Review of Cardiac Imaging Modalities in the Renal Patient

George Youssef

- ECHO
  - Left ventricular hypertrophy (LVH) assessment
  - Diastolic dysfunction
  - Stress ECHO
- Cardiac CT angiography

Echocardiography - positives

- Mobile / portable
  - Bedside assessment
- Fast
- Assessment of ventricular function, mass / LVH.
- Gold standard for assessment of valvular function, diastolic dysfunction.
- Pericardial disease
- Pulmonary disease
- Aorta

Echocardiography - limitations

- Operator dependent
- Patient dependent
  - Poor acoustic windows
    - Very obese, very thin, laying flat / upright, CAL etc
- Reporter dependent
- Many measurements difficult to reproduce (eg,EF measurements, volume measurements, LV mass)

LVH

- Increase in the mass of the left ventricle (LV) – myocyte hypertrophy
  - Increase in wall thickness
  - Increase in size of LV
- ECHO more sensitive than ECG criteria

- Men normal– 135g (71g/m2)
- Women normal – 99g (62g/m2)
- LVH – men LV mass >134g/m2, women >110g/m2
- LV mass increases with age (women)

LVH - aetiology

- Hypertension

- Chronic kidney disease
  - 30-45% of patients not on dialysis - LVH
    - Severity and prevalence increases with decreasing GFR
  - 42% of patients at start of dialysis
  - 75% of patients on haemodialysis for 10 years

LVH - aetiology

- Obesity, OSA, Diabetes - ?independent of Ht

- Other
  - Cardiac - **Hypertrophic cardiomyopathy**, aortic stenosis / regurgitation / co-arctation / **athlete**
  - Non-cardiac - Urinary albumin excretion, acromegaly etc

LVH - mimics

- Infiltration
  - amyloidosis
  - Fabry's disease

- Inflammation
  - Myocarditis

Hypertension

- LVH
- Interstitial fibrosis
  - Angiotensin II
    - ACEI / AII blockers result in more consistent regression of LVH c.f B-Blockers
  - Endothelin
  - ?genetic component
    - Mild Ht – marked hypertrophy
    - LVH may predate hypertension
    - DD genotype of ACE gene.

Hypertension – increased LV mass

- Diastolic dysfunction
  - Diastolic heart failure

- Increase in LV mass independent predictor of mortality and cardiovascular disease. Independent of the level of blood pressure.

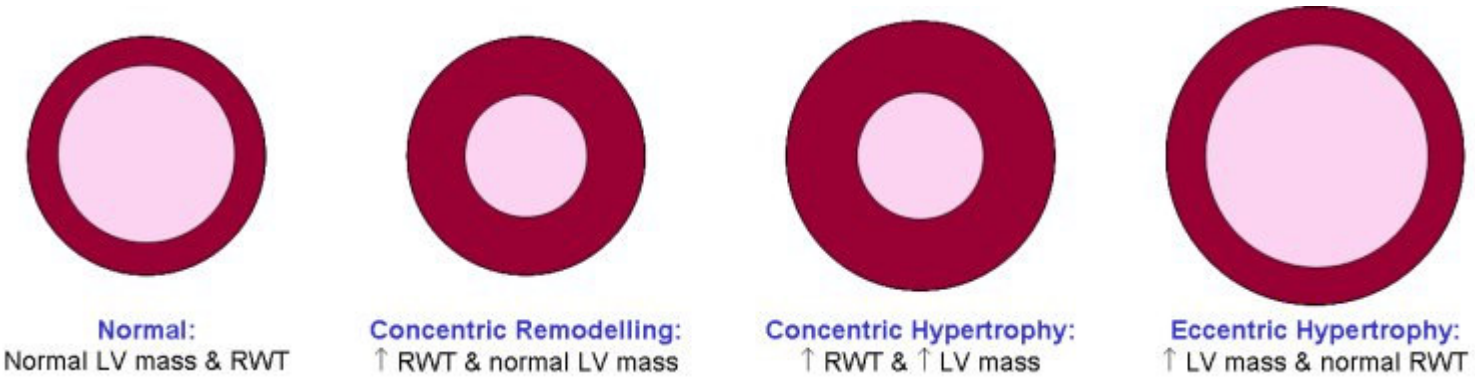
Chronic kidney disease ('uremic cardiomyopathy')

- Increase in LV mass
  - Hypertension
  - Anaemia
  - ?PTH
  - Independent predictor of mortality
- LV dilatation (diastolic diameter)
  - AV fistulae
  - Anaemia

Chronic kidney disease (‘uremic cardiomyopathy

- Heart failure
  - Diastolic dysfunction
  - Systolic dysfunction
- Coronary artery disease (atherosclerosis)
- Valvular calcification
- Pericarditis / effusion

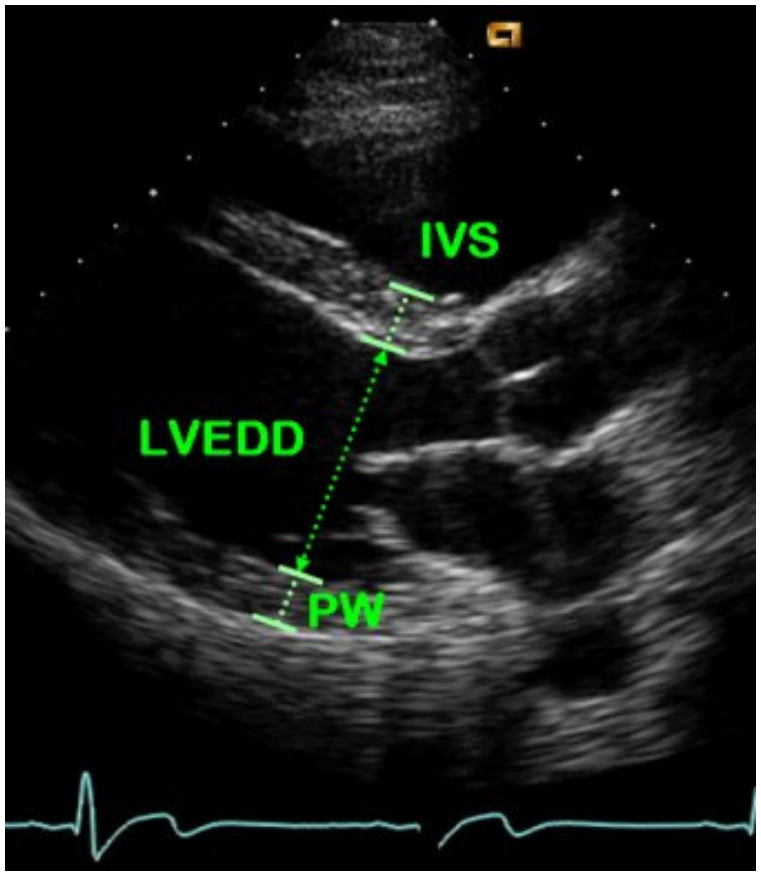
Patterns Of LVH – LV geometry



Concentric remodelling and concentric hypertrophy confer same adverse CVS risk.

