Role of Cardiovascular Imaging in Management of HF

Cardiac imaging helps with:

- **Diagnosis of CHF and etiology of CHF**
- **Prognosis:**

  -Important prognostic factors in HF:

  1-Severity of CHF/ systolic and diastolic dysfunction

  2-Functional capacity.

  3-Cause/etiology of CHF (options available for treatment?).
- **Management/ Treatment follow up**

Cardiac imaging:

- Echocardiography:
  TTE, TEE, Stress echocardiography
- Nuclear cardiology imaging
- Cardiac CT
- Cardiac MRI

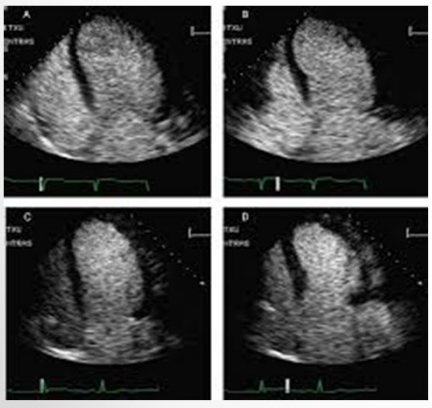
Transthoracic Echocardiography:

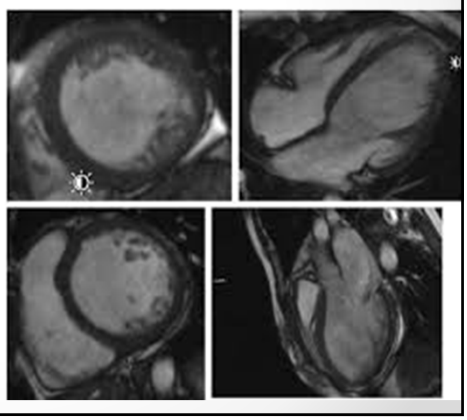
- Easy to perform
- Portable
- Can obtain result fast
- Very useful in emergency setting

Transthoracic Echocardiography:

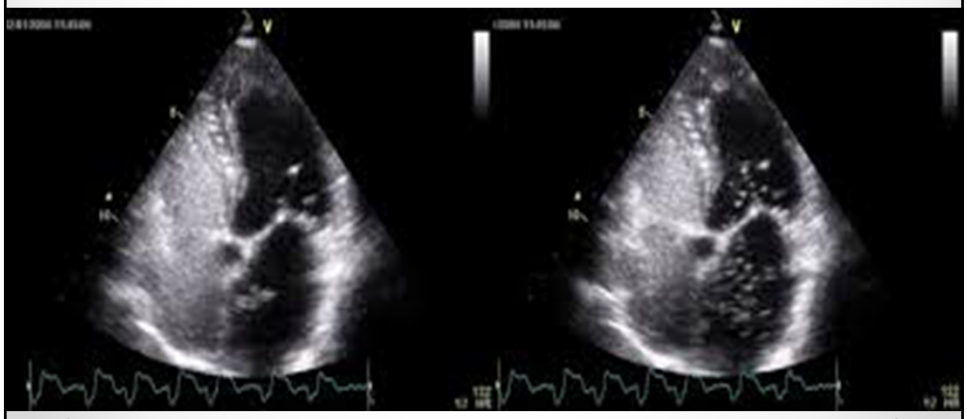
Transthoracic Echocardiography:

- In patients with poor images can use contrast echocardiography:
- Volumetric and EF measurements are comparable to cardiac MRI

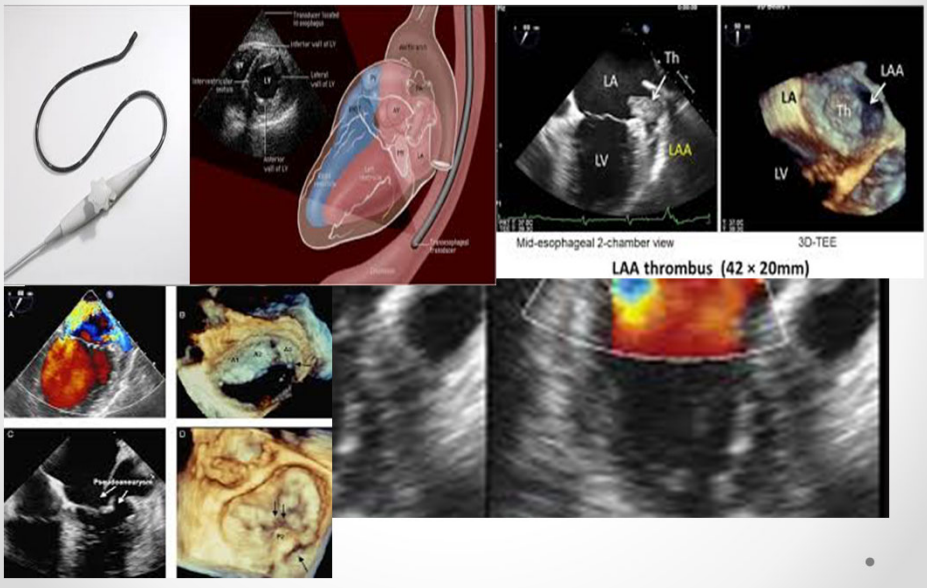




TTE/TEE with Agitated saline



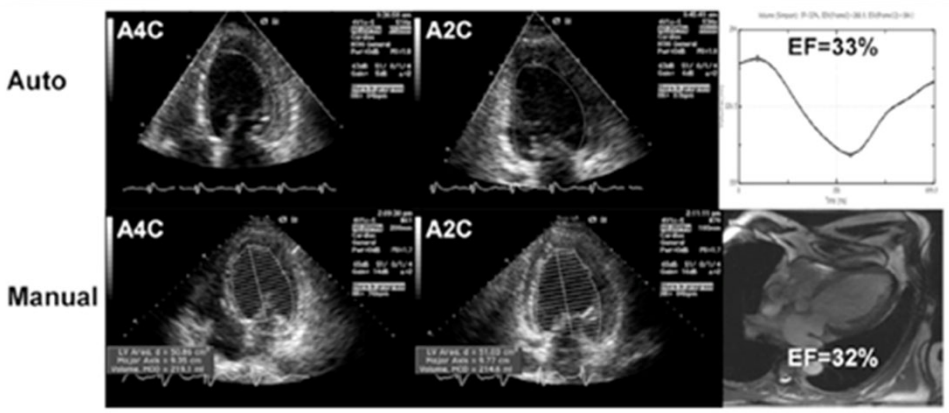
Transesophageal echo can be used.

