Contrast Echocardiography in Cardiology - an update

Is it still acceptable to not use contrast and to accept suboptimal, non-diagnostic images?

Harald Becher
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Heart&Stroke Foundation Chair
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The EAE Textbook of Echocardiography

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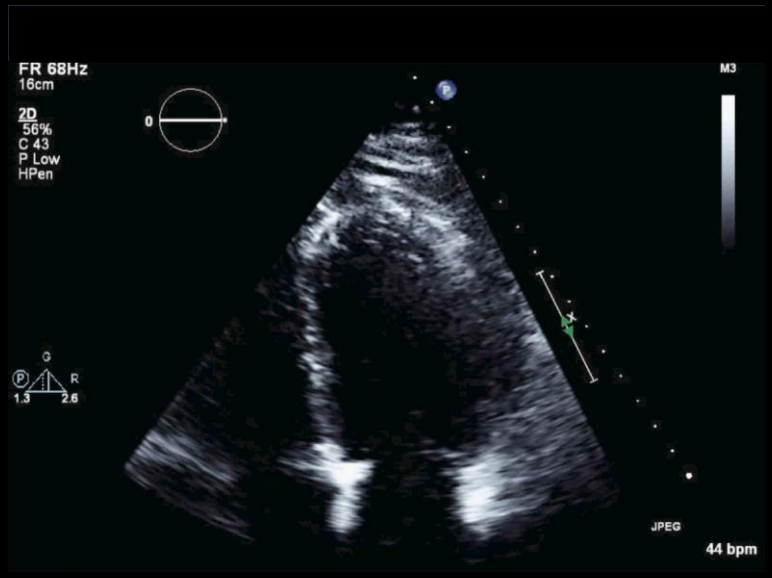

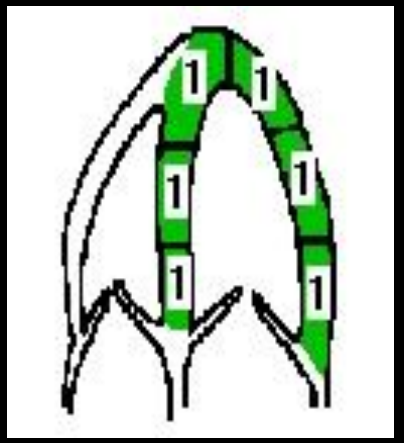

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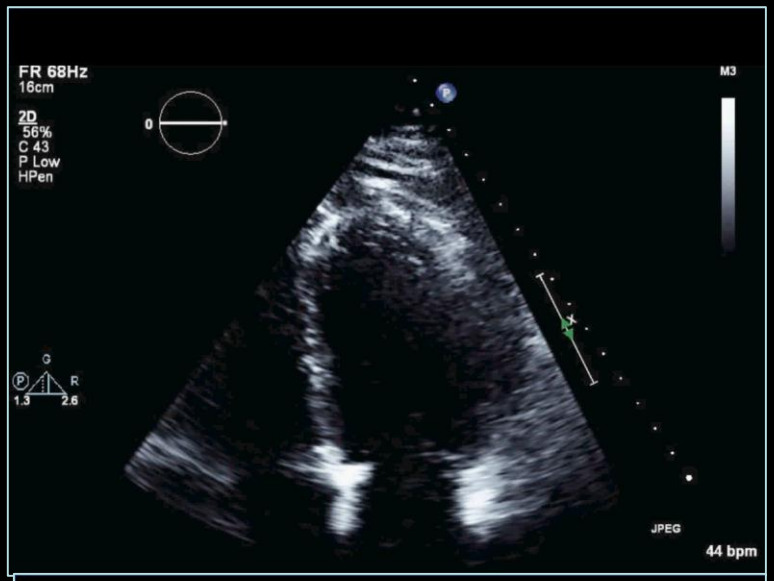

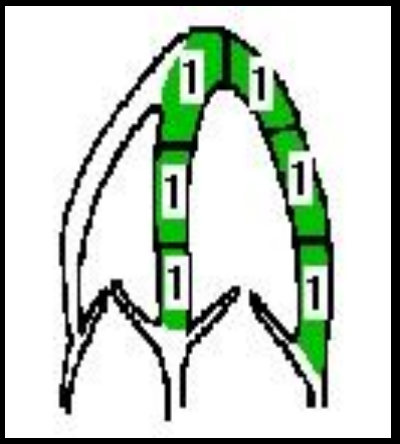

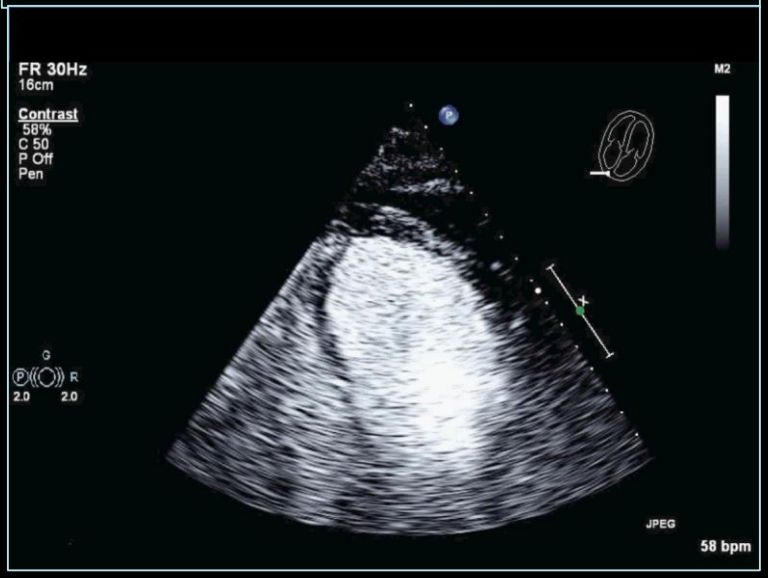

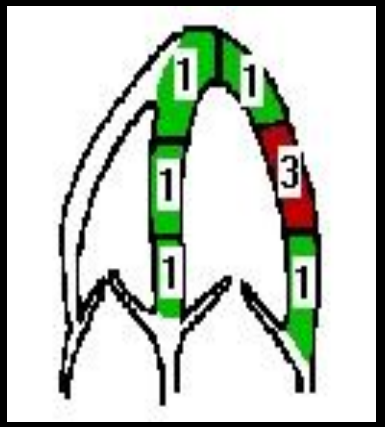

Contrast echocardiography should be considered when 2 or more contiguous LV segments are not clearly visualized and management of the patient will depend on whether there are regional wall motion abnormalities or not.

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Case based update of contrast echocardiography

- New EACVI guidelines which are impossible to follow without contrast agents
- New simplified recommendations to optimize use of contrast agents
- Reference values for LV volumes by contrast echocardiography
- clinical use within and beyond current indications

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GUIDELINES AND STANDARDS

Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

Roberto M. Lang, MD, FASE, FESC, Luigi P. Badano, MD, PhD, FESC, Victor Mor-Avi, PhD, FASE, Jonathan Afilalo, MD, MSc, Anderson Armstrong, MD, MSc, Laura Ernande, MD, PhD, Frank A. Flachskampf, MD, FESC, Elyse Foster, MD, FASE, Steven A. Goldstein, MD, Tatiana Kuznetsova, MD, PhD, Patrizio Lancellotti, MD, PhD, FESC, Denisa Muraru, MD, PhD, Michael H. Picard, MD, FASE, Ernst R. Rietzschel, MD, PhD, Lawrence Rudski, MD, FASE, Kirk T. Spencer, MD, FASE, Wendy Tsang, MD, and Jens-Uwe Voigt, MD, PhD, FESC, *Chicago, Illinois; Padua, Italy; Montreal, Quebec and Toronto, Ontario, Canada; Baltimore, Maryland; Créteil, France; Uppsala, Sweden; San Francisco, California; Washington, District of Columbia; Leuven, Liège, and Ghent, Belgium; Boston, Massachusetts*

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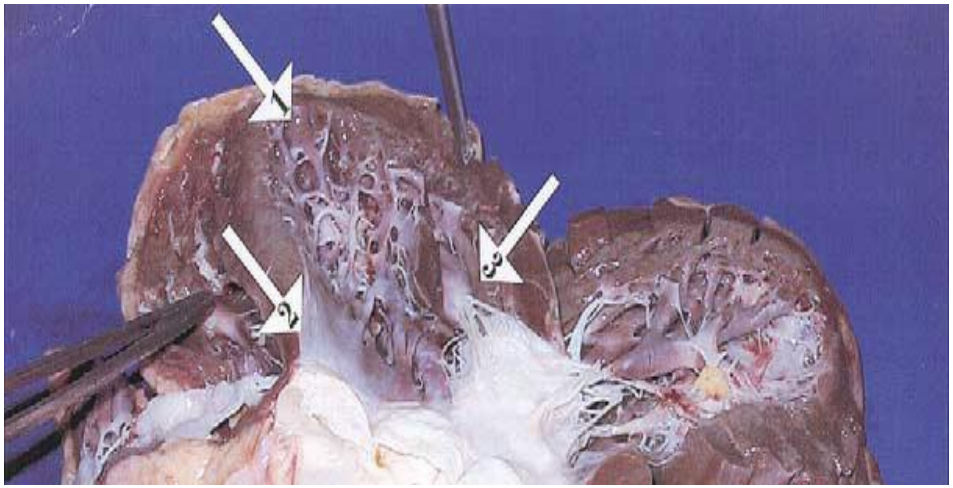
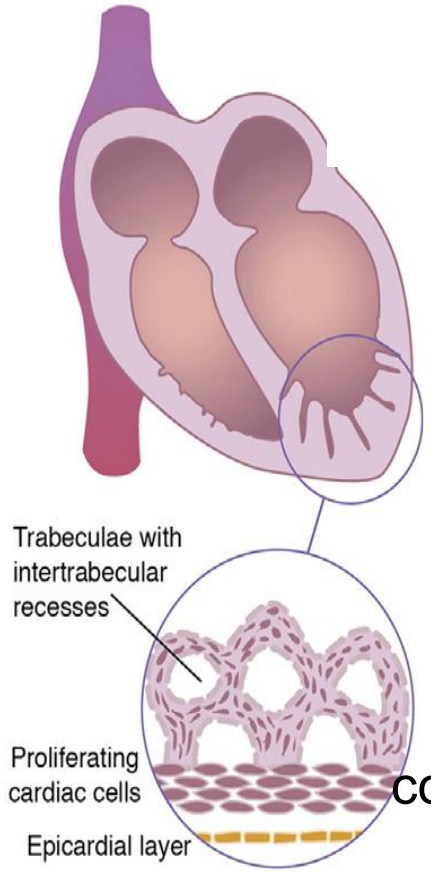
GUIDELINES AND STANDARDS

Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

- LV size to be measured by volume
- Volumetric measurements are usually based on tracings of the interface between the compacted myocardium and the LV cavity
- EF should be measured