RWT – relative wall thickness (>0.42 abnormal)

LVH assessment - ECHO



Cardiologists report LV wall thickness and do not routinely report LV mass

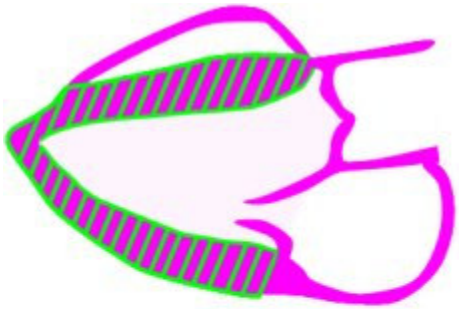
Evidence based on LV mass

LV mass

LV epicardial volume

LV endocardial volume

LV muscle volume



x specific gravity of muscle

= LV mass

LV muscle volume

x 1.04 (or 1.05)

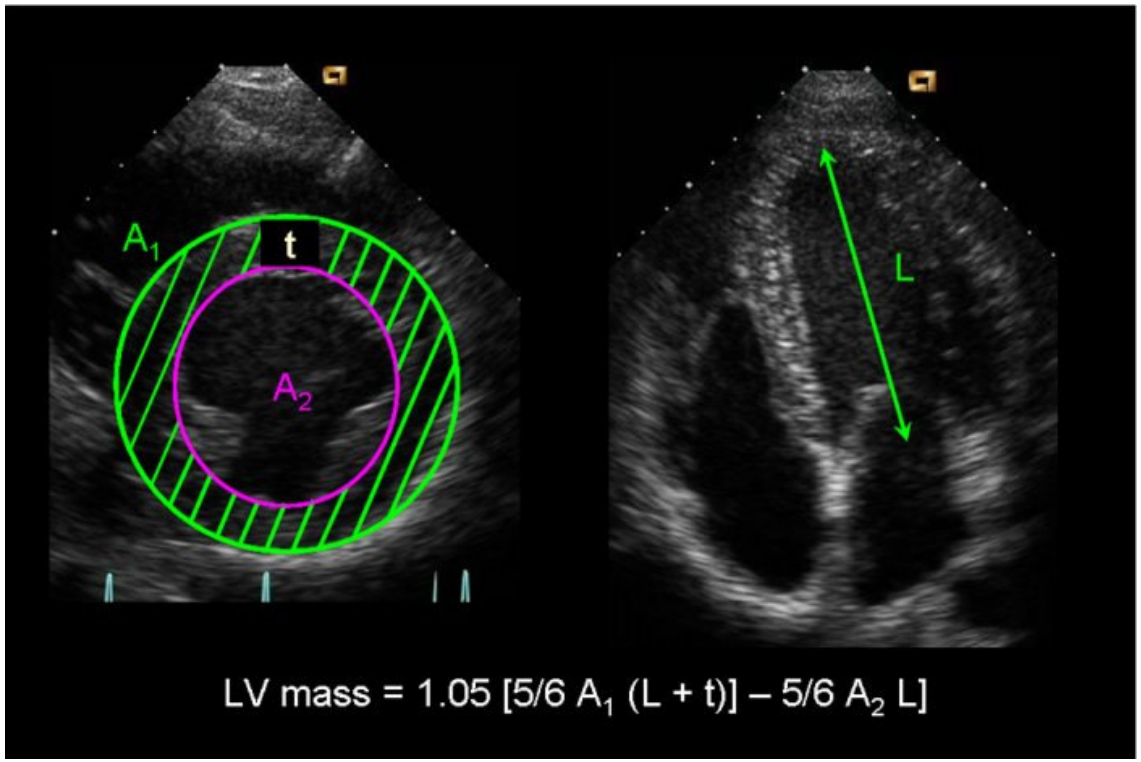
= LV mass

Table 4 Reference limits and partition values of left ventricular mass and geometry

	Women				Men			
	Reference range	**Mildly abnormal**	**Moderately abnormal**	**Severely abnormal**	**Reference range**	**Mildly abnormal**	**Moderately abnormal**	**Severely abnormal**
2D Method								
LV mass, g	66–150	151–171	172–182	>193	96–200	201–227	228–254	>255
LV mass/BSA, g/m²	*44–88*	*89–100*	*101–112*	***≥113***	*50–102*	*103–116*	*117–130*	***≥131***

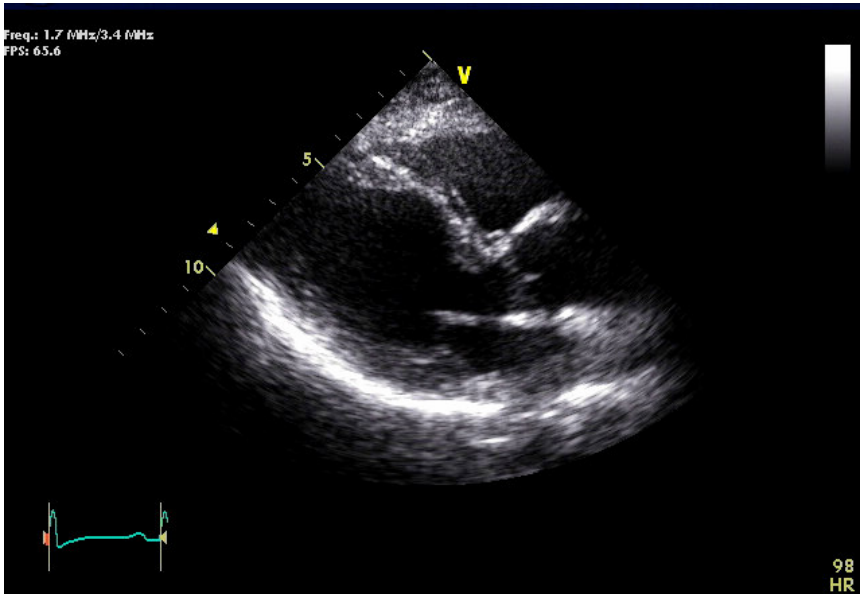
BSA, Body surface area; *LV*, left ventricular; *2D*, 2-dimensional.
Bold italic values: Recommended and best validated.

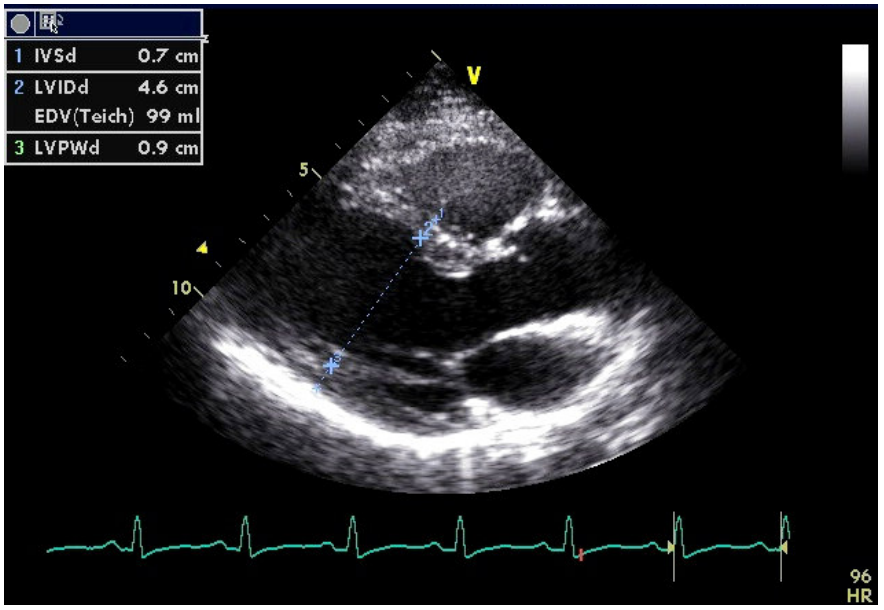
LV mass – 2D (standard)