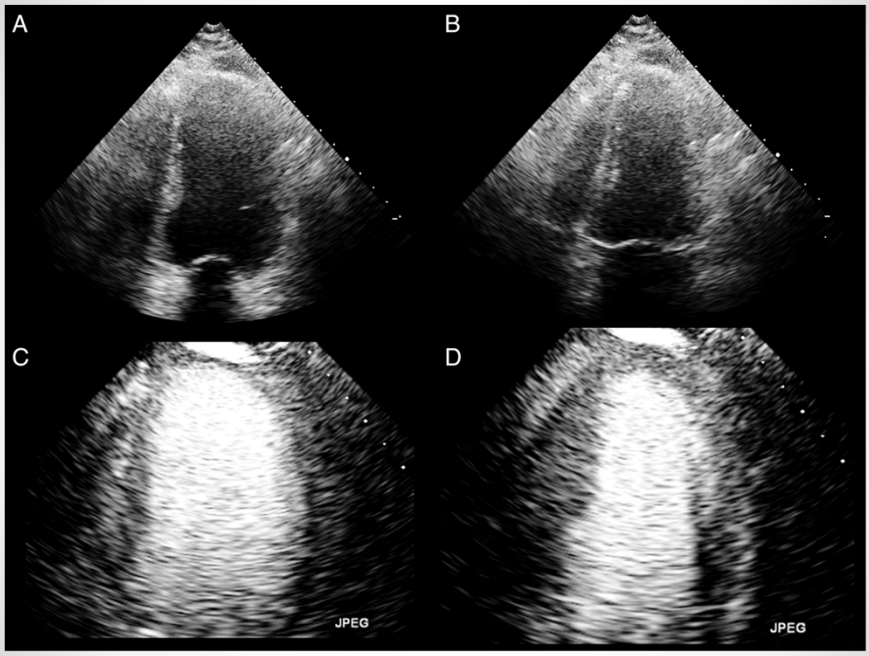


CHF

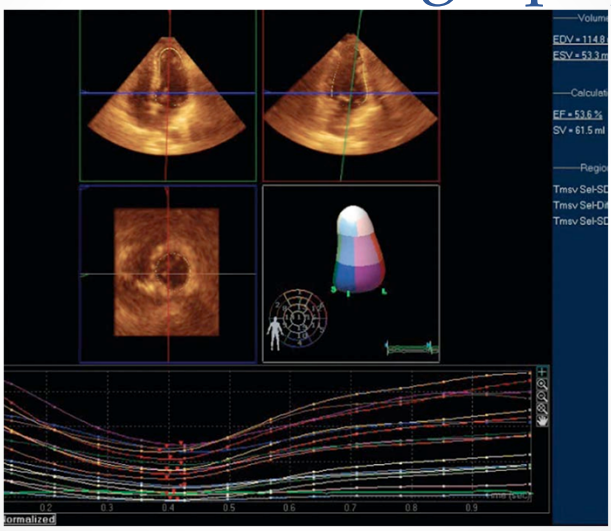
- Systolic dysfunction
- Diastolic dysfunction

Biplane disk method to evaluate LVEF





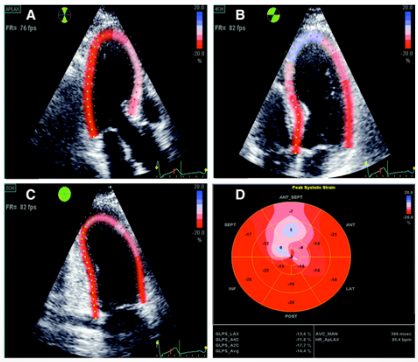
3-D echocardiography



- LVEF and volumes obtained by 3-D and contrast echocardiography has better correlation with CMR measurements.

- Almost always systolic dysfunction is already preceded by diastolic dysfunction
- Meaning everyone with systolic dysfunction already has diastolic dysfunction

- In many patients with with DD strain echo imaging shows evidence of subclinical systolic dysfunction by using strain study.



- Diastolic dysfunction

- The four recommended variables for identifying diastolic dysfunction and their abnormal cutoff values are:

1-Annular e' velocity:

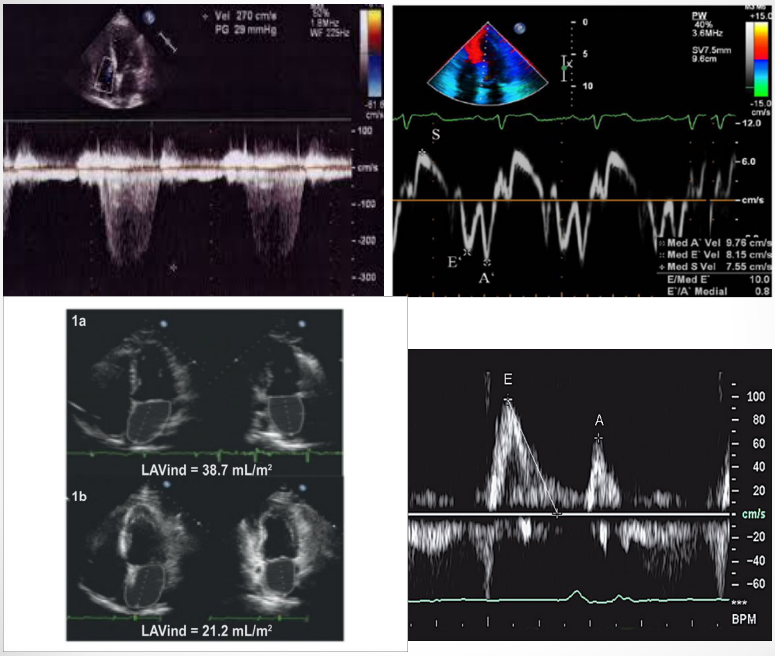
septal e' < 7 cm/sec,

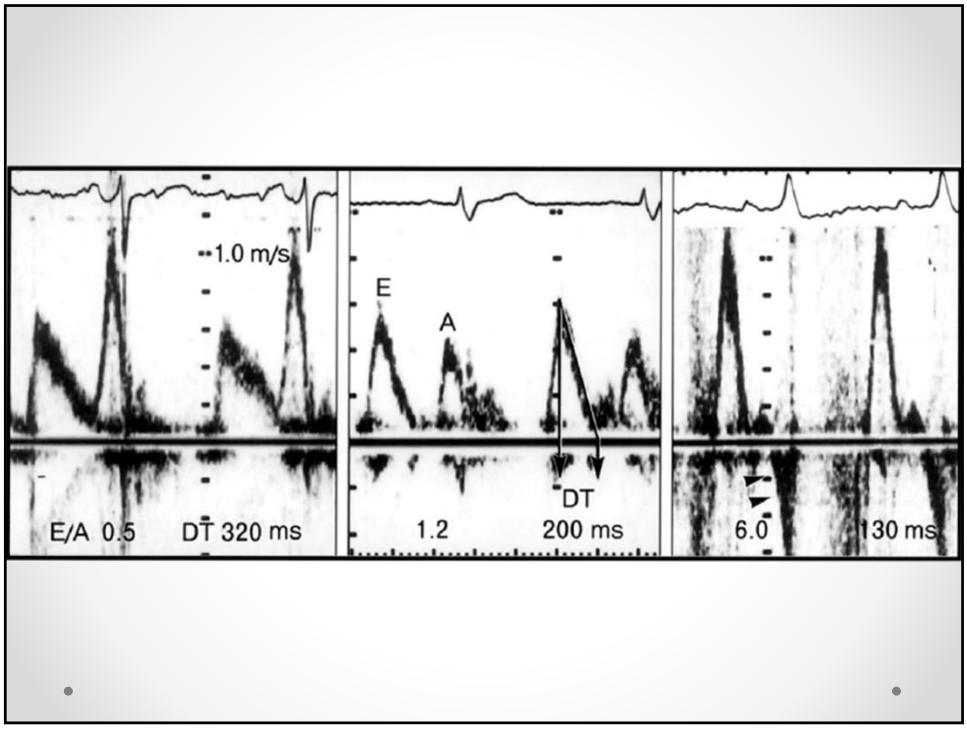
lateral e < 10 cm/sec,

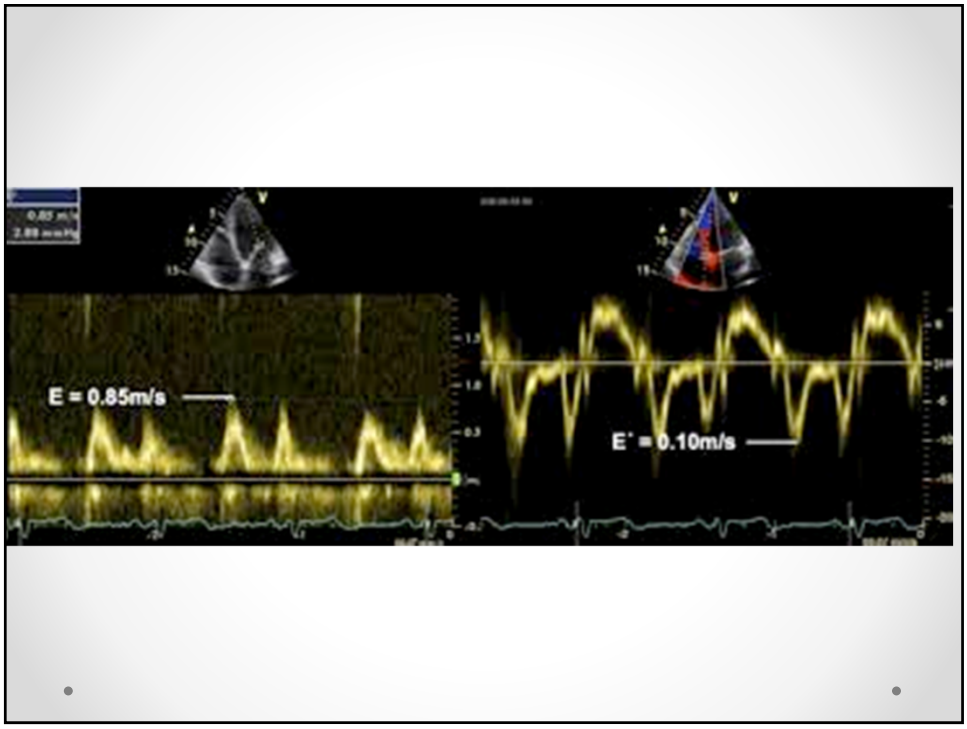
2-Average E/e' ratio > 14,

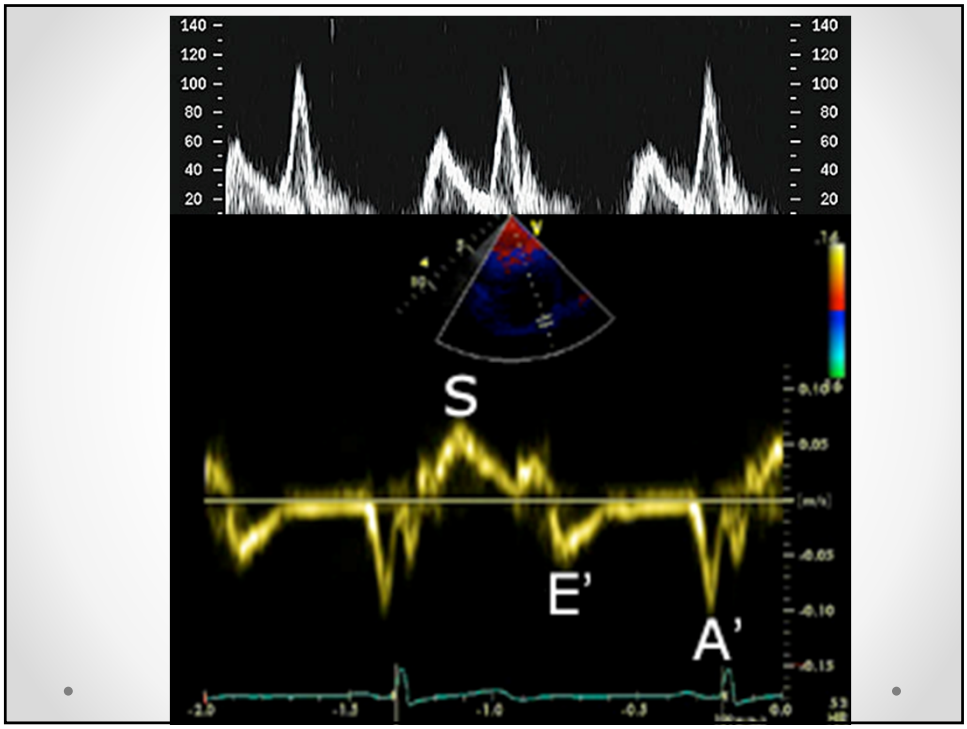
3-LA volume index > 34 mL/m ,

