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

Harald Becher
Professor of Medicine
Heart&Stroke Foundation Chair
Alberta Heart Institute, Canada
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.
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
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
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

Stollberger C, Finsterer J. J Am Soc Echocardiogr 2004;17:91-100
Finding the border between the compact and the trabeculated myocardium
LV trabeculations

Stollberger C, Finsterer J. J Am Soc Echocardiogr 2004;17:91-100
Contrast-Echocardiography displays the volume surrounded by the compacted myocardium
Contrast-Echocardiography displays the volume surrounded by the compacted myocardium.
76 yrs, male referred for CRT
4 chamber view

2 chamber view

3 chamber view

0.5 ml SonoVue single bolus
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.
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
### Table 3.1  Definition of heart failure with preserved (HFpEF), mid-range (HFmrEF) and reduced ejection fraction (HFrEF)

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>HFrEF</th>
<th>HFmrEF</th>
<th>HFpEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Symptoms ± Signs(^a)</td>
<td>Symptoms ± Signs(^a)</td>
<td>Symptoms ± Signs(^a)</td>
</tr>
<tr>
<td>2</td>
<td>LVEF &lt;40%</td>
<td>LVEF 40–49%</td>
<td>LVEF ≥50%</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>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).</td>
<td>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).</td>
</tr>
</tbody>
</table>
Enddiastole  Early Systole  Late Systole

Stankovic et al. 2016 Eur Heart J CVI (modified)
When do we need an accurate EF?

- 10% to 20%
- 30% to 40%
- 50% to 70%

ICD, CRT
Cardio-toxicity
Adequate in LV contrast echocardiography

**APICAL:** No Swirling, No Blooming

**BASAL:** No Attenuation

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

Intensive Contrast
In the entire LV cavity

No Rib Shadow
### Troubleshooting for contrast recordings

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apical swirling</td>
<td>MI too high</td>
</tr>
<tr>
<td>Good basal contrast</td>
<td></td>
</tr>
<tr>
<td>Basal attenuation</td>
<td>too early after bolus</td>
</tr>
<tr>
<td>No apical swirling</td>
<td>MI too low</td>
</tr>
<tr>
<td>Apical blooming and</td>
<td>Contrast too high</td>
</tr>
<tr>
<td>Basal attenuation</td>
<td></td>
</tr>
<tr>
<td>Apical swirling and</td>
<td></td>
</tr>
<tr>
<td>Inhomogeneous contrast in the entire cavity</td>
<td>Contrast too low</td>
</tr>
</tbody>
</table>

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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

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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

<table>
<thead>
<tr>
<th>EF</th>
<th>GLS</th>
<th>EF</th>
<th>GLS</th>
<th>EF</th>
<th>GLS</th>
<th>EF</th>
<th>GLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Trastuzumab +/- Adriamycin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>12 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Echo Measurements</td>
<td>Action</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>--------</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EF decreases &gt;10% but not below 50%</td>
<td>repeat EF measurement shortly after and during the duration of cancer treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EF decreases &gt;10% to EF &lt;50%, asymptomatic</td>
<td>may be considered as stage B HF (in particular with high BNP) ACE inhibitors (or ARBs)+beta-blockers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EF decreases &gt;10% to EF &lt;50% with heart failure</td>
<td>ACE inhibitors (or ARBs)+beta-blockers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GLS decreases &gt; 15% EF remains &gt;50%</td>
<td>No change in chemotherapy!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2016 ESC Position paper on cancer treatments and cardiovascular toxicity
enddiastolic frame  
endsystolic frame

4 chamber View

2 chamber view

ld 8.4 cm  ls 6.8 cm
ld 8.2 cm  ls 6.8 cm
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)
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)
Finding the typical apical shape
Finding the typical apical shape

4 chamber view
Finding the typical apical shape

2 chamber view
EDV index (ml/m²): Upper Limits of Normal

**ASE/EACVI**

- Male
  - Female: 61
  - Male: 74

- Male
  - Female: 78
  - Male: 85

- Male
  - Female: 83
  - Male: 98

- Male
  - Female: 96
  - Male: 105

*submitted to JASE*

2D

3D

2D contrast

MRI
No difference in EF between non-contrast and contrast echocardiograms

<table>
<thead>
<tr>
<th></th>
<th>female</th>
<th>male</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal</td>
<td>&gt;54</td>
<td>&gt;52</td>
</tr>
<tr>
<td>mildly abnormal</td>
<td>41-53</td>
<td>41 - 51</td>
</tr>
<tr>
<td>Moderately abnormal</td>
<td>30-40</td>
<td>30-40</td>
</tr>
<tr>
<td>Severely abnormal</td>
<td>&lt;20</td>
<td>&lt; 20</td>
</tr>
</tbody>
</table>
EDV: 131.3 ml
ESV: 54.8 ml
SV: 76.5 ml
EF: 58.3 %
Mass: --.--
GLS: -17.2 %
GCS: -29.5 %
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
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
62 yrs, male, 2 days after STEMI
9 days after STEMI and 1 day after stroke: apical long axis view

thrombus

LV
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
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°
TEE 2 days post TAVI:
mid esophageal 140°
TEE 3 days post TAVI:
descending aorta

left pleura effusion
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

Which change in EF is real?

Inter-observer variability

EF baseline

EF follow up

EF follow up

20

30

40

50

60

70
Which change in EF is real?

Inter-observer variability

EF baseline

EF follow up

EF follow up 70
5% drop 60
5% drop 50
5% drop 40
5% drop 30
20
Which change in EF is real?

Inter-observer variability

deterioration likely

EF baseline

EF follow up

improvement likely

EF follow up

EF follow up
Which change in EF is real?

EF follow up

EF baseline

EF follow up

deterioration likely

improvement likely

2 SD of mean error
<table>
<thead>
<tr>
<th>Pt</th>
<th>EF1</th>
<th>EF2</th>
<th>EF1-EF2/average EF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n
Mean
SD
Which change in EF is real?

EF follow up  ↓  EF baseline  ↑  EF follow up

deterioration likely

improvement likely

2 SD of mean error
EDV index - reference values

<table>
<thead>
<tr>
<th></th>
<th>Guideline values</th>
<th>Current values without contrast</th>
<th>Current values with contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>(-2SD...+2SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Biplane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EF (%)</td>
<td>64 (5)</td>
<td>54-74</td>
<td>62.6 (5.2)</td>
</tr>
<tr>
<td>EDV (ml)</td>
<td>76 (15)</td>
<td>46-106</td>
<td>80.0 (19.3)</td>
</tr>
<tr>
<td>EDV/BSA (ml/m2)</td>
<td>45 (8)</td>
<td>29-61</td>
<td>44.8 (9.7)</td>
</tr>
</tbody>
</table>

Paakknenan R et al., ASE (abstract) 2016
Enddiastolic Frames for measurement of EF