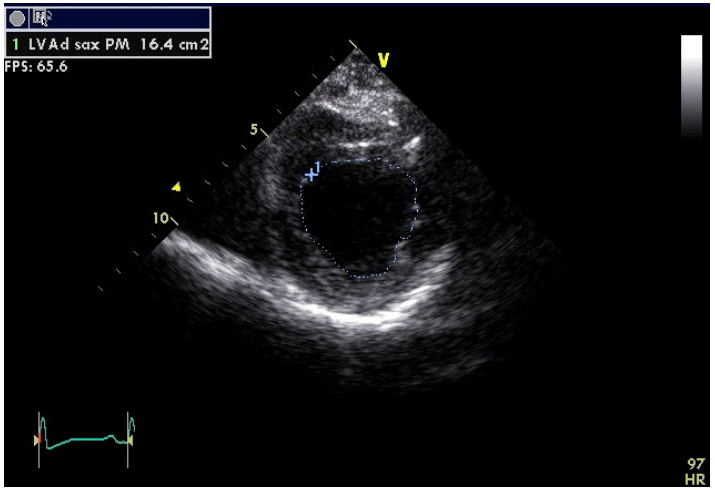
AREA / LENGTH METHOD

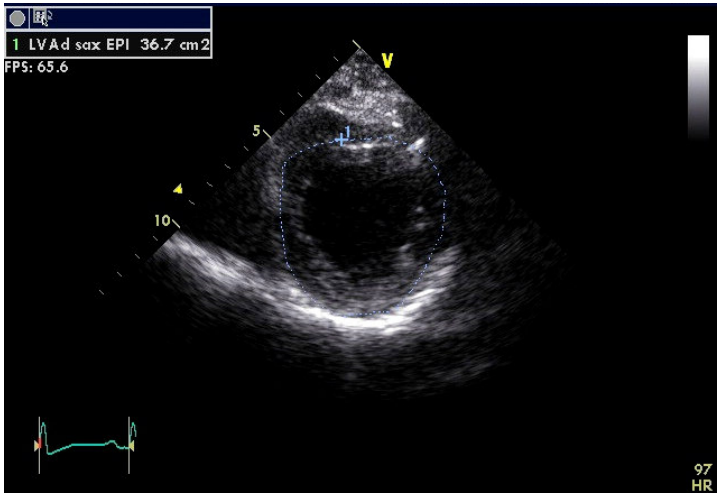
Normal wall thickness



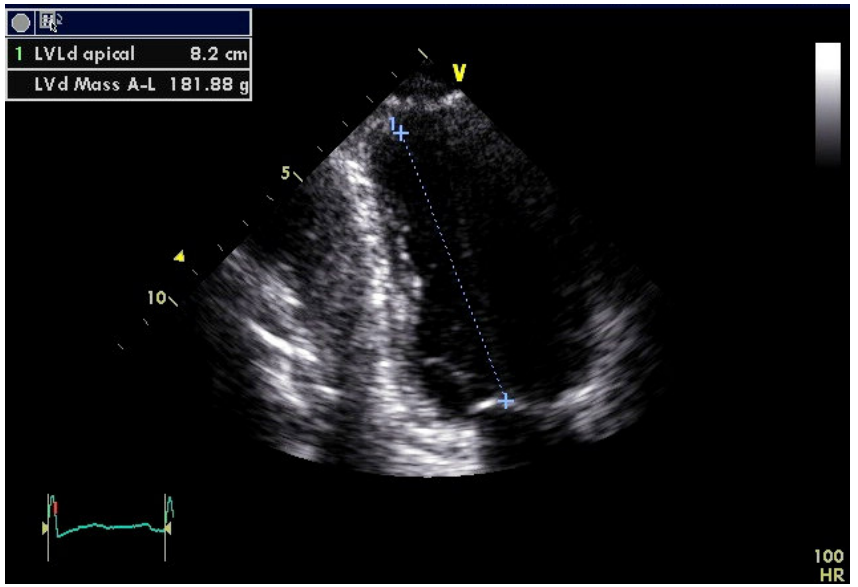


LV mass - increased

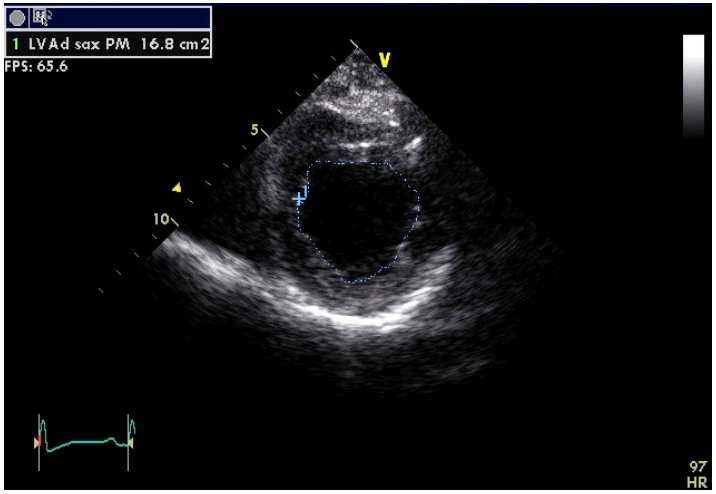


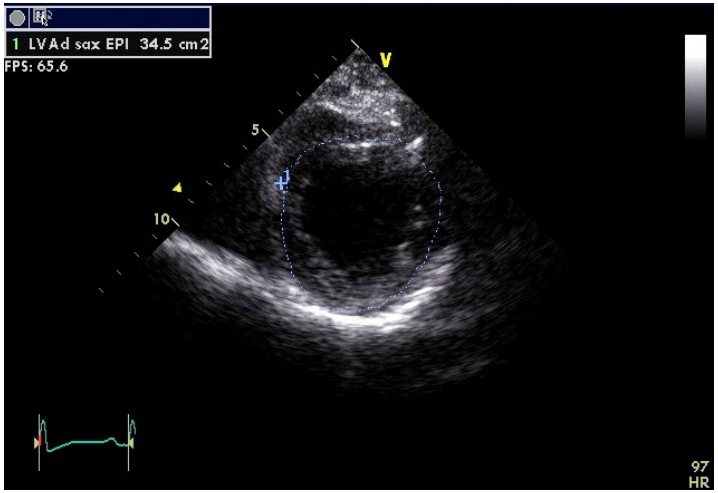


LV mass indexed 104g/m2

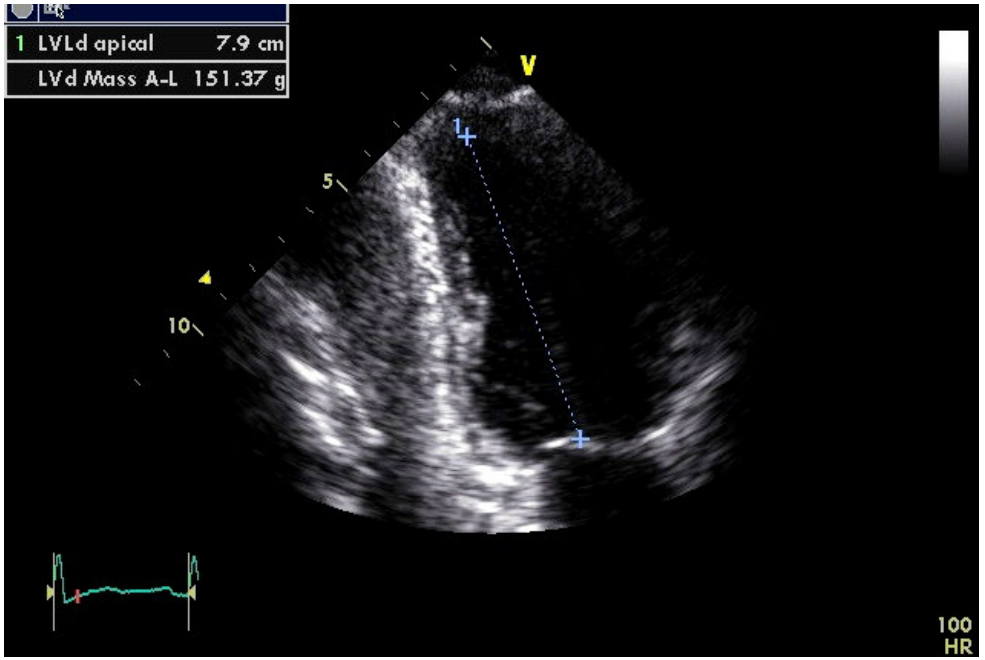


LV mass – normal (same patient)





