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

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<thead>
<tr>
<th></th>
<th>Women</th>
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<th>Men</th>
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<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mildly abnormal</td>
<td>Moderately abnormal</td>
</tr>
<tr>
<td>LV mass/BSA, g/m²</td>
<td>44–88</td>
<td>89–100</td>
<td>101–112</td>
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BSA, Body surface area; LV, left ventricular; 2D, 2-dimensional.
Bold italic values: Recommended and best validated.
LV mass – 2D (standard)

LV mass = 1.05 \left[ \frac{5}{6} A_1 (L + t) - \frac{5}{6} A_2 L \right]

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 heart attack that tends to kill because it occurs so suddenly
Next time you see a heart attack victim, see if you can diagnose it before it kills your victim.

Dr. Davey said that many people who have heart attacks are killed by the heart attack itself, not by the heart attack.

WHAT CAN CAUSE THE BLOCKAGE

Nolds of blood clots can cause sudden death in otherwise healthy people.

RESULTS FROM THE COMPUTER TOMOGRAPHY SCANNER

A computerized scan of the heart can help doctors detect blockages that may cause heart attacks.

BY LOUISE HALL

A MACHINING that detects heart disease in people who have no symptoms is proving to be one of the most effective ways to prevent heart disease.

In one case, the 3D scanner captured the image of a heart attack victim before it occurred.

The victim died a few minutes later.

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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 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)