LV trabeculations

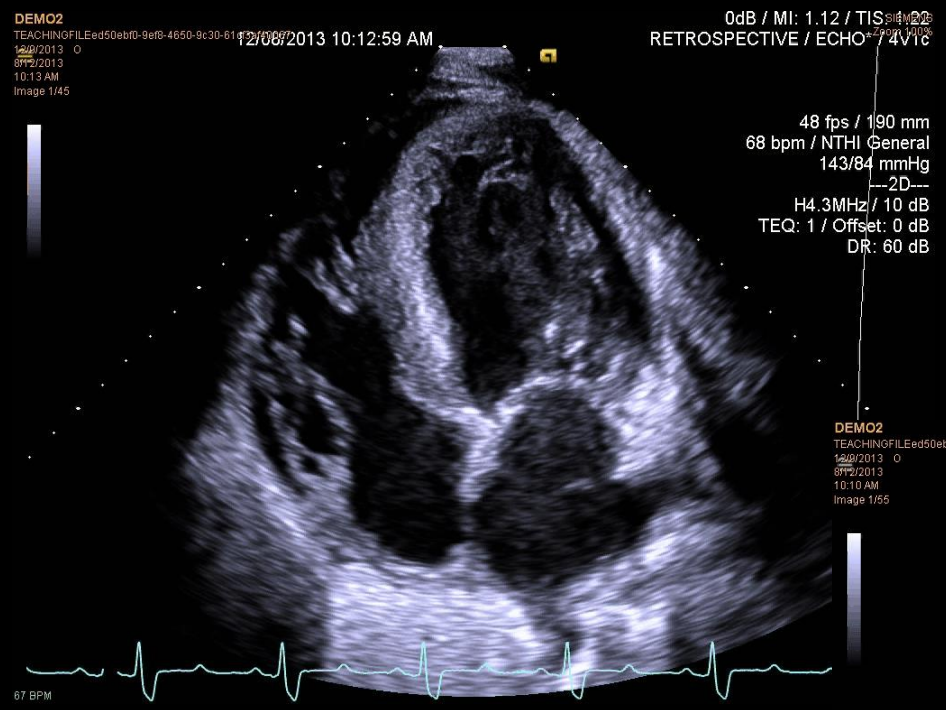


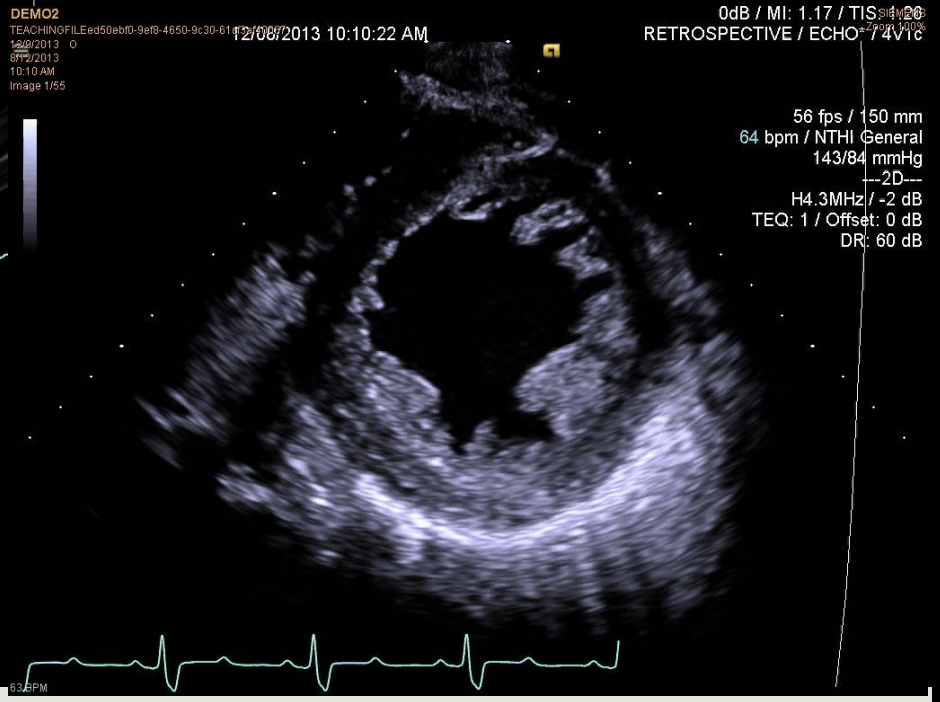


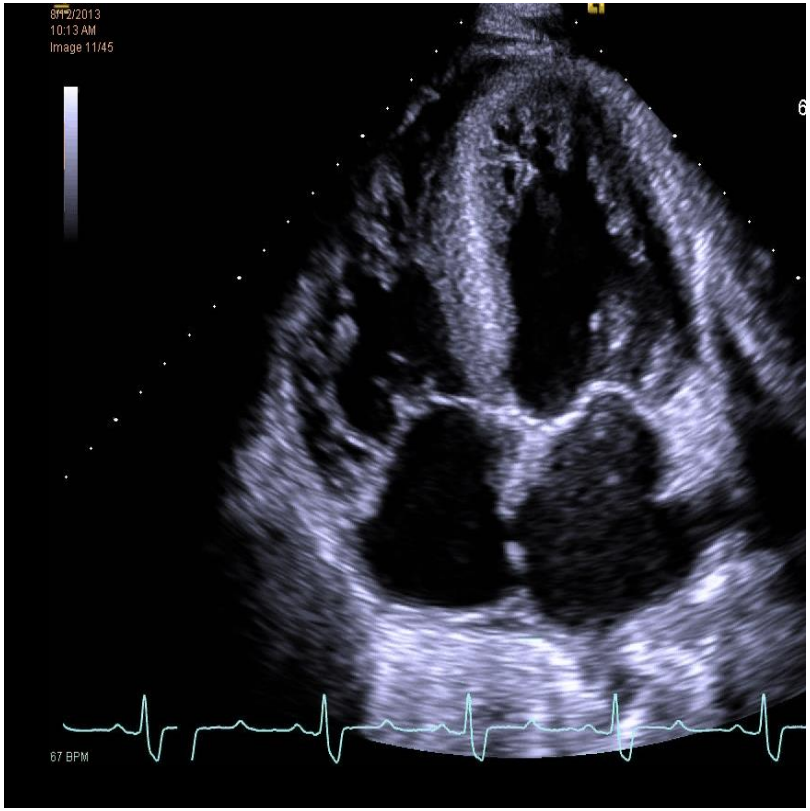
compacted

Stollberger C, Finsterer J. J Am Soc Echocardiogr 2004;17:91-100

Finding the border between the compact and the trabeculated myocardium



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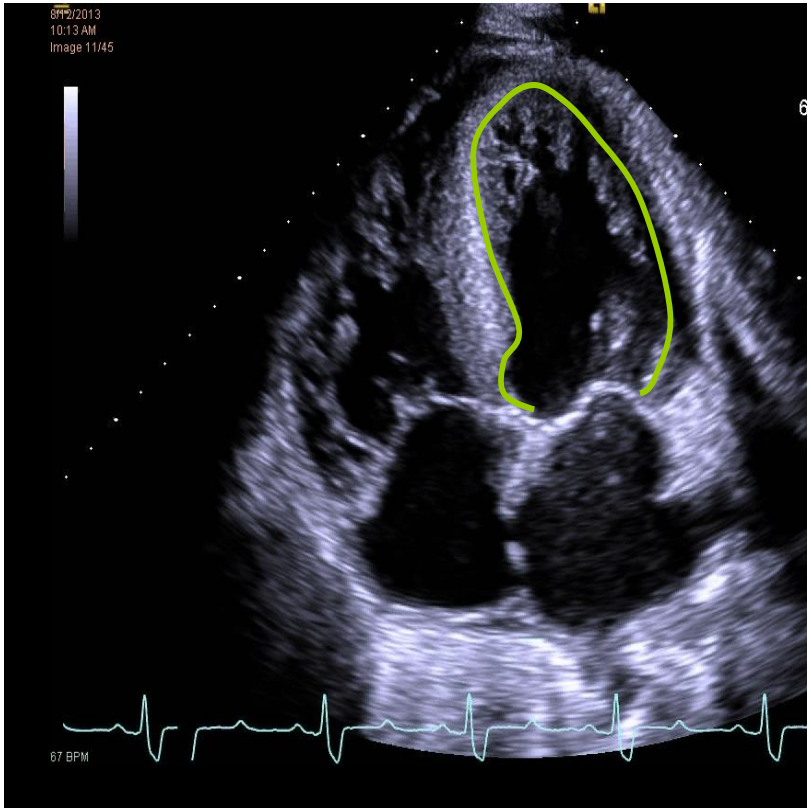
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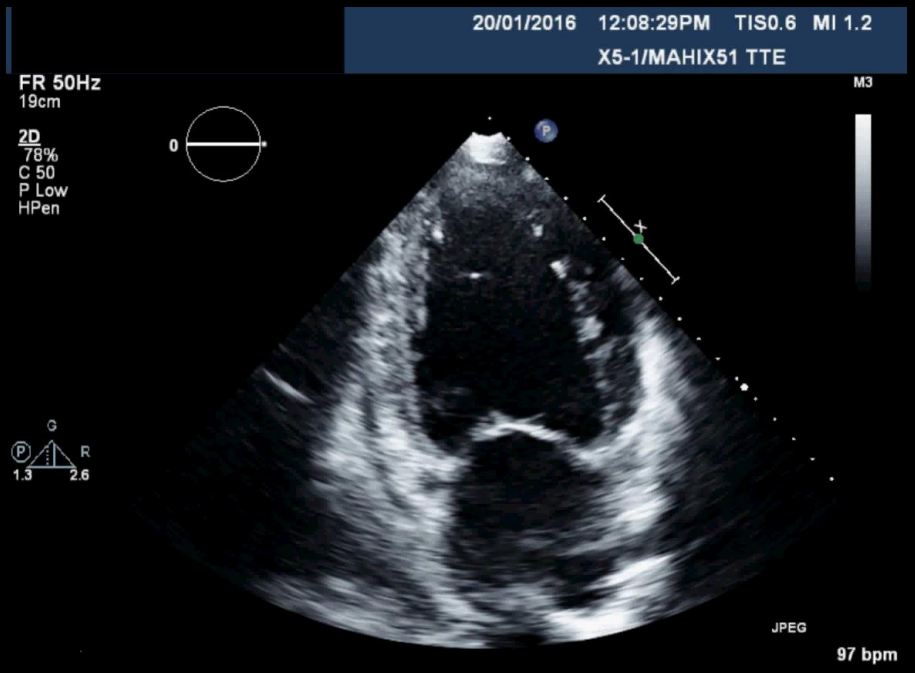
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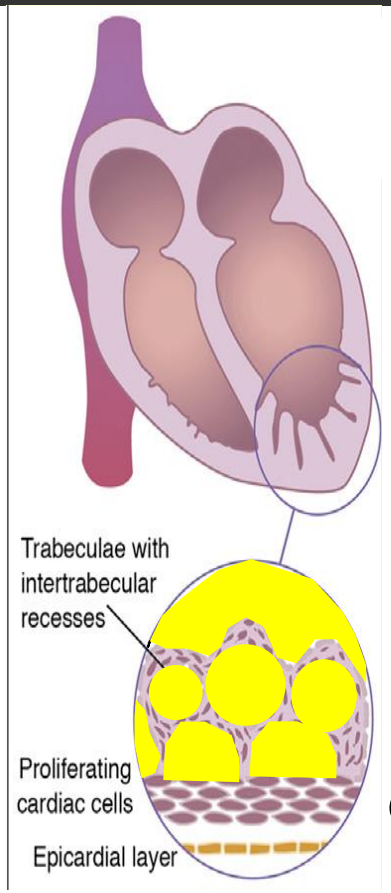
97 bpm

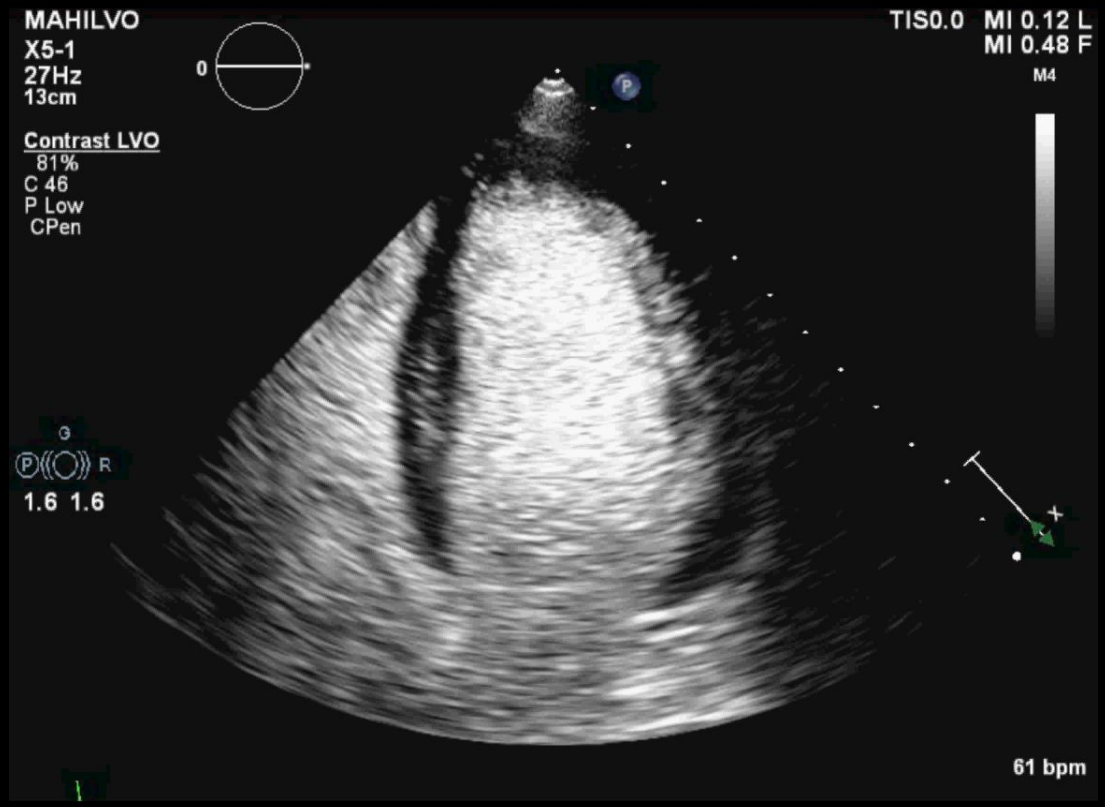
LV trabeculations



compact

Stollberger C, Finsterer J. J Am Soc Echocardiogr 2004;17:91-100

Contrast-Echocardiography displays the volume surrounded by the compacted myocardium



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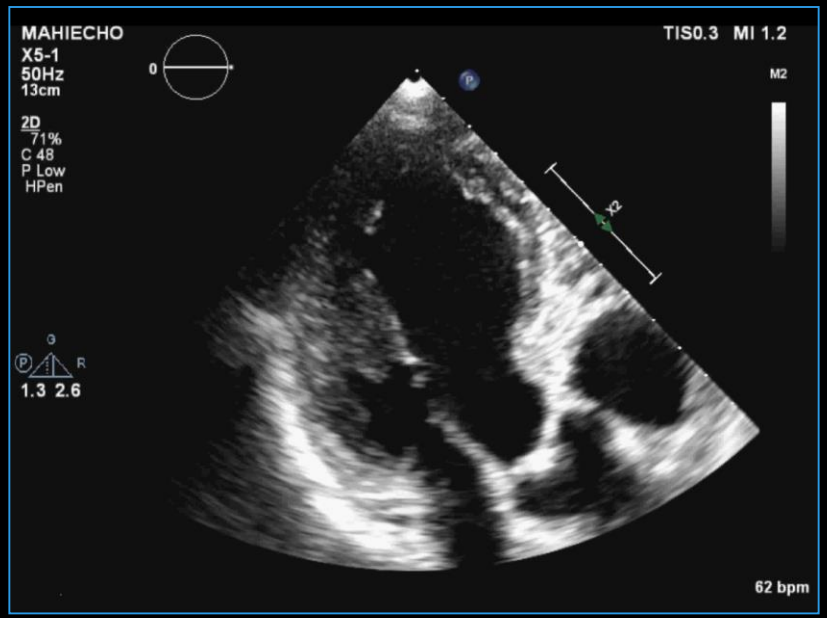

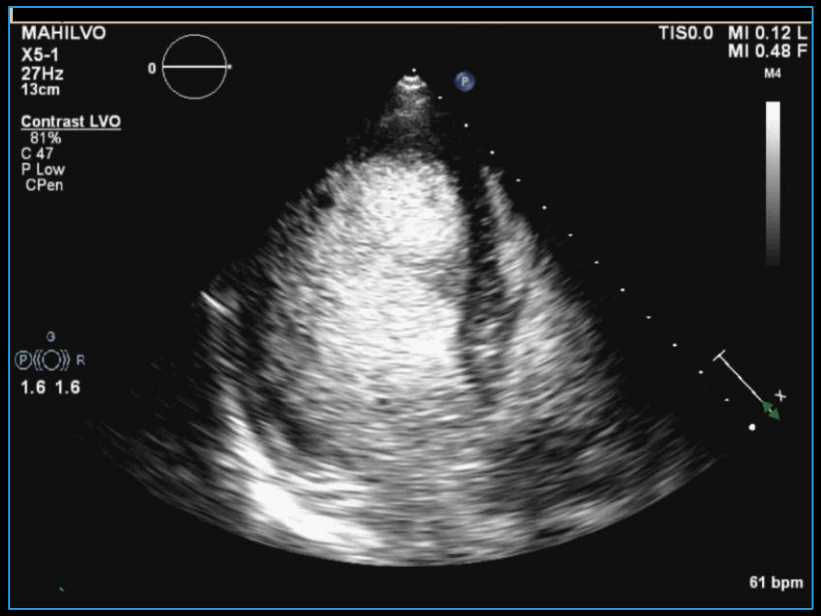

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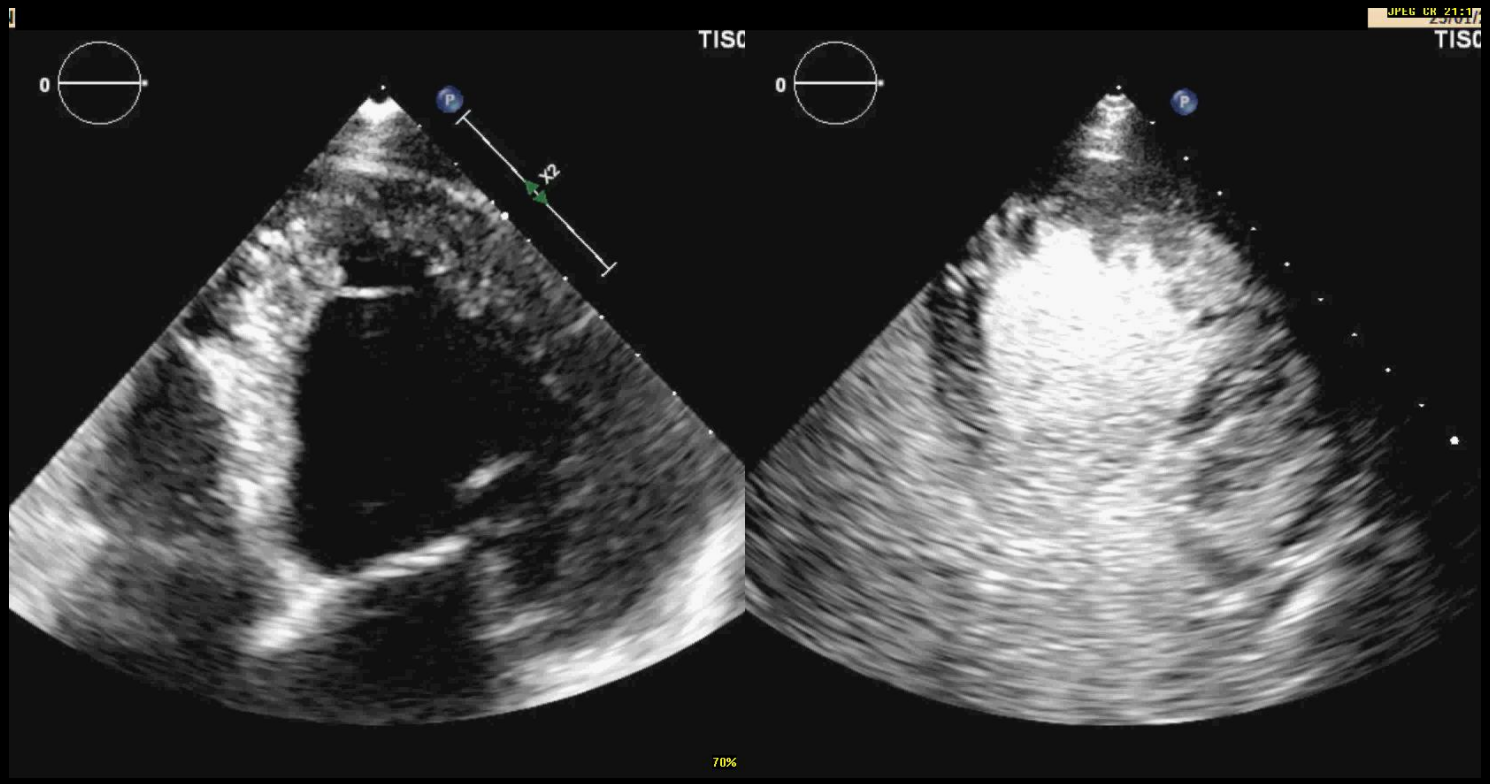
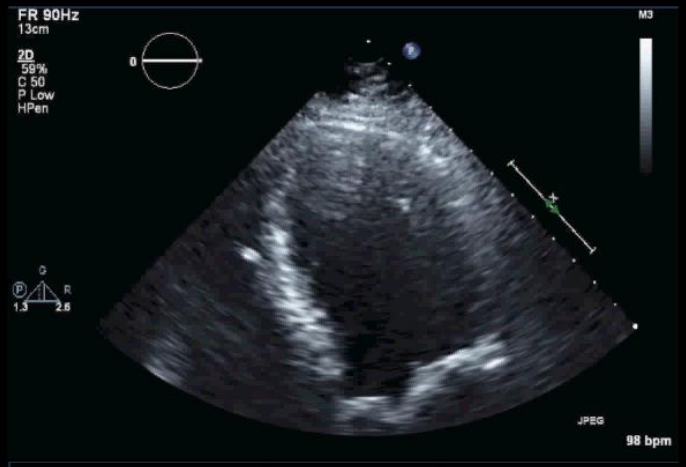
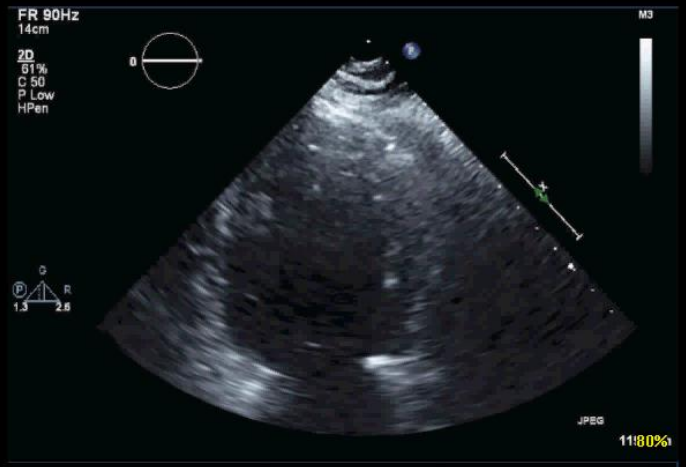
76 yrs, male referred for ?CRT



