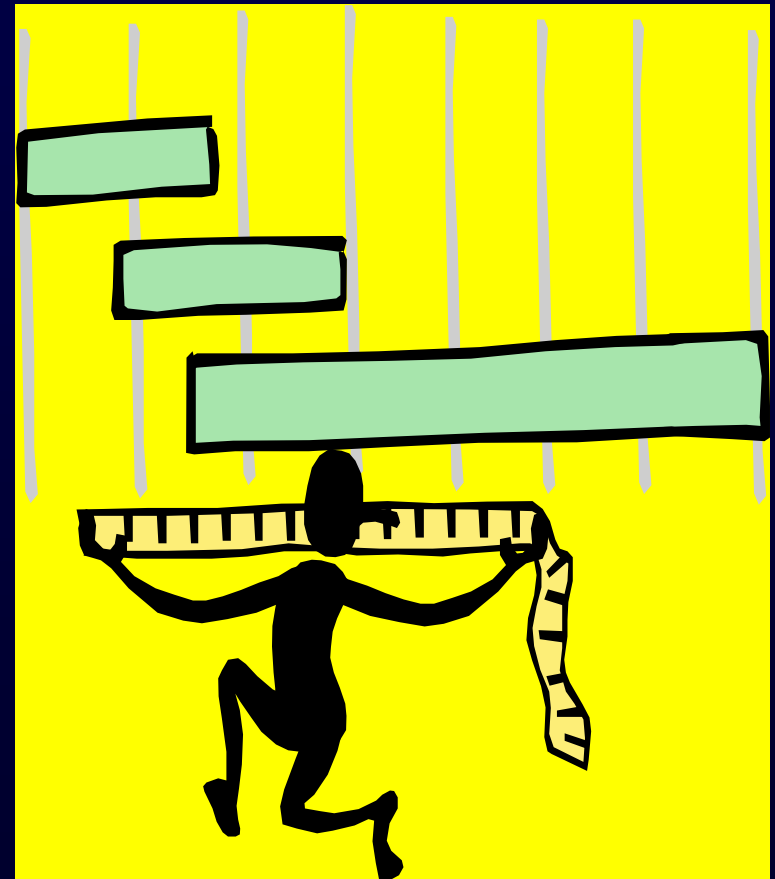


Framingham-Based Risk Tables



Framingham-Based CVS Risk Tables: Risk Factors Used in NZ

- Age (decades)
- Gender
- Diabetes Status (Y/N)
- Hypertension
- Smoker (Y/N)
- Total Cholesterol/HDL Ratio



Additional 5% CVS Risk Factors (2003/2009 NZ Guidelines)

Family history of premature CHD or ischaemic stroke:

- In a first-degree male relative before the age of 55 years or
- In a first-degree female relative before the age of 65 years

Maori

Pacific peoples or people from the Indian subcontinent

People with both diabetes and microalbuminuria

People who have had type 2 diabetes mellitus:

- For more than 10 years or
- Who have an HbA1c consistently greater than 8%

(People with the metabolic syndrome) GONE 2009

IF Total Cholesterol ≥ 8 then risk $\geq 15\%$

if Total Cholesterol/ HDL ≥ 8 then risk $\geq 15\%$

if BP consistently $\geq 170/100$ then risk $\geq 15\%$

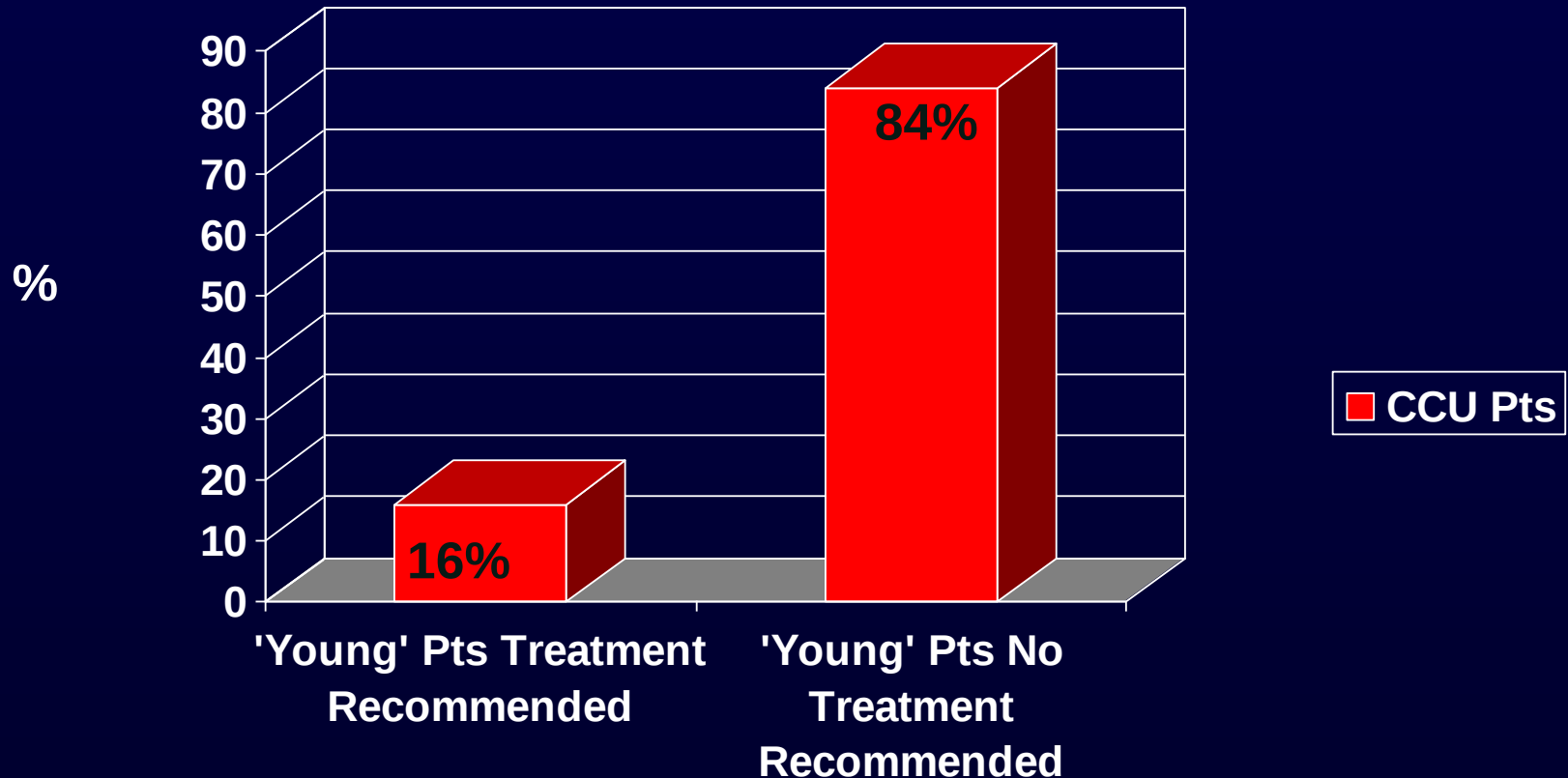
Can the USA Framingham Tables Really Predict CVS Risk: in Acute Coronary Syndrome Patients in NZ?



Auckland City Hosp CCU Pts 1 June 06 to 30 June 07

J Looi, CJ Ellis et al CSANZ 2008

Pts with NZ Framingham CVS Risk > 15% over 5 Years

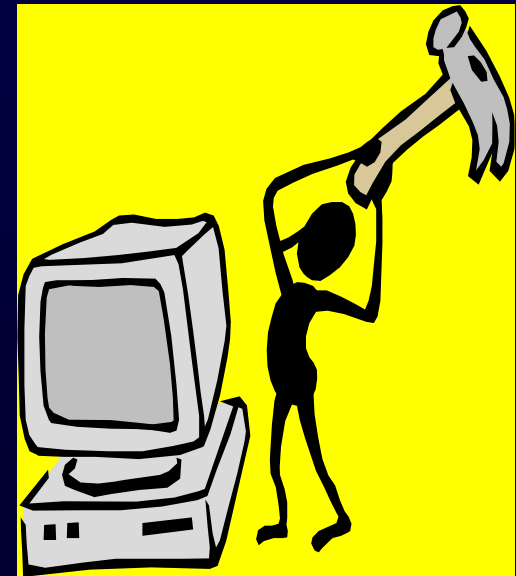


229 pts: 'Young' (male<55, female<65 years), no prior CVS disease



Gradual Realisation over time.....

- Even the best Epidemiological models of CVS risk assessment are inaccurate
- NZ Model is changing (again)
 - Epidemiological focus (most Guidelines)
- Certainly a reasonable way to start:
 - Focus on risk factors, can be addressed
 - Smoking, obesity, diabetes
 - High BP, high cholesterol
- BUT is it really good enough....?



Patient Risk Assessment: Methods

- Epidemiology Based
 - Risk Factors
 - Complex Equation

VS

- Imaging Based
 - Look for Atheroma



Calcified Coronary Arteries

- Intuitive for CVS Risk
 - *Look for disease*
 - Concept used elsewhere
 - Mammography, Colonoscopy
- Calcified Atherosclerosis
 - The ‘End Product’ of all CVS risk factors [known or unknown]
 - The *extent* of coronary atherosclerosis is the strongest predictor of CVS events



Image-Based Assessment of CVS Risk : CT Calcium Score Test

X-Ray ‘slices’ of the heart

3mm Intervals

About 50 cardiac slices per scan



Score relates to volume and density of calcium in the coronary arteries

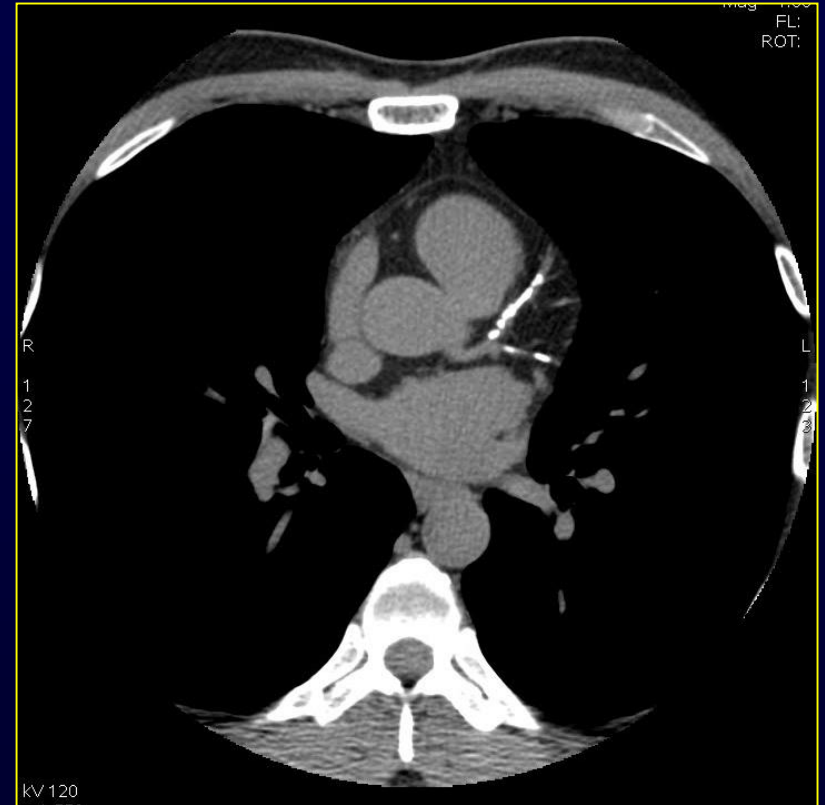
“Agatston” Units

Use for *asymptomatic* People

Images from a CT Calcium Score Test



No calcium



Heavy calcium

GE MEDICAL SYSTEMS
LightSpeed VCT
Ex:
Se: 2
Im: 1
SN 1100.00 Ax
DFOV 25.0cm
STND

A 133

TS1
M46Y
AW148002216.937.1305529664
Mar 08 2010
02:40:45 PM
SEGM512 X 512

Mag = 1.00
FL:
ROT:

R
1
0
8

L
1
4
2

kV 120
mA 200

SFOV 32.0cm
2.500mm /8i 32 row
Tilt: 0.0
0.4s /CI/00.00

WW: 400WL: 40

P 117



GE MEDICAL SYSTEMS
LightSpeed VCT
Ex:
Se: 2
Im: 1
SN 1100.00 Ax
DFOV 25.0cm
STND

A 133

TS1
M46Y
AW148002216.937.1305529664
Mar 08 2010
02:40:45 PM
SEGM512 X 512

Mag = 1.00
FL:
ROT:

R
1
0
8

L
1
4
2

kV 120
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SFOV 32.0cm
2.500mm /8i 32 row
Tilt: 0.0
0.4s /CI/00.00

WW: 400WL: 40

P 117

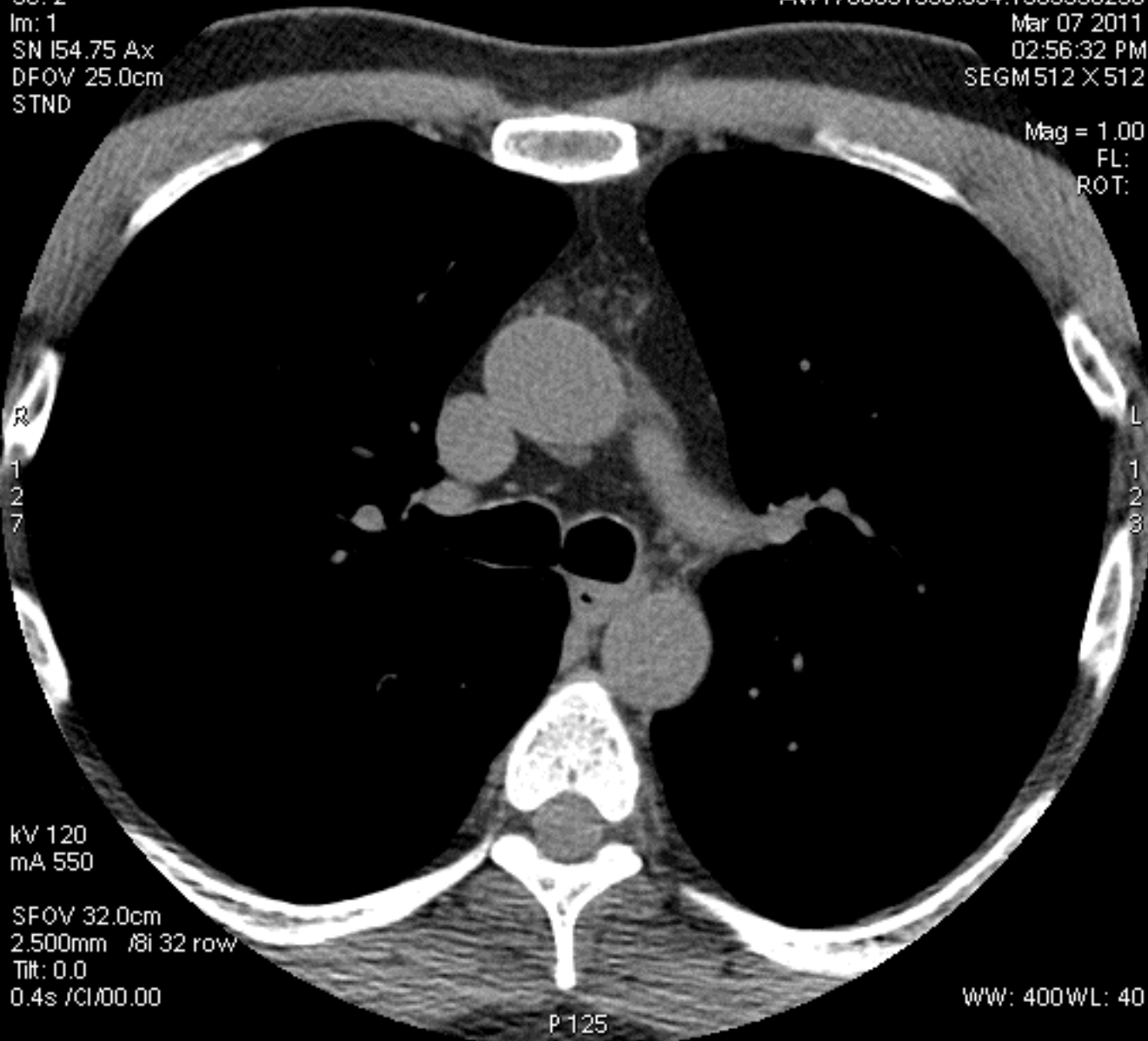


GE MEDICAL SYSTEMS
LightSpeed VCT
Ex:
Se: 2
Im: 1
SN 154.75 Ax
DFOV 25.0cm
STND

A 125

VS
M48Y
AW1700651958.994.1305536230
Mar 07 2011
02:56:32 PM
SEGM512 X 512

Mag = 1.00
FL:
ROT:

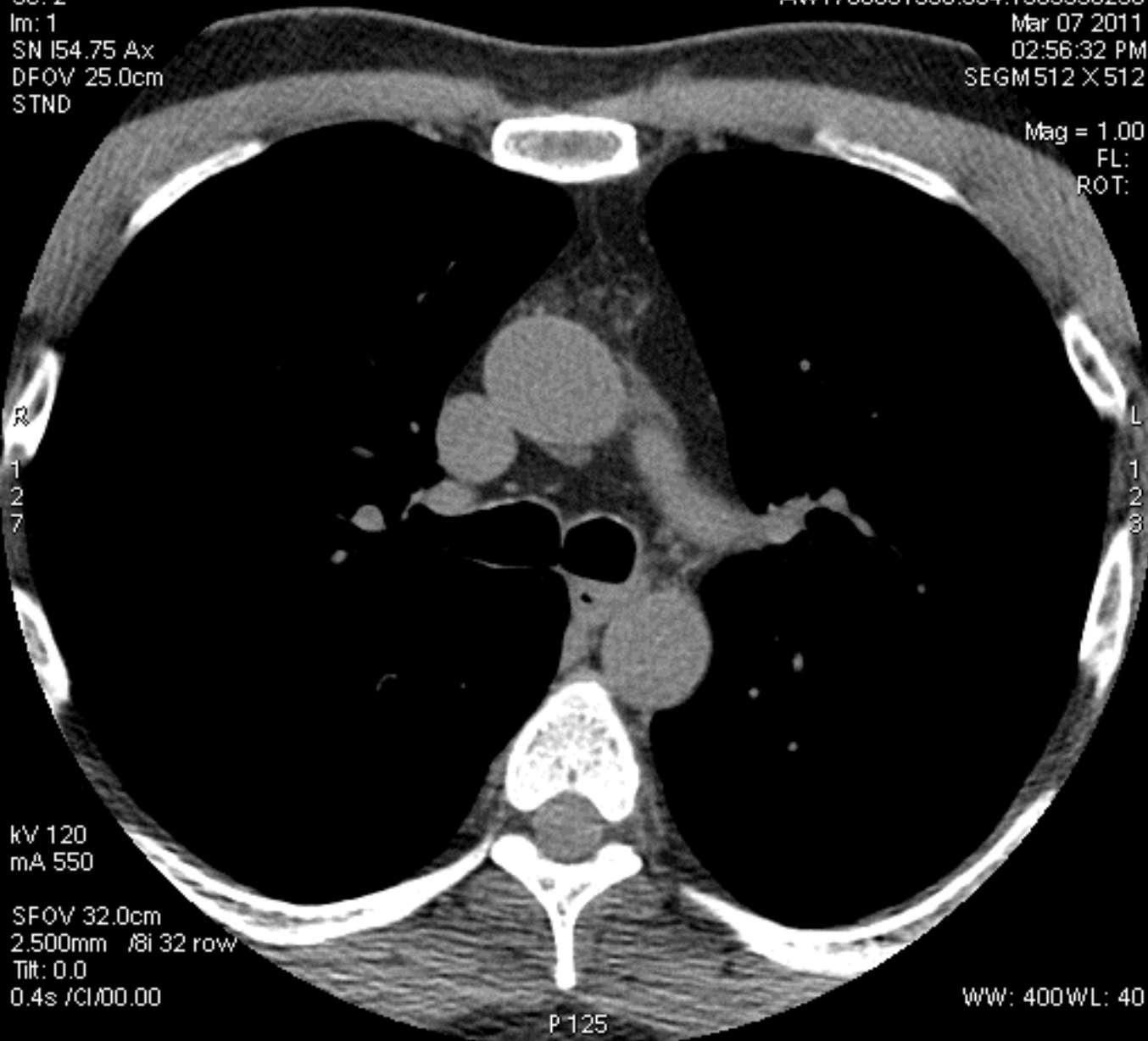


GE MEDICAL SYSTEMS
LightSpeed VCT
Ex:
Se: 2
Im: 1
SN 154.75 Ax
DFOV 25.0cm
STND

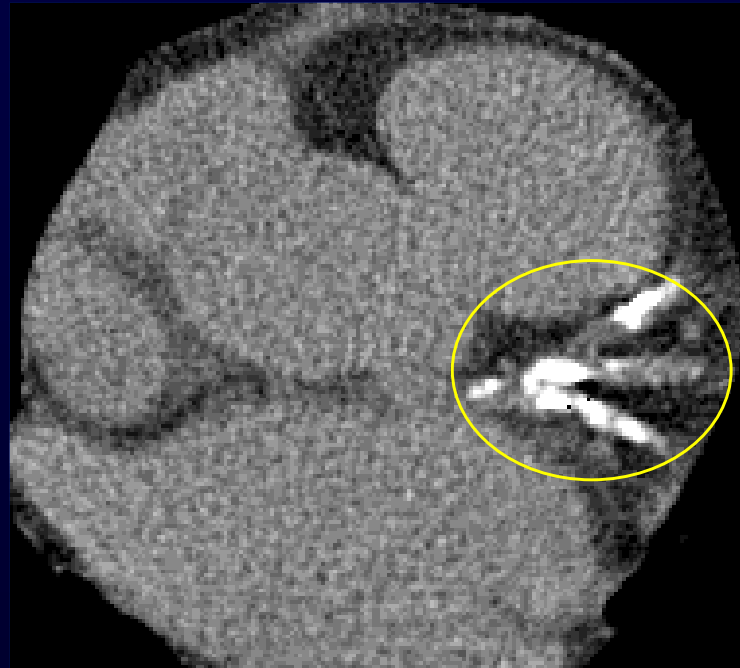
A 125

VS
M48Y
AW1700651958.994.1305536230
Mar 07 2011
02:56:32 PM
SEGM512 X 512

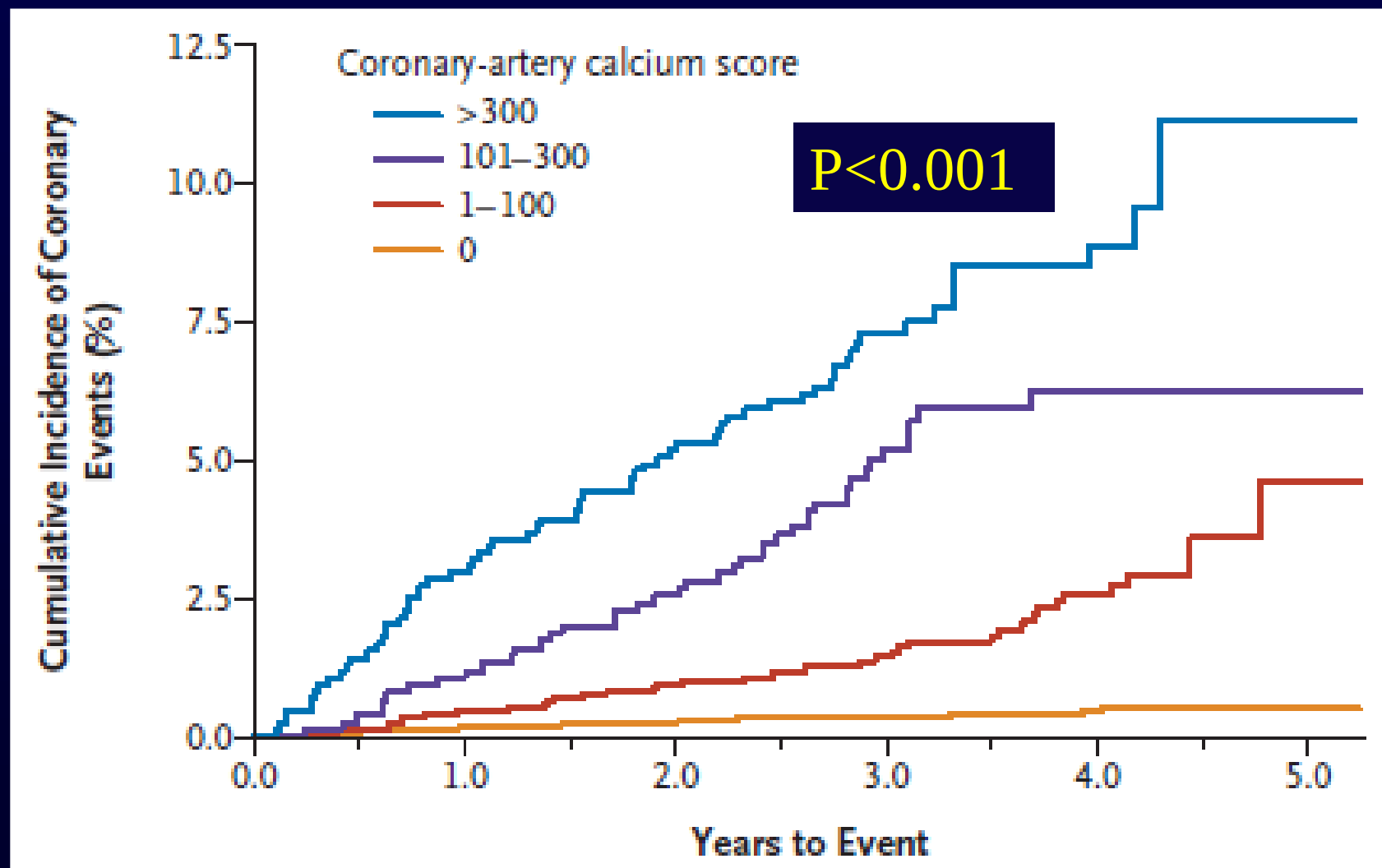
Mag = 1.00
FL:
ROT:



What is the Science to show that Calcium Scores Predict CVS Risk?



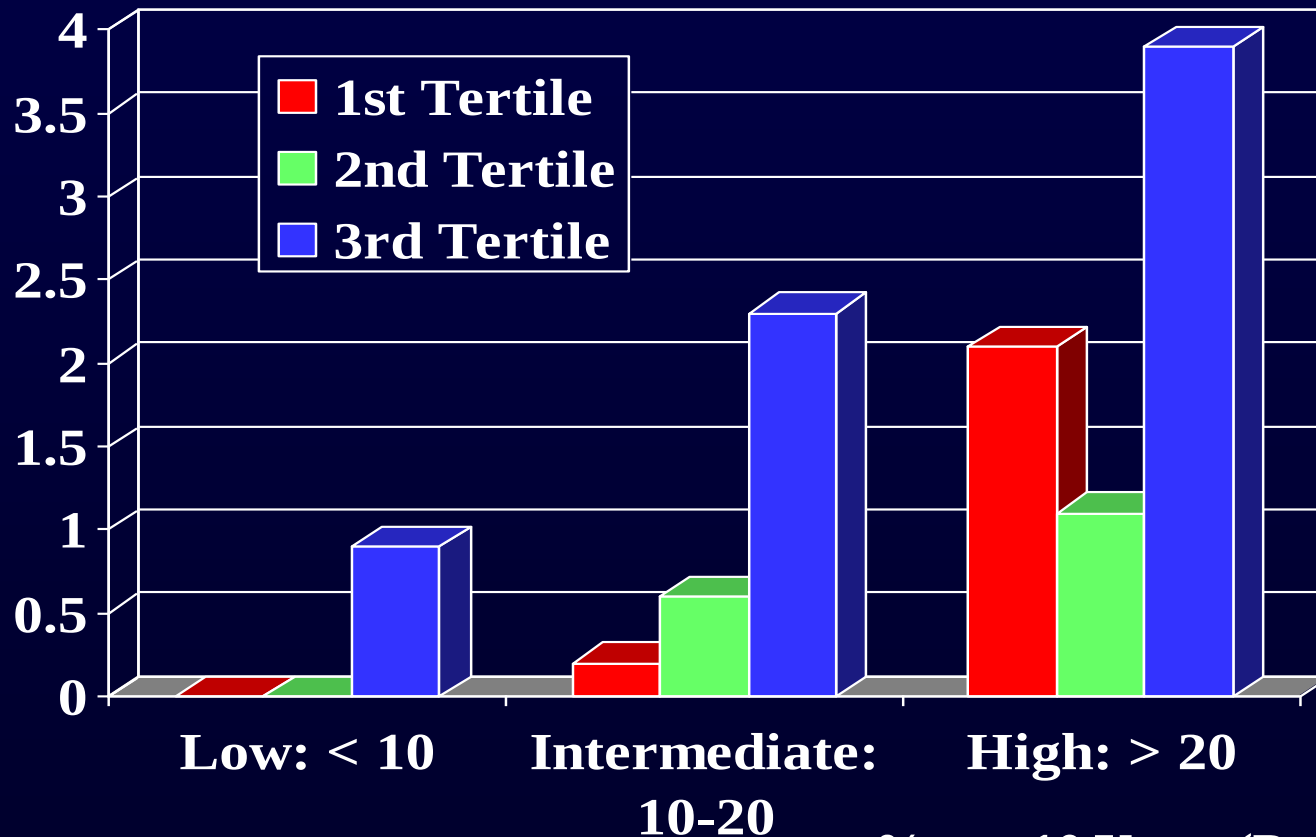
Calcium Score & Any Coronary Events: MESA Study NEJM 2008;358:1336-45



St Francis Heart Study: Coronary Event Rates as a function of Calcium Score within Framingham Risk Groups

Arad JACC 2005;46:158-65

% per year (CVS Events)



4613 Asymptomatic People

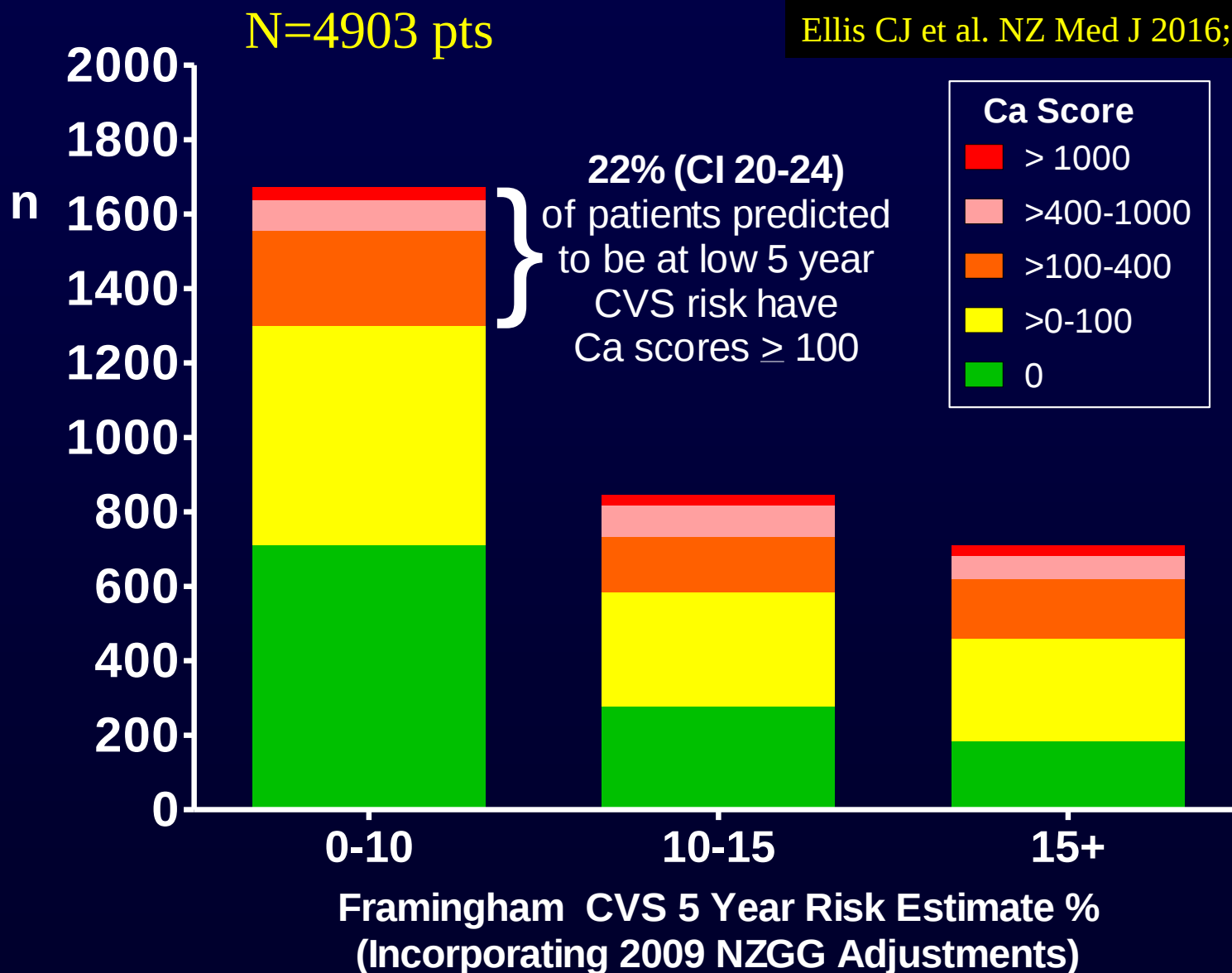
% per 10 Years (Predicted)

St Francis Heart Study [of 4,613 Asymptomatic People]

Arad et al. JACC 2005;46: 158-65, 166-72.