4-and peak TR velocity > 2.8 m/sec.




1.0 m/s
E
A
DT
E/A 0.5
DT 320 ms
1.2
200 ms
6.0
130 ms


E = 0.85m/s
E' = 0.10m/s


140
120
100
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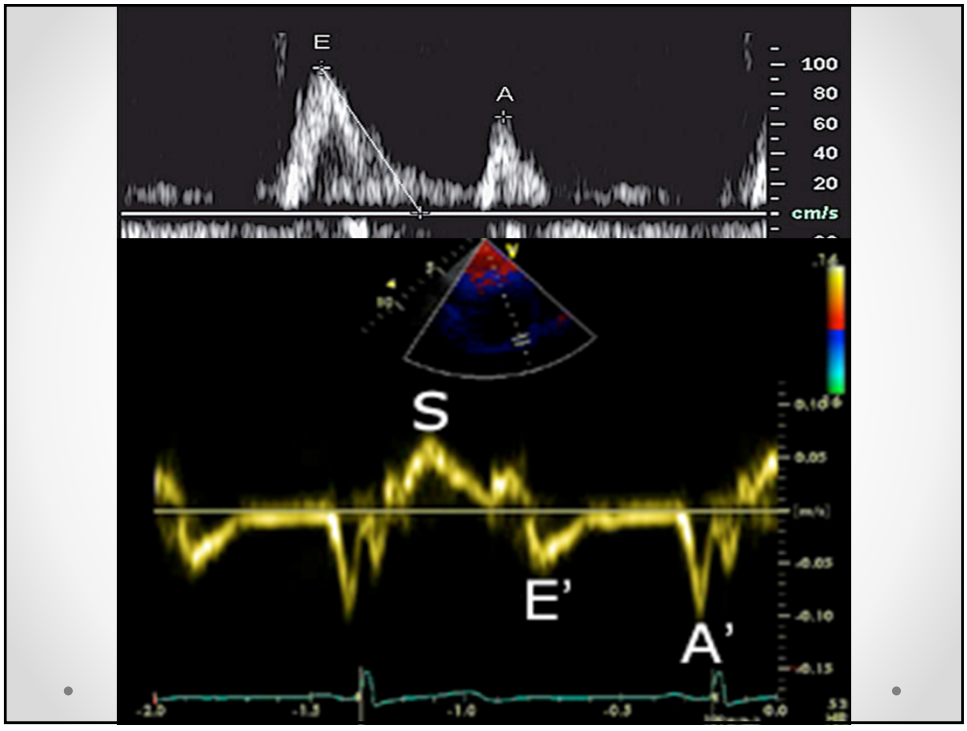
40
20
S
E'
A'