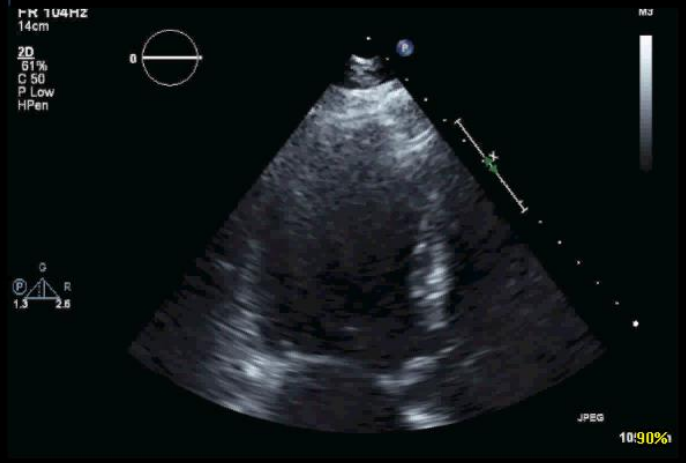
4 chamber view



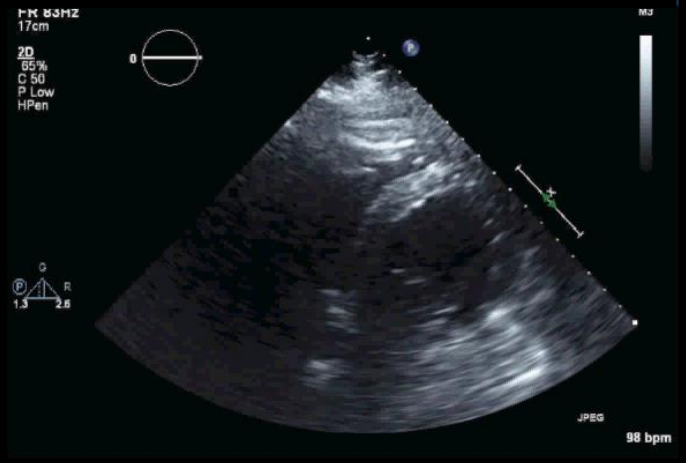
2 chamber view



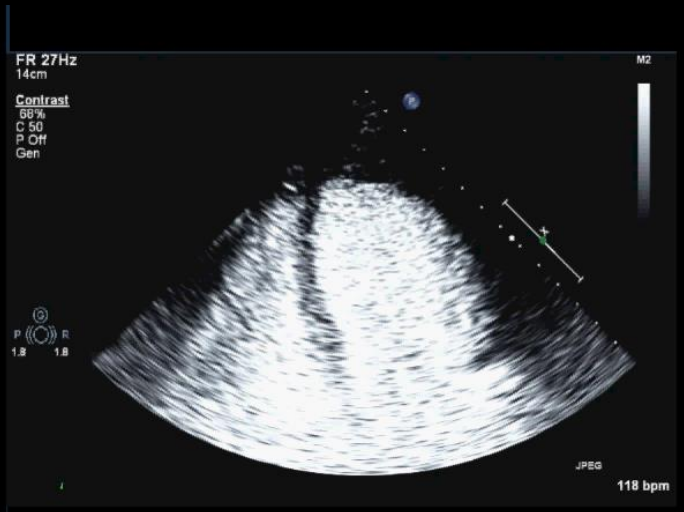
3 chamber view



short axis view



4 chamber view



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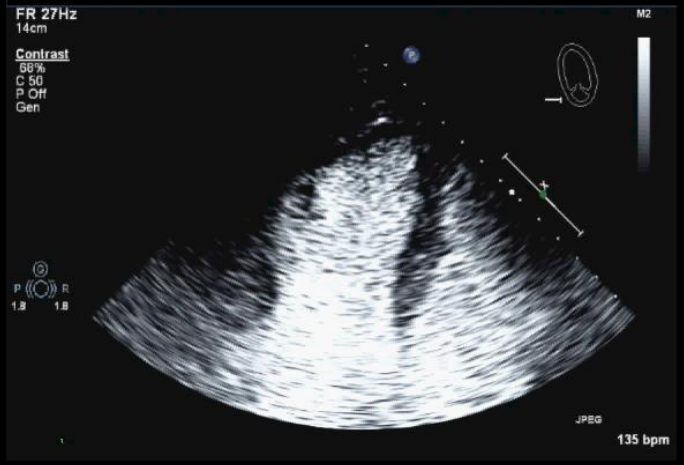
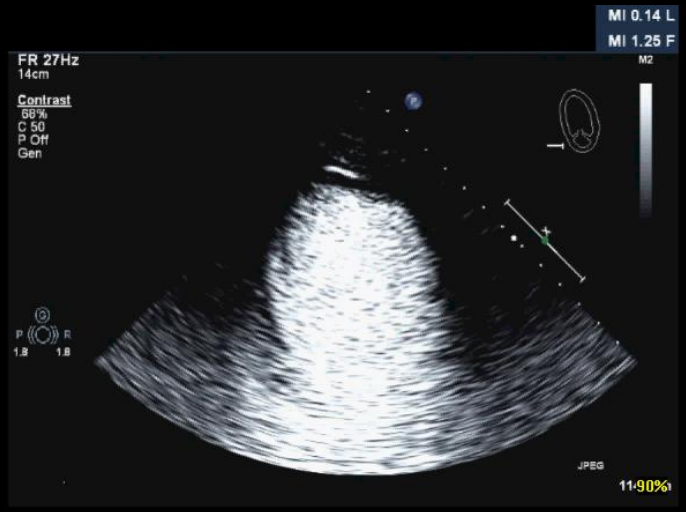
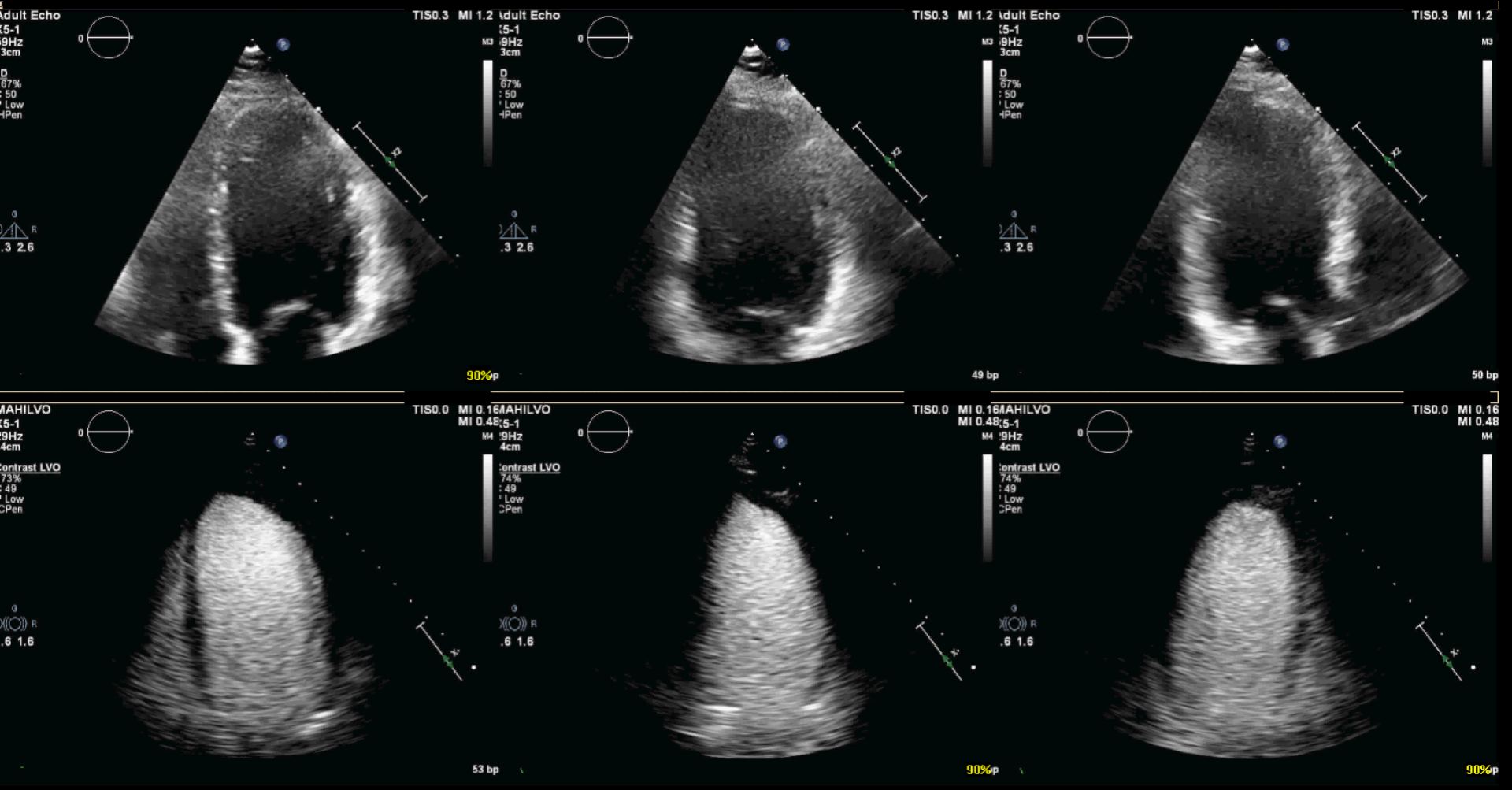


3 chamber view

2 chamber view



0.5 ml SonoVue single bolus



4 CV 2 CV 3CV

Larsson *et al. Cardiovascular Ultrasound* (2016) 14:2
DOI 10.1186/s12947-015-0045-0

Cardiovascular Ultrasound

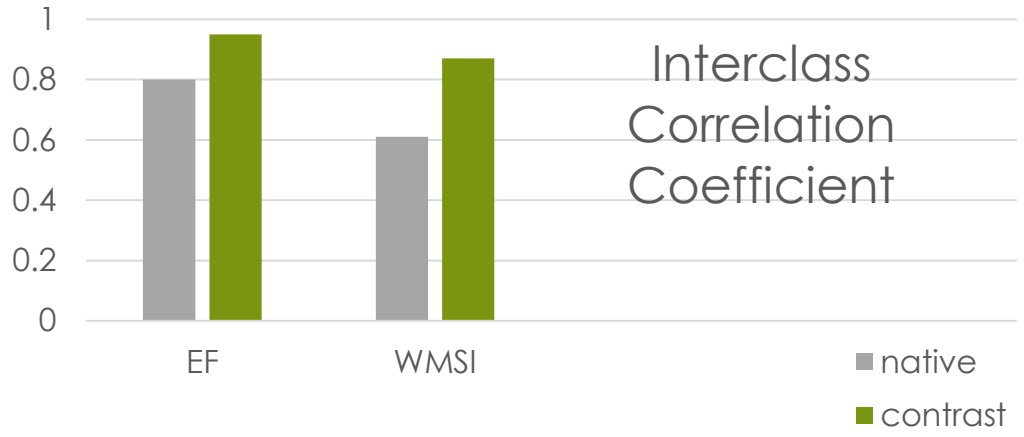
RESEARCH Open Access

The potential clinical value of contrast-enhanced echocardiography beyond current recommendations

Malin K. Larsson[1*], Cristina Da Silva[2], Elif Gunyeli[2], Ali Akebat Bin Ilami[2], Karolina Szummer[2], Reidar Winter[1,2] and Anna Bjällmark[1,3]

Contrast Echo in Patients with "adequate" Image Quality for assessment of LV function

- 192 patients referred for stress echocardiography



- **Intra- and interobserver variability for experienced readers as well as the variability between inexperienced and experienced readers decreased for WMSI and EF after contrast analysis.**

Larsson et al. Cardiovascular Ultrasound (2016) 14:2

2D Contrast Echocardiography
LV volumes and function

- low MI (<0.2) contrast imaging mode
- **bolus injection (0.5 ml SonoVue©/**

  0.2-0.3 ml Optison©, 0.1 ml Luminity©)
- start optimize images and record
  not before 20 s after contrast injection
- 2 loops of each apical view
- Analyse like in non contrast echocardiography

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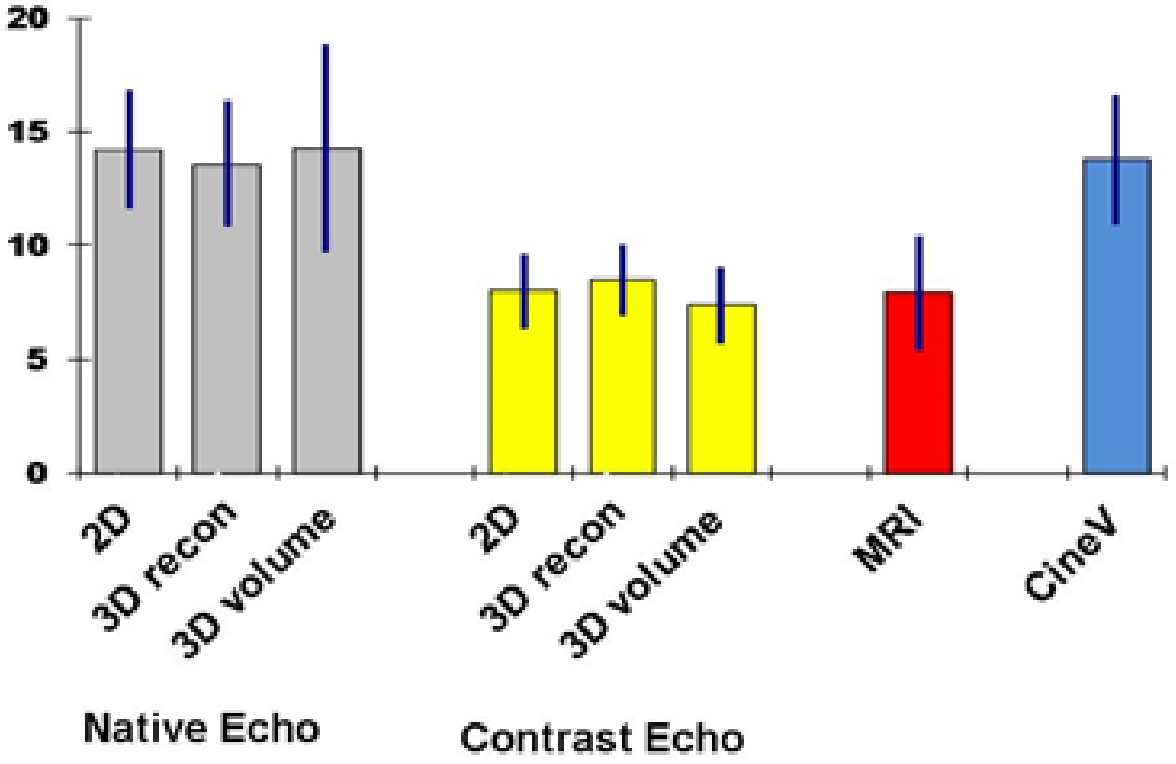
Table 3.1 Definition of heart failure with preserved (HFpEF), mid-range (HFmrEF) and reduced ejection fraction (HFrEF)

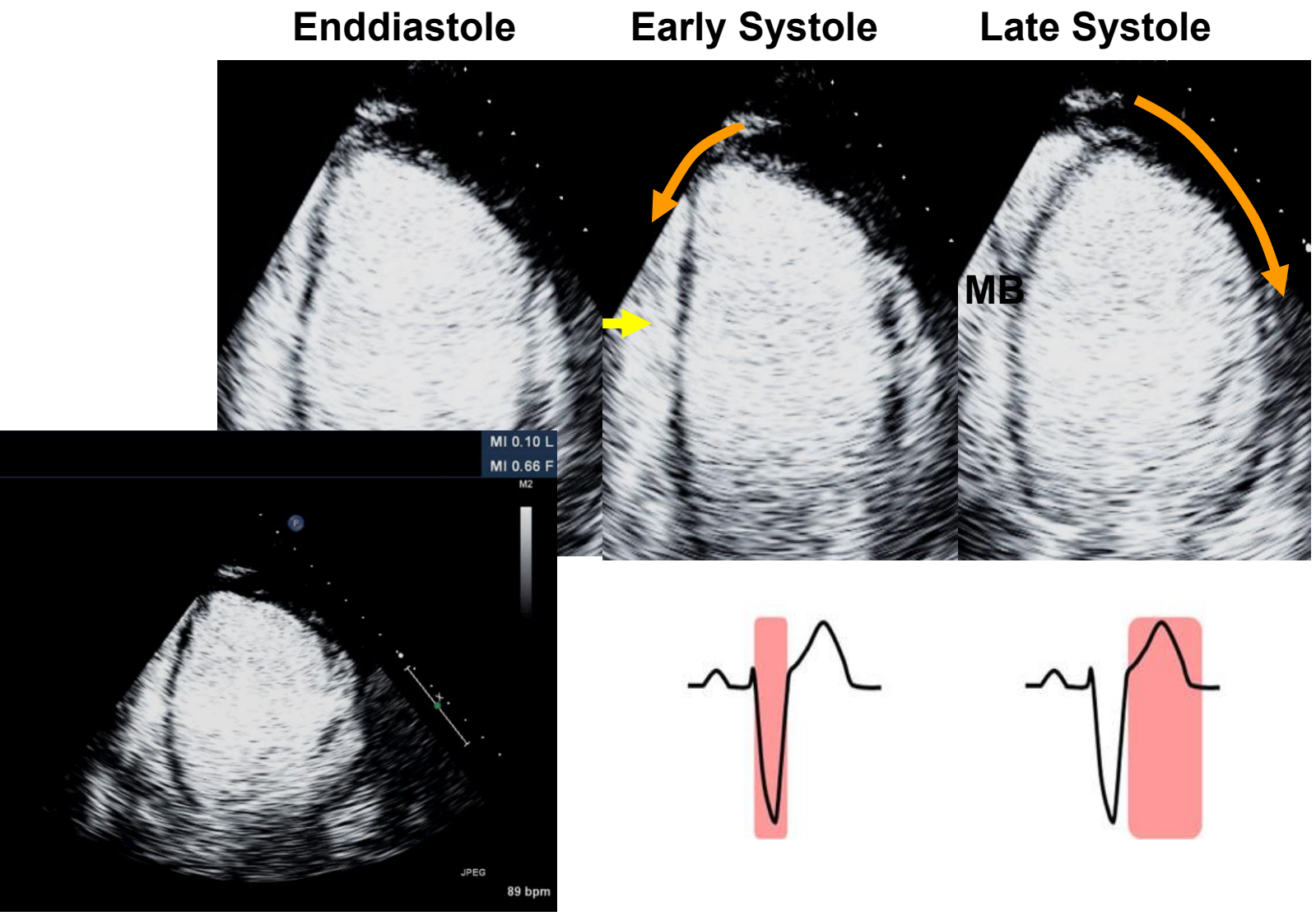
Type of HF		HFrEF	HFmrEF	HFpEF
CRITERIA	1	Symptoms ± Signs[a]	Symptoms ± Signs[a]	Symptoms ± Signs[a]
	2	LVEF <40%	LVEF 40–49%	LVEF ≥50%
	3	–	1. Elevated levels of natriuretic peptides[b]; 2. At least one additional criterion: a. relevant structural heart disease (LVH and/or LAE), b. diastolic dysfunction (for details see Section 4.3.2).	1. Elevated levels of natriuretic peptides[b]; 2. At least one additional criterion: a. relevant structural heart disease (LVH and/or LAE), b. diastolic dysfunction (for details see Section 4.3.2).

2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

Interreader Variability on LVEF in %

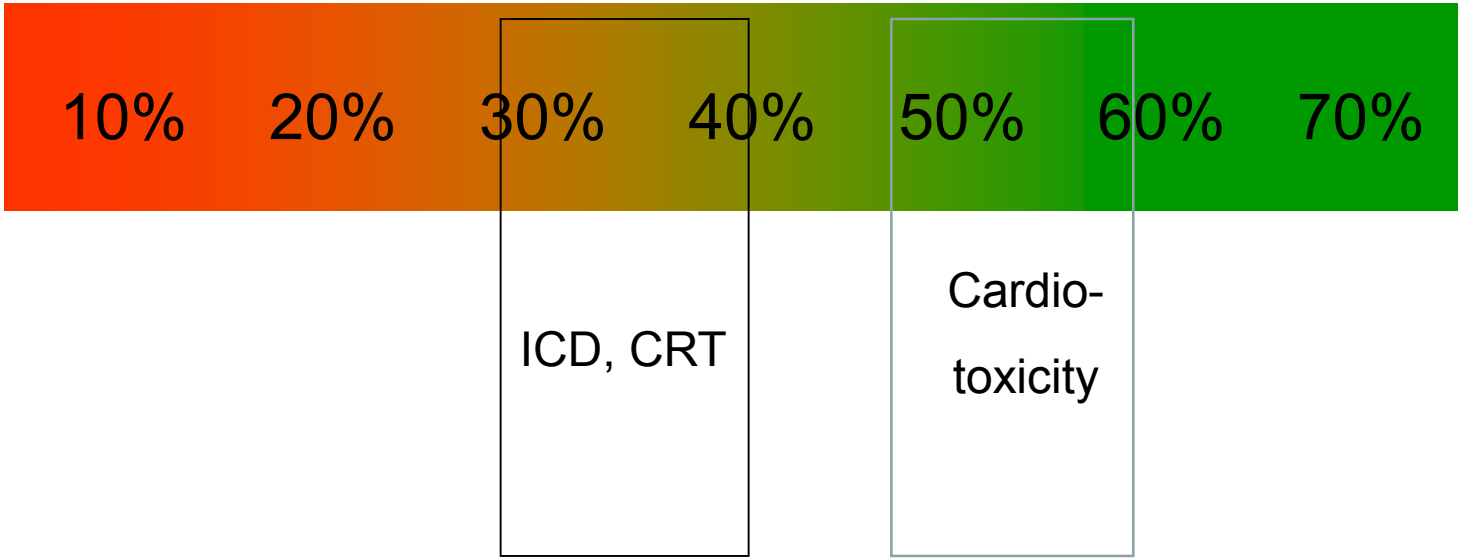


Hoffmann R et al. *JASE* 2014



Stankovic et al. 2016 Eur Heart J CVI (modified)

When do we need an accurate EF?



