Echocardiography in diagnosis and management of CAD

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Cardiovascular imaging

- Coronary artery disease (CAD) is one of the major causes of morbidity and mortality.
- In patients with suspected acute coronary syndrome (ACS), cardiac imaging offers incremental value over routine clinical assessment, ECG, and blood biomarkers of myocardial injury, to confirm or refute the diagnosis of coronary artery disease and to assess future cardiovascular risk.
- Echocardiography is one of the most useful imaging methods due to its availability, ease of use, price, capacity to serve as bedside technique and repeatability
The Full Spectrum of IHD
IHD Mortality Rate in 21 World Regions (2010)

Age-standardized IHD mortality rate per 100,000 persons in 21 world regions, the Global Burden of Disease 2010 Study.

Moran AE, Circulation 2014

Echocardiography for Acute Coronary Syndrome
Acute Coronary Syndrome

- Acute Coronary Syndrome is a serious condition, without proper management, the outcome will be poor.
- Early detection and accurate diagnosis is of importance to improve the outcome.
- ACS could present with atypical symptom, lack of specific ECG changes, and negative cardiac biomarkers.
- Accurate assessment of chest pain in the emergency department requires a thorough knowledge of the differential diagnosis and appropriate use of diagnostic tools.

Acute Coronary Syndromes

*Role of Echocardiography in Suspected ACS*

[Diagram showing the role of echocardiography in suspected ACS]

Modified from Garg P et al., Nature Reviews 2016
Acute Coronary Syndromes
Role of Echocardiography in Suspected ACS

Table 2: Guideline endorsement of advanced imaging when ACS is suspected but ECG and biomarkers are inconclusive

<table>
<thead>
<tr>
<th>Modality</th>
<th>Guidelines</th>
<th>Endorsement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D TTE</td>
<td>• ESC guidelines for NSTE-ACS (2011)(^1)</td>
<td>• Primary bedside modality</td>
</tr>
<tr>
<td></td>
<td>• ACCF/ASE/SCA Appropriate Use Criteria for Echocardiography (2011)(^*)</td>
<td>• To assess resting RWMA</td>
</tr>
<tr>
<td>Stress Echo</td>
<td>• ESC guidelines for NSTE-ACS (2011)(^1)</td>
<td>• In all suspected ACS to assess RWMA</td>
</tr>
<tr>
<td></td>
<td>• ACCF/ASE/SCA Appropriate Use Criteria for Echocardiography (2011)(^*)</td>
<td></td>
</tr>
</tbody>
</table>

Acute Coronary Syndromes
Role of Echocardiography in Suspected ACS
Regional Wall Motion Abnormality (RWMA)

- Wall thickening, assessed in 16/17 segments → Wall Motion Index
- RWMA are characteristic of myocardial ischemia and infarction.
- Subjective, sometimes difficult to assess due to suboptimal echo window → tissue harmonic imaging, contrast echocardiography and myocardial contrast echo
- Their location correlates well with the distribution of CAD and pathological evidence of infarction
Algorithm of Chest Pain Assessment in ER

- Chest pain
  - Non specific ECG changes
  - Normal cardiac biomarkers

  → Resting TTE

  - Normal
    → Within 5-6 hrs
      → DSE
        - Negative
        - Positive
          - Sensitivity 89.5%
          - Specificity 89%
          - NPP 98.5%

          Cardiac event: 30%

          Cardiac event: 4%

JAMA 1999;281:707-713
Otto C. In The Practice of Clinical Echocardiography 2012
ACC/AHA/ASE 2003 Guideline Update for the Clinical Application of Echocardiography

Recommendations for Echocardiography in Patients With Chest Pain

Class I
1. Diagnosis of underlying cardiac disease in patients with chest pain and clinical evidence of valvular, pericardial, or primary myocardial disease (see sections II, IV through VI, VIII, and IX).
2. Evaluation of chest pain in patients with suspected acute myocardial ischemia, when baseline ECG and other laboratory markers are nondiagnostic and when study can be obtained during pain or within minutes after its abatement (see section IV).
3. Evaluation of chest pain in patients with suspected aortic dissection (see section VIII).
4. Evaluation of patients with chest pain and hemodynamic instability unresponsive to simple therapeutic measures (see section XIII).

Class III
1. Evaluation of chest pain for which a noncardiac etiology is apparent.
2. Diagnosis of chest pain in a patient with electrocardiographic changes diagnostic of myocardial ischemia/infarction (see section IV).

