Echocardiography in diagnosis and management of CAD

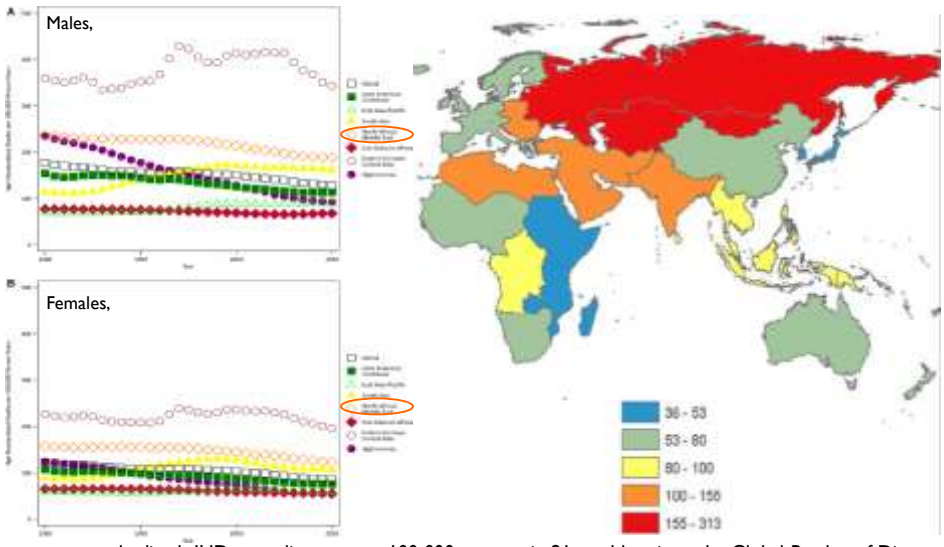
Azza El Eraky, MD

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

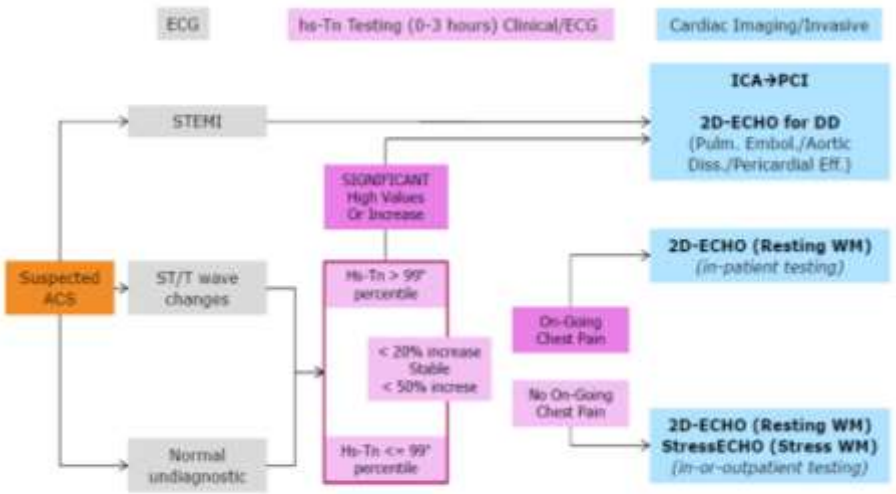
Echocardiography for Acute Coronary Syndrome

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 presents 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