- A Coronary Calcium Score of ≥ 100 Agatston units
 - Resulted in x 10 times increase risk of a CVS events
- The Coronary Calcium Score
 - Was superior to the Framingham Risk Equation (Receiver-operator curve 0.79 ± 0.03 vs 0.69 ± 0.03 , $p=0.0006$)
 - Enhanced stratification of Framingham Risk categories, low, intermediate, high risk ($p<0.0001$)

Agatston Calcium Score by Band of 5-Year CVS Risk Estimated by the NZ Guidelines Group 2009 'Adjusted' (Anderson) Framingham Equation

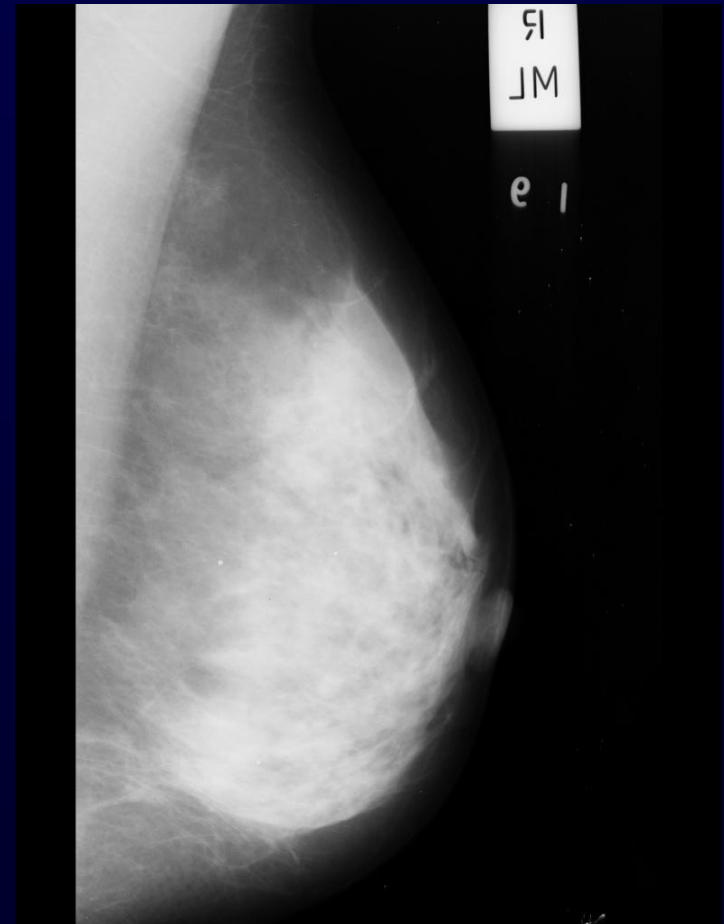


The Radiation Dose of a CT Calcium

Calcium Score (Alone)

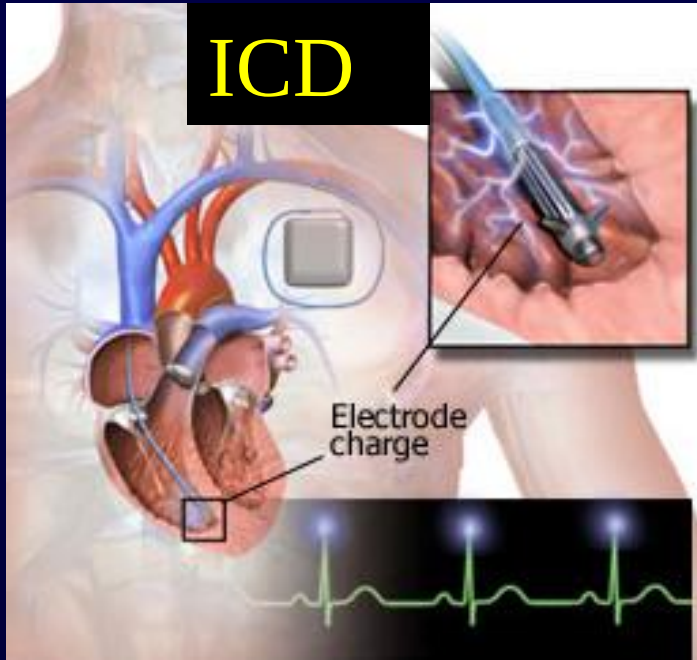
~ 1 mSv: ~ Same
as a Mammogram

Background Radiation
dose in NZ is 3 mSv/year



Secondary Care: Expensive with Invasive Treatments

ICD



STENTS



CABG



Prevention is Better than Cure

Primary Prevention is Better than Cure (We Have to do Better than This)

Collapsed January 2016

Sunday Star Times: 1 May 2016



- Age 54 years
- Physical activity
- Cardiac arrest
- Club's AED
- FH IHD
- High Cholesterol
- No Treatment....

“There was no pain, no numbness, no warning. I was running for a pass, and then the light changed - a bit like an eclipse.”

Geoff Brogan, above, with wife Tara.

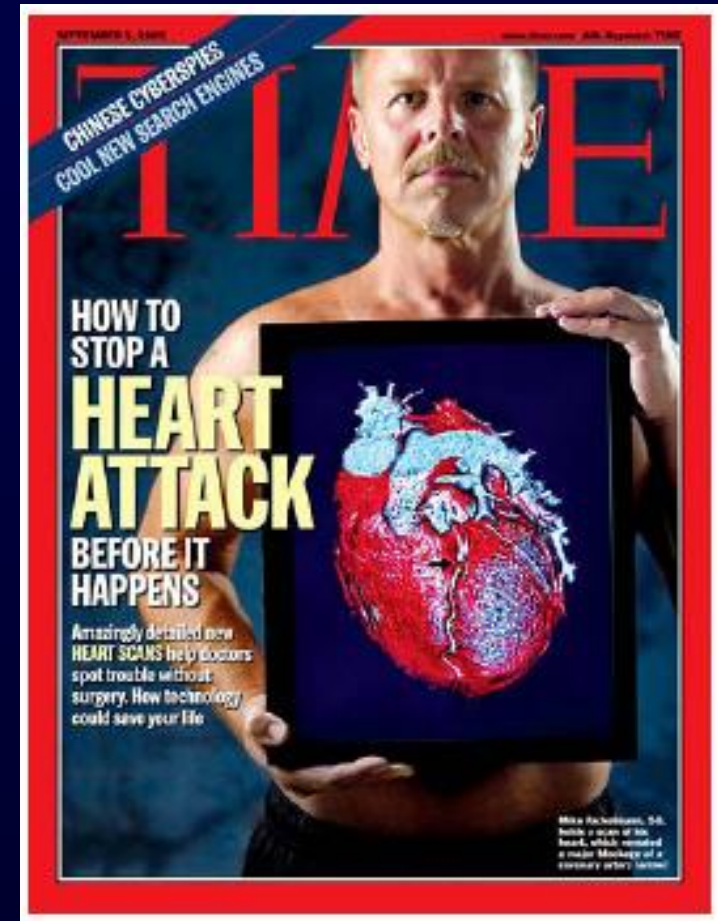
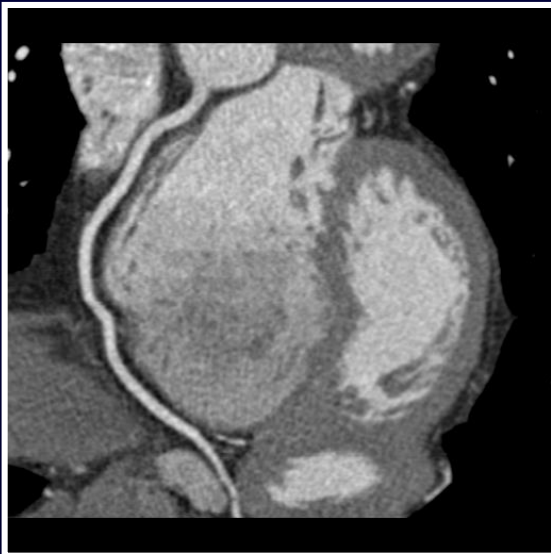
Summary: Combine Strategies to Investigate those at High Risk

- Epidemiology Based
 - Risk Factors
 - Complex Equation
- **Additional** Imaging Based
 - Strategies are now available
 - Look for Atheroma



The Basics of a Full CT Cardiac Angiogram (CTCA)

CT Cardiac Angiography 2017: What is it? How Does it Work?



CT Cardiac Angiography 2017: Development Challenges

Coronary arteries:

- small and tortuous (2-4mm).
- Subjected to complex respiratory and cardiac motion.
- RCA moves at up to 120 km/hour

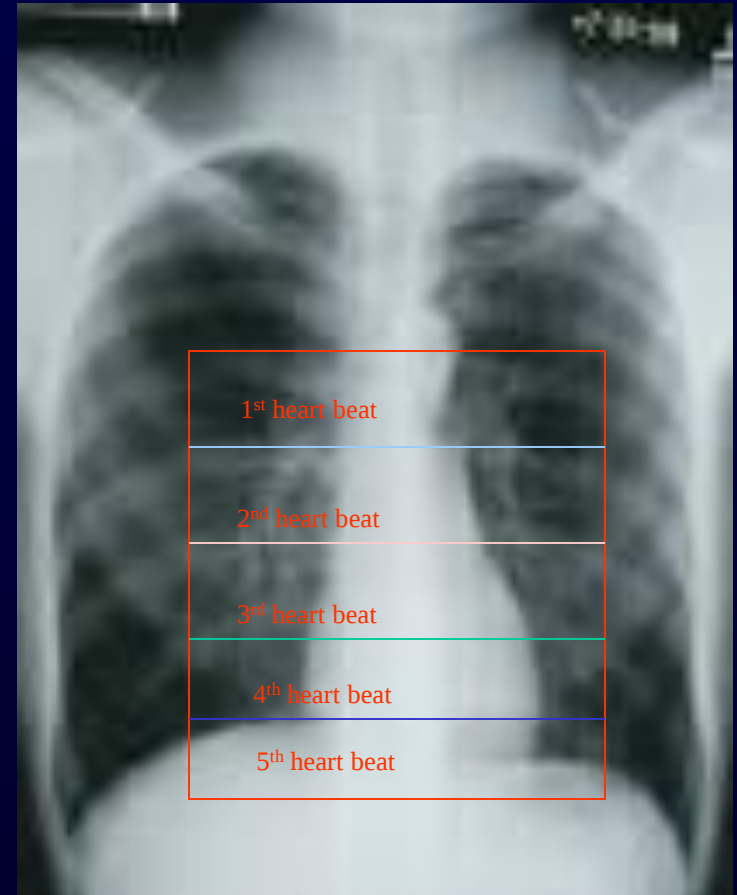
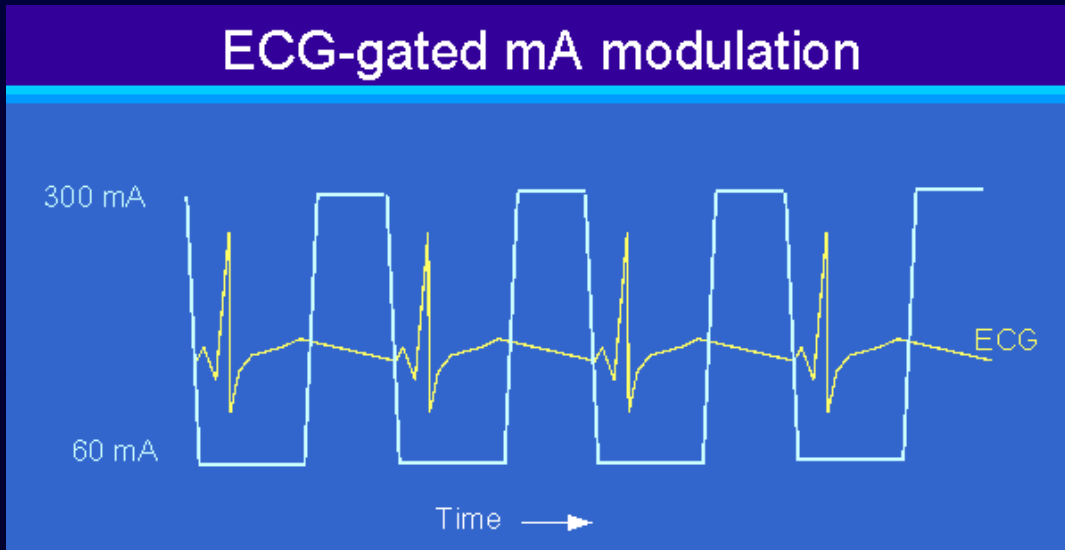
CTCA 2017: the Speed of the Right Coronary Artery