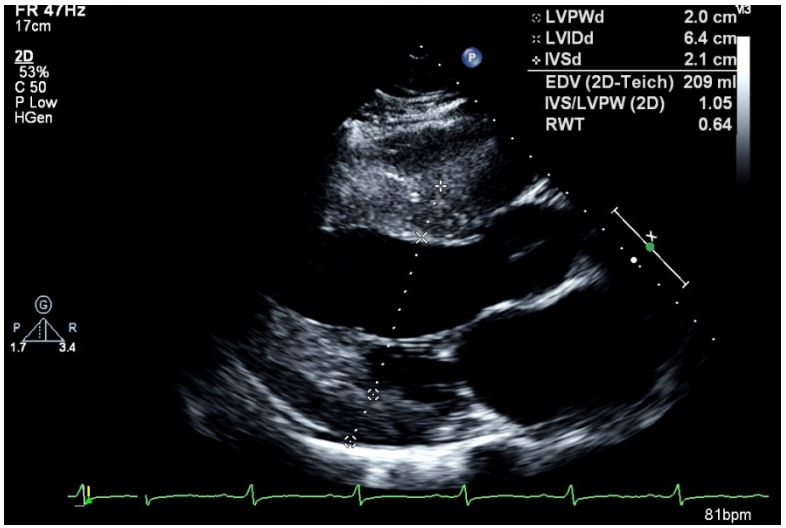
LV mass – 90 g /m2

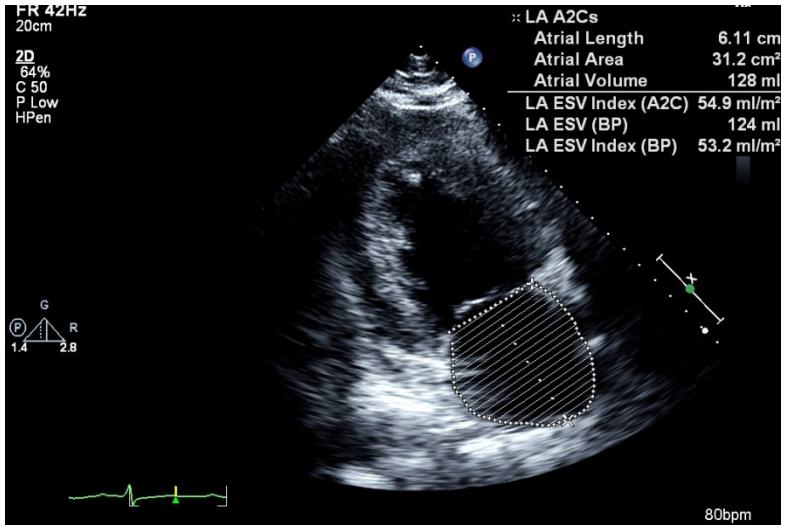


LV mass - echo

- Errors in measurement limit use
- Not useful to follow progression / regression of LVH on treatment
- 3D echo – allow better volume estimation
- MRI - superior endocardial / epicardial definition
  - Allows fibrosis estimate
  - Most accurate method to estimate LV mass.

28 yo male hypertension





Severe LVH

Diastolic Dysfunction

- Inability to fill LV to a normal end-diastolic volume without an abnormal increase in LV end-diastolic or LA pressure
- Accounts for approx 50% of heart failure with normal systolic function.
- Survival over 5 years equivalent to patients with heart failure and impaired systolic function
- Degree of diastolic dysfunction in 'healthy individuals' correlates with adverse events

Diastolic Dysfunction

- Stiff ventricle fails to relax
- Progressive increase in stiffness (reduced compliance) of LV associated with progressive rise in LVED pressure and LA pressure (filling pressure)
- LA dilates
- Increase in LA pressure accounts for symptoms
  - Dyspnoea, LVF
- Increased risk of atrial fibrillation
- Long standing can predispose to pulmonary hypertension

Diastolic Dysfunction

- Acute heart failure precipitants
  - Uncontrolled hypertension
  - Ischaemia
  - AF
  - NSAIDS
  - ARF
  - Anaemia

Diastolic Dysfunction - aetiology

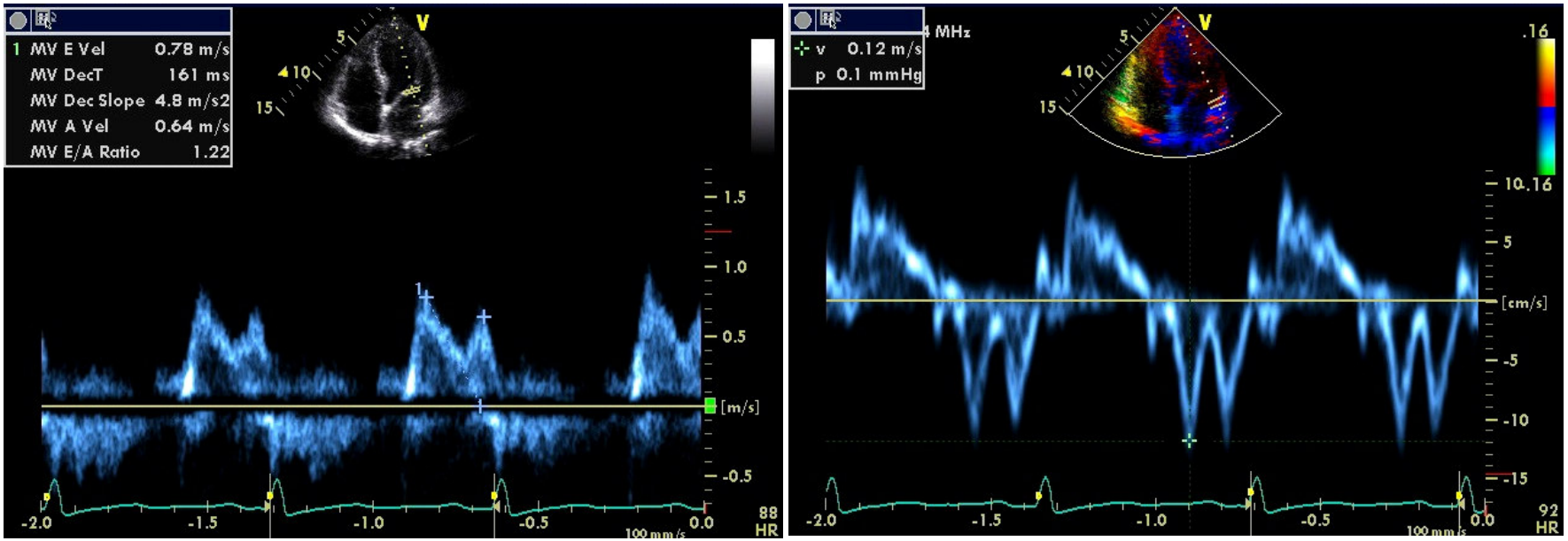
- Most common cause is hypertension (80% of diastolic dysfunction attributed to hypertension)