Modified from Garg P et al. , Nature Reviews 2016

Acute Coronary Syndromes

Role of Echocardiography in Suspected ACS

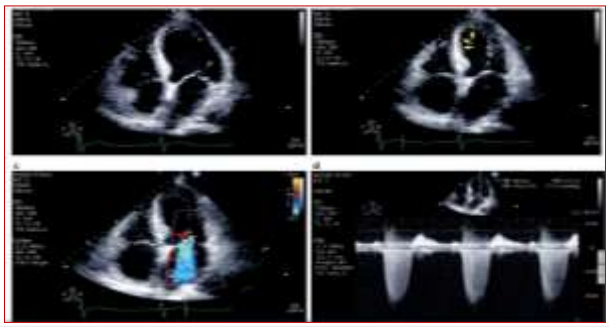
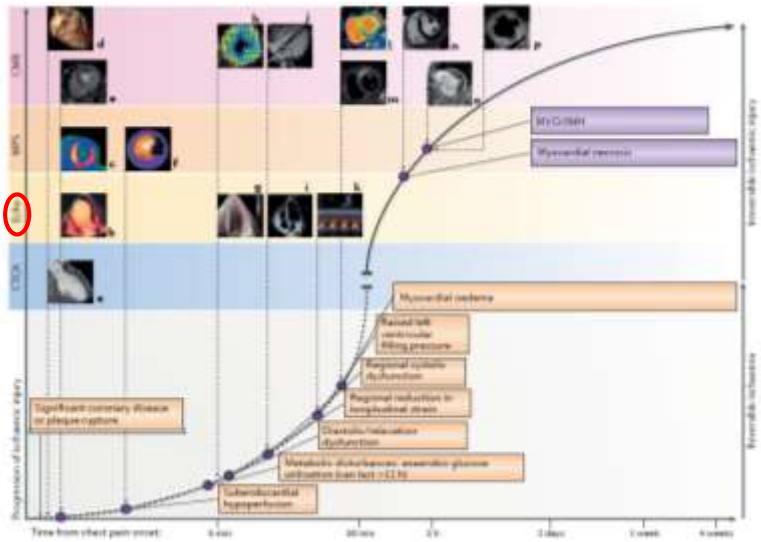


Table 2 | Guideline endorsement of advanced imaging when ACS is suspected but ECG and biomarkers are inconclusive

Modality	Guidelines	Endorsement
2D-TTE	• ESC guidelines for NSTE-ACS (2011)[17] • ACCF/ASE/AHA Appropriate Use Criteria for Echocardiography (2011)[18]	• Primary bedside modality • To assess resting RWMA
Stress Echo	• ESC guidelines for NSTE-ACS (2011)[17] • ACCF/ASE/AHA Appropriate Use Criteria for Echocardiography (2011)[18]	• In all suspected ACS to assess RWMA