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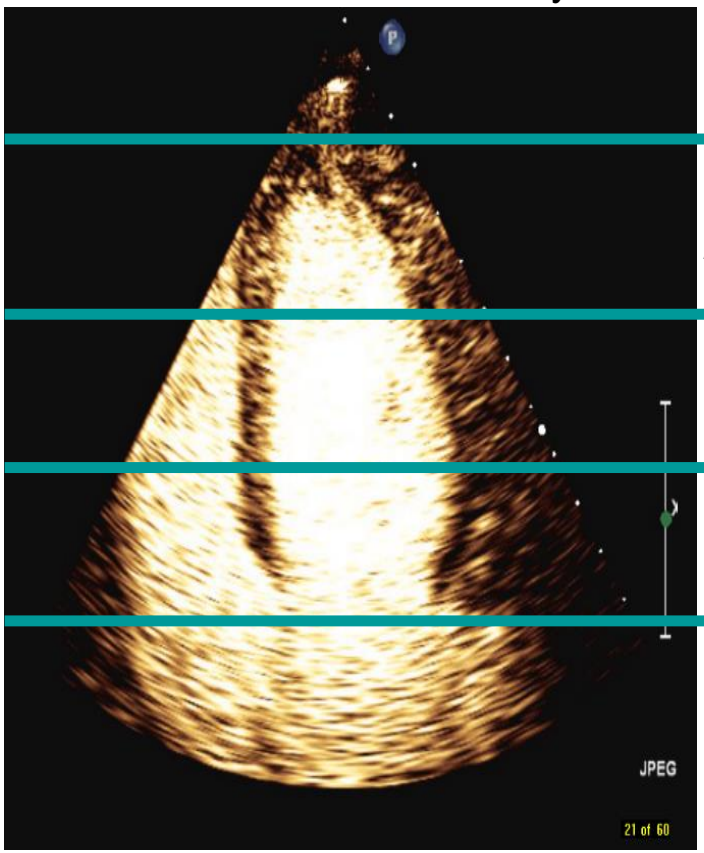
Adequate in LV contrast echocardiography

Helfen, A

Intensive Contrast
In the entire LV cavity



APICAL: No Swirling, No Blooming

BASAL: No Attenuation

Contrast should be visible in LA
1-2 cm behind the mitral valve

No Rib Shadow

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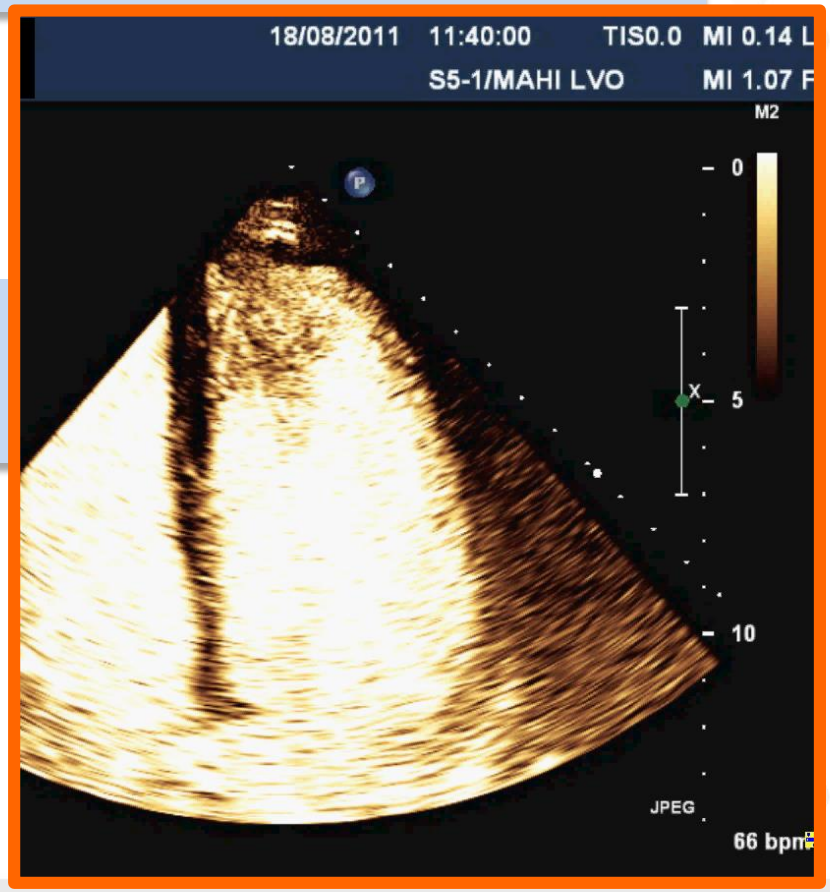
Troubleshooting for contrast recordings

• Apical swirling good basal contrast	MI too high
• Basal attenuation no apical swirling	too early after bolus MI too low
• Apical blooming and basal attenuation	Contrast too high
• Apical swirling and inhomogeneous contrast in the entire cavity	Contrast too low

Troubleshooting for contrast recordings

- Apical swirling
  good basal contrast

MI too high



- Basal attenuation
  no apical swirling

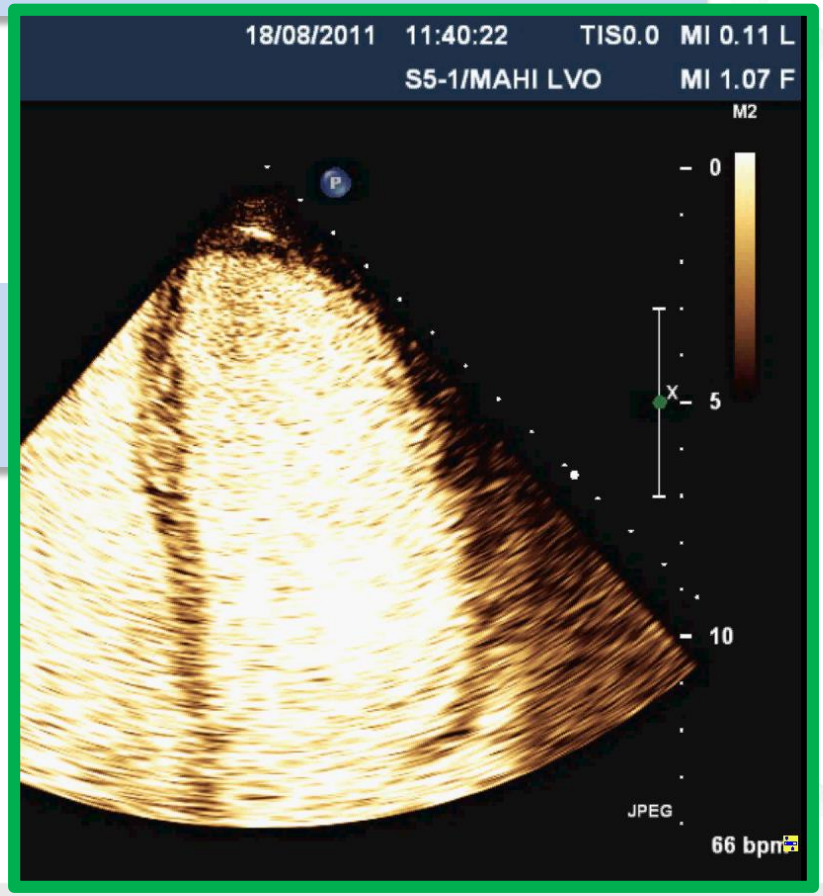
- Apical blooming and
  basal attenuation

- Apical swirling and
  inhomogeneous contrast
  in the entire cavity

Troubleshooting for contrast recordings

- Apical swirling
  good basal contrast

MI too high



- Basal attenuation
  no apical swirling

- Apical blooming and
  basal attenuation

- Apical swirling and
  inhomogeneous contrast
  in the entire cavity

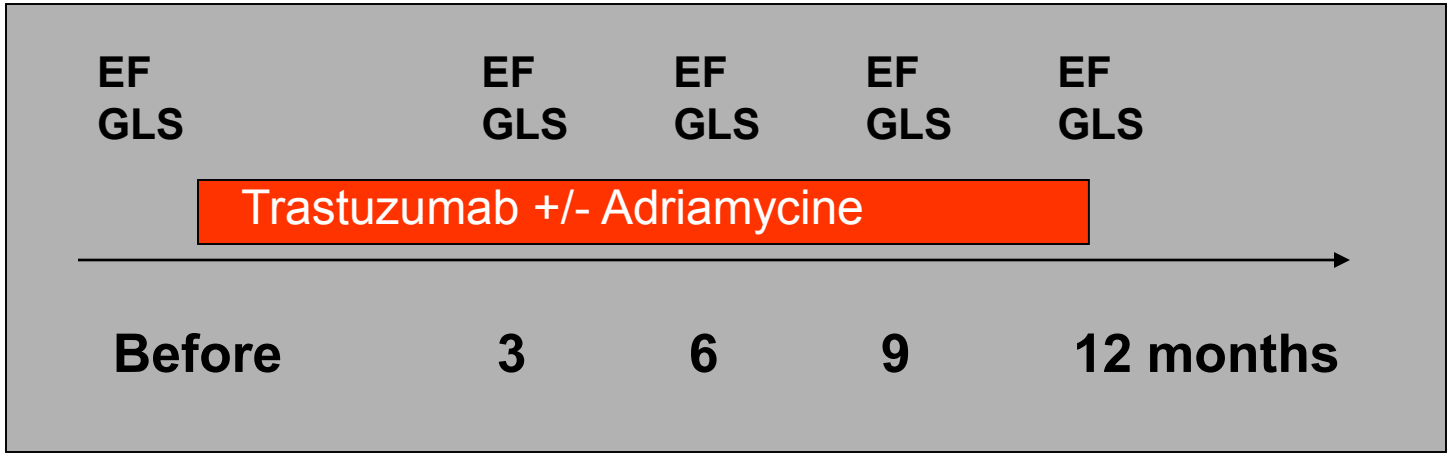
European Heart Journal (2016) **37**, 2768–2801
doi:10.1093/eurheartj/ehw211

ESC CPG POSITION PAPER

2016 ESC Position Paper on cancer treatments and cardiovascular toxicity developed under the auspices of the ESC Committee for Practice Guidelines

The Task Force for cancer treatments and cardiovascular toxicity of the European Society of Cardiology (ESC)

Echocardiographic measurements in pts with breast cancer

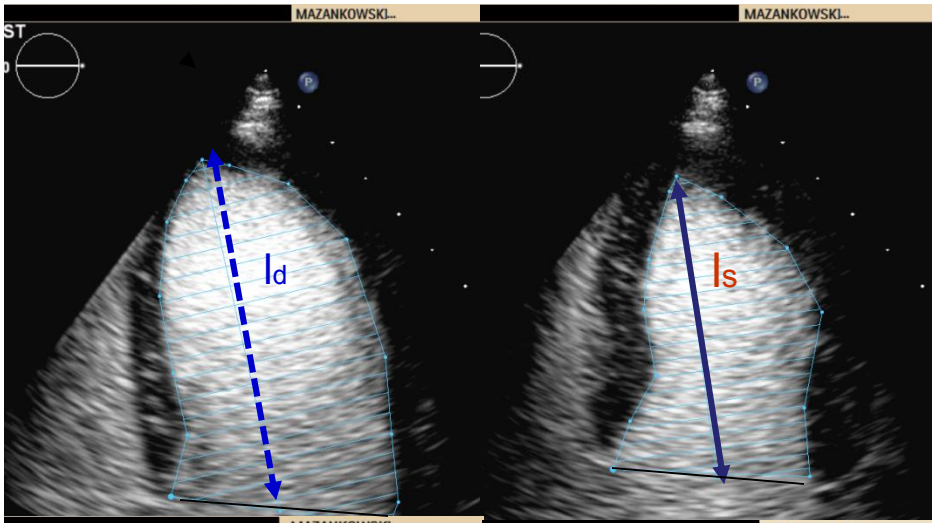


Echo Measurements	Action
EF decreases >10% but not below 50%	repeat EF measurement shortly after and during the duration of cancer treatment
EF decreases >10% to EF <50%, asymptomatic	may be considered as stage B HF (in particular with high BNP) ACE inhibitors (or ARBs)+beta-blockers
EF decreases >10% to EF <50% with heart failure	ACE inhibitors (or ARBs)+beta-blockers
GLS decreases > 15% EF remains >50%	**No change in chemotherapy!**

2016 ESC Position paper on cancer treatments and cardiovascular toxicity

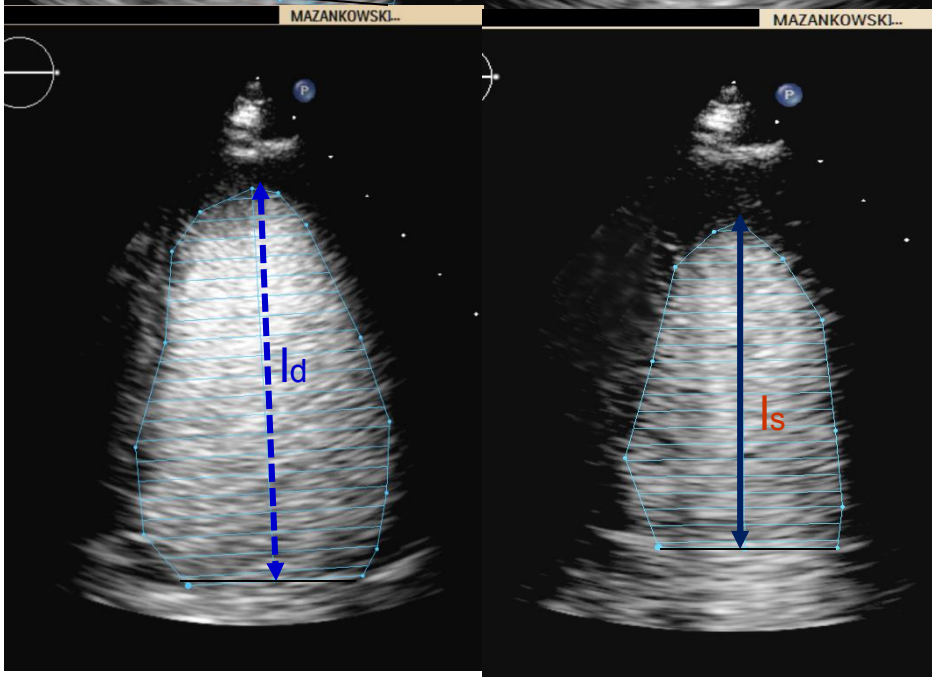
enddiastolic frame **endsystolic frame**

4 chamber View



ld 8.4 cm ls 6.8 cm

2 chamber view



ld 8.2 cm ls 6.8 cm

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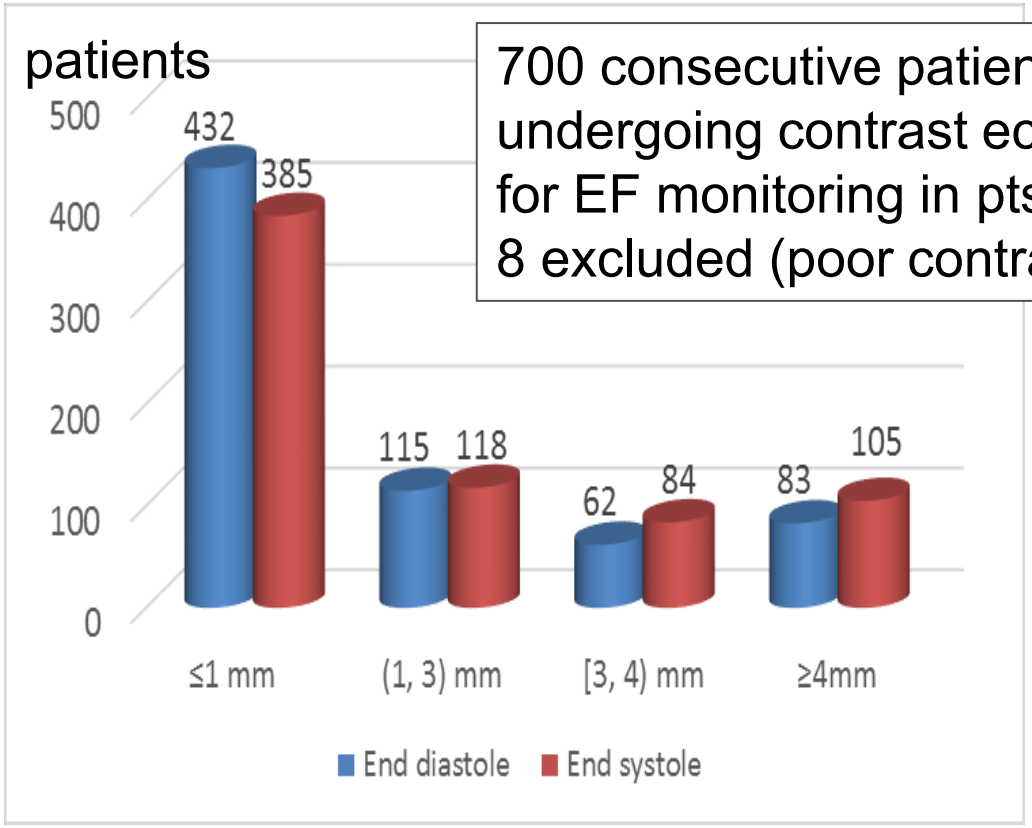
2D contrast echo - Difference of LV long axis length between LV 4 chamber and 2 chamber views



700 consecutive patients
undergoing contrast echo
for EF monitoring in pts with cancer
8 excluded (poor contrast echo)

He, A et al. ASE 2016 (sonographer research award winner)

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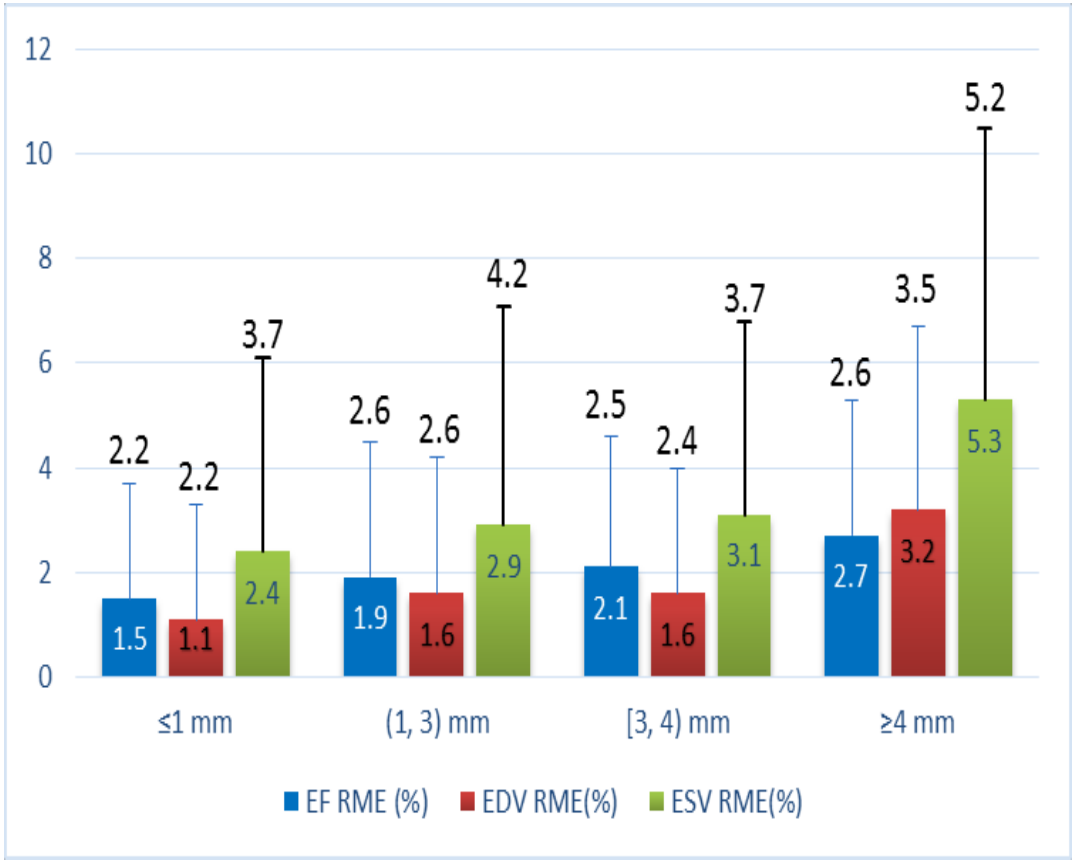
Relative mean error of EF, EDV and ESV measurements: The influence of length difference in LV long axis between 4 and 2 chamber views



He, A et al. ASE 2016 (sonographer research award winner)