- Other – CKD, HCM / Restrictive CMP, constrictive Pericarditis, obesity, DM, OSA, coronary disease

Diastolic dysfunction

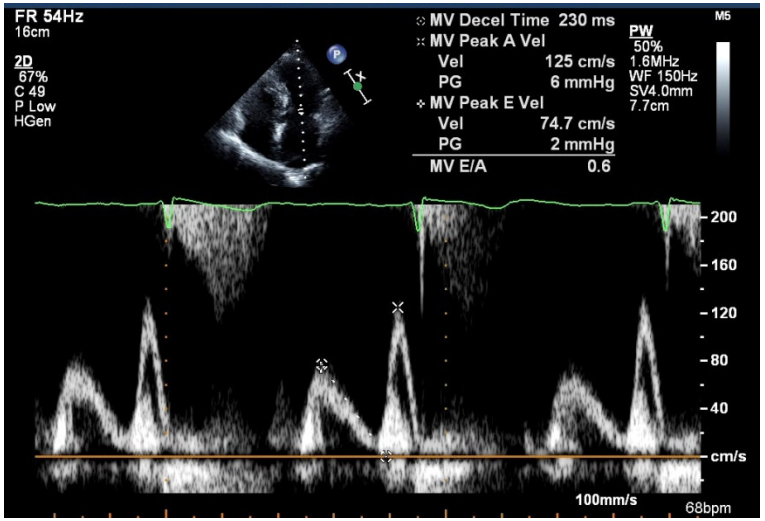
- ECHO - LV hypertrophy, +/- increase in LA size
- Trans-mitral Doppler - velocity assessment of blood flow across mitral valve between LA and LV
- Tissue Doppler – measure of LV tissue velocity at annulus during diastole
- Change in pattern reflects progressive increase in LVED pressure or LA pressure

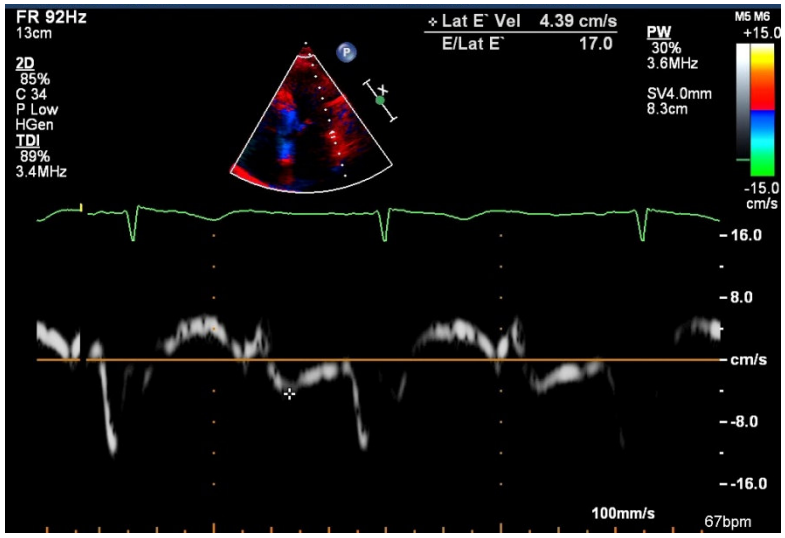
Diastolic function - normal



E/A ratio between 0.7 and 1.3. Dec time between 140 and 220ms. E' >8cm/s, E/E' <10. Normal LA pressure

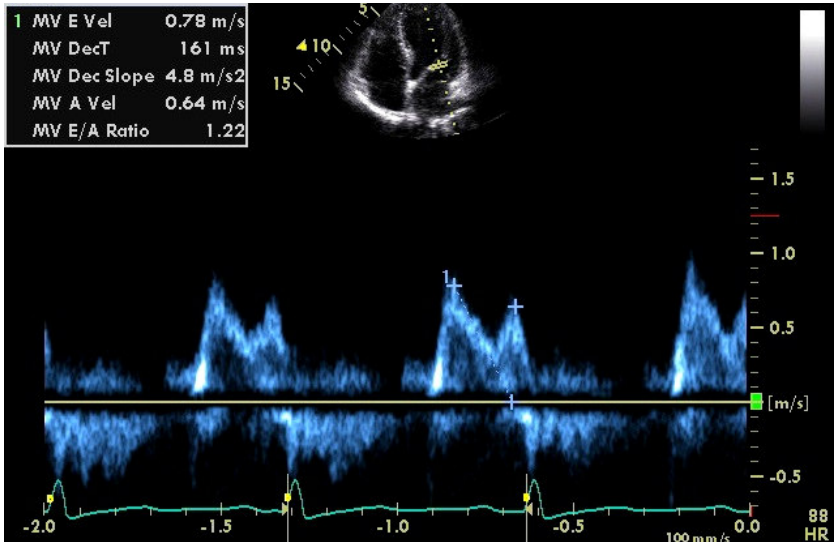
Diastolic Dysfunction grade 1 (impaired relaxation)

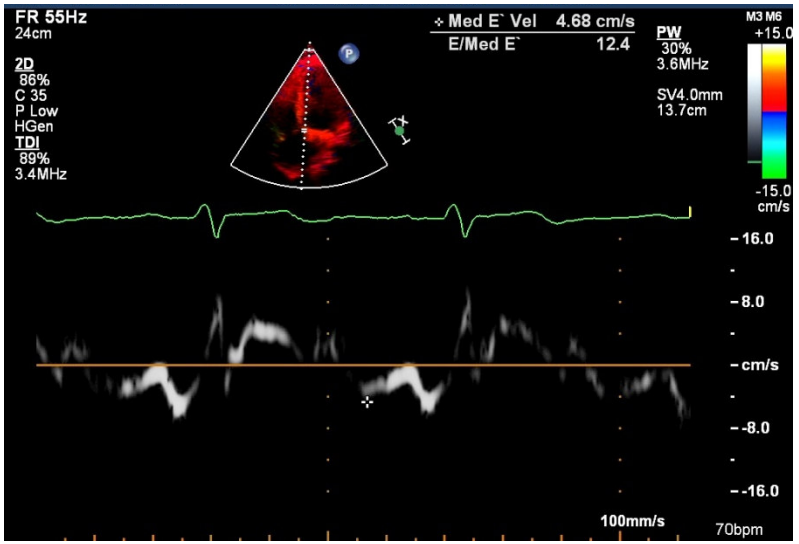




E/A <0.7, E/E' >10, E' <8 cm/s, E Dec t 230ms.
LA pressure normal or mildly increased (Grade 1a)