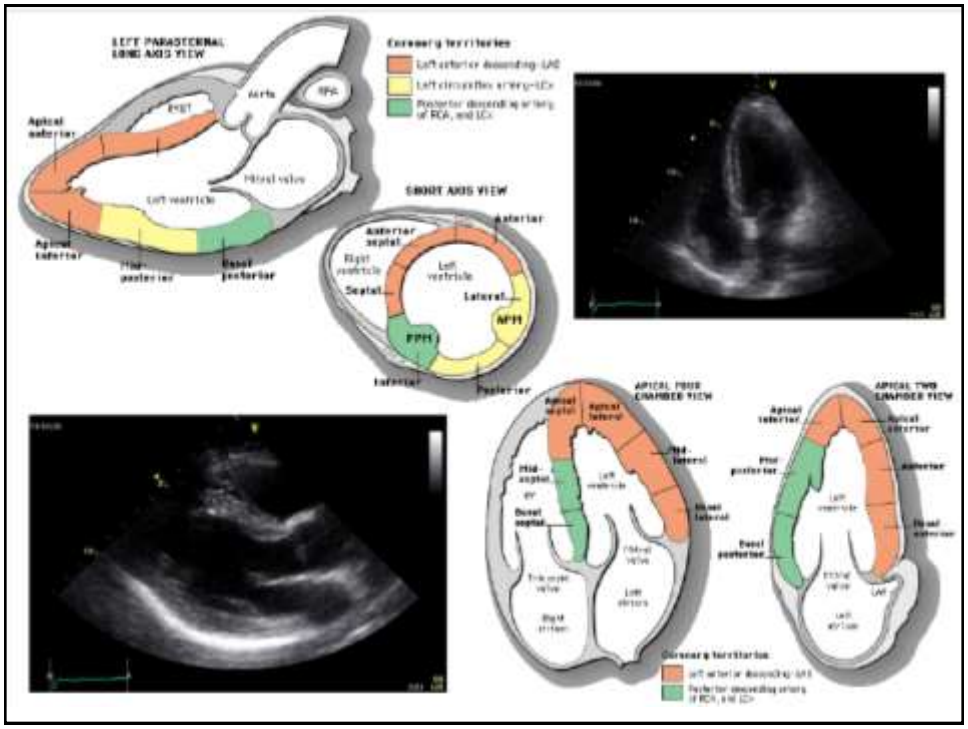
Acute Coronary Syndromes

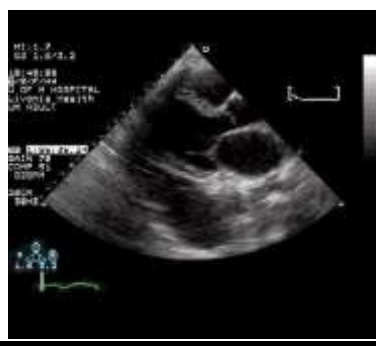
Role of Echocardiography in Suspected ACS

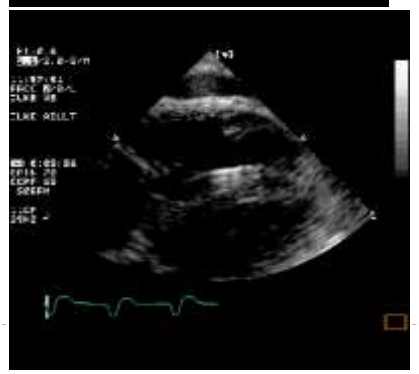


Regional Wall Motion Abnormality (RWMA)

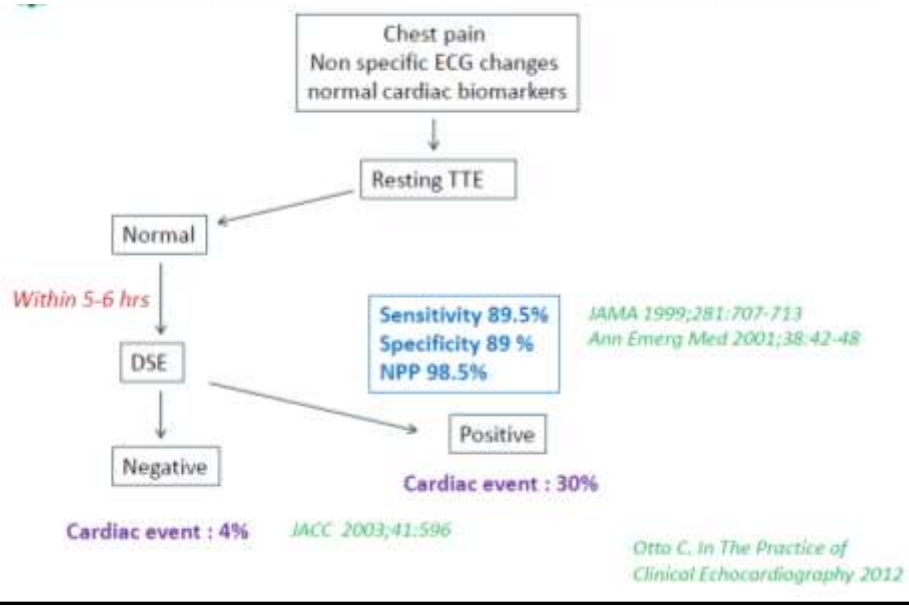
- Wall thickening , assessed in 16/17 segments → Wall Motion Index
- RWMA are characteristic of myocardial ischemia and infarction.
- Subjective, sometimes difficult to assess due to suboptimal echo window → tissue harmonic imaging, contrast echocardiography and myocardial contrast echo
- Their location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





Algorithm of Chest Pain Assessment in ER



ACC/AHA/ASE 2003 Guideline Update for the Clinical Application of Echocardiography

A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/ASE Committee to Update the 1997 Guidelines 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	A (9)
22.	• Evaluation of a patient without chest pain but with other features of an ischemic equivalent or laboratory markers indicative of ongoing MI	A (8)
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	A (9)

ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR 2011 Appropriate Use Criteria for Echocardiography
Pamela S. Douglas
J. Am. Coll. Cardiol. published online Nov 19, 2010;

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.**
2. **Measurement of baseline LV function.**
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

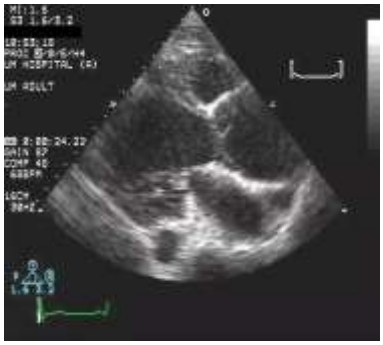
Diagnosis of acute myocardial infarction already evident by standard means.