E
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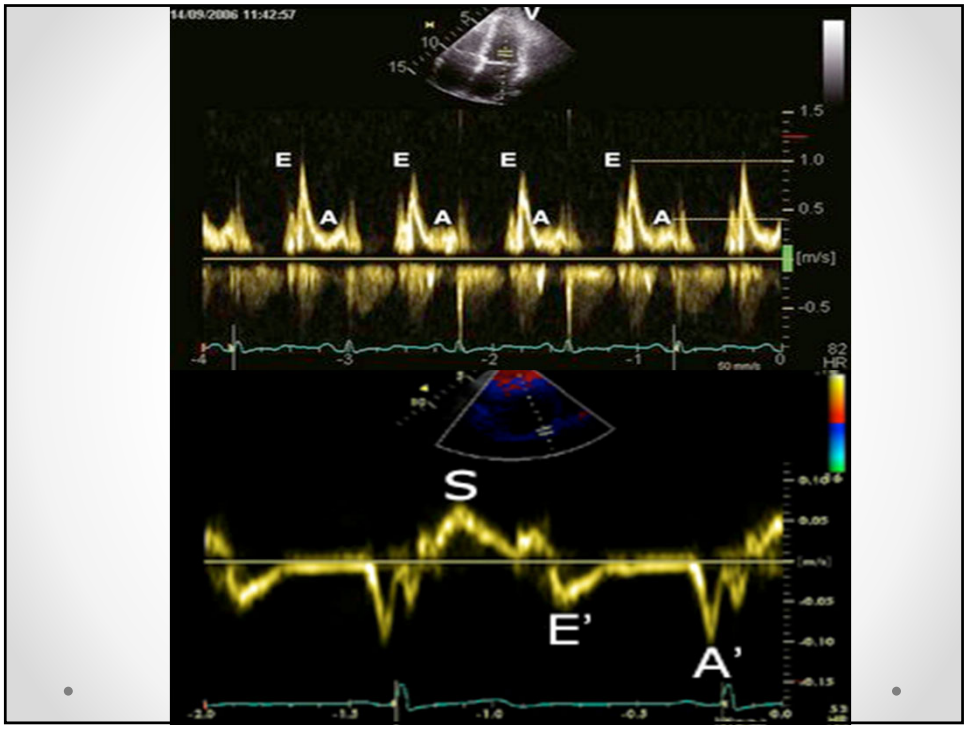
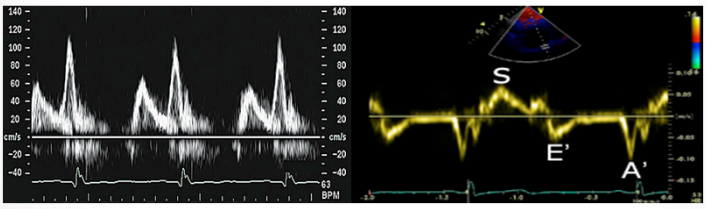


- We like to see this pattern in patient with low LVEF



- If patient has grade 1 diastolic dysfunction (normal LAP) but symptomatic when active:
- A symptom limited diastolic stress test will help:
- Grade 1 diastolic dysfunction changes to grade 2 or higher with activity: high LAP and PCWP.

Stress echocardiography

- To evaluate etiology of CHF (coronary vs non-coronary)
- Low dose dobutamine echocardiography to evaluate for hibernating myocardium vs irreversible damages:

  -Hibernating myocardium: Improvement in lower dose and worsening in higher dose.

  -No improvement: irreversible damages.

- Myocardial perfusion stress imaging:
- To evaluate etiology of CHF
- Evaluate for viability with delayed imaging or PET scan.

Cardiac MRI

- Gold standard in volumetric evaluation
- CMR has evolved into a gold-standard technique for the assessment of myocardial viability in patients with CAD with the technique called LGE (Late Gadolinium Enhancement).
- Can differentiate etiology of CHF/ cardiomyopathy (eg: coronary vs non-coronary or mix)

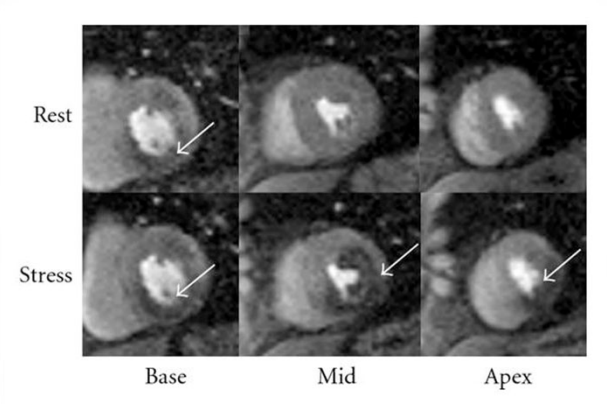
- Advantages of CMR include:
- Lack of ionizing radiation and its flexibility,
- High spatial resolution,
- Three-dimensional capabilities that enable imaging in any desired plane.
- Complete evaluation of myocardial structure and function, perfusion, tissue characteristics, and viability can be performed in a single study of 35-40 minutes.

- Disadvantages include:
- Expensive
- Not available most of the time in emergency setting
- Concerns regarding the use of gadolinium-based contrast agents in patients with class 4 or 5 chronic kidney disease due to the potential of nephrogenic systemic fibrosis,
- Inability to image most patients with pacemakers or implantable cardioverter-defibrillators due to safety concerns.
- However, MRI-compatible devices are now being developed and implanted, and performing CMR in these patients and in patients with noncompatible devices, under the right conditions, is becoming more feasible.

Stress CMR:

- Most perfusion stress testing is performed at 1.5T, although there are data to suggest that the higher spatial resolution available at 3T improves overall accuracy.
- Can be done with vasodilator/ Adenosine or Regadenoson (looking for perfusion defects) or dobutamine (looking for wall motion abnormalities)
- Usually vasodilators used
- Cannot do with exercise.

- Typically, the first pass of gadolinium is tracked qualitatively through the myocardium in at least three short-axis slices during rest and the infusion of either adenosine or regadenoson , both times during a prolonged breath hold



- Meta-analysis reviewing the diagnostic performance of stress perfusion CMR demonstrated a ***sensitivity of 89%, specificity of 76%,*** and a ***diagnostic odds ratio of a positive study of 26.4 (95% confidence interval: 17.7-39.5)***.

