Cracking the HF Code: Your Basic Echo Guide to EF-Based Classification

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Disclosure

- Nothing to disclose

Introduction:
EF in Heart Failure

Measurement of LV Systolic Function

- Measures of LV systolic function:
  - Fractional shortening (FS)
  - Ejection fraction (LV EF)
  - Stroke volume (SV)
  - dP/dT
  - LV-GLS
  - LV Myocardial Work

- Role of LV EF
  - Diagnosis
  - Treatment decision
  - Device therapy
  - Prognosis

Ejection Fraction is the mostly used

Accurate EF measurement is very important

Critical Role of LV EF - Diagnosis

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).

ESC Guidelines Heart Failure 2016

Peripartum Cardiomyopathy (PPCM)

Definition:

- Non-ischemic cardiomyopathy with reduced LVEF (<45%)
- Commonly presents in the first months postpartum or towards the end of pregnancy

Risk Factors:

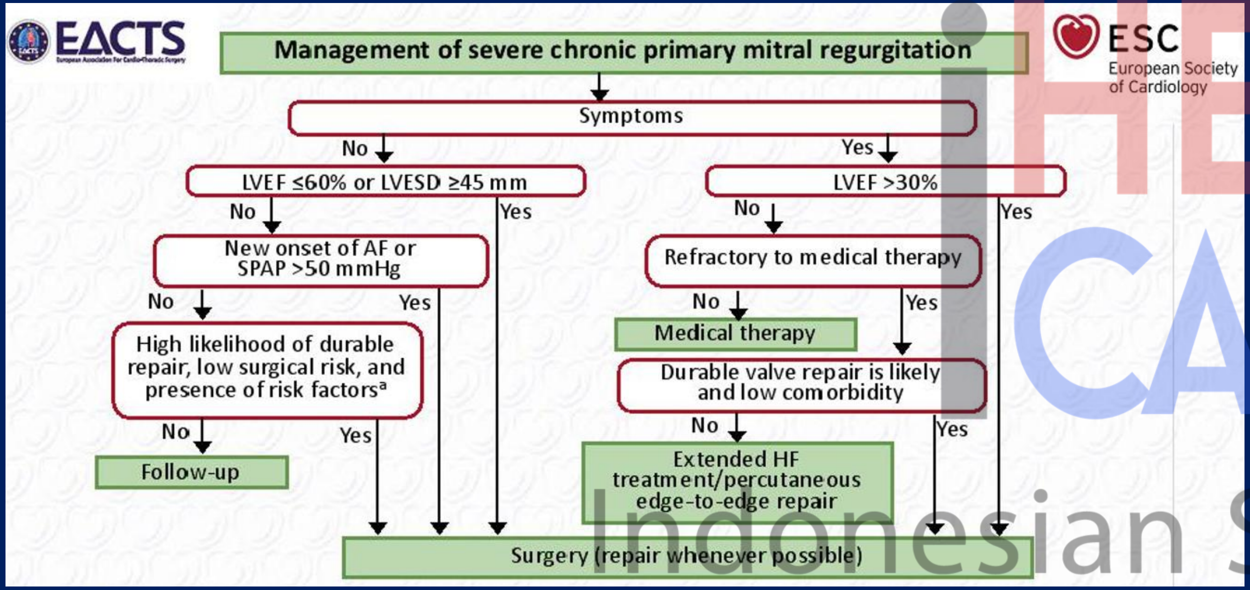
- African-American race, preeclampsia, hypertension, multigestational pregnancies, age >30 years

Symptoms:

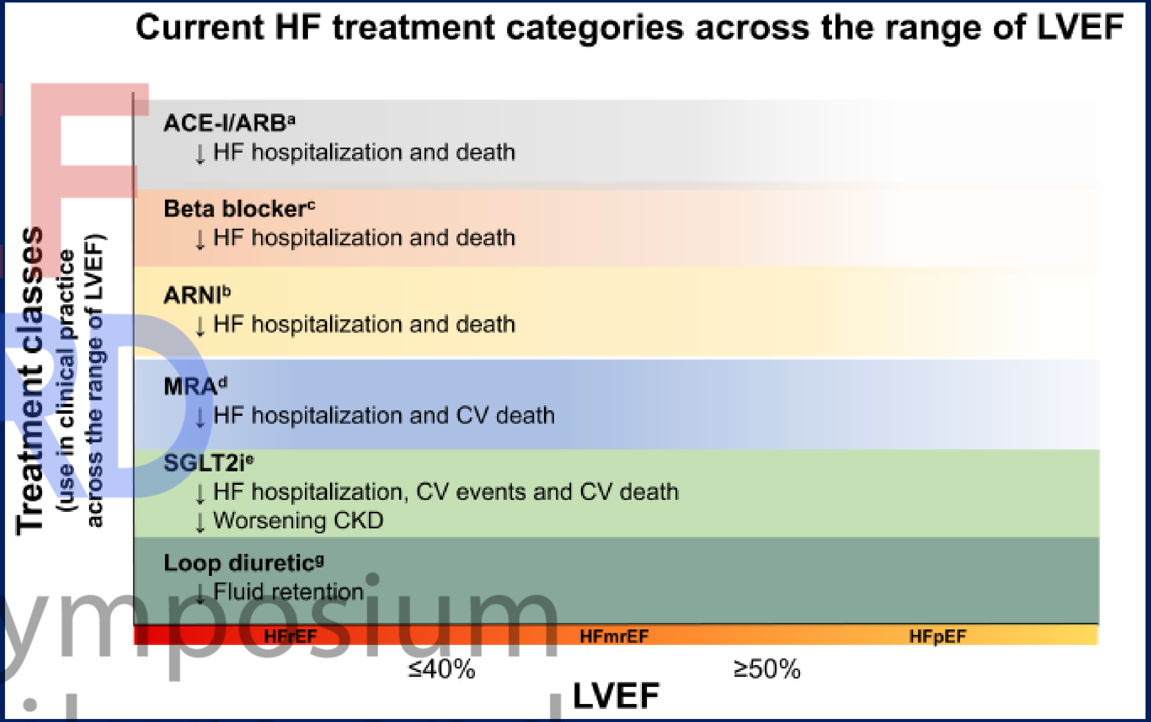
- Heart failure symptoms can be confused with common symptoms of normal pregnancy

PPCM. JACC State-of-the-Art Review 2020

Critical Role of LV EF - Treatment



ESC Guidelines Valvular Heart Disease 2017



European Journal of Heart Failure (2025) **27**, 1174–1187
doi:10.1002/ejhf.3646

The 6th Indonesian Symposium on Heart Failure and Cardiometabolic Disease

Critical Role of LV EF – Device Therapy

Indications for CRT in patients in sinus rhythm

Recommendations	Class	Level
1) LBBB with QRS duration >150 ms is recommended in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, and ambulatory IV despite adequate medical treatment. (*)	I	A
2) LBBB with QRS duration 120-150 ms should be considered in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, and ambulatory IV despite adequate medical treatment. (*)	I	B
3) Non-LBBB with QRS duration >150 ms should be considered in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, and ambulatory IV despite adequate medical treatment. (*)	IIa	B
4) Non-LBBB with QRS duration 120-150 ms may be considered in chronic HF patients and LVEF ≤35% who remain in NYHA functional class II, and ambulatory IV despite adequate medical treatment. (*)	IIb	B
5) QRS duration <120 ms CRT in patients with chronic HF with QRS duration <120 ms is not recommended.	III	B

www.escardio.org/guidelines

European Heart Journal 2013; 34: 2281–2329

Europace 2013; 15: 1070-1118

EUROPEAN SOCIETY OF CARDIOLOGY

Device Therapy for Stage C HF*r*EF

I IIa IIb III

A

ICD therapy is recommended for primary prevention of SCD to reduce total mortality in selected patients with nonischemic DCM or ischemic heart disease at least 40 days post-MI with LVEF of 35% or less, and NYHA class II or III symptoms on chronic GDMT, who have reasonable expectation of meaningful survival for more than 1 year.