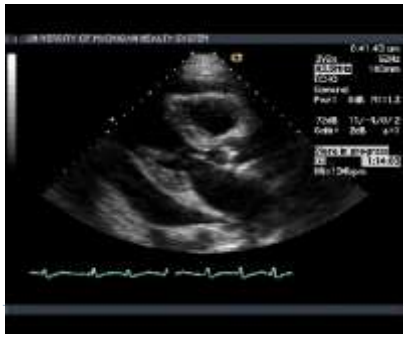
ACC/AHA/ASE 2003 Guideline Update for the Clinical Application of Echocardiography

A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/ASE Committee to Update the 1997 Guidelines for the Clinical Application of Echocardiography)

Evaluation other causes of cardiac chest pain

- Aortic Disection
- Valvular Heart Disease (Aortic Stenosis, Aortic Regurgitation)
- Pericarditis
- Myocarditis
- Pulmonary Embolism





Detecting complications

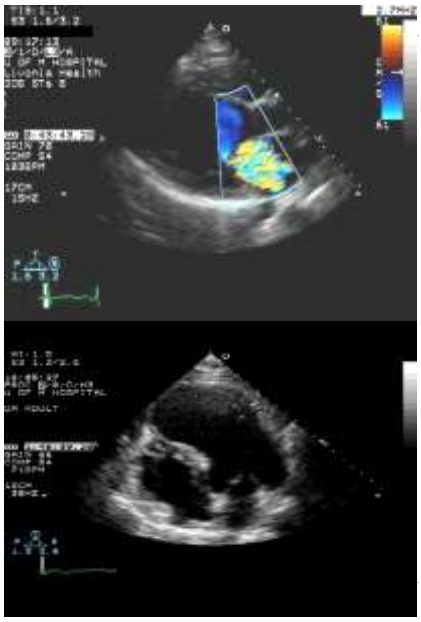
Un-explained haemodynamic deterioration → immediately evaluated.

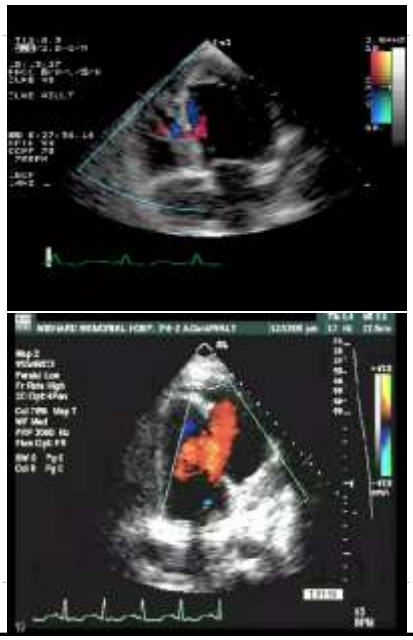
- TTE and TOE are complementary
  - –TTE (experienced echocardiographer) → immediate diagnosis
  - –TOE → for critically ill patients (difficult image acquisition)

- 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



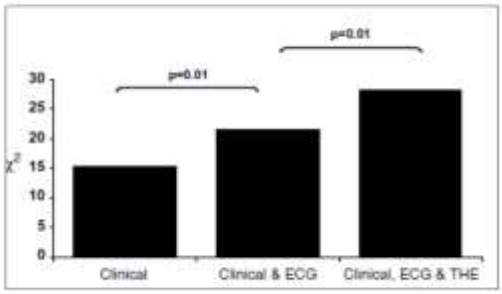


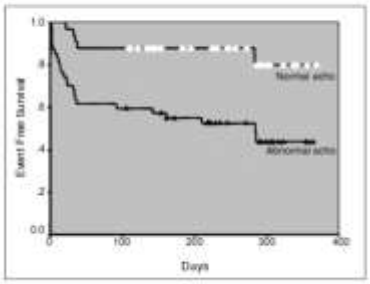
Echocardiography Improves Risk Stratification