TTE for Cardiovascular Evaluation in an Acute Setting
Myocardial Ischemia/Infarction

21. Acute chest pain with suspected MI and nondiagnostic ECG when a resting echocardiogram can be performed during pain
22. Evaluation of a patient without chest pain but with other features of an ischemic equivalent or laboratory markers indicative of ongoing MI
23. Suspected complication of myocardial ischemia/infarction, including but not limited to acute mitral regurgitation, ventricular septal defect, free-wall rupture/tamponade, shock, right ventricular involvement, HF, or thrombus

ACR/AHA/ASE/ACC/HRS/SCAI/SCCM/SCCT/SCMR 2011 Appropriateness Criteria for Echocardiography
Panels S. Douglas

Recommendations for Echocardiography in the Diagnosis of Acute Myocardial Ischemic Syndromes

Class I
1. Diagnosis of suspected acute ischemia or infarction not evident by standard means.
3. Evaluation of patients with inferior myocardial infarction and clinical evidence suggesting possible RV infarction.
4. Assessment of mechanical complications and mural thrombus.*

Class IIa
Identification of location/ severity of disease in patients with ongoing ischemia.

Class III
Diagnosis of acute myocardial infarction already evident by standard means.
Evaluation other causes of cardiac chest pain

- Aortic Dissection
- Valvular Heart Disease (Aortic Stenosis, Aortic Regurgitation)
- Pericarditis
- Myocarditis
- Pulmonary Embolism
Detecting complications

**Un-explained haemodynamic deterioration → immediately evaluated.**

- TTE and TOE are complementary
  - TTE (experienced echocardiographer) → immediate diagnosis
  - TOE → for critically ill patients (difficult image acquisition)

- Mechanical Complication :
  - Rupture ventricular septum,
  - Rupture free wall,
  - Apical aneurysm + thrombus
  - RV infarction
  - ruptured papillary muscle

Heart 2002;88:419–425

**Mechanical Complication of MI**
Echocardiography Improves Risk Stratification

Table 3: Accuracy of clinical, ECG and echocardiographic variables for the prediction of any cardiac event during follow-up.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Specificity (%)</th>
<th>Sensitivity (%)</th>
<th>Positive predictive value (%)</th>
<th>Negative predictive value (%)</th>
<th>Univariate ( \chi^2 )</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous MI</td>
<td>71</td>
<td>55</td>
<td>52</td>
<td>73</td>
<td>5.4</td>
<td>( p &lt; 0.05 )</td>
</tr>
<tr>
<td>Hypertension</td>
<td>59</td>
<td>41</td>
<td>36</td>
<td>64</td>
<td>0.0</td>
<td>( p &gt; 0.1 )</td>
</tr>
<tr>
<td>Smoker</td>
<td>44</td>
<td>55</td>
<td>52</td>
<td>63</td>
<td>0.1</td>
<td>( p &gt; 0.1 )</td>
</tr>
<tr>
<td>Diabetes</td>
<td>75</td>
<td>24</td>
<td>35</td>
<td>63</td>
<td>0.1</td>
<td>( p &gt; 0.1 )</td>
</tr>
<tr>
<td>Abnormal ECG</td>
<td>41</td>
<td>73</td>
<td>21</td>
<td>72</td>
<td>1.8</td>
<td>( p &gt; 0.1 )</td>
</tr>
<tr>
<td>ST-deviation</td>
<td>68</td>
<td>14</td>
<td>40</td>
<td>84</td>
<td>0.0</td>
<td>( p &gt; 0.1 )</td>
</tr>
<tr>
<td>T-wave inversion</td>
<td>59</td>
<td>38</td>
<td>64</td>
<td>63</td>
<td>0.1</td>
<td>( p &gt; 0.1 )</td>
</tr>
<tr>
<td>Abnormal FE</td>
<td>96</td>
<td>71</td>
<td>61</td>
<td>76</td>
<td>2.4</td>
<td>( p &lt; 0.05 )</td>
</tr>
</tbody>
</table>

Abnormal TTE: 55, 81, 53, 85, 10.0, 0.02

ECC, electrocardiogram; MI, myocardial infarction; FE, fundamental echocardiogram; TTE, tissue harmonic; echo-antigram.

Eur J Echocardiogr 2004; 5: 142-8

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The American Journal of Cardiology

(n= 470)

Echo score

In ACS, effective risk stratification can be achieved by simple echo and chest ultrasound. It is comparable with TIMI and GRACE score.