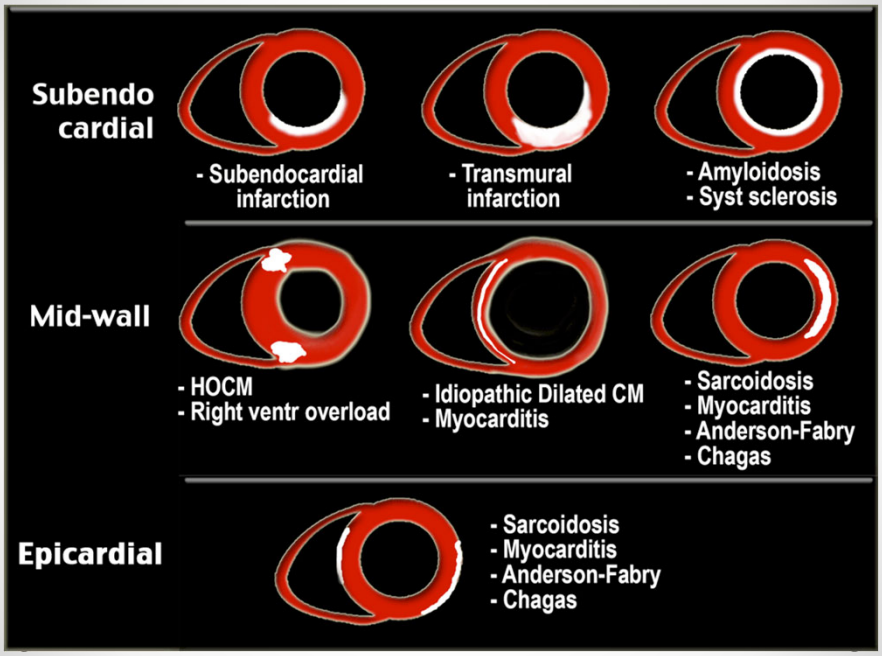
- CMR has evolved into a gold-standard technique for the assessment of myocardial viability in patients with CAD with the technique called LGE (Late Gadolinum Enhancement).

- In patients with CAD prior to revascularization, evaluation of the transmural extent of LGE enables prediction of recovery of function with revascularization.
- There is an inverse relationship between the transmurality of infarction and the likelihood of functional recovery
- Segments with >75% transmural LGE have little likelihood of recovery.

- In a meta-analysis of 24 studies and 698 patients:
- LGE demonstrated the highest sensitivity and negative predictive value for predicting improved function (95% and 90%, respectively) whereas the contractile response to low-dose dobutamine as an alternative approach demonstrated the highest specificity and positive predictive value (91% and 92%, -
- See more at: http://www.acc.org/latest-in-cardiology/articles/2016/02/22/08/49/role-of-cmr-in-the-assessment-and-prognosis-of-patients-with-stable-cad#sthash.C0puumCa.dpuf

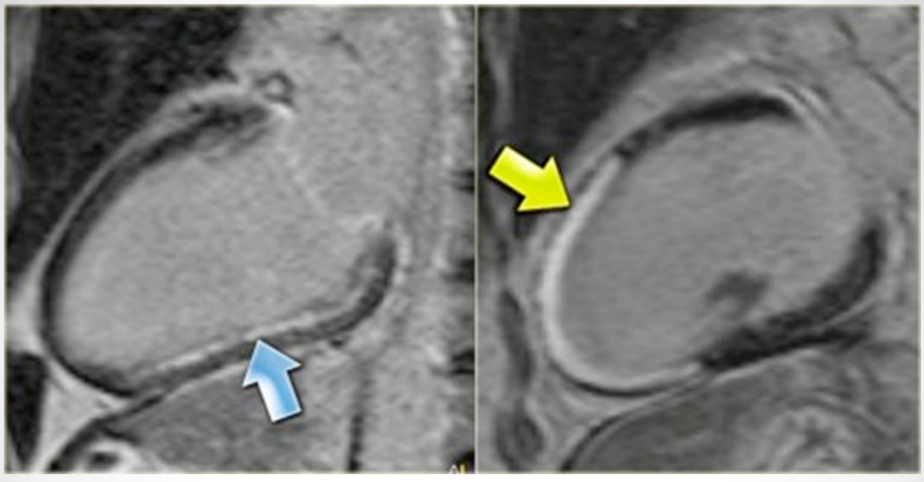
Etiology of Cardiomyopathy:

- Ischemic cardiomyopathy
- Non-ischemic cardiomopathy:
  Dilated CMP
  Myocarditis
  HCM
  ARVC
  Restrictive
  Tako-Tsubo



- CMR Can evaluate perfusion defects and scar on the same study in a patient with CAD causing CHF.
- Follow up CMR can detect negative remodeling