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

	Specificity (%)	Sensitivity (%)	Positive predictive value (%)	Negative predictive value (%)	Univariate (χ^2)	Significance (p)
Previous MI	71	55	52	73	3.9	<0.05
Hypertension	59	41	36	64	0.0	>0.1
Smoker	44	55	36	63	0.0	>0.1
Diabetes	75	24	35	63	0.1	>0.1
Abnormal ECG	41	72	41	72	1.6	>0.1
ST-deviation	88	14	40	64	0.0	>0.1
T-wave inversion	59	38	64	63	0.1	>0.1
Abnormal FE	46	71	43	74	2.1	>0.1
Abnormal THE	55	83	51	85	10.0	0.002

ECG, electrocardiogram; MI, myocardial infarction; FE, fundamental echocardiogram; THE, tissue harmonic echocardiogram.



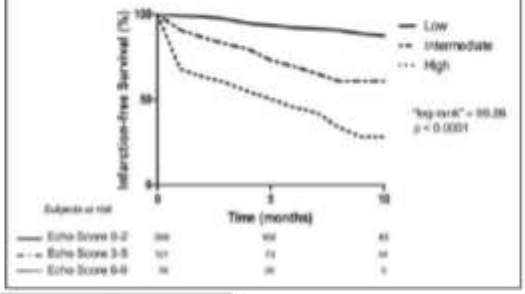


Eur J Echocardiogr 2004; 5: 142-8

American Journal of Cardiology

Echo score

(n= 470)



Echo score

Score	0	1	2	3
EF	≥50%	40-49%	30-39%	<30%
TAPSE	≥20 mm	15-19 mm	10-14 mm	<10 mm
ULCs	<5	5-15	16-30	>30

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

EF : Ejection Fraction
TAPSE : Tricuspid Annular Plane Systolic Excursion
ULCs : Ultrasound Lung Comets

Am J Cardiol 2010; 106 : 1709-1716

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.**

Acute Coronary Syndromes

Role of Echocardiography in Suspected ACS

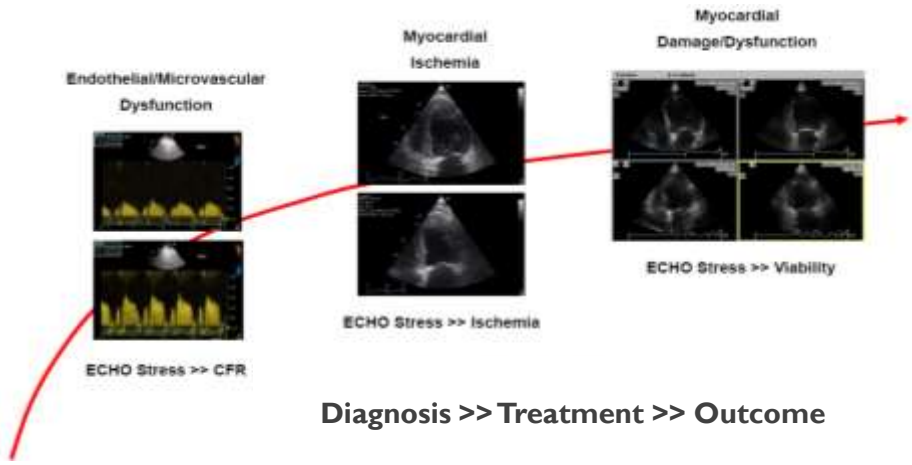
Table 1 | **Overview of noninvasive cardiac imaging for the assessment of acute chest pain**

Modality	Advantages	Disadvantages
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