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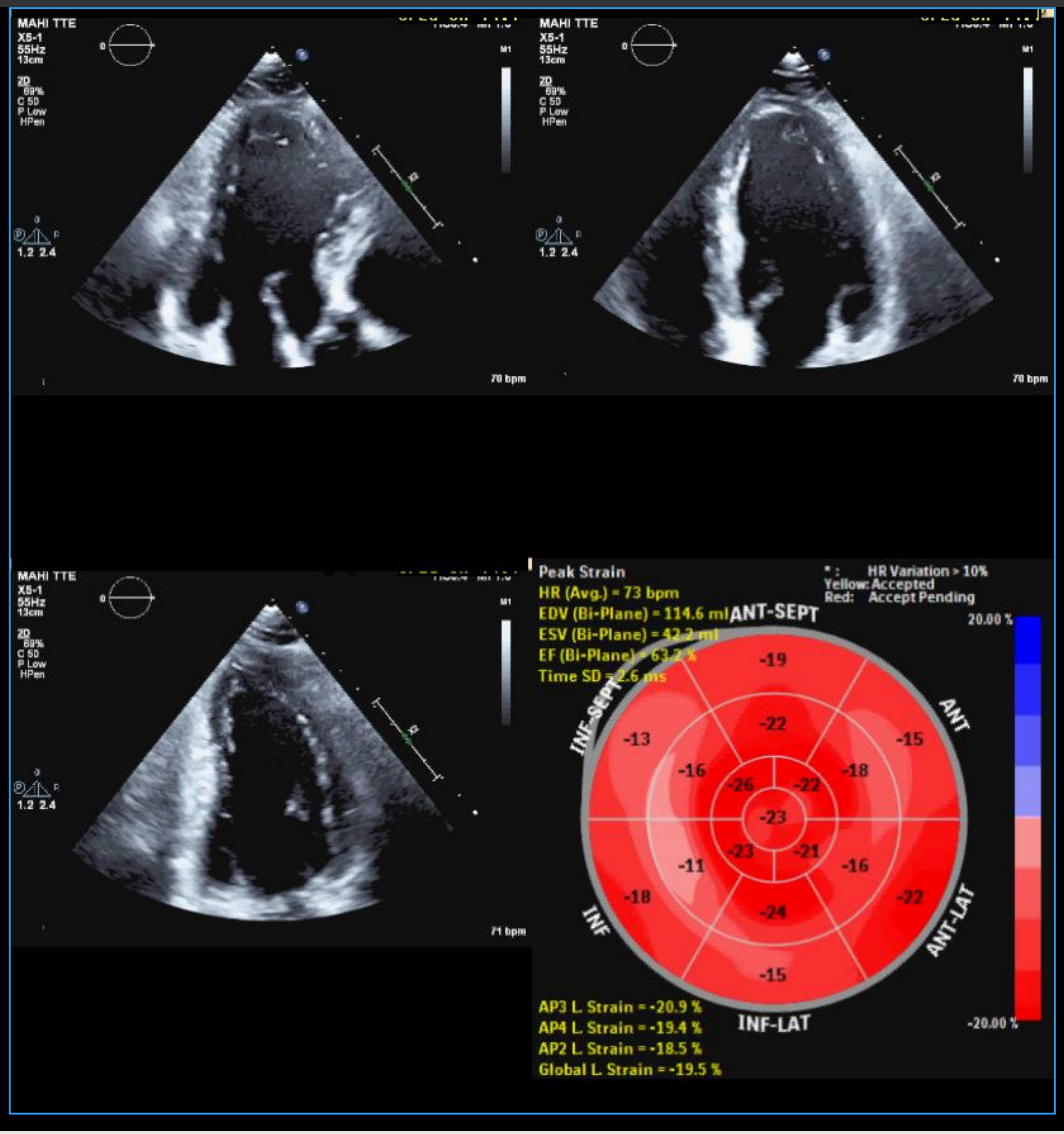
Finding the typical apical shape



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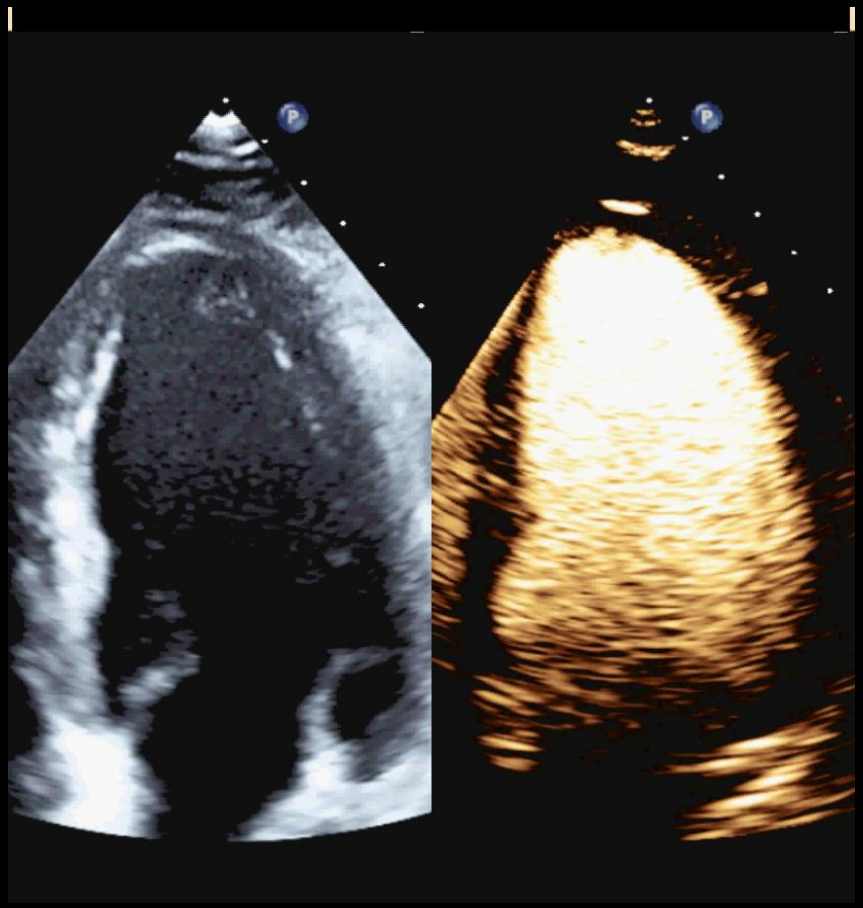

4 chamber view

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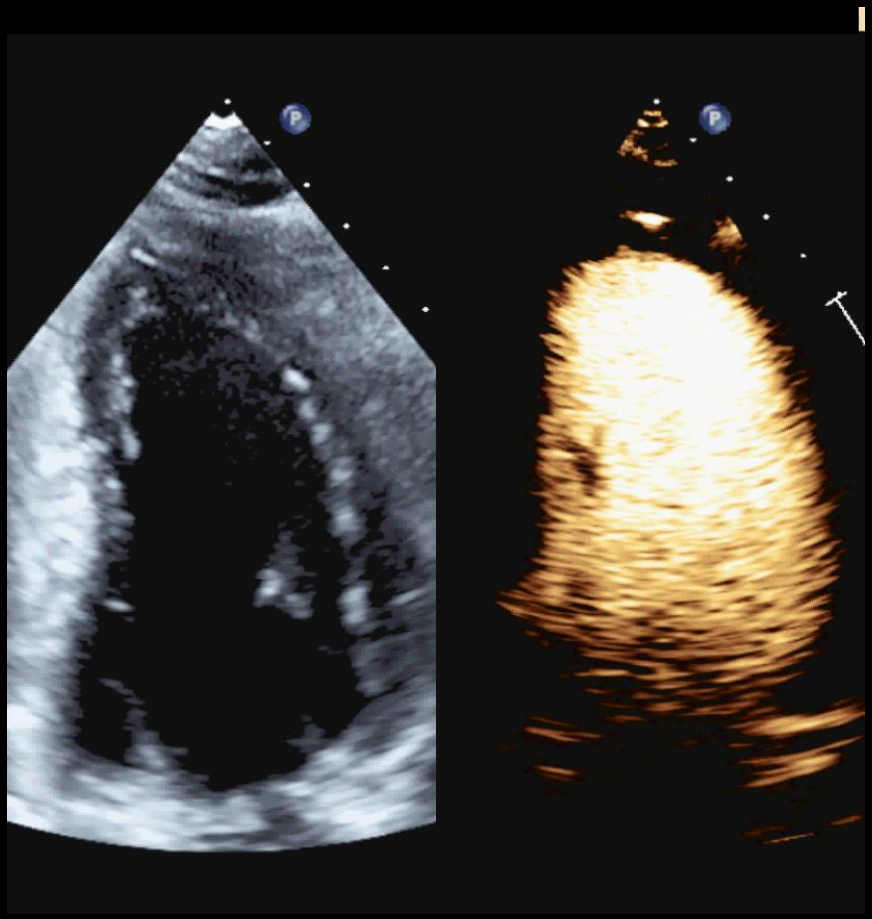
Finding the typical apical shape



2 chamber view

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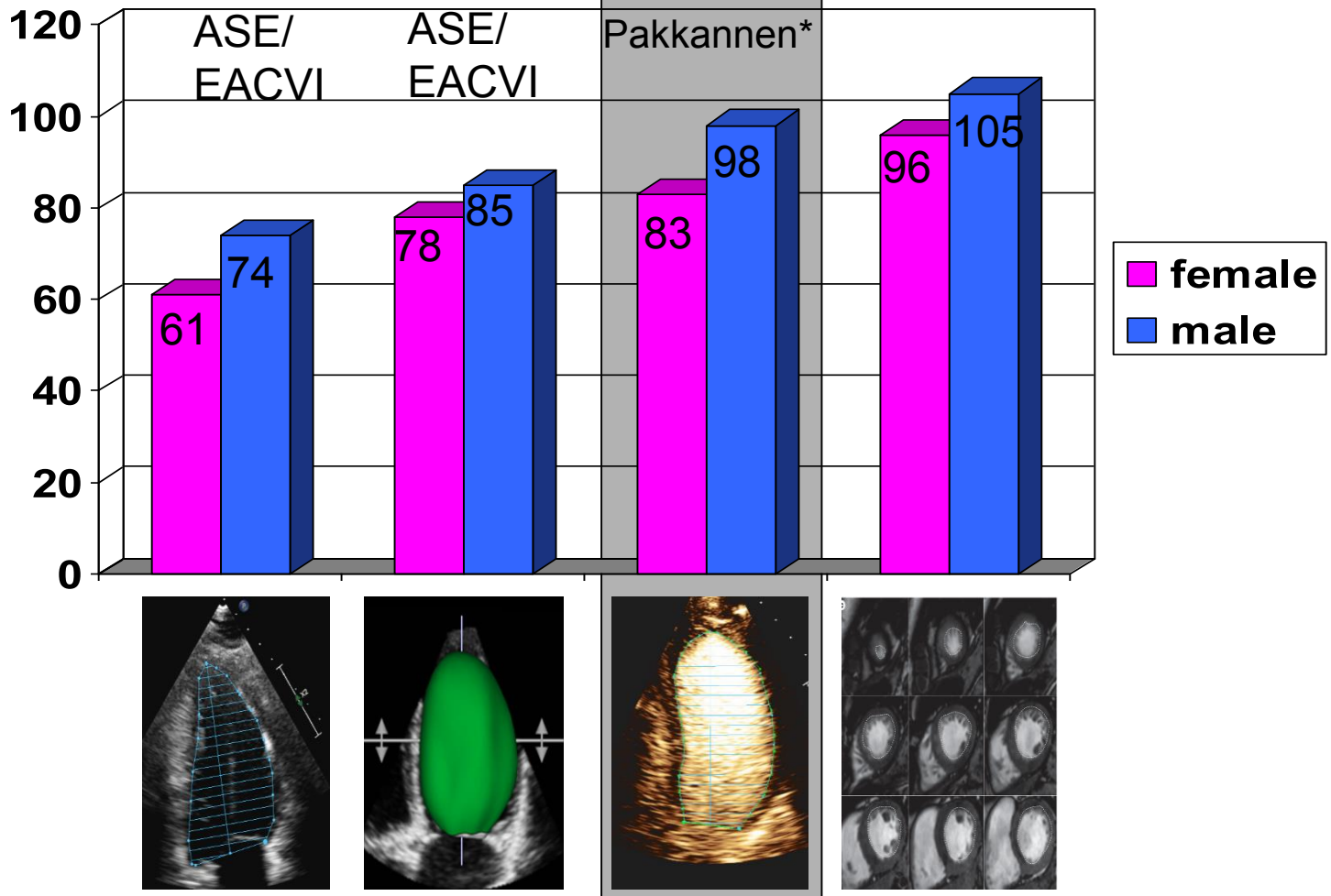
EDV index (ml/m^2): Upper Limits of Normal



*submitted to JASE

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No difference in EF between non-contrast and contrast echocardiograms

	female	male
normal	>54	>52
mildly abnormal	41-53	41 - 51
Moderately abnormal	30-40	30-40
Severely abnormal	<20	< 20

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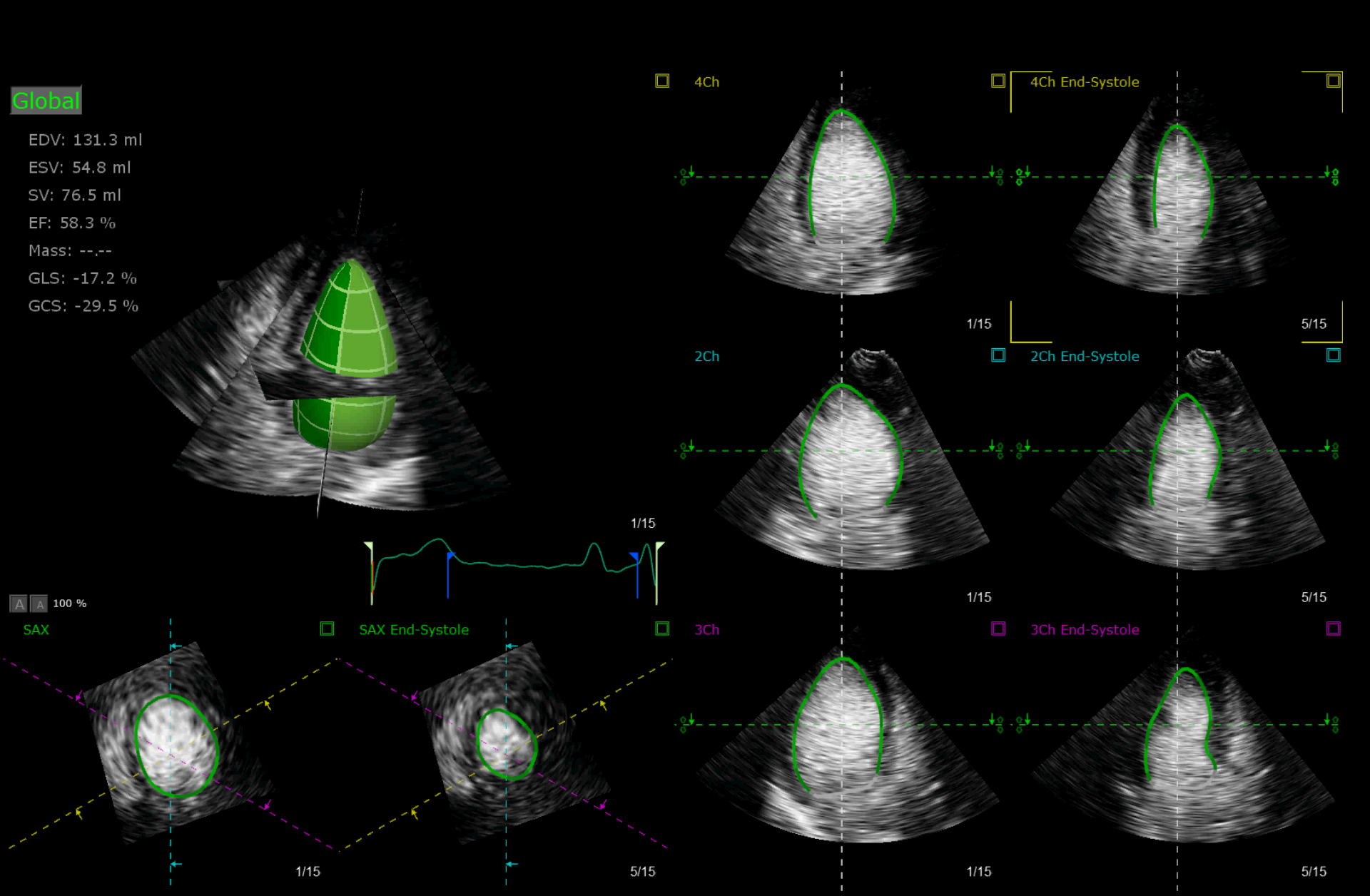
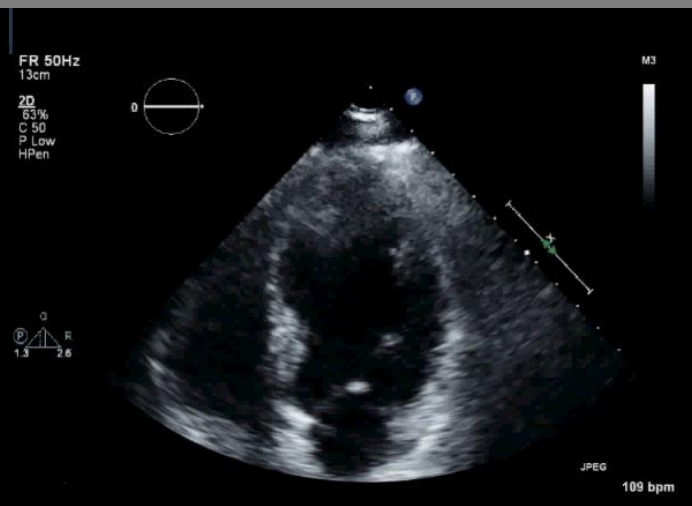
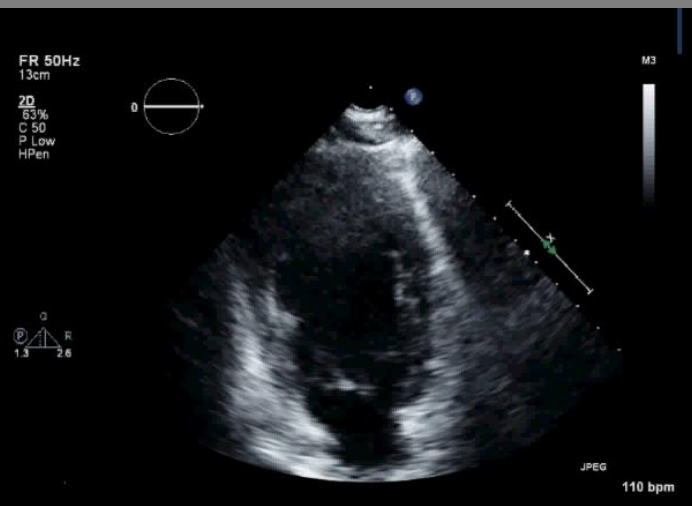

Global
EDV: 131.3 ml
ESV: 54.8 ml
SV: 76.5 ml
EF: 58.3 %
Mass: --.--
GLS: -17.2 %
GCS: -29.5 %
1/15
100 %
SAX
SAX End-Systole
1/15
5/15
4Ch
4Ch End-Systole
1/15
5/15
2Ch
2Ch End-Systole
1/15
5/15
3Ch
3Ch End-Systole
1/15
5/15

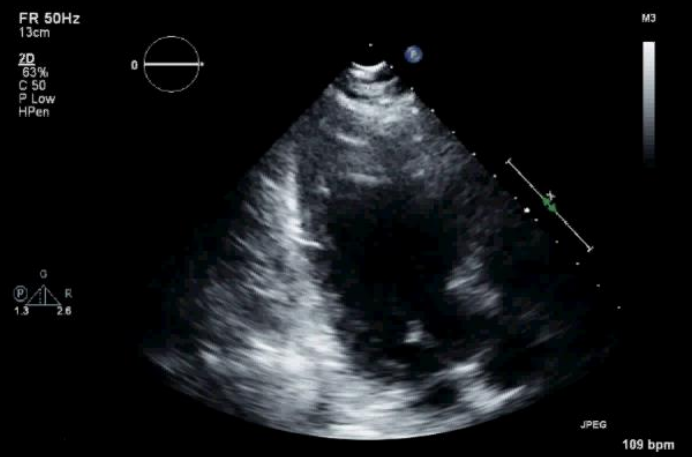
Limitations of 3D echocardiography where is a benefit from contrast?