120 km/h

Multi-Slice CTCA

- ECG is 'gated'; requires slow and steady HR (50-65 bpm).
- Acquires a 3D data set of the whole heart, in 6-10 seconds
- Scans in Diastole, static coronaries



3D
Ex:
Se: 133 +c
Volume Rendering No cut

SPR

TS1
M 46 AW148002216.937.1305529664
DoB:
Ex: Mar 08 2010

DFOV 20.0cm
STND/C2 Ph:75% (No Filter)

0 L 30 LAO 30 CRA

R
A

L
P

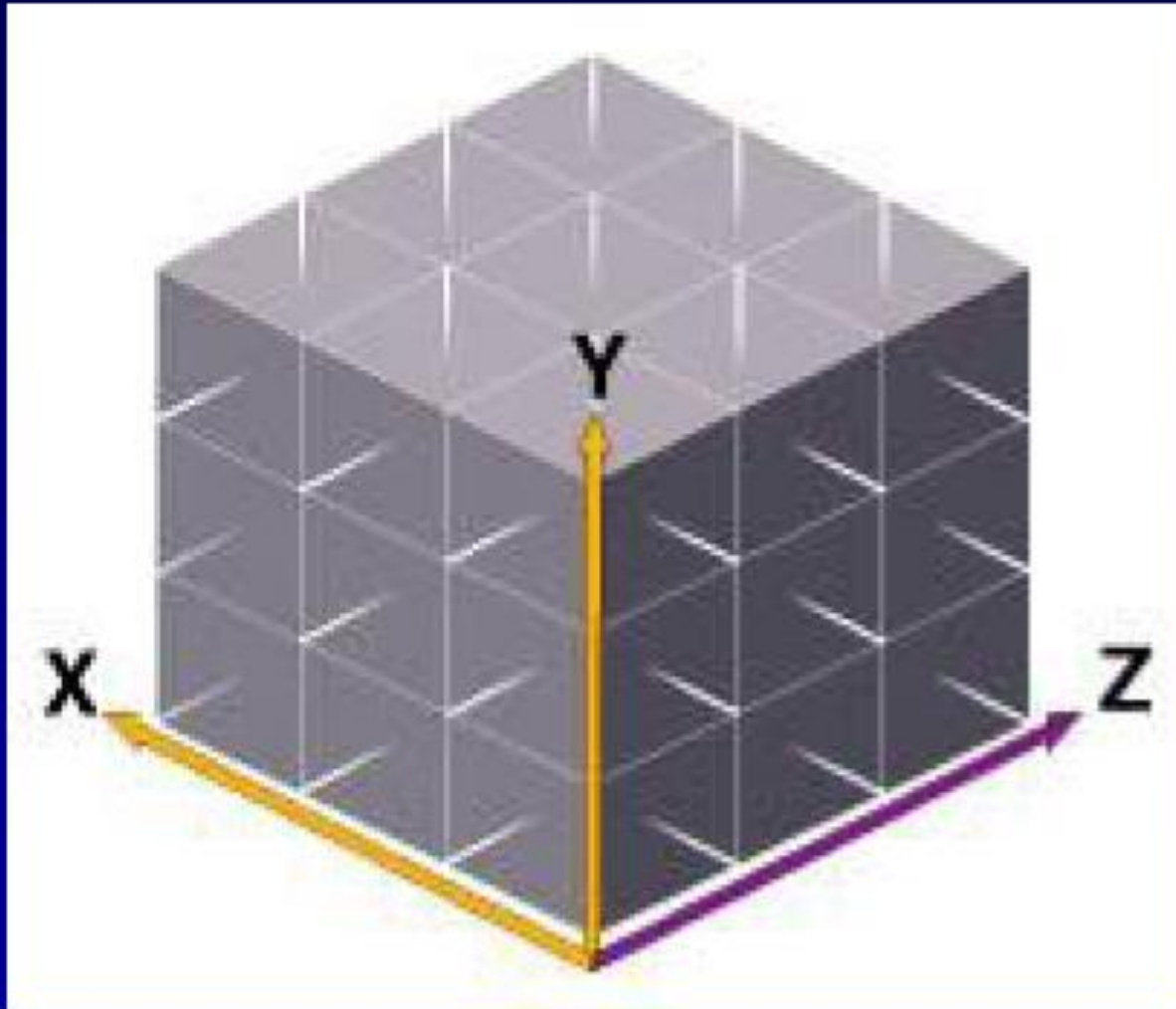
No VOI
kv 100
mA 647
Rot 0.35s/CH 6.4mm/rot
0.6mm 0.16:1/0.6sp
Tilt: 0.0
02:44:49 PM
W = 4095 L = 2048

IAL



Voxel Size

Spatial resolution 0.4mm x 0.4mm x 0.625mm



Voxel = “3-dimensional Pixel”

Oblique phase 70%
Ex: 1917
Se: 533
I: 192.6 (col)

AI

MERCY RADIOLOGY

M 59 IGC793Z

Mar 12 2007

DFOV 21.3cm
STND Ph:70% (No Fil.)

15 L 180 LAO 52 CAU

R

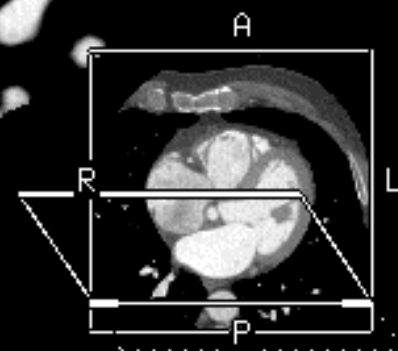
9
1

L

1
2
2

0.4/
kv 120
mA Mod.
Rot 0.35s/CH 7.2mm/rot
0.6mm 0.18:1/0.6sp
Tilt: 0.0
03:30:55 PM
W = 800 L = 100

PS



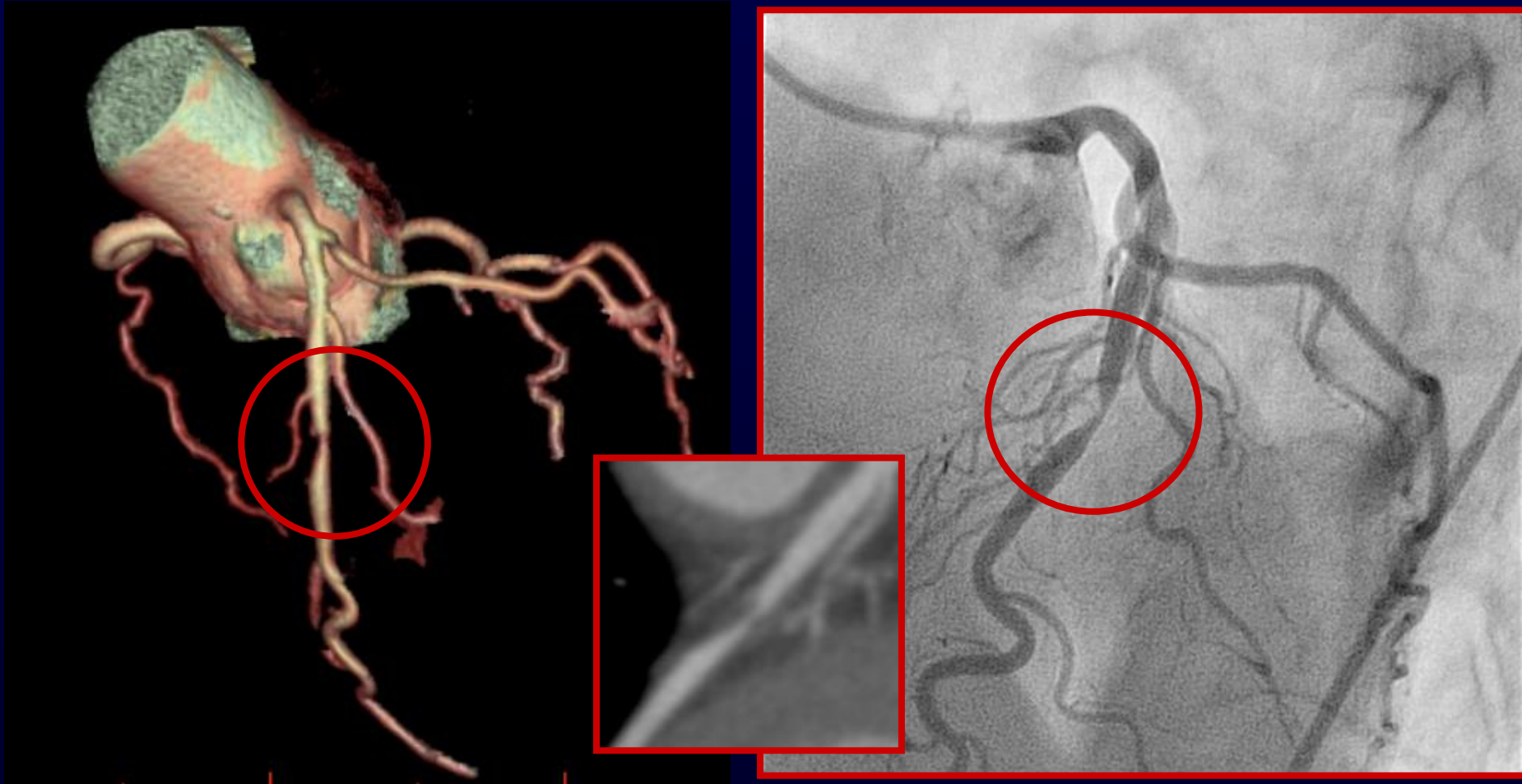
MPR: Curved Multiplanar Reformatted Image, Single Frame



CT Angiography: Vessel Assessment



Case 1: Excellent correlation between CT Angiography and Conventional Angiography. Mid LAD stenosis. PCI



CTCA Case A: Male of 40 Years Presentation with Atypical Chest Pain

3D
Ex:
Se: 133
Volume Rendering No cut

SPR

CL
M 40 AW1314886089.245.1306640202
DoB:
Ex: Apr 27 2011

DFOV 17.8cm
STND/C2 Ph:75% (No Filt.)