Echocardiography in Stable ischemic heart disease

Stable Ischemic Heart Disease

Role of Echocardiography



Diagnosis >> Treatment >> Outcome

European Heart Journal (2013) 34, 2949–3003
doi:10.1093/eurheartj/eht296

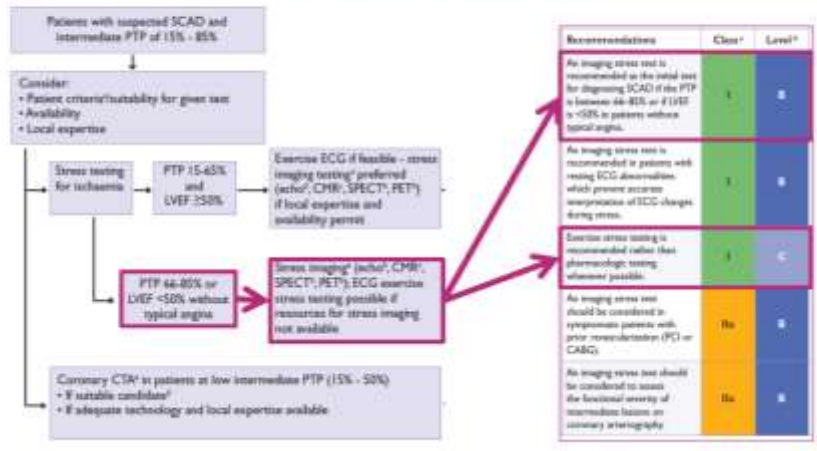
ESC GUIDELINES

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), Felicita Andreotti (Italy), Chris Arden (UK), Andrzej Budaj (Poland), Raffaele Bugiardini (Italy), Filippo Crea (Italy), Thomas Cuisset (France), Carlo Di Mario (UK), J. Rafael Ferreira (Portugal), Bernard J. Gersh (USA), Anselm K. Gitt (Germany), Jean-Sebastien Hulot (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).

2013 ESC guidelines on the management of stable coronary artery disease



2013 ESC guidelines on the management of stable coronary artery disease

Table 17 Definitions of risk for various test modalities[a]

Exercise stress ECG[b]	High risk	CV mortality >3%/year.
	Intermediate risk	CV mortality between 1 and 3%/year.
	Low risk	CV mortality <1%/year.
Ischaemia imaging	High risk	Area of ischaemia >10% (>10% for SPECT; limited quantitative data for CMR – probably ≥2/16 segments with new perfusion defects or ≥3 dobutamine-induced dysfunctional segments; ≥ 3 segments of LV by stress echo).
	Intermediate risk	Area of ischaemia between 1 to 10% or any ischaemia less than high risk by CMR or stress echo.
	Low risk	No ischaemia.
Coronary CTA[c]	High risk	Significant lesions of high risk category (three-vessel disease with proximal stenoses, LM, and proximal anterior descending CAD).
	Intermediate risk	Significant lesion(s) in large and proximal coronary artery(ies) but not high risk category.
	Low risk	Normal coronary artery or plaques only.

Exercise Stress Echo

Additional Prognostic Value over ECG

Prospective, multicenter (2 US Centers), observational Study
5375 consecutive patients

Exercise ECG and Echocardiography

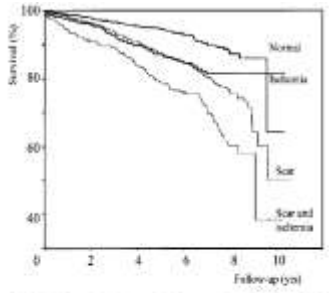


Figure 1. Survival of patients with normal results, ischemia, scar, and combined scar and ischemia.