- CMR can differentiate CAD vs non CAD pattern

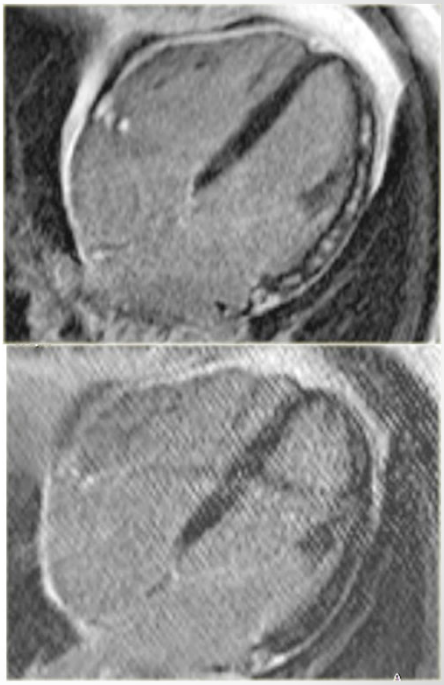


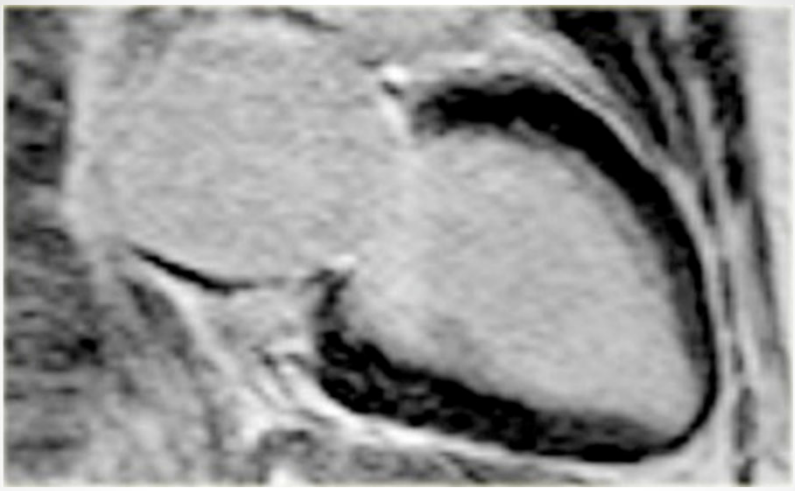
Left: subendocardial infarction,
Right: transmural infarction

Myocarditis:

A patient with myocarditis. Notice the midmyocardial enhancement of the lateral wall.

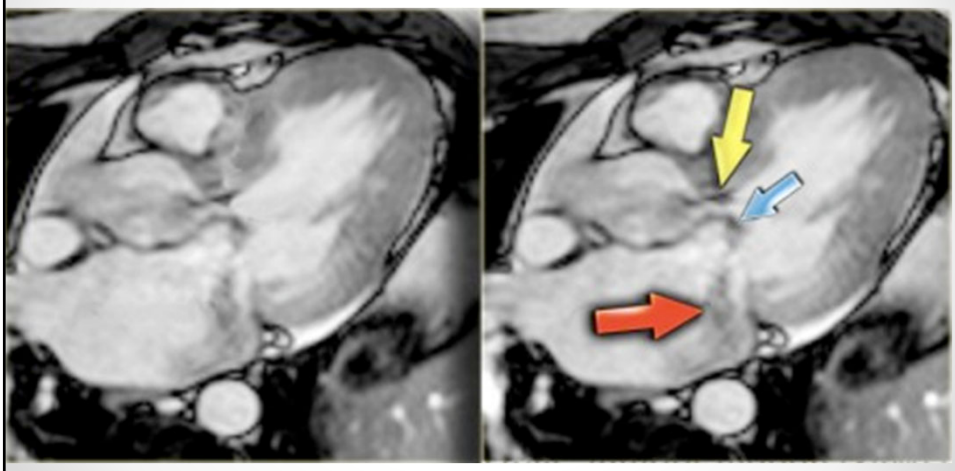
Same patient with myocarditis. Notice that the midmyocardial enhancement of the lateral wall has diminished.