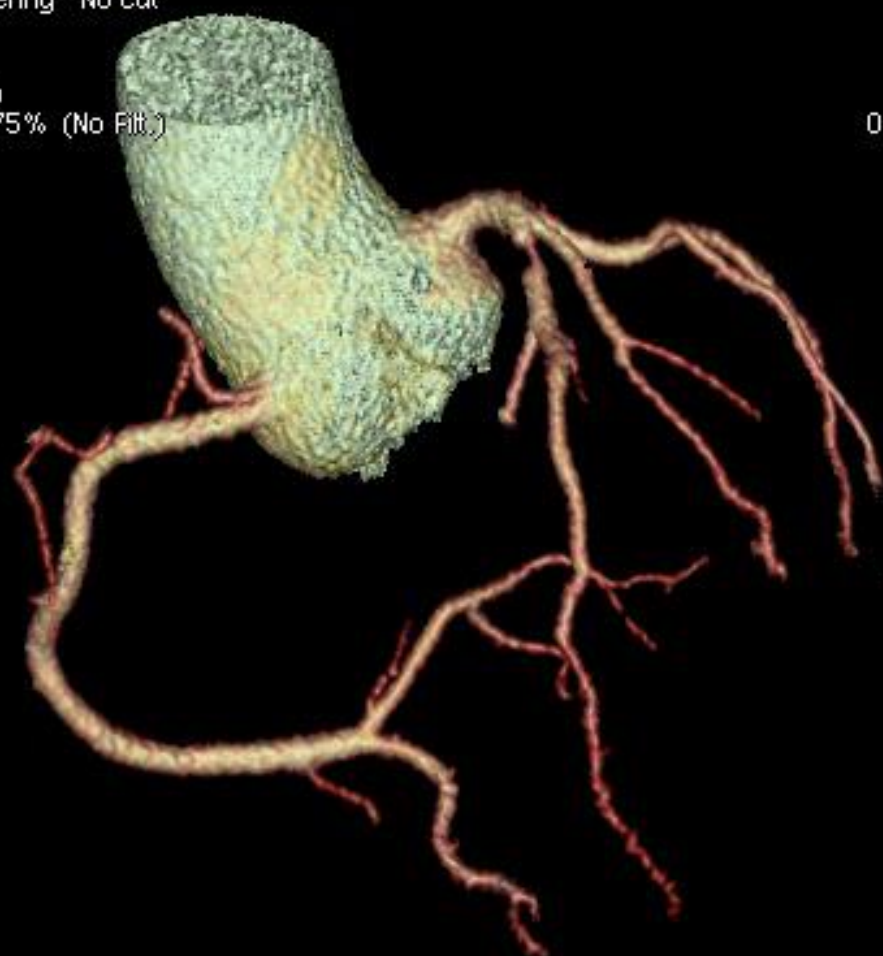
0 L 30 LAO 30 CRA

R
A

L
P

No VOI
kv 100
mA Mod.
Rot 0.35s/CH 8.0mm/rot
0.6mm 0.2:1 /0.6sp
Tilt: 0.0
01:59:41 PM
W = 4095 L = 2048

IAL



3D
Ex:
Se: 133
Volume Rendering No cut

P 53

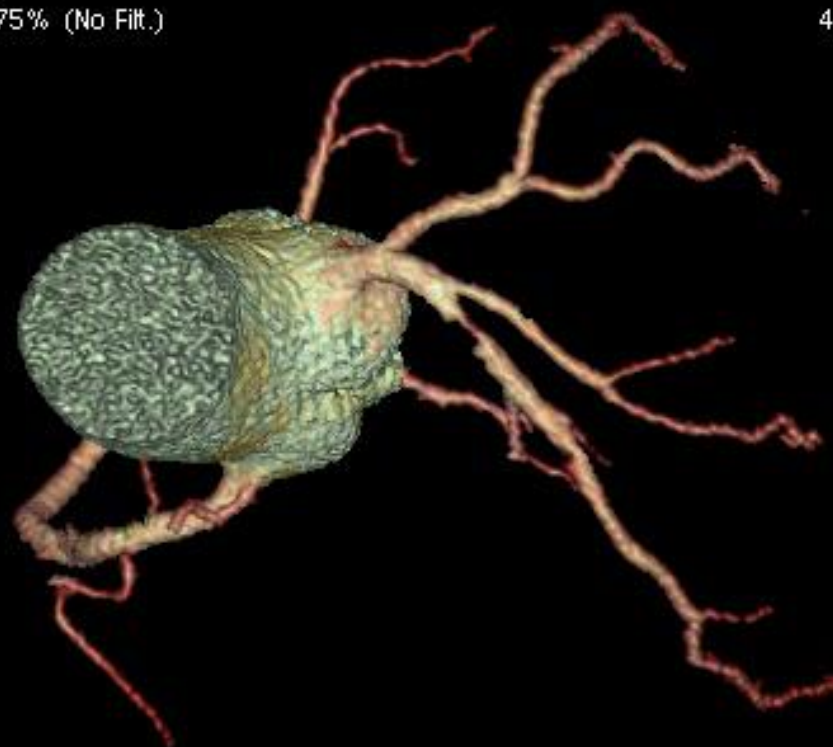
CL
M 40 AW1314886089.245.1306640202
DoB:
Ex: Apr 27 2011

DFOV 17.8cm
STND/C2 Ph:75% (No Filt.)

40 L 180 LAO 90 CRA

R
4
4

L
1
3
4



No VOI
kv 100
mA Mod.
Rot 0.35s/CH 8.0mm/rot
0.6mm 0.2:1/0.6sp
Tilt: 0.0
01:59:41 PM
W = 4095 L = 2048

A 125

Oblique
Ex:
Se: 133
Left Anterior Descending Artery LP: 33.4

LAI

CL
M 40 AW1314886089.245.1306640202
DoB:
Ex: Apr 27 2011

DFOV 8.5cm
STND/C2 Ph:75% (No Filt.)

A
R
I

P
L
S

5.2/MP LSection / 0°
kv 100
mA Mod.
Rot 0.35s/CH 8.0mm/rot
0.8mm 0.2:1 / 0.8ap
Tilt: 0.0
01:58:41 PM
W = 1200 L = 240

RPS

CTCA Challenges 2017: Patient Selection

Heart rate inversely proportional to image quality:
Need to lower HR to <60 bpm

- Oral & iv metoprolol tartrate before scan
- Significant asthma is a relative contra-indication

Calcification obscures lumen views

- Old patients (> 70 years) may not be suitable
- Prior CABG or PCI patients are not suitable

CTCA Challenges: Patient Selection 2

Obese patients: images are worse

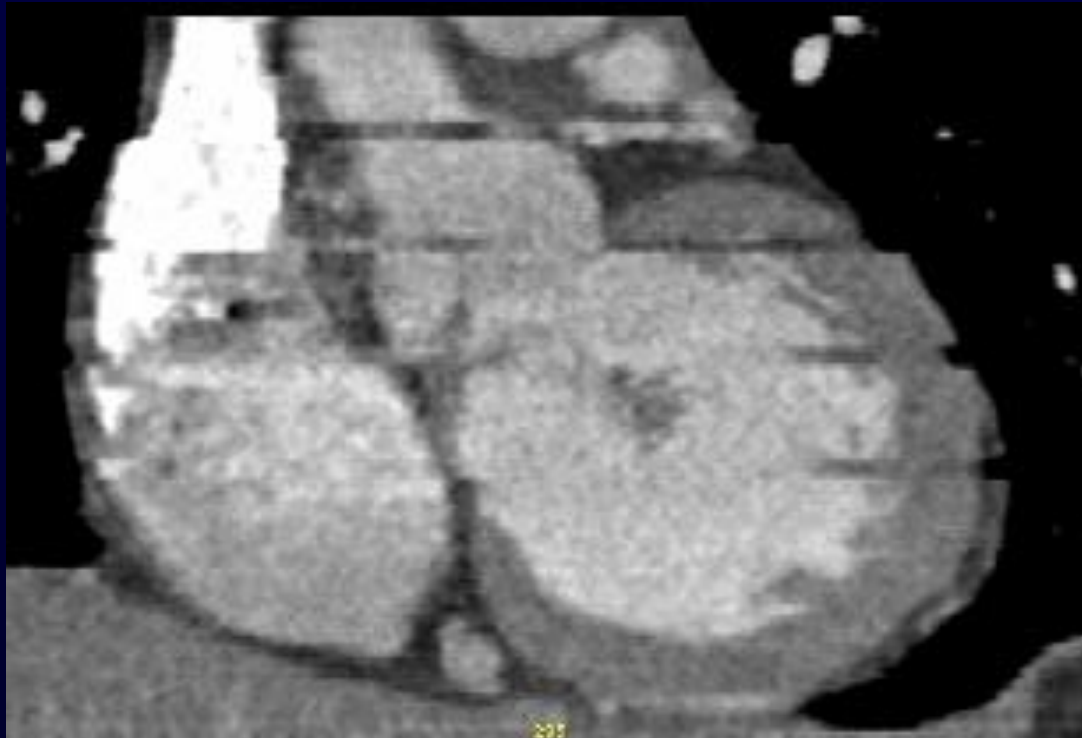
- Slender patients give better (more accurate) images

Irregular heart beats: limit accuracy

- Avoid patients with multiple atrial/ventricular ectopy
- Atrial fibrillation patients not usually suitable

CTCA Challenges 2017: Irregular Heart Beat

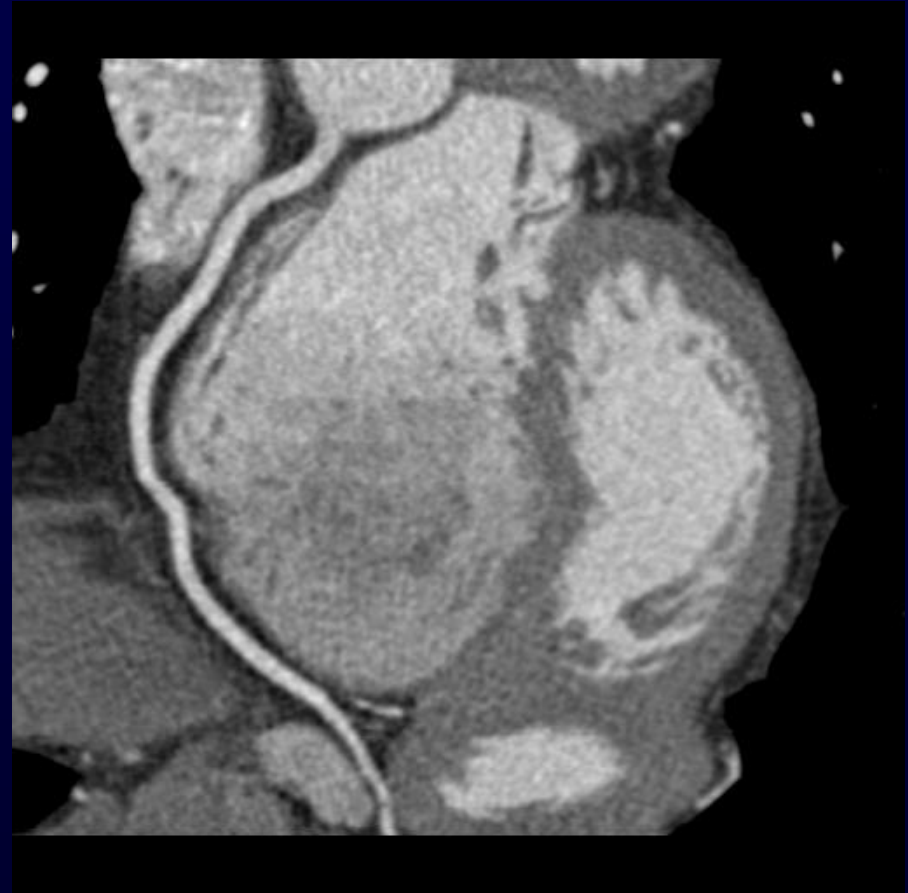
- Irregular rhythm results in a ‘artefact’
 - ‘Steps’ in the cardiac image
 - e.g. Atrial fibrillation, frequent ectopy