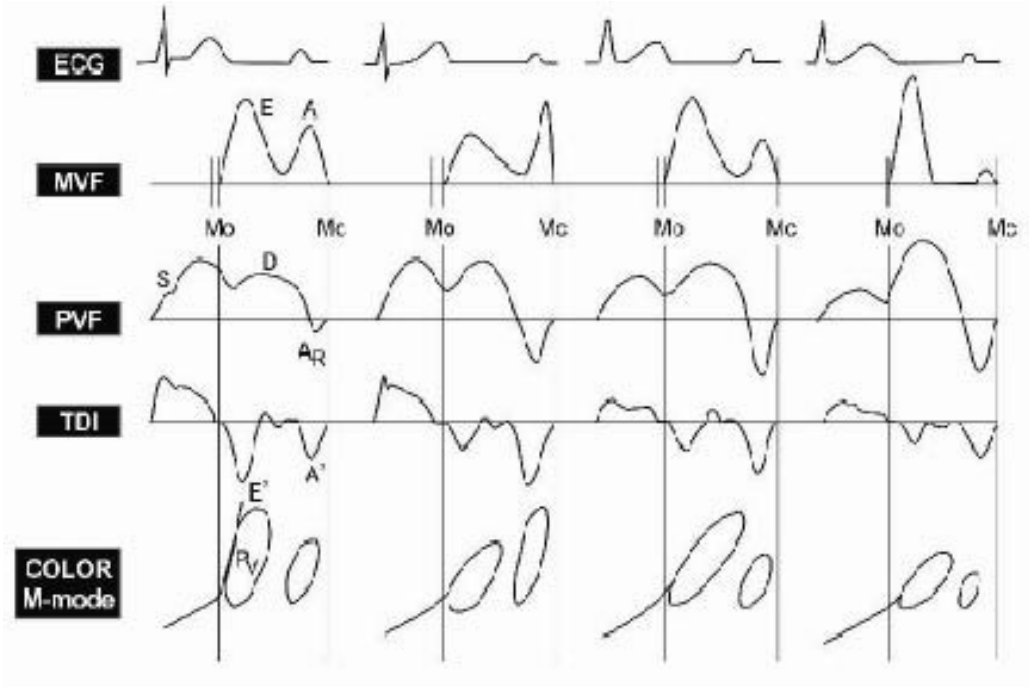
Diastolic dysfunction grade 2 (Pseudo normal)



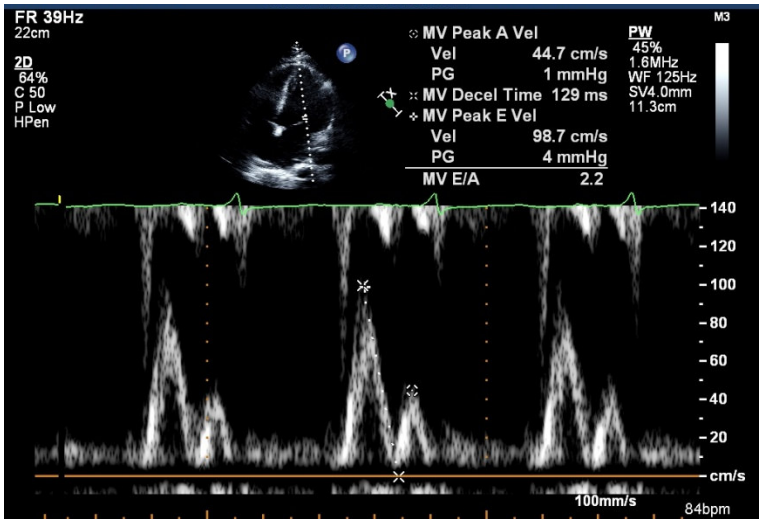


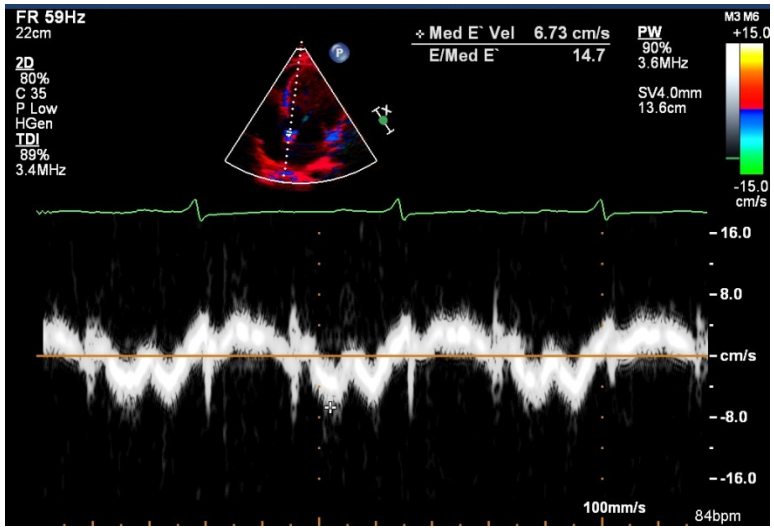
E/A ratio normal, Dec T normal, E/E' >10, E' <8cm/s. LA pressure moderately increased

Diastolic dysfunction - grade



Diastolic dysfunction grade 3 (Restrictive)





E/A >1.5 (or >2), E/E' >10, E' <8, Dec t <140ms. Significantly increased LA pressure. Reversible initial stages. Irreversible – grade 4

Diastolic dysfunction - numbers to remember

- E/A ratio < 0.7 (Stage 1 diastolic dysfunction)
- E/A > 1.5 (usually greater than 2) - Stage 3 / restrictive
- E'<8cm/s consistent with diastolic dysfunction
- E/E' >10 (lateral) >15 (medial annulus) consistent with diastolic dysfunction with elevated LA pressure
- All numbers found on ECHO report (often not in conclusion)
- Presence of LVH and LA dilatation suggestive of diastolic dysfunction.

Diastolic dysfunction - Rx

- Treat underlying cause
- Gentle diuresis
- A2 receptor blockers (candesartan)
- Slow heart rate – B-blockers

Stress ECHO vs Stress ECG

- Improves sensitivity and specificity ~85%
  - False positive / negative rate ~15% (depends on pre-test probability)
  - Less sensitive, more specific than nuclear myocardial perfusion
- Allows determination of vessel involved and extent of ischaemia.
- ECHO – quick valve / LV function assessment.
- Problems
  - More time (~15mins)
  - Operator / patient dependent
  - Difficult to interpret peri-infarctional ischaemia / and in LBBB

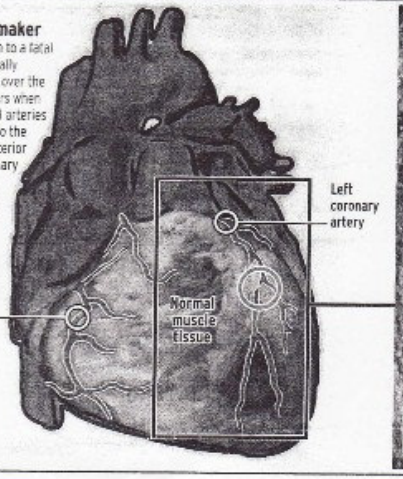
CT coronary angiography (CTCA)

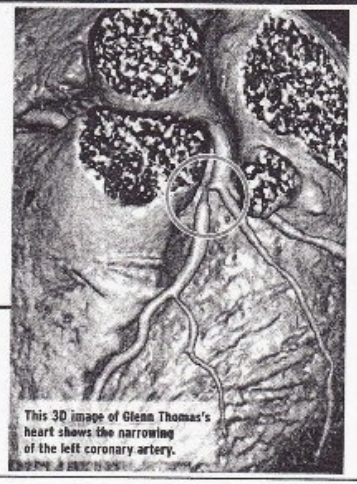
Nine seconds that could save your life

WHEN THE HEART SHOWS NO MERCY

The widow-maker

A nickname given to a fatal heart attack, usually prevalent in men over the age of 50. It occurs when one of the critical arteries supplying blood to the heart, the left anterior descending coronary artery, suffers a blockage due to narrowing of the artery.