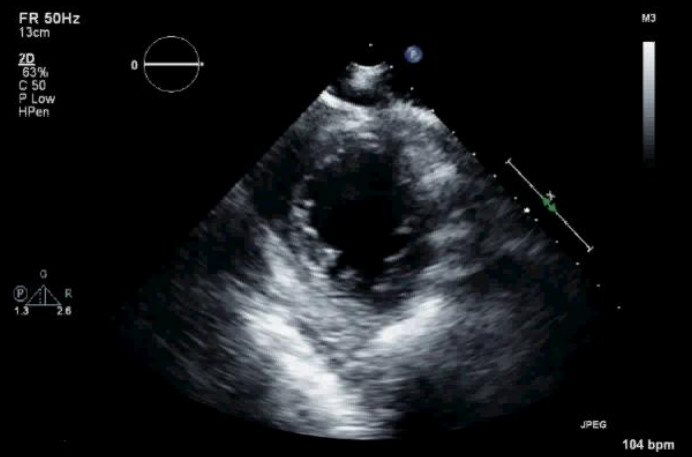
• Definition of compact myocardium	**improved**
• Stitching artifacts	unchanged
• Field of view	unchanged
• Volume rate	worse
• Spatial resolution	worse
	limited tools for processing

62 yrs, male, 2 days after STEMI









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Alberta Heart Institute standing order for contrast echocardiograms

- CRT/ICD candidates
- Cardiotoxicity monitoring
- Suspected non compaction cardiomyopathy
- **After acute anterior/apical STEMI**
- Suspected vascular/myocardial leak
- Stress echocardiography

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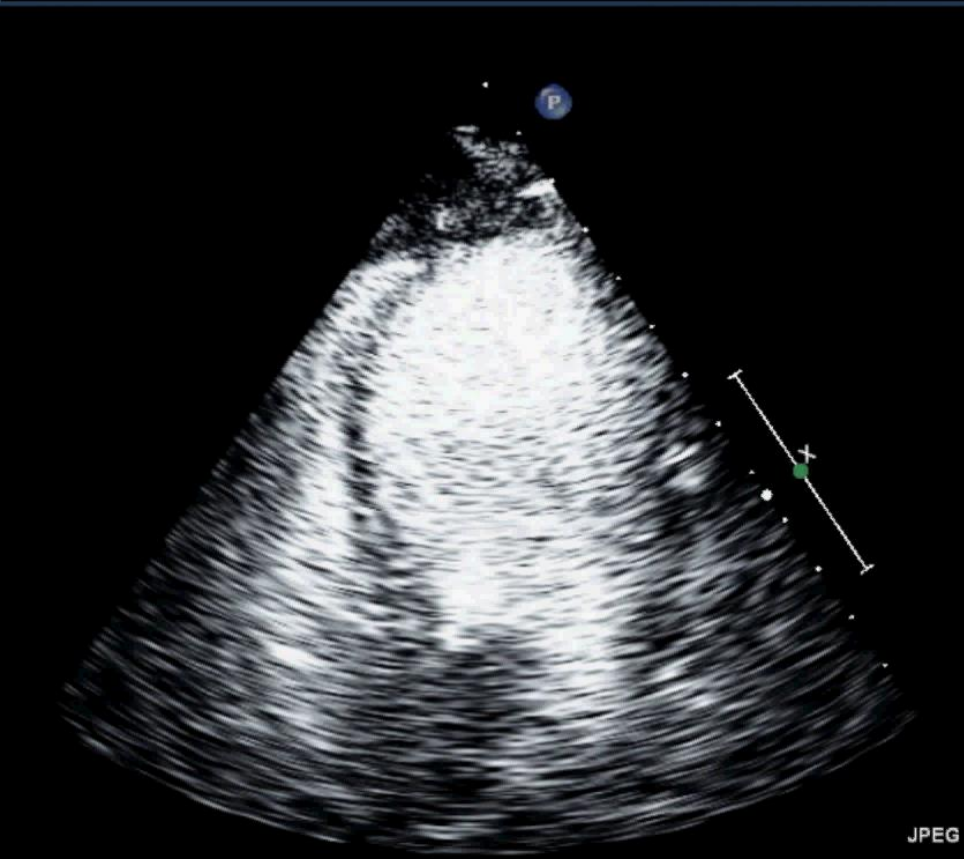
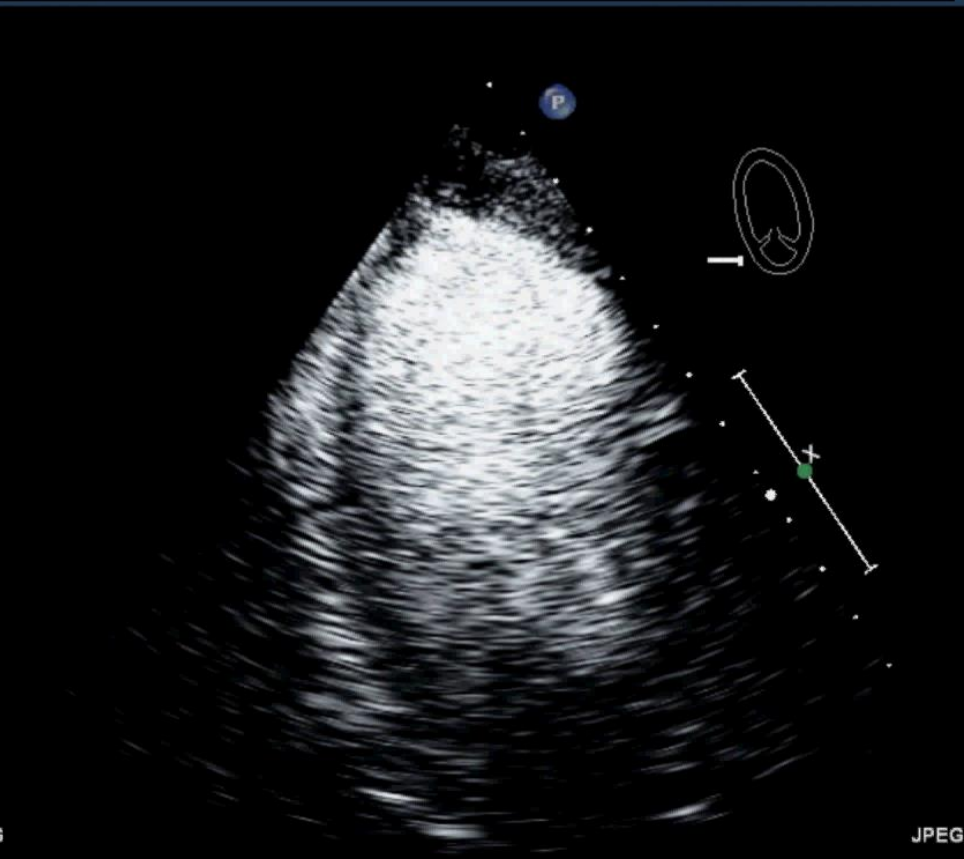
62 yrs, male, 2 days after STEMI





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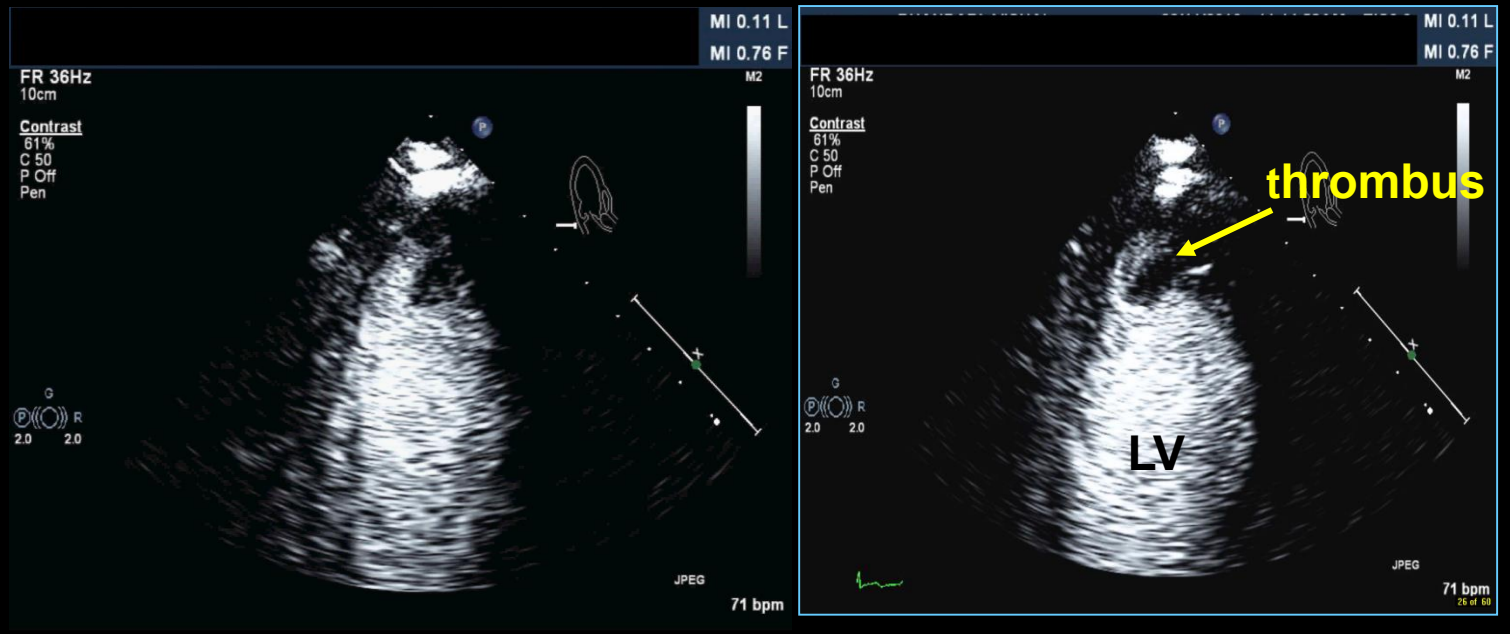
9 days after STEMI and 1 day after stroke: apical long axis view



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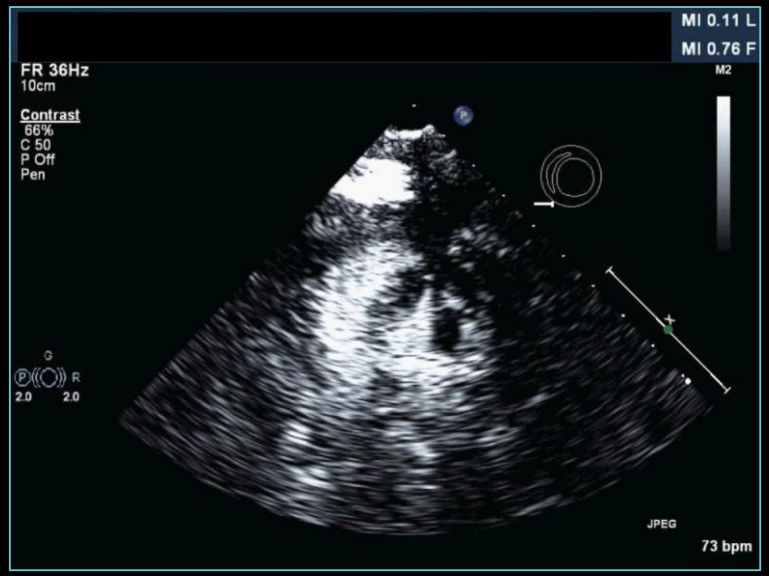
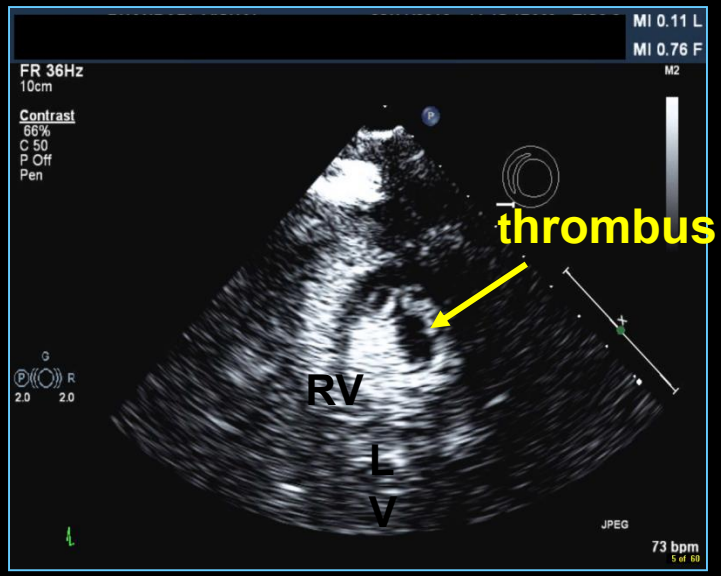
9 days after STEMI and 1 day after stroke: apical short axis view





"90% of LV thrombi occur between 24 h and 11 days after STEMI, median 6 days, early echocardiography after STEMI misses LV thrombi"

Delewi R et al. 2012 Heart, Solheim S et al. 2010 Am J Cardiol

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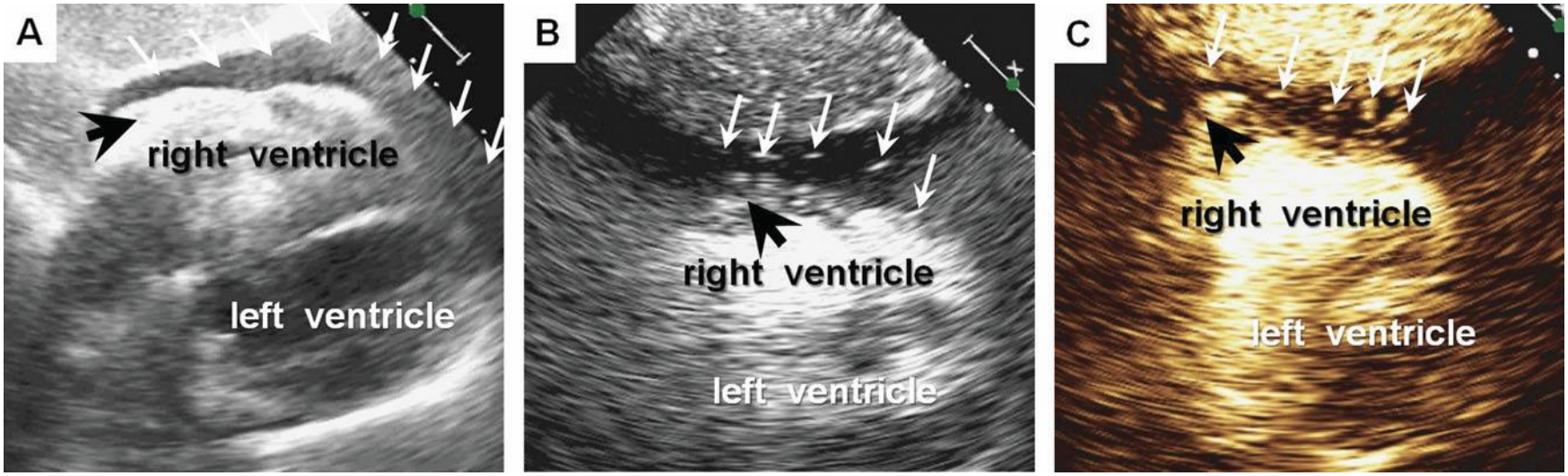
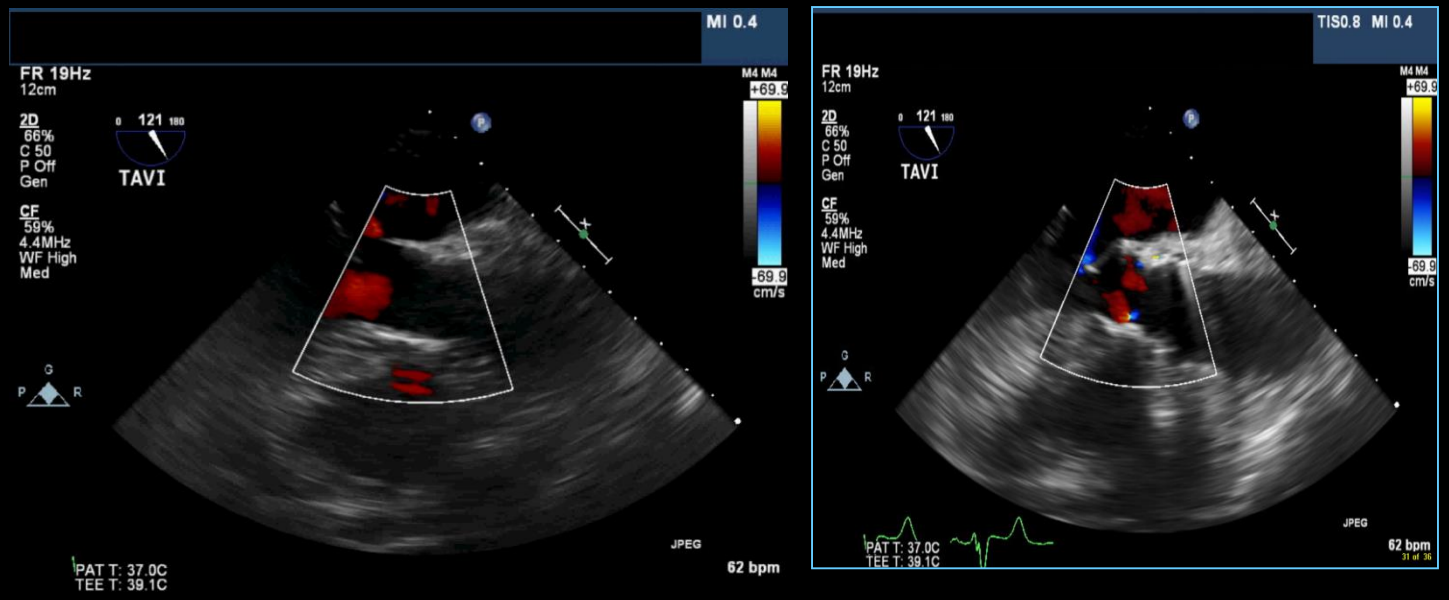
Clinical Decision Making