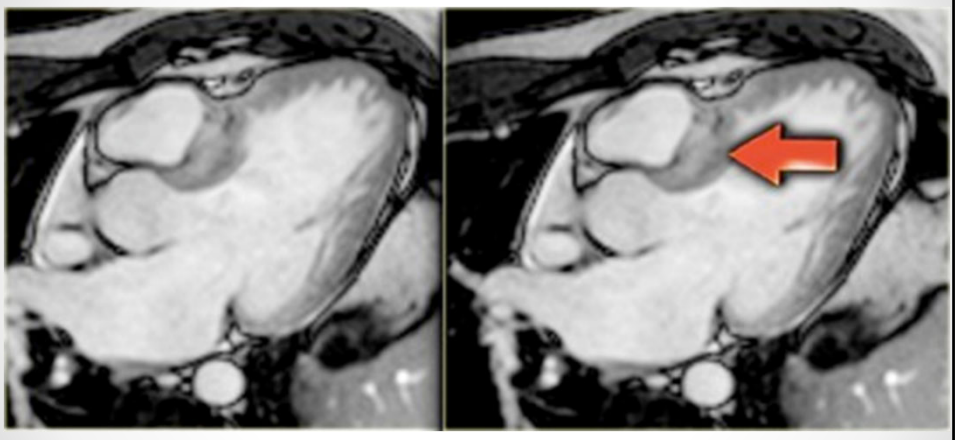


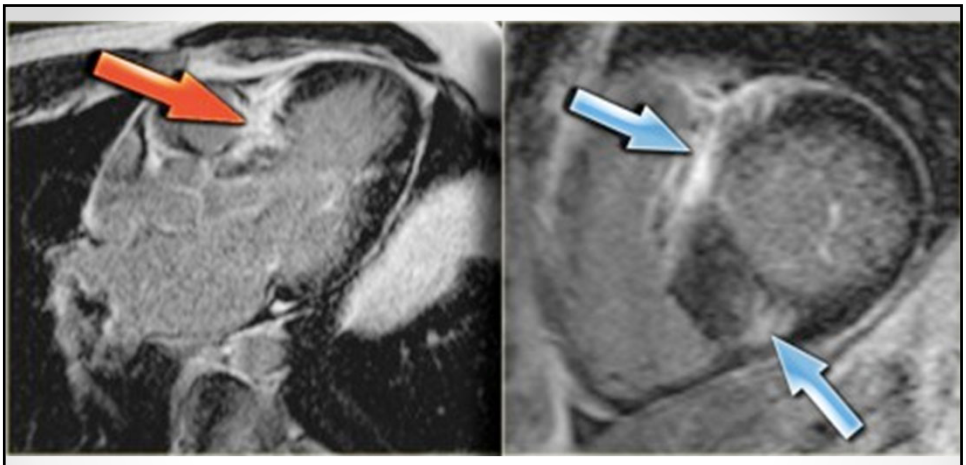


Tako-Tsubo cardiomyopathy: no late enhancement

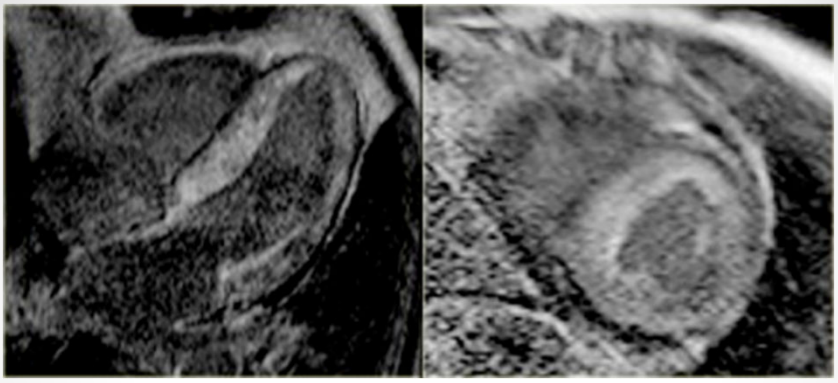
Hypertrophic cardiomyopathy







On left a 3-chamber late enhancement image which nicely demonstrates the enhancement of the hypertrophic basal septum (arrow).
On the right short axis late enhancement image which demonstrates the typical enhancement at the anterior and posterior right ventricular insertion points (arrows).

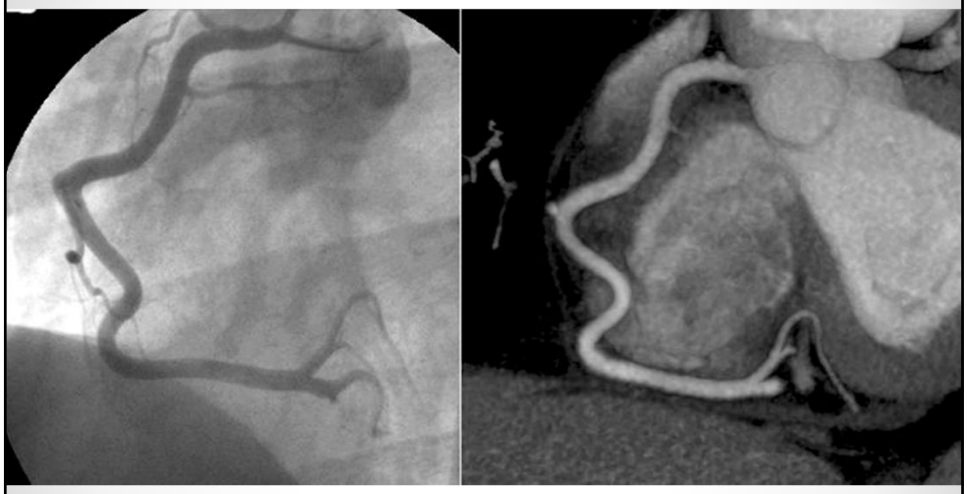


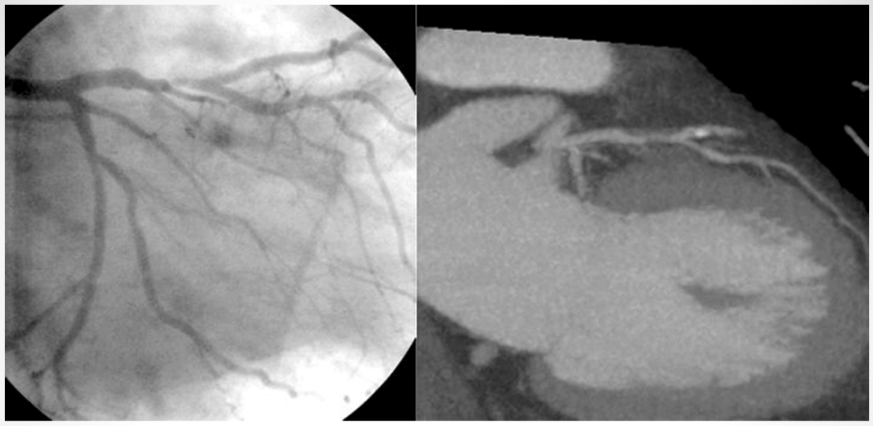
Restrictive/infiltrative cardiomyopathy

There is circumferential subendocardial enhancement extending into the neighboring myocardium.

Cardiac CT

- Calcium scoring.
- Patient with CHF and negative calcium score: unlikely CAD (strong negative predictive value).
- Gated cardiac CT : valuable tool for LV volumetric and LVEF evaluation
- Can access raw data any time and crop desired images (cannot do with CMR)
- Fast to perform
- Great tool to evaluate for congenital anomalies
- Radiation dose concern
- Expense
- Concern in patients with impaired renal function





As seen in the above images of a left anterior descending coronary artery from the CATSCAN study, soft plaque can be visualized on both conventional angiography and CTA. The CTA also reveals calcium, which is not visible in the cine view.

- Cardiac imaging is an important part of diagnosis and management of CHF
- Base line study is indicated in a patient with CHF
- Subsequent studies are done to follow up of effect of treatment or when patient's clinical condition changes
- Echocardiography is still considered imaging of choice in most cases:
- Relatively cheaper,
- Fast to perform,
- Comes with different modalities,
- Very useful in urgent and emergency setting,
- Most of the time totally noninvasive
- If needed, other imaging modalities : CMR and cardiac CT are additional tools to further evaluate etiology of CHF and follow up on the treatment.