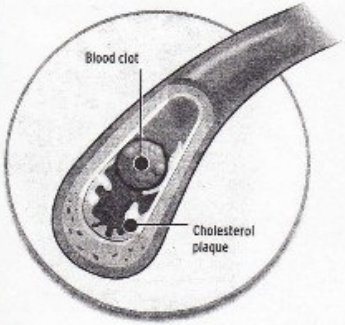




This 3D image of Glenn Thomas's heart shows the narrowing of the left coronary artery.

What can cause the blockage

Stenosis - or narrowing - of the blood vessel is caused by cholesterol deposits - a process called atherosclerosis. Complete obstruction of the artery by a blood clot can result in a major heart attack.



SOURCE: WORLD HEART FEDERATION

By LOUISE HALL
HEALTH REPORTER

A MACHINE that detects heart disease in people who have no symptoms is saving the lives of thousands of Australians at risk of heart attack.

In nine seconds the CT scanner can diagnose blocked arteries – known as "widow-makers" for their tendency to cause sudden death in seemingly healthy people.

Results from the computer tomography coronary angiogram are so good the Federal Government's Medical Services Advisory Committee (MSAC) last month recommended it be paid for by the public purse. Health Minister Nicola Roxon is considering the recommendation.

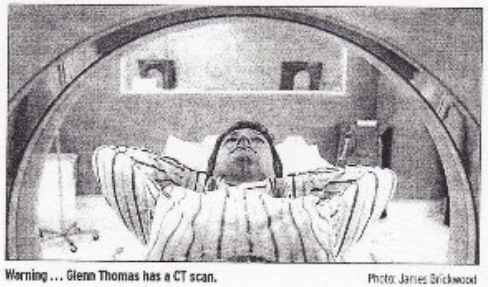
Coronary heart disease is the largest single cause of death and the most common cause of sudden death in Australia, claiming 24,576 lives in 2004 (19 per cent of all deaths).

Sydney Adventist Hospital took a gamble on the $3 million 128-slice dual source scanner in January last year. Chief radiologist Martin Davis said an average of five patients a day now undergo the test.

Health-conscious baby boomers, and even people in their 30s and 40s, are signing up – but without Medicare rebates the scan costs $825.

Dr Davis said about two-thirds of patients had no history or symptoms of heart disease but wanted to eliminate or confirm the possibility.

NSW Health has since installed the scanners at Liverpool, Concord, Royal Prince Alfred and Fairfield hospitals. A spokesperson said: "In terms of costs, generally speaking the aim is for there to be no 'out of pocket' expenses. How that is achieved depends on whether it's billed to Medicare or a private health fund."



Warning ... Glenn Thomas has a CT scan. Photo: James Brickwood

MSAC found the machine, which scans faster than a beating heart, is safer than conventional, invasive catheter angiography, in which contrast agents are injected near the heart. It is also more cost-effective in detecting heart disease in low-to-medium risk patients, the report, handed to Ms Roxon on April 11, found.

The scan works by capturing a series of cross-sectional images which the computer compiles into a detailed 3-D model. Doctors can then identify the extent of atherosclerosis – the hardening and narrowing of the arteries – which causes almost all cardiovascular disease.

North Narrabeen father-of-two Glenn Thomas, 45, was a "walking heart attack" when he experienced slight chest pain while cleaning the backyard pool. His GP sent him for a scan, which detected a 90 per cent blockage in his artery.

"I was leaving and the radiologist ran down the corridor and tapped me on the shoulder and said I had to come back immediately," he said. A few days later he had two stents surgically implanted, saving his life.

"At the time I was going to the gym and doing taekwondo and while I was struggling a bit I just put it down to getting older and being unfit.

"I was very lucky – the blockage was so large even doing the gardening could have caused a heart attack any time."

Heart Week begins today and with two out of three families affected by heart disease, the Heart Foundation is urging parents, grandparents and carers to get active with their young ones.

The foundation will today launch a new practical guide full of activities parents can do with their children to get them off the couch and make them "huff and puff".

CT Coronary Angiography

- Non-invasive coronary angiography
- Allows assessment of vessel wall and lumen
- 64 slice CT scanner or above
  - 0.5-0.6mm slices, 0.35mm spatial resolution
  - Image heart in single breath hold (with B-blockade)
  - Requires approx 80ml contrast

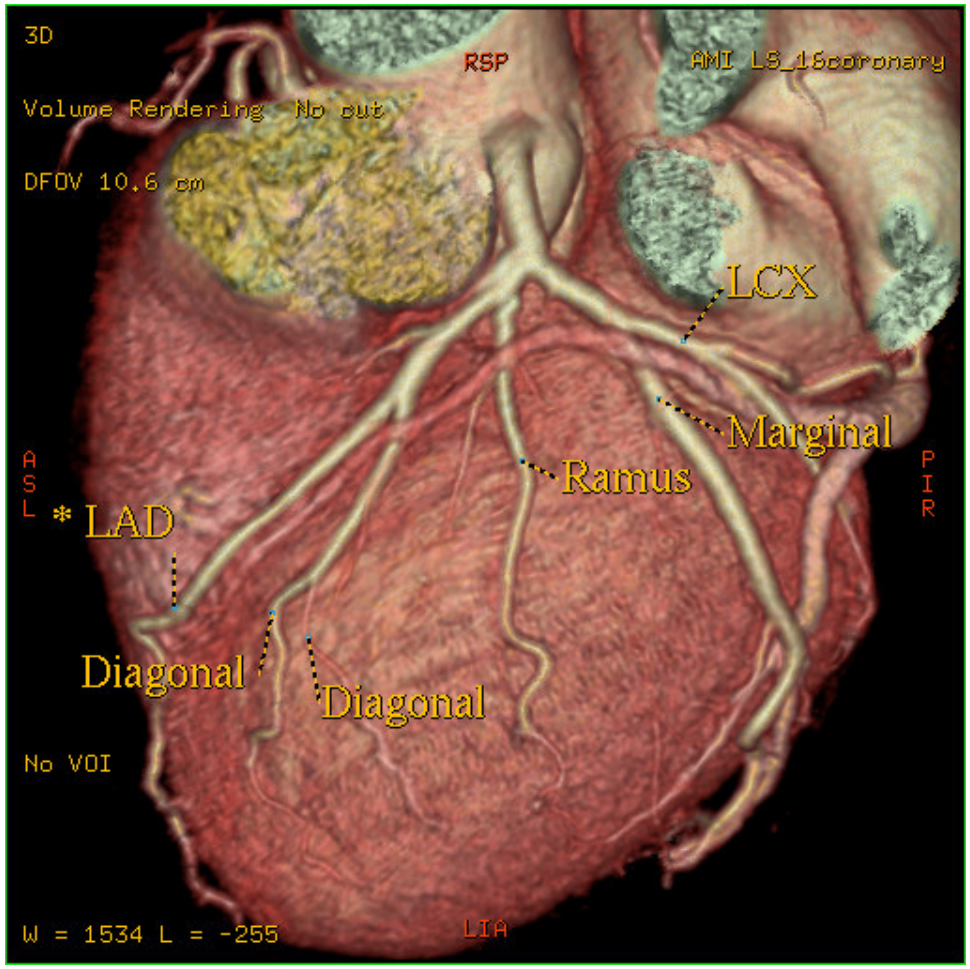
CTCA cf conventional angiography

- Sensitivity ~ 90%
- Specificity ~85%
- Negative predictive value 90 to 95% - good at ruling out significant disease (>50% stenosis)