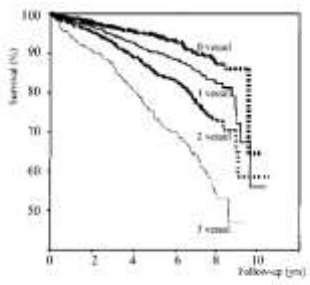
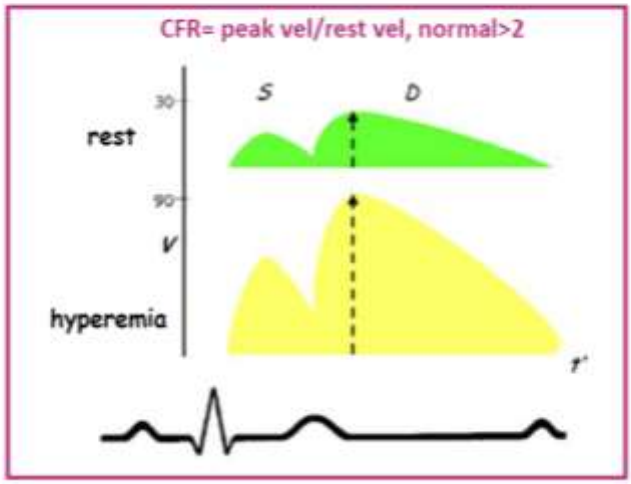


Figure 4. Mortality of patients according to total extent of wall motion abnormalities (summed stress score) at peak stress.

Marwick TH et al. Circulation 2001

CFR by TTE Doppler



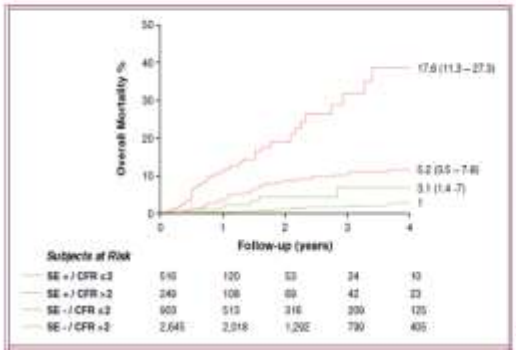
Dipyridamole Stress Echo

Abnormal CFR >> Additional Prognostic Value over WM

ORIGINAL RESEARCH

Coronary Flow Reserve During Dipyridamole Stress Echocardiography Predicts Mortality

Lucio Cortigiani, MD,* Fausto Rigo, MD,† Sonia Gherardi, MD,‡ Francesco Bovenzi, MD,* Silvana Molinaro, BSc,§ Eugenio Picano, MD, PhD,§ Rosa Sicari, MD, PhD§
Lucca, Monte Urano, and Pisa, Italy



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

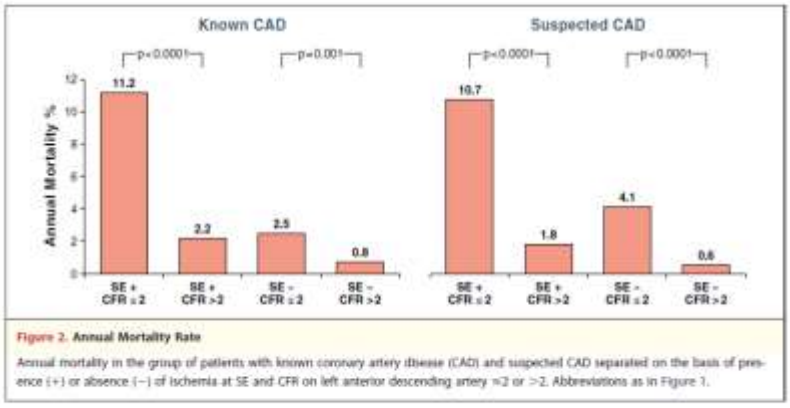


Figure 2. Annual Mortality Rate

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.

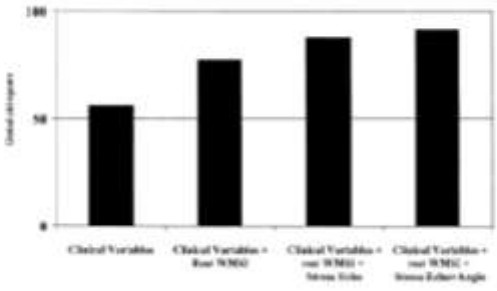
Cortigiani L et al. J Am Coll Cardiol Img 2012;5:1079–85

Pharmacological Stress Echo → Ischemia

Additional Prognostic Value over Clinical an Functional Variables

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

Rosa Sicari, MD, PhD, Emilio Pasanisi, MD, Lucia 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