A Novel Application of Contrast Echocardiography to Exclude Active Coronary Perforation Bleeding in Patients with Pericardial Effusion



Bagur R et al.
Catheterization and Cardiovascular Interventions 82:221–229 (2013)

TEE immediately after TAVI:
mid esophageal view 121^0



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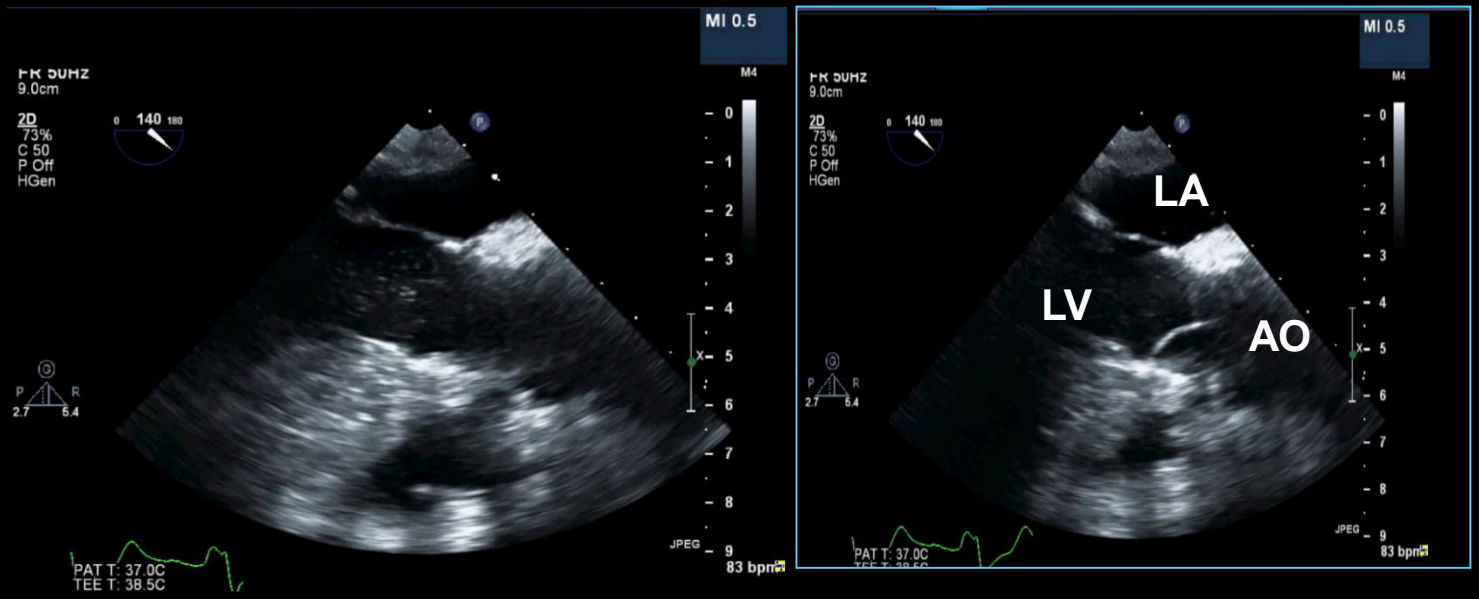
TEE 2 days post TAVI:
mid esophageal 140^0



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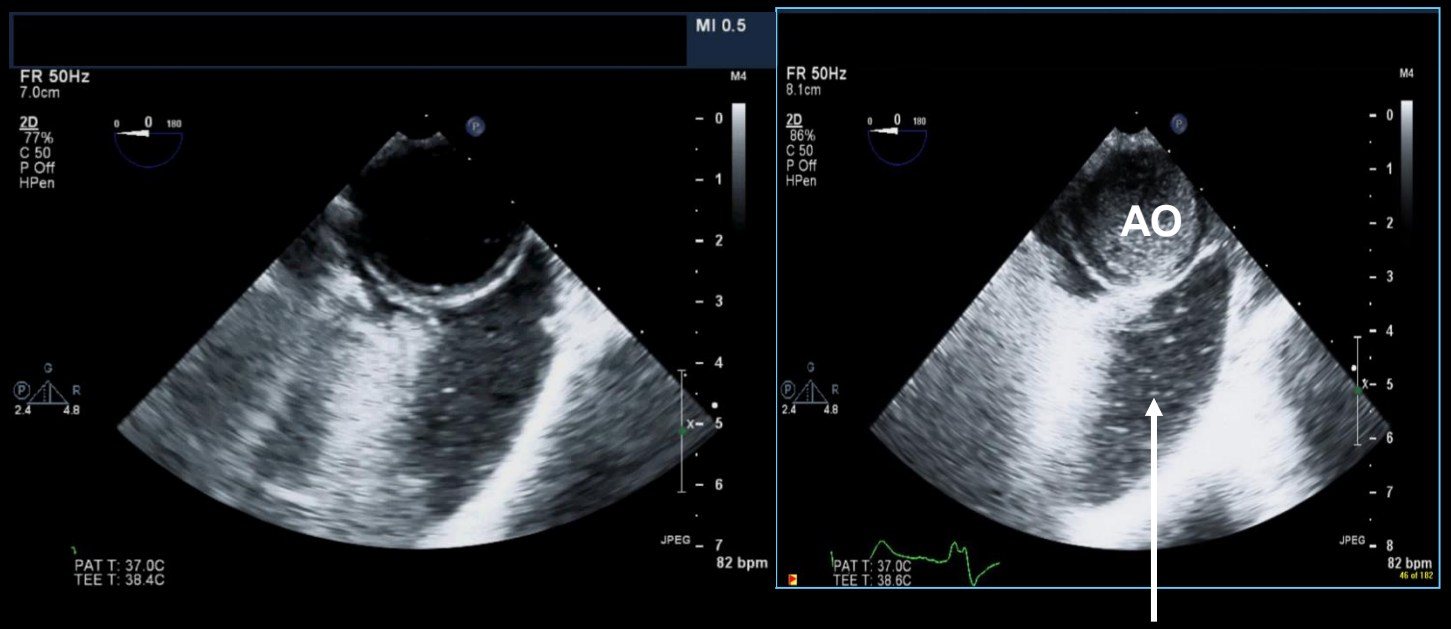
TEE 3 days post TAVI:
descending aorta



left pleura effusion

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Conclusions

- Do not accept suboptimal, non-diagnostic recordings
- There are simple protocols for contrast echocardiography which provide diagnostic images in the majority of patients
- Contrast echocardiography irrespective of the image quality of the native echocardiogram is suggested
  - when an accurate EF is needed
  - When myocardial/arterial rupture is suspected
  - In stress echocardiography

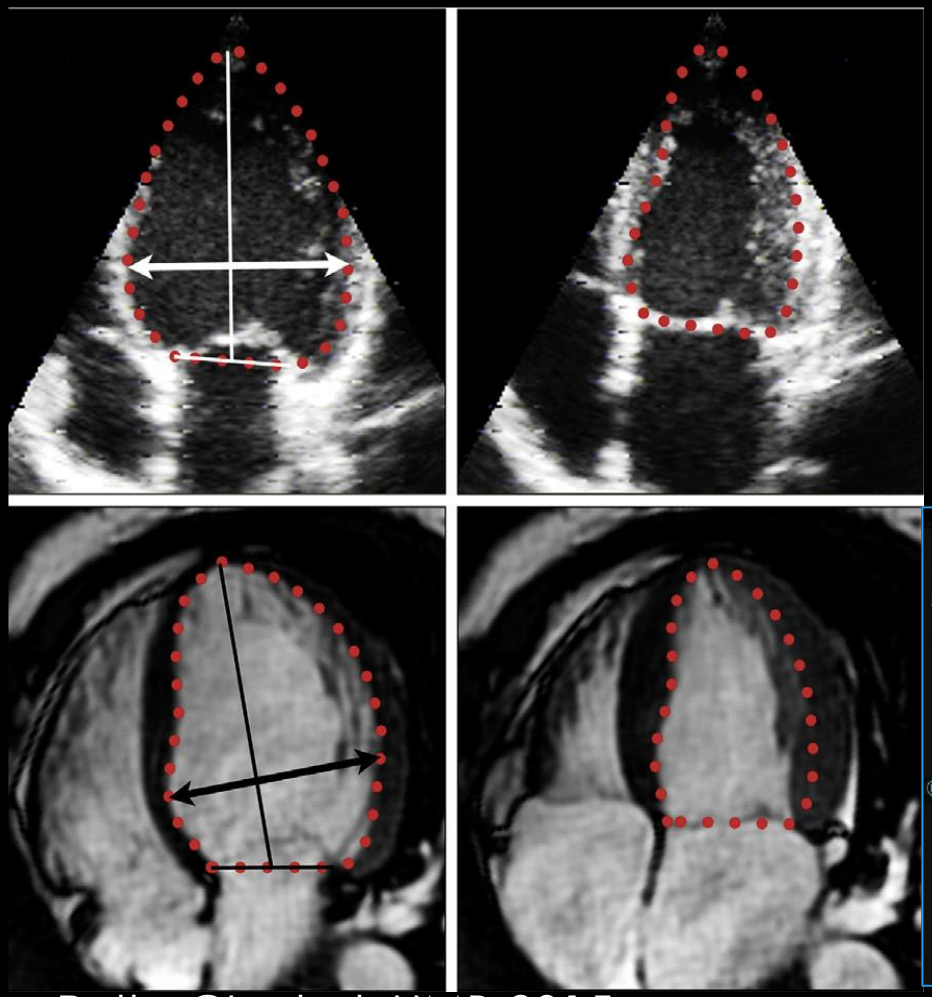
On-line teaching material

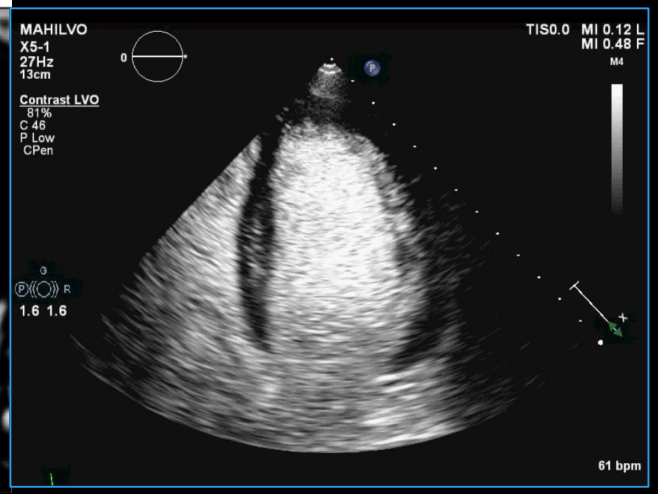
- Presentation (pdf):
- www.abacusresearch.ca

- Becher H and Helfen A. Use of Contrast-Enhanced Ultrasound in Echocardiography. Springer Healthcare publisher Europe
- www.cardiocontrast.com

- Email: harald@ualberta.ca

Trabeculations in Echocardiography and MRI





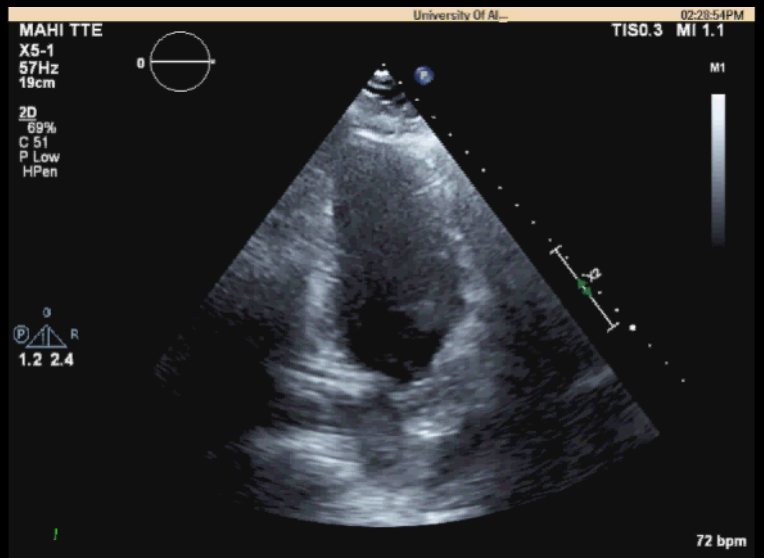
Polte CL et al. UMB 2015

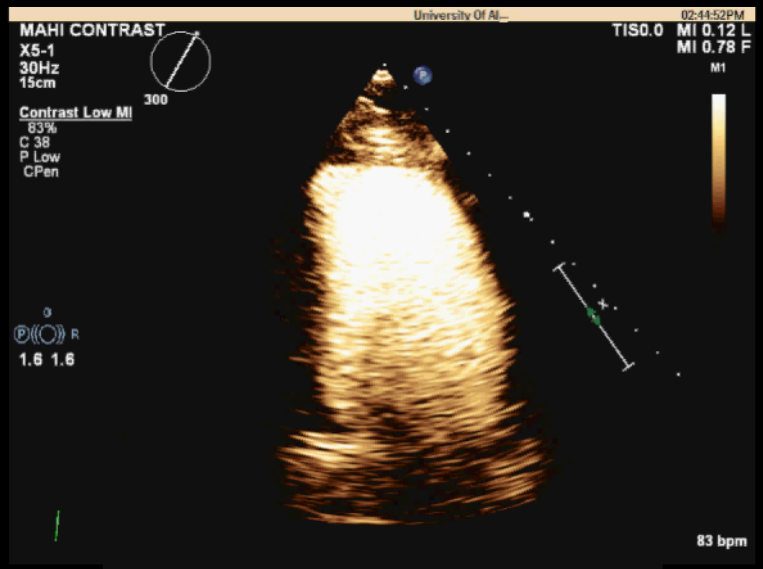
Limitations of GLS

- **Heavy dependence on the quality of the 2D echocardiographic images**
- Influenced by loading conditions
- Lack of long-term randomized clinical trials evaluating the ability of GLS to predict persistent decreases in LVEF or symptomatic HF
- Lack of data as to the reproducibility of GLS in nonacademic centers or community hospitals
- Vendor and software specific

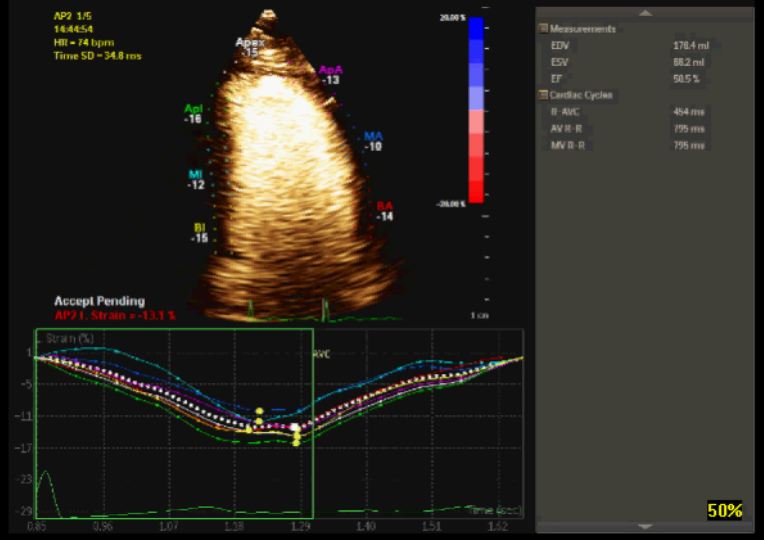
J Am Soc Echocardiogr 2014;27:911-39

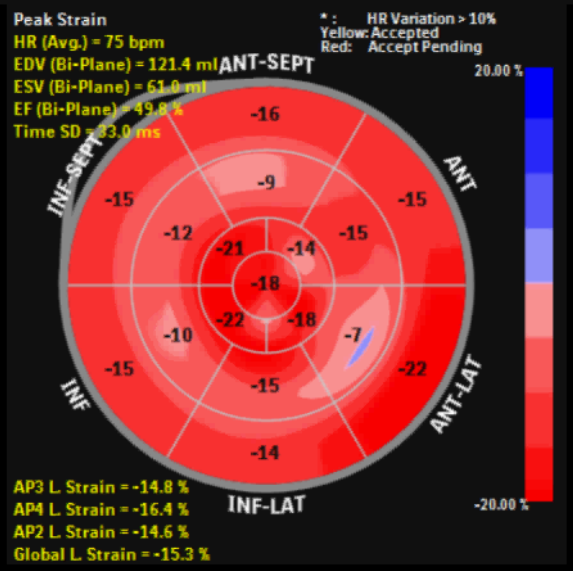
JPEG CR 15:1



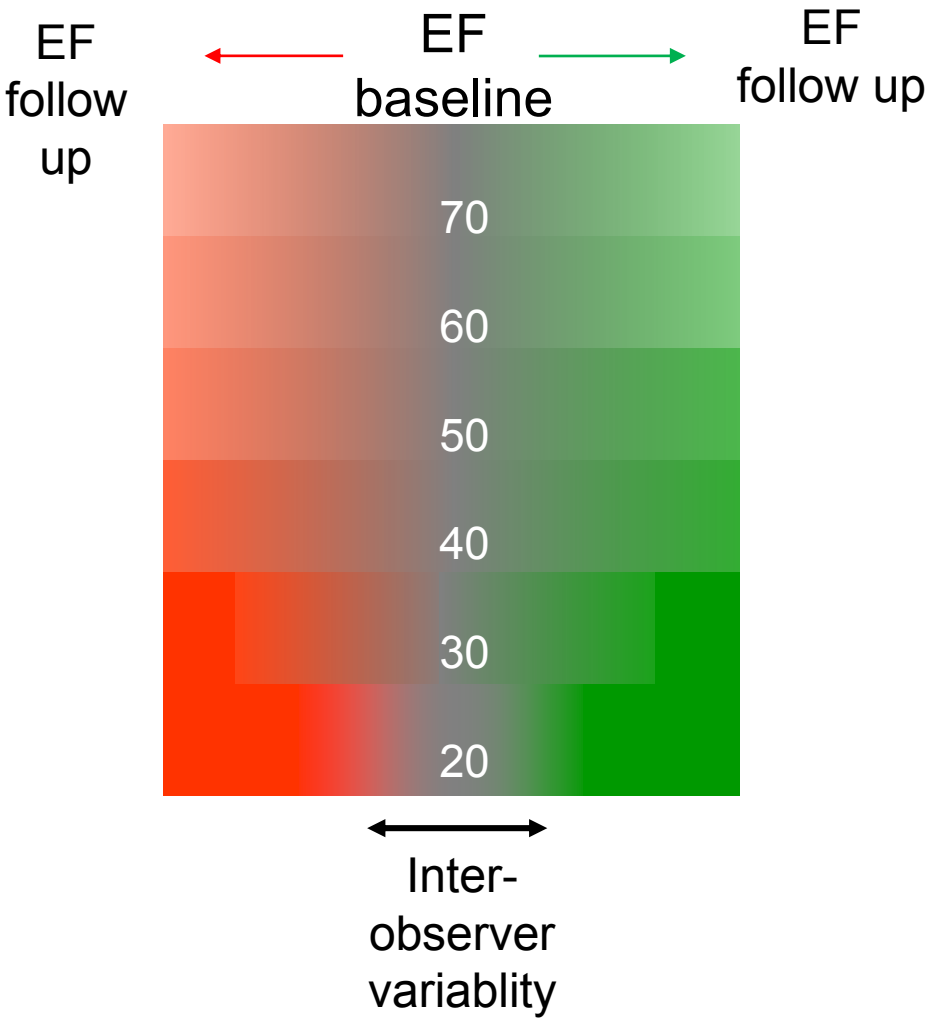


JPEG CR 10:1





Which change in EF is real?