- Radiation dose equivalent (~3-4mSv) – prospective scan

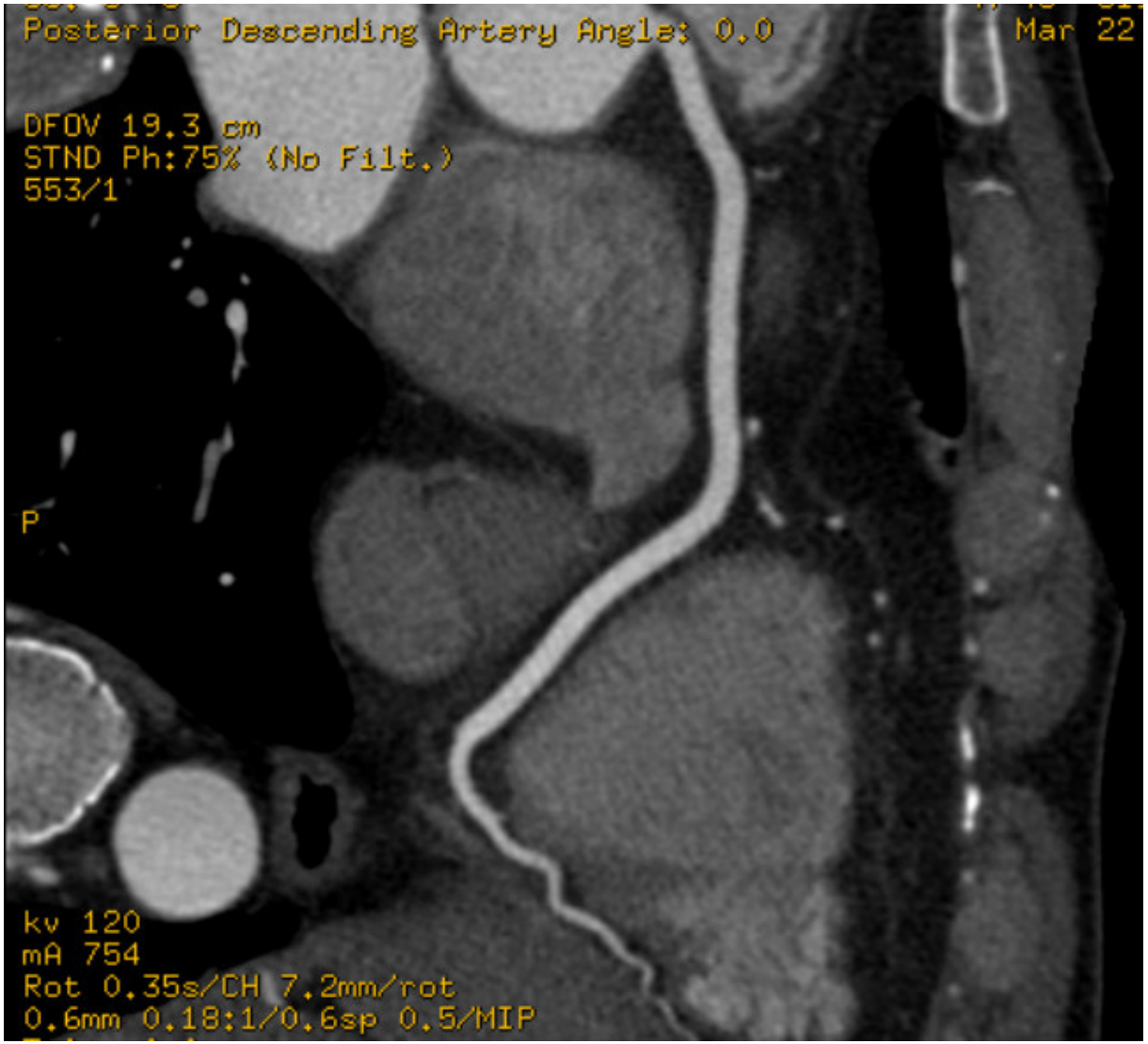
- Similar contrast dose (may need more in invasive angiography)

CTCA – volume image

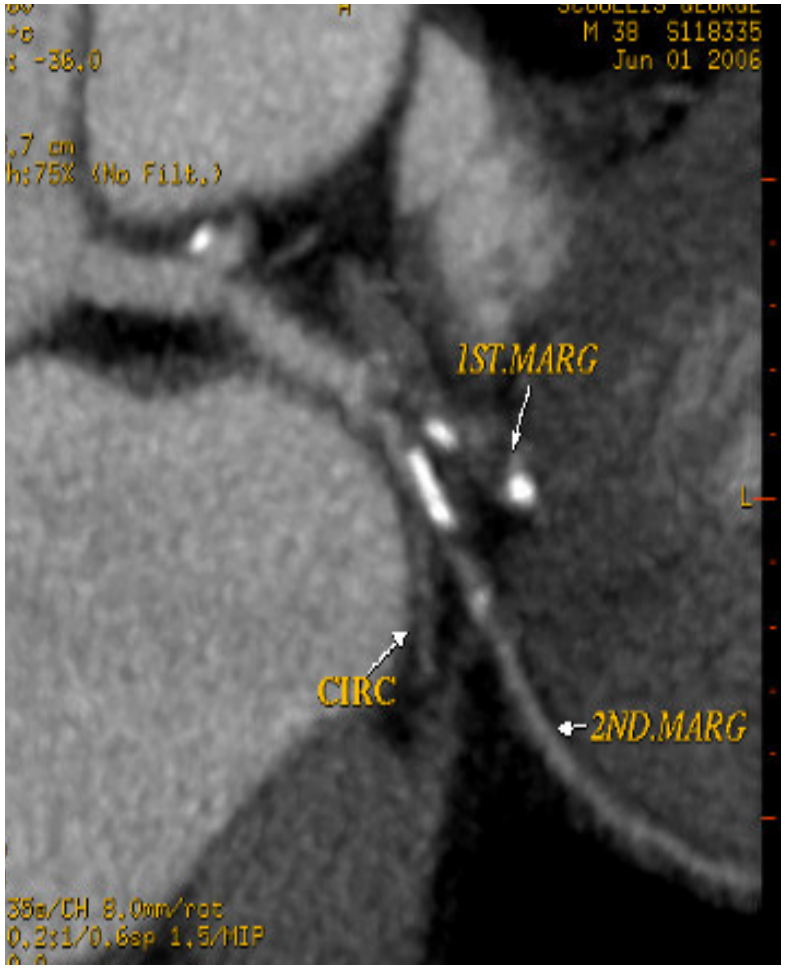


CTCA -


Left Anterior Descending Artery Angle: 160.0
Mar 22 2006
DFOV 18.3 cm
STND Ph:75% (No Filt.)
556/9
A
P
kv 120
mA 754
Rot 0.35s/CH 7.2mm/rot


Posterior Descending Artery Angle: 0.0
Mar 22
DFOV 19.3 cm
STND Ph:75% (No Filt.)
553/1
P
kv 120
mA 754
Rot 0.35s/CH 7.2mm/rot
0.6mm 0.18:1/0.6sp 0.5/MIP

CTCA and catheter angiogram comparison



CTCA –

- Problems
  - Cost
  - Contrast
  - Calcium – decreases diagnostic accuracy
  - Radiation

- Pro's
  - Non-invasive
  - Vessel imaging (wall and lumen)
  - Supplements/ replace stress test
  - Prognostic data – Ca, plaque detection and events

CTCA – in who?

- Equivocal EST in low / intermediate risk patient with chest pain

- Coronary artery anomalies

- ?Risk evaluation (asymptomatic)
- ?all low / intermediate risk chest pain (replace EST)