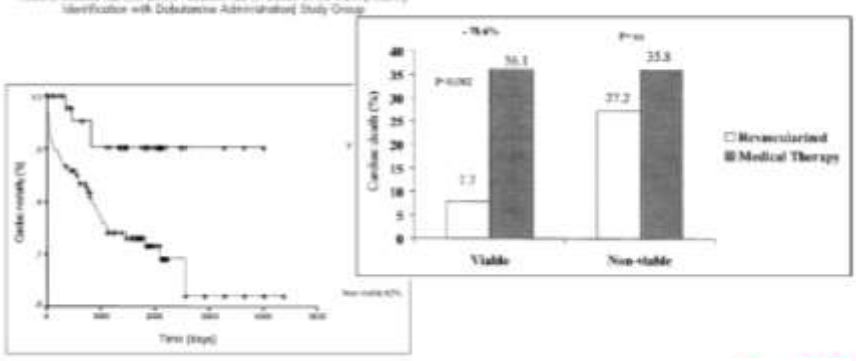
Sicari R et al. JACC 2003

Pharmacological Stress Echo → Viability

Additional Prognostic Value over Clinical an Functional Variables

Prognostic Value of *Myocardial* Viability Recognized by Low-Dose *Dobutamine* Echocardiography in Chronic Ischemic Left Ventricular Dysfunction

Rosa Sicari, MD, PhD; Eugenio Picano, MD; Laura Cortigiani, MD; Adrian C. Borges, MD; Albert Vargo, MD; Caterina Palagi, MD; Riccardo Bigi, MD; Roberta Brunini, MD; and Emilio Pasanisi, MD; on behalf of the VIDA (Viability Identification with Dobutamine Administration) Study Group

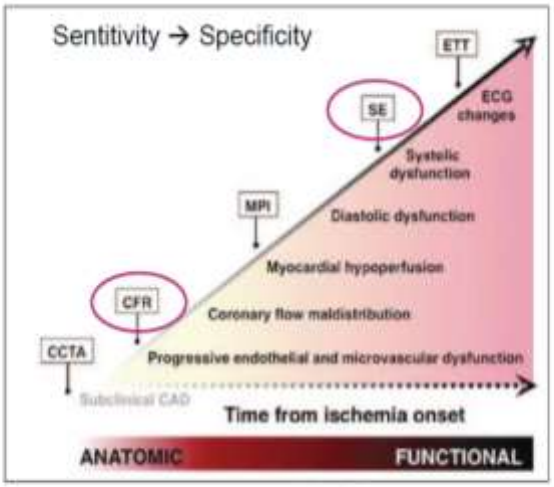


Sicari R et al. Am J Cardiol 2003

2013 ESC guidelines on the management of stable coronary artery disease

Technique	Advantages	Disadvantages
Echocardiography	Wide access Portability No radiation Low cost	Echo contrast needed in patients with poor ultrasound windows Dependent on operator skills
SPECT	Wide access Extensive data	Radiation
PET	Flow quantitation	Radiation Limited access High cost
CMR	High soft tissue contrast including precise imaging of myocardial scar No radiation	Limited access in cardiology Contra-indications Functional analysis limited in arrhythmias Limited 3D quantification of echocardiography High cost
Coronary CTA	High NPV in pts with low PTP	Limited availability Radiation Assessment limited with extensive coronary calcification or previous stent implantation Image quality limited with arrhythmias and high heart rates that cannot be lowered beyond 60-65/min Low NPV in patients with high PTP

Ischemic Cascade echocardiography



Taquety VR 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

	Diagnosis of CAD	
	Sensitivity (%)	Specificity (%)
Exercise ECG	45–50	85–90
Exercise stress echocardiography	80–85	80–88
Exercise stress SPECT	73–92	63–87
Dobutamine stress echocardiography	79–83	82–86
Dobutamine stress MRI	79–88	81–91
Vasodilator stress echocardiography	72–79	92–95
Vasodilator stress SPECT	90–91	75–84
Vasodilator stress MRI	67–94	61–85
Coronary CTA	95–99	64–83
Vasodilator stress PET	81–97	74–91

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