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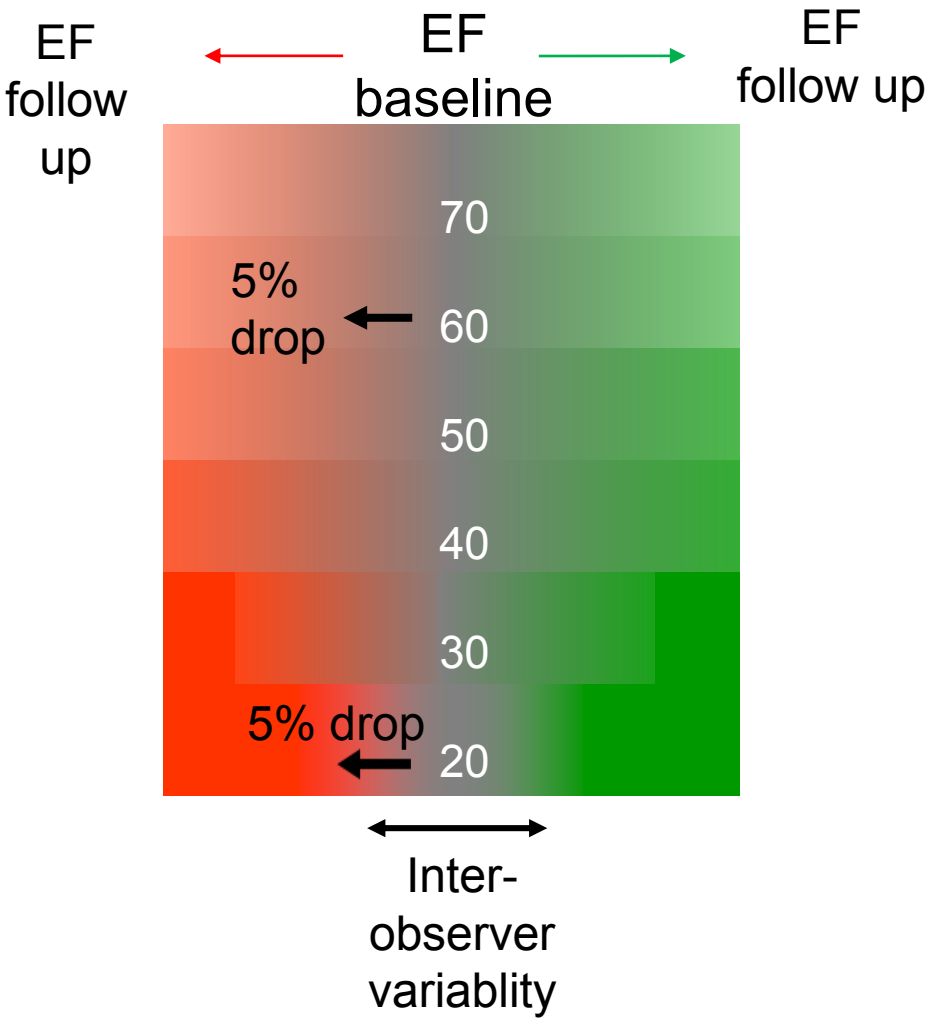
Which change in EF is real?



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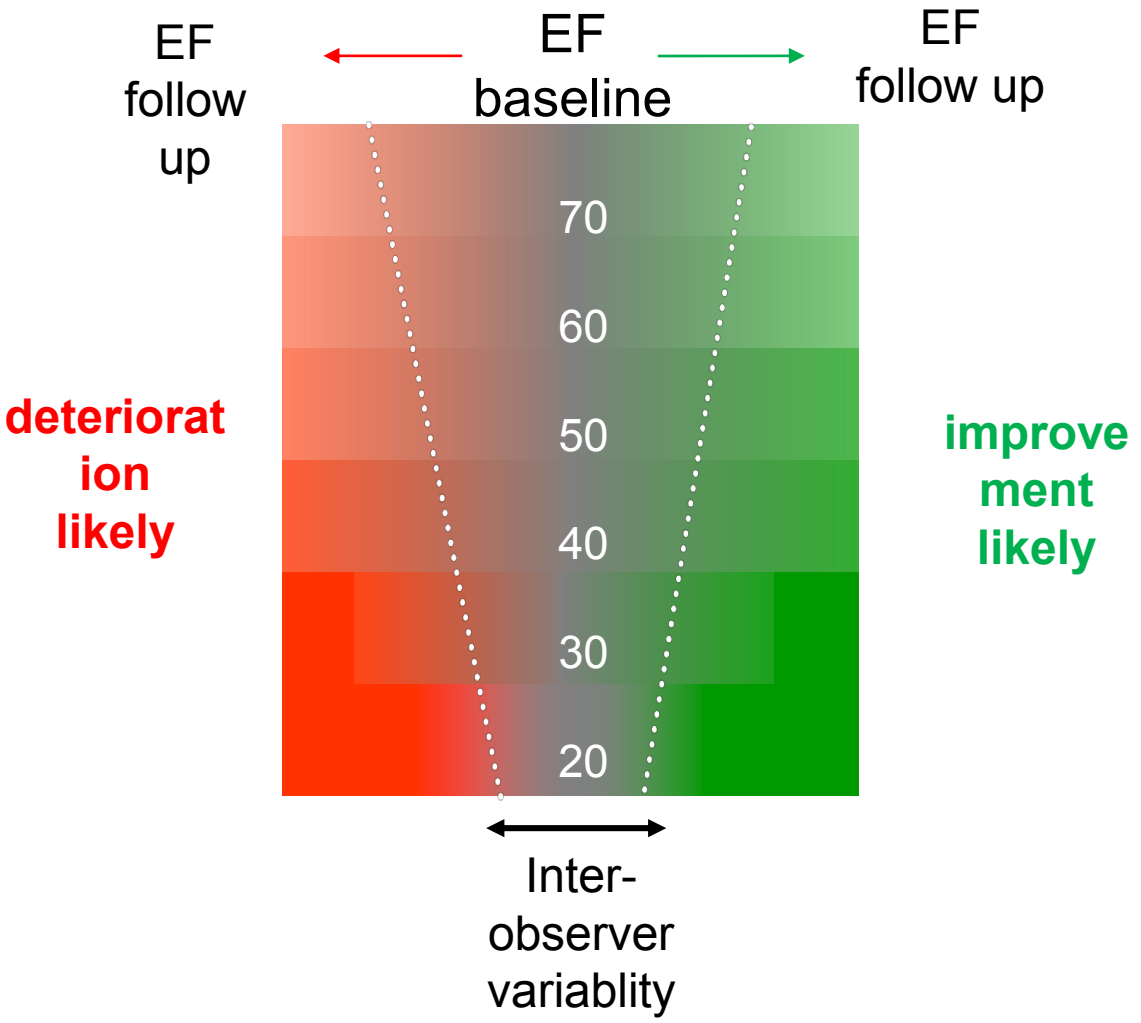

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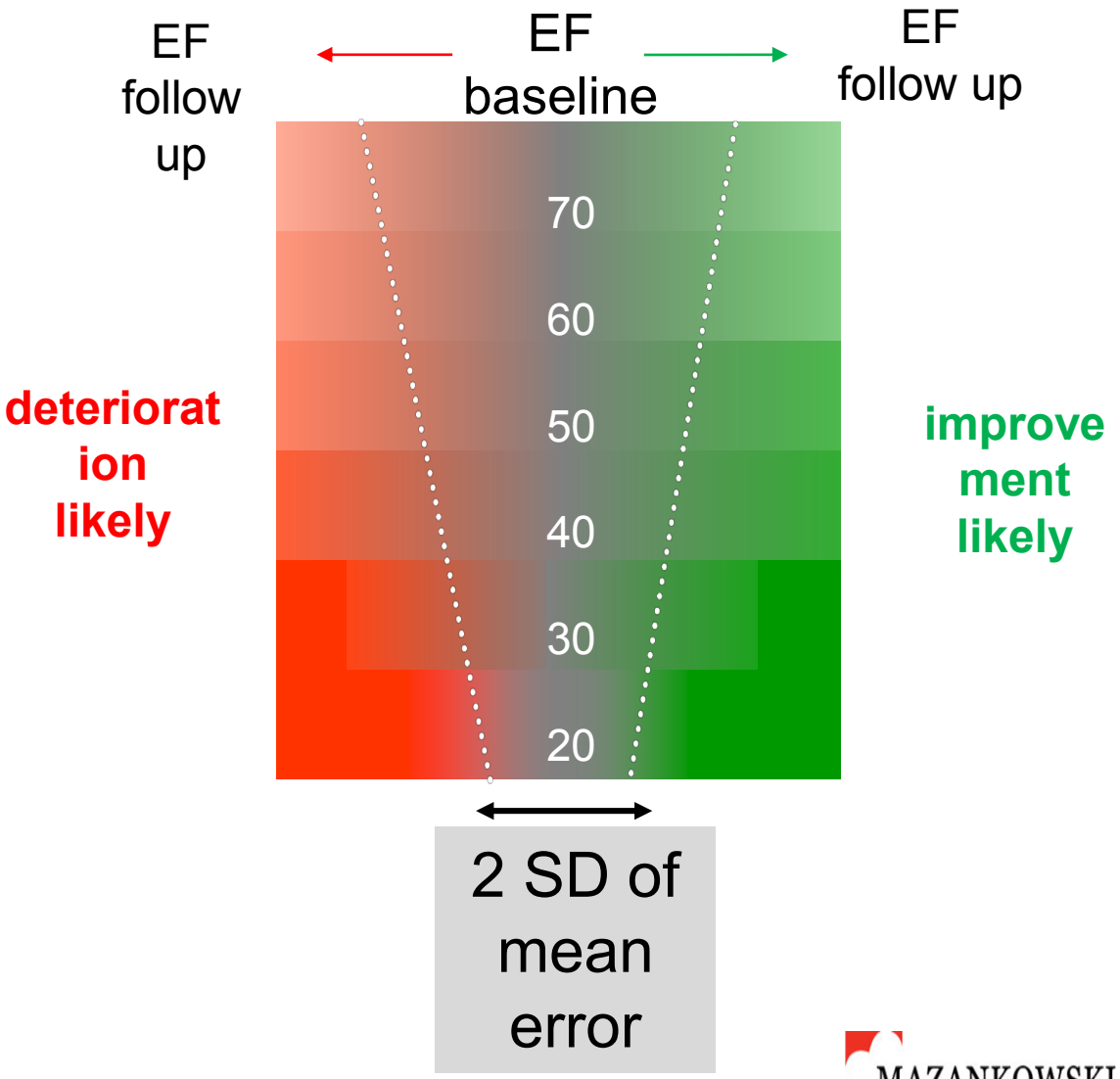

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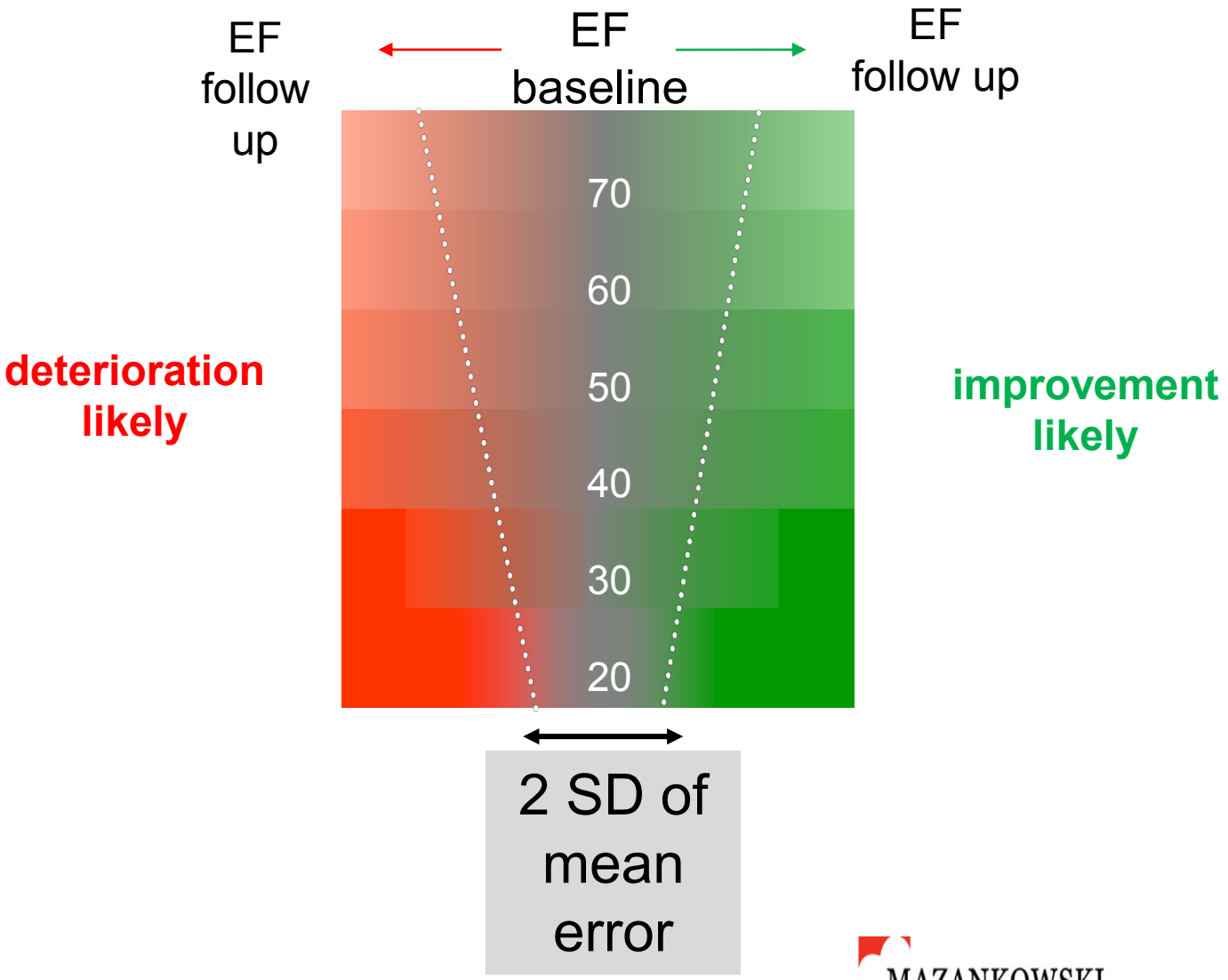
Relative Mean Error

Pt	EF1	EF2	EF1-EF 2/average EF (%)
1			
2			
3			
.			
.			
.			
.			
n			
Mean			
SD			

Which change in EF is real?



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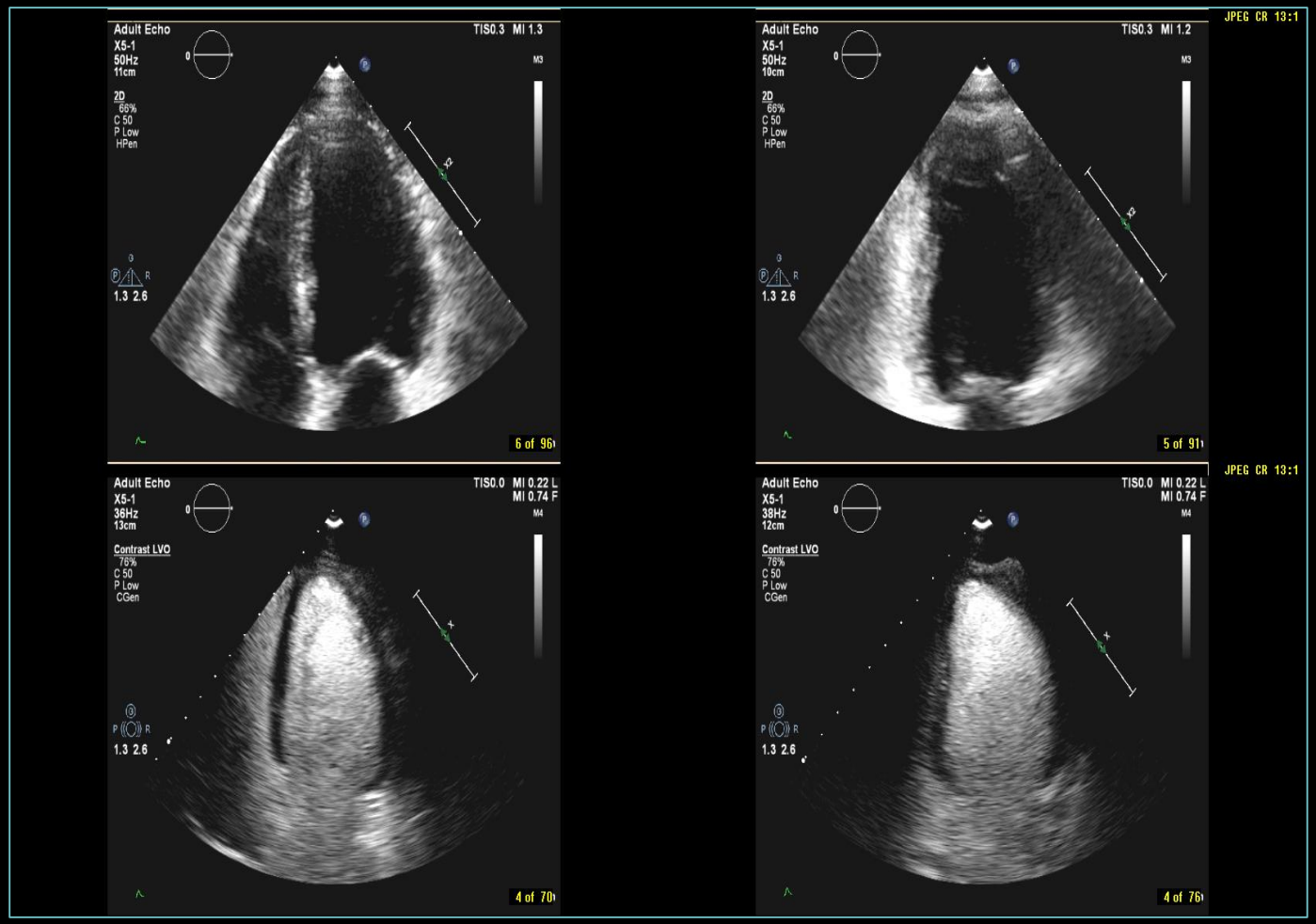
EDV index - reference values

	Guideline values		Current values without contrast		Current values with contrast	
	Mean (SD)	(-2SD...+2SD)	Mean (SD)	(-2SD...+2SD)	Mean (SD)	(-2SD...+2SD)
Biplane						
EF (%)	*64 (5)*	*54-74*	62.6 (5.2)	52.2-73.1	63.0 (5.3)	52.4-73.9
EDV (ml)	*76 (15)*	*46-106*	80.0 (19.3)	41.41-118.68	112.8 (23.5)	65.93-159.79
EDV/BSA (ml/m2)	*45 (8)*	*29-61*	44.8 (9.7)	25.49-64.10	63.3 (12.2)	38.86-87.83

Paakkanen R *et al.*, ASE (abstract) 2016

Enddiastolic Frames for measurement of EF



4 chamber view

2 chamber view