Case 1 (MM): Recurrent Atypical Symptoms

- 59 year old female, 'vice-like' chest pains
 - ACH admission: Xmas holidays
 - ECG/Troponins normal
 - SOB at 7 mins ETT, No ECG changes
- FH of hypertension; T Chol. 6.0 mmol/l
- Options:
 - Nil else, stress echo, Cath, CTA, Other?

CTA: High Negative Predictive Value for Non-obstructive Coronary Disease



As long as the images obtained are of good quality

CASE 1: MM

Accession number:

16416398

Date: 23/1/15



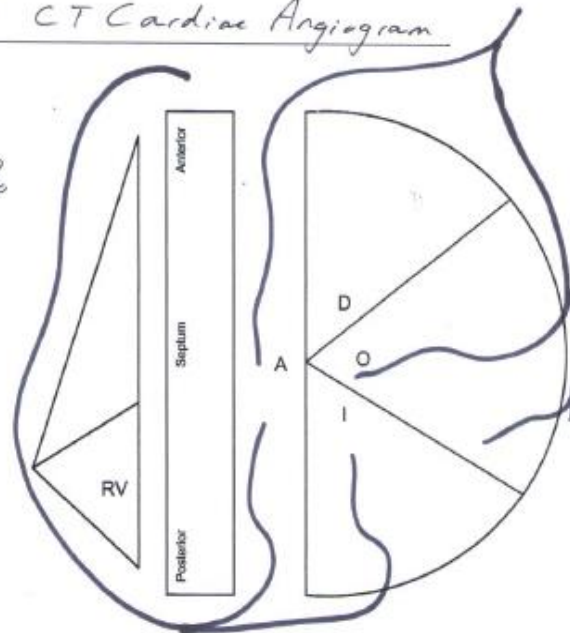
Green Lane
Coronary Diagram

Operator/s: 1 C Ellis 2 3

Reporter/s: 1 C Ellis 2

ADHB CT Cardiac Angiogram

MB
Please also
review the
General
Radiology
Report
for the
pt.



- Y Muscle Bridge
- + Calcification
- ~ Irregularities
- ★ Prev. Interv. Site
- || Stent

DLP 655 mGycm

Calcium Score: N: 1 Agatston Units:
0-25th percentile for 59 year old female

ACCESS _____ F

CATHETERS Diagnostic Guide

LCA _____ F _____ F

RCA _____ F _____ F

Grafts _____ F _____ F

NITROGLYCERIN

- None
- Sublingual
- Intracoronary



Normal 0
Hypokinetic 1
Akinesis 2
Dyskinetic 3

Post ectopic Sinus

COMMENTS: CT Cardiac Angiogram

No atheroma seen.

No stenoses. Calcium Score: N: 1

Diastolic volume	mls	ml/m ²
Systolic volume	mls	ml/m ²
LV Pressure	mmHg	mls ml/sec

Case 1 (MM) Atypical Symptoms: Summary

- CT Angiogram excluded flow limiting stenoses
 - Ca score optimally assessed CVS risk
- Gastroscopy, GORD, Omeprazole
 - Patient happy
 - Drs confident of diagnoses
 - Management clear

CASE 2 (BA): Inconclusive ETT Results

- 70 year old male, usually fit & well
 - 2 month history of exertional chest pain & SOB/OE
 - COPC ETT to 12 mins
 - No chest pain or ST segment changes
- FH IHD (F < 60 years), hypertension, on statin
- Options:
 - Nil else, stress echo, Cath, CTA, Other?

The Problem with HIGH Calcium load



CASE 2: BA

Accession number:

16417069

Date: 23/1/15



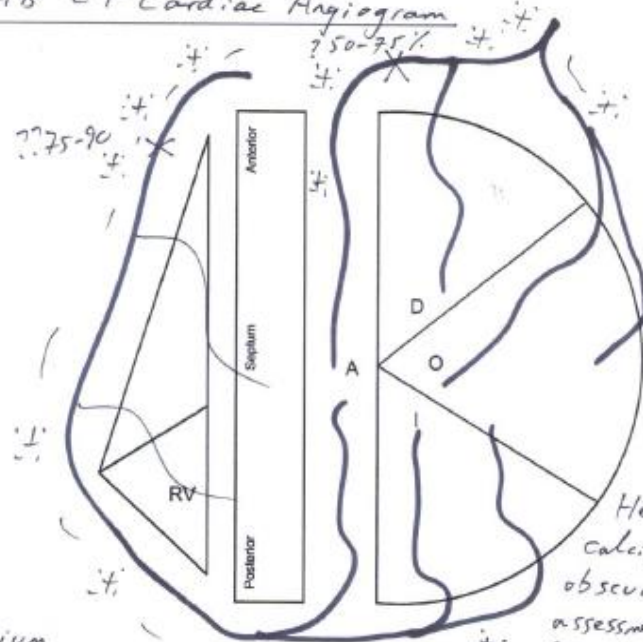
Green Lane
Coronary Diagram

Operator/s: 1 C Ellis 2 _____ 3 _____

Reporter/s: 1 C Ellis 2 _____

ADHB CT Cardiac Angiogram

- Y Muscle Bridge
- + Calcification
- ~ Irregularities
- * Prev. Intv. Site
- || Stent



NB
Please Also
review
the
General
Radiology
Report
for thpt

Heavy
calcification
obscures good
assessment of lumen.
Recommend Invasive
Coronary angiogram.

Calcium
Score = 977 Agatston Units
75 to 90th percentile for
a 70 year old male.

ACCESS _____ F
CATHETERS Diagnostic Guide
LCA _____ F _____ F
RCA _____ F _____ F
Grafts _____ F _____ F

DLP 818 mgy/cm

NITROGLYCERIN
None
Sublingual
Intracoronary



Normal 0
Hypokinetic 1
Aknetic 2
Dyskinetic 3

Post ectopic Sinus

COMMENTS:
Ca Score: 977 (75-90th)
Calcium obscures lumen.
Possible Stenosis. Recommend Invasive Angiogram.

Diastolic volume	mls	ml/m ²
Systolic volume	mls	ml/m ²
LV Pressure	mmHg	mls ml/sec

Diastolic volume	130 ml	64 ml/min
Systolic volume	30 ml	15 ml/min
LV Pressure	121/16 mmHg	350/120 mmHg/sec

Case 2 (BA) Inconclusive ETT: Summary

- CT Calcium score: 75-90th percentile
 - CT Angiogram incomplete, but probable flow limiting stenoses
 - Conventional angiogram required, then PCI
- Reasonable use of CTA (Could have gone straight to Cath)
 - Drs confident of diagnoses
 - Management clear (PCI & prevention medication)
 - Patient properly diagnosed and treated

CTCA 2017: Imaging Aberrant Coronary Arteries

3D
Ex:
Se: 133 +c
Volume Rendering No cut

SPR

IB 31 May 2011
M 75 AW1261973821.342.1306822898
DoB:
Ex: Sep 30 2009

DFOV 17.0cm
STND/C2 Ph:75% (No Filt.)

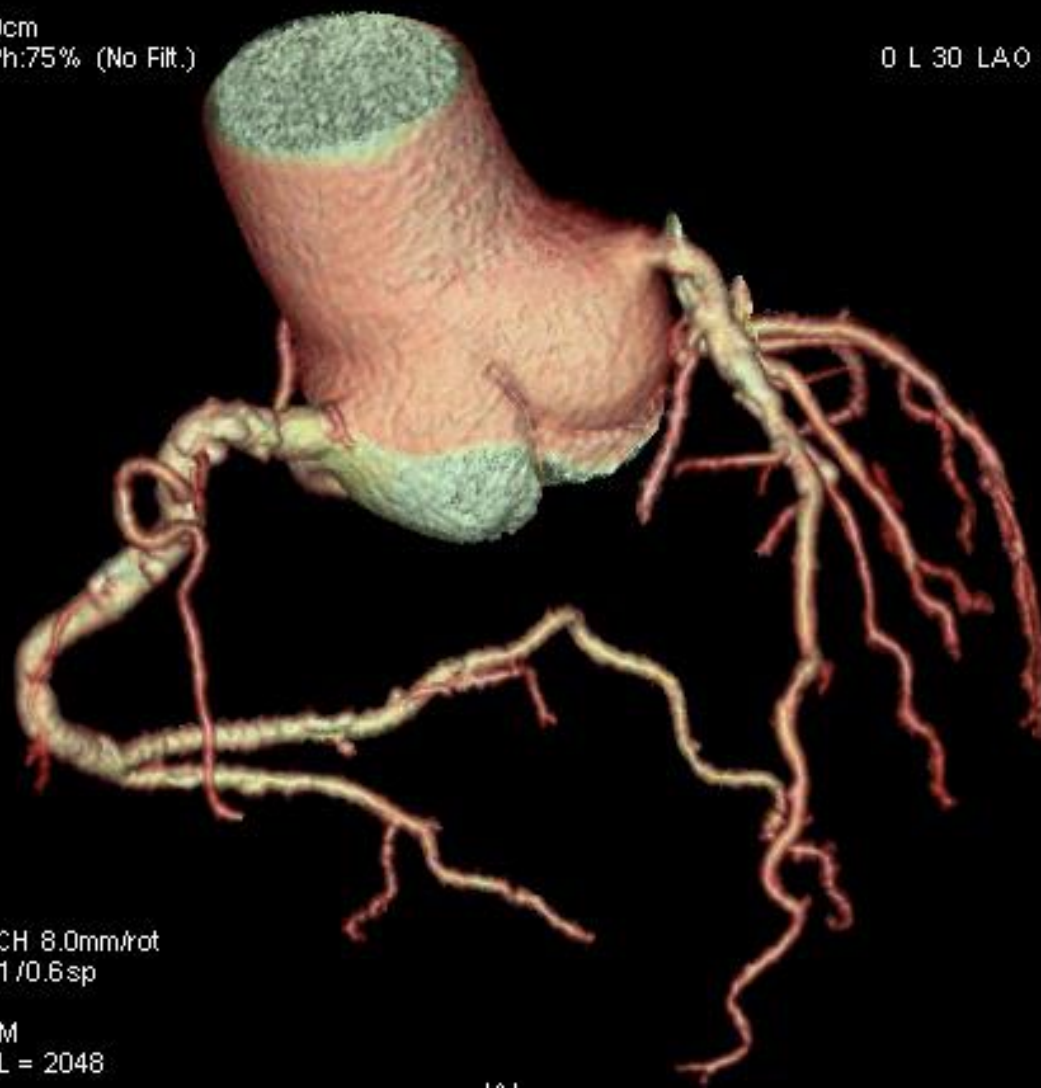
0 L 30 LAO 30 CRA

R
A

L
P

No VOI
kv 120
mA Mod.
Rot 0.35s/CH 8.0mm/rot
0.6mm 0.2:1/0.6sp
Tilt: 0.0
02:52:38 PM
W = 4095 L = 2048

IAL



3D
Ex:
Se: 133 +c
Volume Rendering No cut

I 83

IB 31 May 2011
M 75 AW1261973821.342.1306822898
DoB:
Ex: Sep 30 2009

DFOV 17.0cm
STND/C2 Ph:75% (No Filt.)