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Am J Cardiol 2010; 106: 1709-1716
Acute Coronary Syndromes
Role of Echocardiography in Suspected ACS

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Overview of noninvasive cardiac imaging for the assessment of acute chest pain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modality</strong></td>
<td><strong>Advantages</strong></td>
</tr>
</tbody>
</table>
| 2D-TTE | • Bedside  
• Widely available  
• Relatively low cost compared with other imaging modalities  
• RCT and observational data support the use of 2D-TTE  
• Standard reporting approach  
• Strain-related techniques might add to the diagnostic accuracy | • Poor endocardial definition that reduces the diagnostic yield  
• Quantification is not as reliable as for other techniques  
• Reliability is questionable when symptoms subside |
| Contrast Echo or MCE (Perfusion) | • Contrast Echo increases the diagnostic yield of 2D-TTE  
• RCT and observational data support use of contrast Echo and MCE  
• Incremental diagnostic and prognostic information over 2D-TTE | • Reporting approach for MCE is not standardized  
• MCE is mostly used in research centres |
| Stress Echo | • Stress Echo (exercise) is superior to EET (and similar to exercise MPS) in risk stratification  
• RCT and observational data support the use of stress Echo (mainly exercise with/without contrast)  
• Contrast is safe to use in stress Echo  
• Can be used even when symptoms have subsided  
• Provides incremental prognostic information | • Not available at all times  
• Available only in centres with local expertise in stress Echo |

Recommendations for Echocardiography in Risk Assessment, Prognosis, and Assessment of Therapy in Acute Myocardial Ischemic Syndromes

Class I
1. Assessment of infarct size and/or extent of jeopardized myocardium.
2. In-hospital assessment of ventricular function when the results are used to guide therapy.
3. In-hospital or early postdischarge assessment of the presence/extent of inducible ischemia whenever baseline abnormalities are expected to compromise electrocardiographic interpretation.※
4. Assessment of myocardial viability when required to define potential efficacy of revascularization.†

Class IIa
1. In-hospital or early postdischarge assessment of the presence/extent of inducible ischemia in the absence of baseline abnormalities expected to compromise ECG interpretation.※
2. Re-evaluation of ventricular function during recovery when results are used to guide therapy.
3. Assessment of ventricular function after revascularization.
Echocardiography in Stable ischemic heart disease

Stable Ischemic Heart Disease
Role of Echocardiography

Diagnosis >> Treatment >> Outcome
2013 ESC guidelines on the management of stable coronary artery disease

The Task Force on the management of stable coronary artery disease of the European Society of Cardiology

Task Force Members: Gilles Montalescot (Chairperson) (France), Udo Sechtem (Chairperson) (Germany), Stephan Achenbach (Germany), Felicia Andreotti (Italy), Chris Arden (UK), Andrzej Budaj (Poland), Raffaele Bugiardini (Italy), Filippo Crea (Italy), Thomas Cuisnet (France), Carlo Di Mario (UK), J. Rafael Ferreira (Portugal), Bernard J. Gersh (USA), Anselm K. Gitt (Germany), Jean-Sebastien Halot (France), Nikolaus Marx (Germany), Lionel H. Opie (South Africa), Matthias Pfisterer (Switzerland), Eva Prescott (Denmark), Frank Ruschitzka (Switzerland), Manel Sabaté (Spain), Roxy Senior (UK), David Paul Taggart (UK), Ernst E. van der Wall (Netherlands), Christiaan J.M. Vrints (Belgium).
Exercise Stress Echo
Additional Prognostic Value over ECG

Prospective, multicenter (2 US Centers), observational Study
5375 consecutive patients
Exercise ECG and Echocardiography

Figure 1. Survival of patients with normal results, ischemia, scar, and combined scar and ischemia.

Figure 4. Mortality of patients according to total extent of wall motion abnormalities (summed stress score) at peak stress.

Marwick TH et al. Circulation 2001
CFR by TTE Doppler

CFR = peak vel/rest vel, normal > 2

Dipyridamole Stress Echo
Abnormal CFR >> Additional Prognostic Value over WM

PROSPECTIVE, multicenter, observational study

4,313 patients
- known CAD (n = 1,547)
- suspected CAD (n = 2,766)

High-dose Dip Stress ECHO
CFR evaluation of LAD by Doppler

CFR on LAD is a strong and independent indicator of mortality, over wall motion analysis, in patients with known or suspected CAD. A negative result confers an annual risk of death <1% in both patient groups.

(J Am Coll Cardiol Img 2012;5:1079-85)
**Dipyridamole Stress Echo**
Abnormal CFR >> Additional Prognostic Value over WM

![Graph](image)

*Figure 2. Annual Mortality Rate*
Annual mortality in the group of patients with known coronary artery disease (CAD) and suspected CAD separated on the basis of presence (+) or absence (−) of ischemia at SE and CFR on left anterior descending artery >2 or ≥2. Abbreviations as in Figure 1.