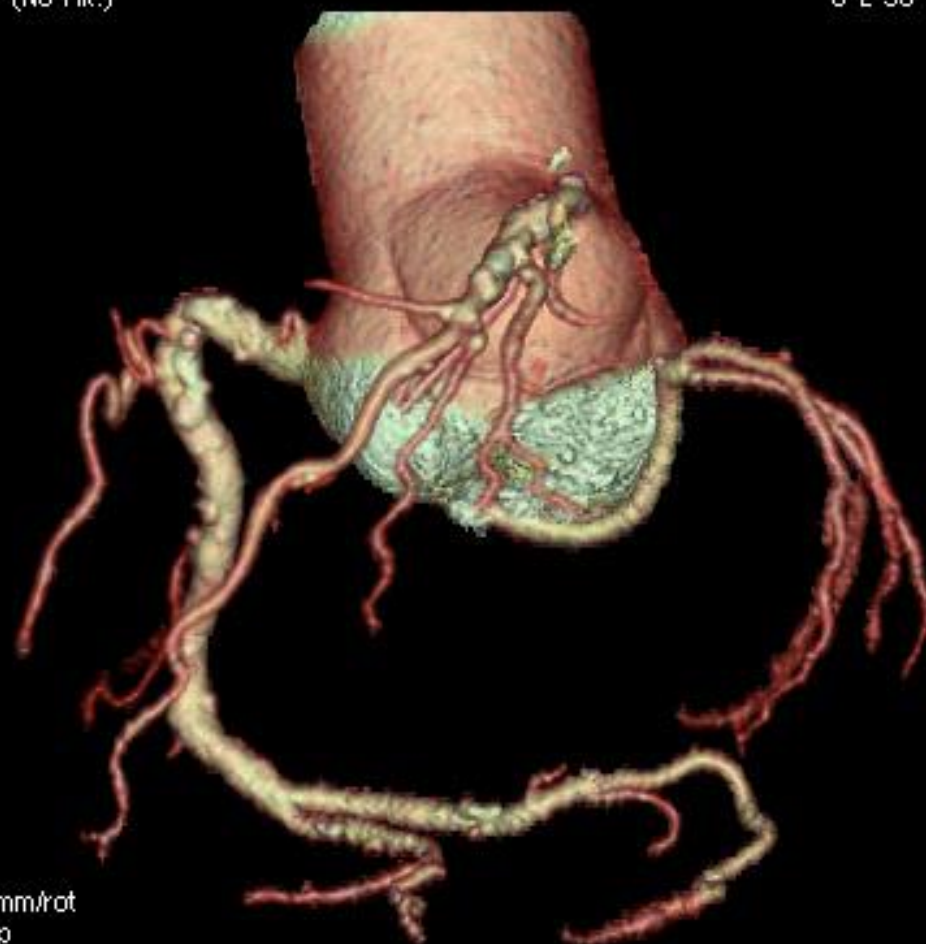
0 L 90 LA 0 0 CRA

A
1
0
3

P
6
7

No VOI
kv 120
mA Mod.
Rot 0.35s/CH 8.0mm/rot
0.6mm 0.2:1 /0.6sp
Tilt: 0.0
02:52:38 PM
W = 4095 L = 2048

I 253



CTCA 2017: Imaging Thoracic Aorta

3D
Ex:
Se: 133
Volume Rendering No cut

DFOV 21.1cm
STND/C3 Ph:75% (No Filt.)

SPR

AM Ao Dil Mass
F 71 AW1481183568.892.1307328849
DoB:
Ex: Dec 10 2008

0 L 30 LAO 30 CRA

R
A

L
P

No VOI
kv 100
mA Mod.
Rot 0.35s/CH 8.0mm/rot
0.6mm 0.2:1/0.6sp
Tilt: 0.0
02:14:19 PM
W = 4095 L = 2048

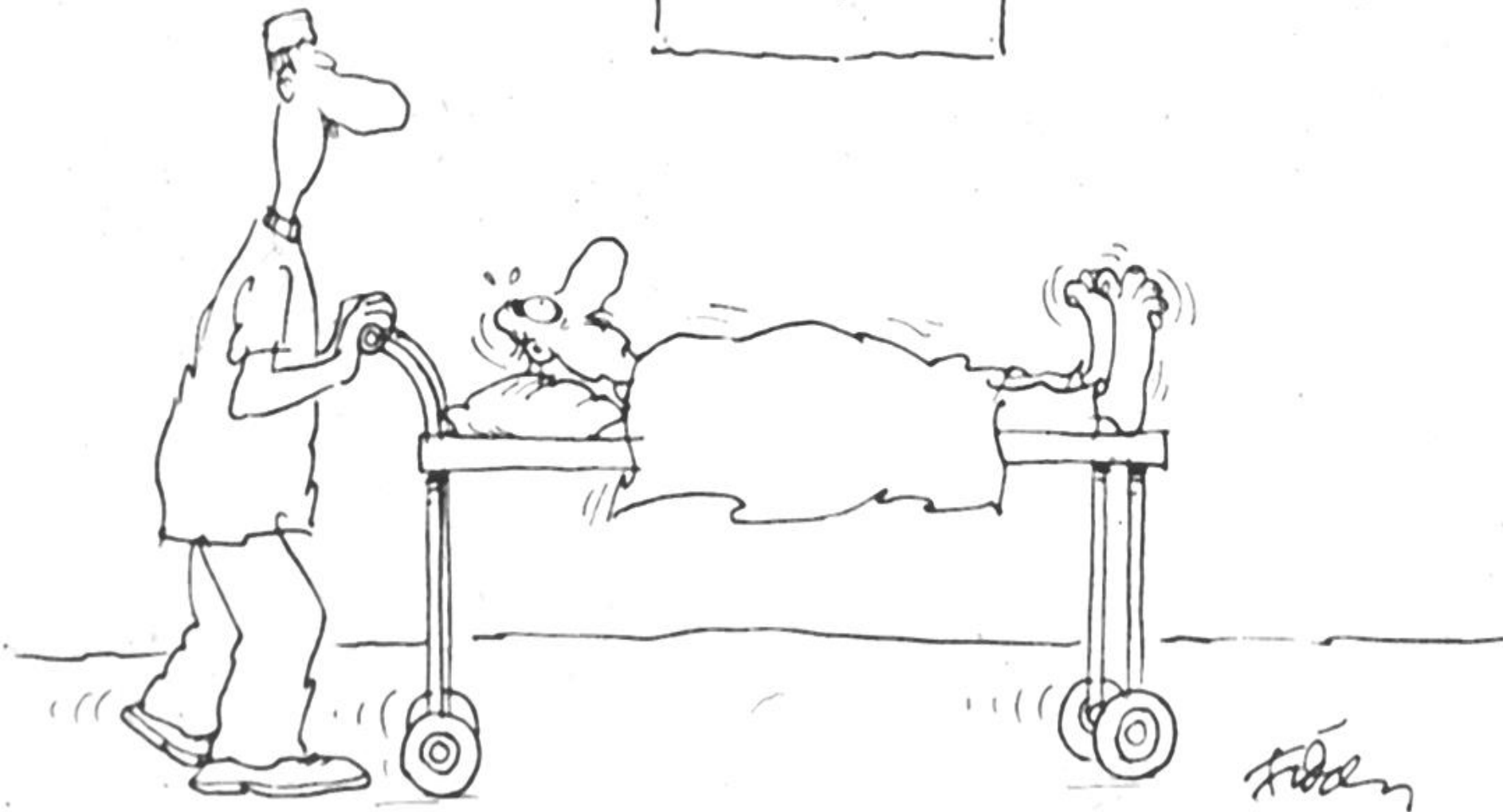
IAL

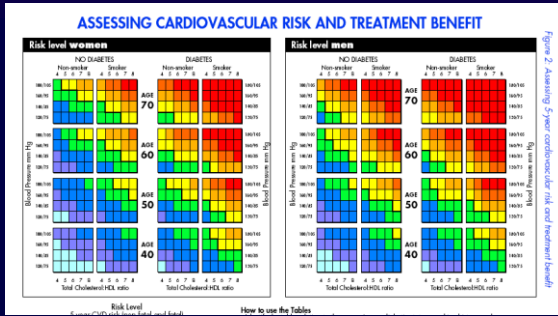


CT Heart Scanning 2017: Summary

- Ca Score alone: CVS Risk
- Ca Score & CT Angiography
 - Atypical symptoms
 - Equivocal ETT
- CT Angiography alone
 - Aorta, Pericardium imaging
 - TAVI assessment
 - EP (Pre-Af ablation assessment)

The End
➔

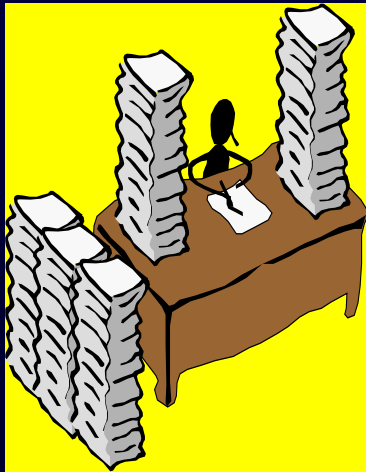
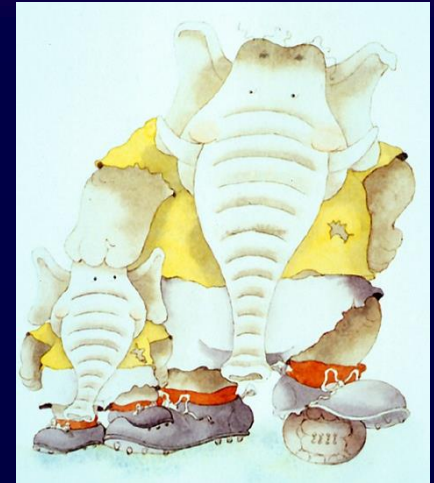




Framingham-Based:
5 or 10-Year Risk &
“Lifetime-Risk”

CVS Risk Assessment

Family History



“Modern Risk Factors”



Calcium Scoring & CT
Angiography

Personal Risk: No
longer abstract!
Very motivating:
Lifestyle &
Medication