Cortigiani L et al. J Am Coll Cardiol Img 2012;5:1079–85

**Pharmacological Stress Echo → Ischemia**
Additional Prognostic Value over Clinical and Functional Variables

**Stress Echo Results Predict Mortality:**
A Large-Scale Multicenter Prospective International Study

Rosa Sicari, MD, PhD, Emiliano Pasinini, MD, Lucio Venneri, MD, Patrizia Landi, BSc,
Lauro Cortigiani, MD, Eugenio Picano, MD, PhD, on behalf of the Echo Persantine International Cooperative (EPIC) and Echo Dobutamine International Cooperative (EDIC) Study Groups

Pisa, Italy

![Graph](image)

Sicari R et al. JACC 2003
Pharmacological Stress Echo → Viability
Additional Prognostic Value over Clinical and Functional Variables

Prognostic Value of Myocardial Viability Recognized by Low-Dose Dobutamine Echocardiography in Chronic Ischemic Left Ventricular Dysfunction
Rosa Sicari, re, no, Eugenio Picano, re, Lucio Conti, re, Adriano C. Borges, re, Albert Vargas, re, Caterina Polito, re, Ricardo Borgi, re, Roberto Rosano, re, and Enrico Pegoraro, re, on behalf of the VIDA Viability Identification with Dobutamine Administration Study Group

Sicari R et al. Am J Cardiol 2003

2013 ESC guidelines on the management of stable coronary artery disease

<table>
<thead>
<tr>
<th>Technique</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echocardiography</td>
<td>Wide access, Portability, No radiation, Low cost</td>
<td>Echo contract needed in patients with poor ultrasonographic windows, Dependent on operator skills</td>
</tr>
<tr>
<td>MPS-1</td>
<td>Wide scope, Economics data</td>
<td>Radiation</td>
</tr>
<tr>
<td>PET</td>
<td>Radioactive</td>
<td>Radiation, Limited access, High cost</td>
</tr>
<tr>
<td>CMR</td>
<td>High soft tissue contrast including precise imaging of myocardial scar, No radiation</td>
<td>Limited access to cardiology, Cost reductions, Functional analysis limited in arrhythmia, Limited 3D spatiotemporal of ischaemia, High cost</td>
</tr>
<tr>
<td>Coronary CTA</td>
<td>High NPV in persistent low PTP</td>
<td>Limited availability, Radiation, Assessment limited with extensive coronary calcification or previous stent implantation, Image quality limited with arrhythmia and high heart rates that cannot be lowered beyond 60-45 mm/s, Low NPV in patients with high PTP</td>
</tr>
</tbody>
</table>
Ischemic Cascade echocardiography

Taquet Y, R and Di Carli MF
Progress in CV Diseases, 2015

Performance of Diagnostic Tests in Trials
Retrospective or Prospective studies comparing 1 or 2 modalities
Patients with ~50% prevalence of disease (>50% stenosis at ICA)

Table 12 Characteristics of tests commonly used to diagnose the presence of coronary artery disease

<table>
<thead>
<tr>
<th>Test</th>
<th>Diagnosis of CAD</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise ECG [5,14,15]</td>
<td></td>
<td>45–50</td>
<td>85–90</td>
</tr>
<tr>
<td>Exercise stress SPECT [51]</td>
<td></td>
<td>73–92</td>
<td>63–87</td>
</tr>
<tr>
<td>Dobutamine stress MRI [52]</td>
<td></td>
<td>79–88</td>
<td>81–91</td>
</tr>
<tr>
<td>Vasodilator stress SPECT [53]</td>
<td></td>
<td>90–91</td>
<td>75–84</td>
</tr>
<tr>
<td>Vasodilator stress MRI [54]</td>
<td></td>
<td>67–94</td>
<td>61–85</td>
</tr>
<tr>
<td>Coronary CTA [55-57]</td>
<td></td>
<td>95–99</td>
<td>64–83</td>
</tr>
<tr>
<td>Vasodilator stress PET [58-60]</td>
<td></td>
<td>81–97</td>
<td>74–91</td>
</tr>
</tbody>
</table>
Take home messages

- Bedside echocardiography is the first-line imaging test in patients with acute chest pain to assist in the diagnosis and management of patients presenting with suspected ACS
- Echocardiography can be used to rapidly detect the presence of RWMA resulting from acute infarction / ischemia, stratify patients into high- or low-risk categories, diagnose important complications, and predicts the prognosis.

Take home messages

- Echocardiography for diagnosis of myocardial infarction is most helpful in patients with a high clinical suspicion but a normal or non-diagnostic ECG and cardiac biomarkers
- Stress echocardiography adds diagnostic and prognostic value in patients with suspected ACS
Thank You