I IIa IIb III

A

NYHA Class III/IV

I IIa IIb III

B

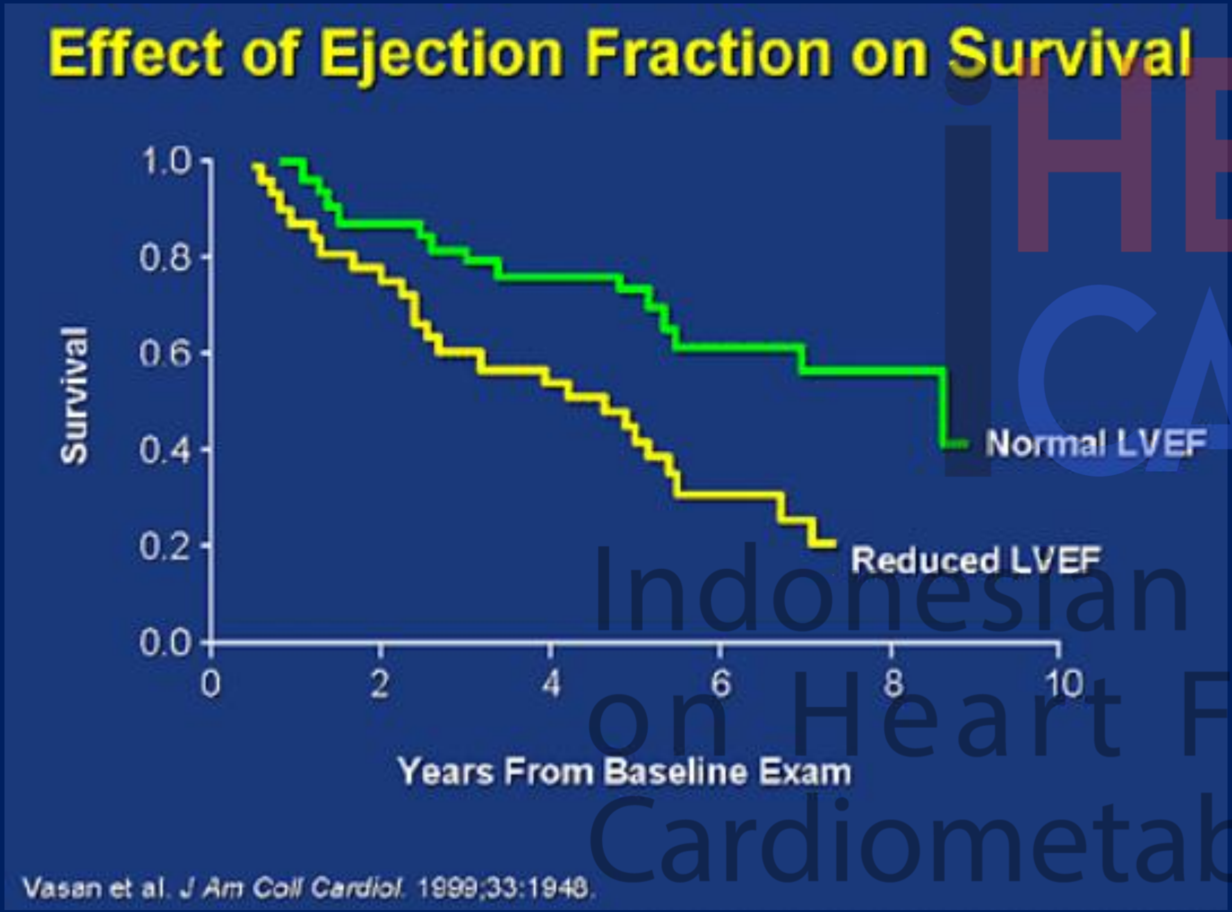
NYHA Class II

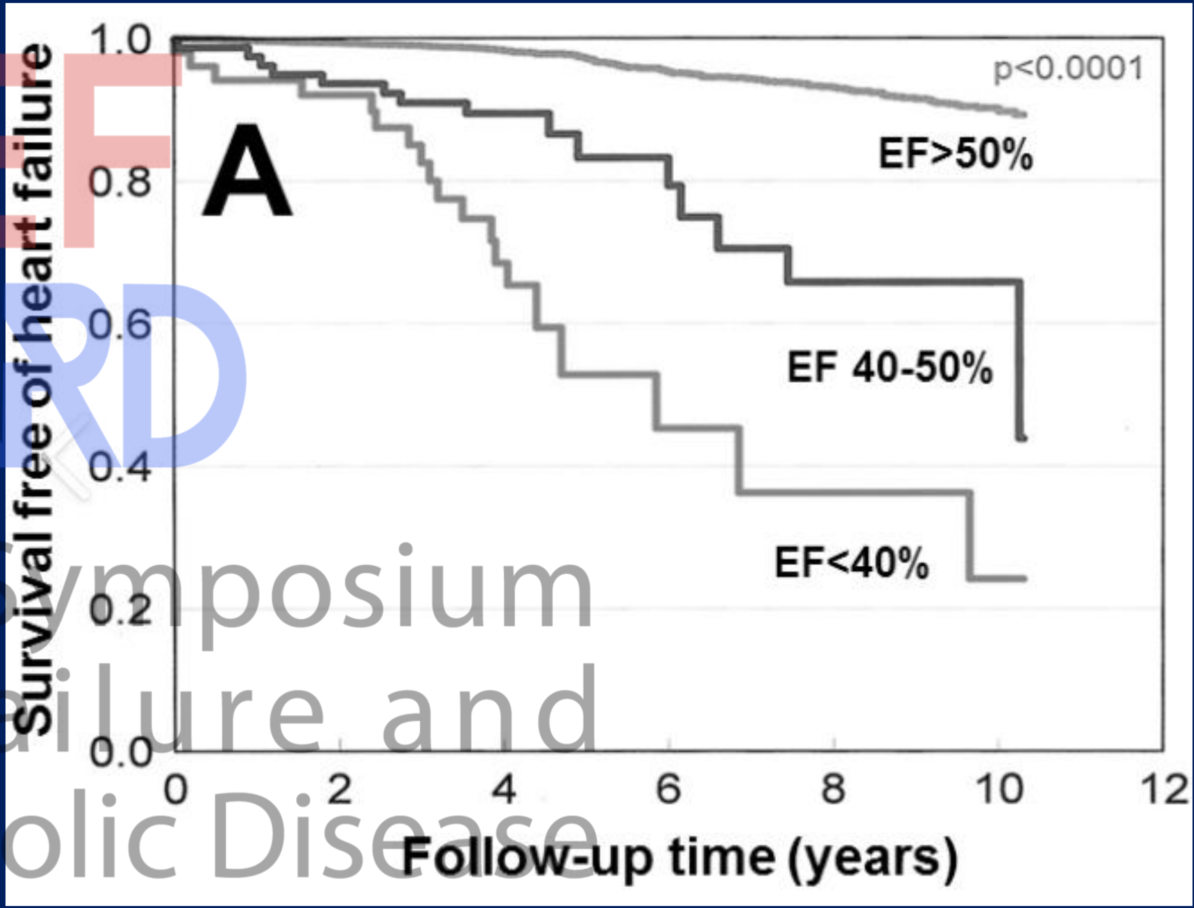
CRT is indicated for patients who have LVEF of 35% or less, sinus rhythm, left bundle-branch block (LBBB) with a QRS duration of 150 ms or greater, and NYHA class II, III, or ambulatory IV symptoms on GDMT.

Helping Cardiovascular Professionals Learn. Advance. Heal.

American Heart Association.

Critical Role of LV EF – Prognosis



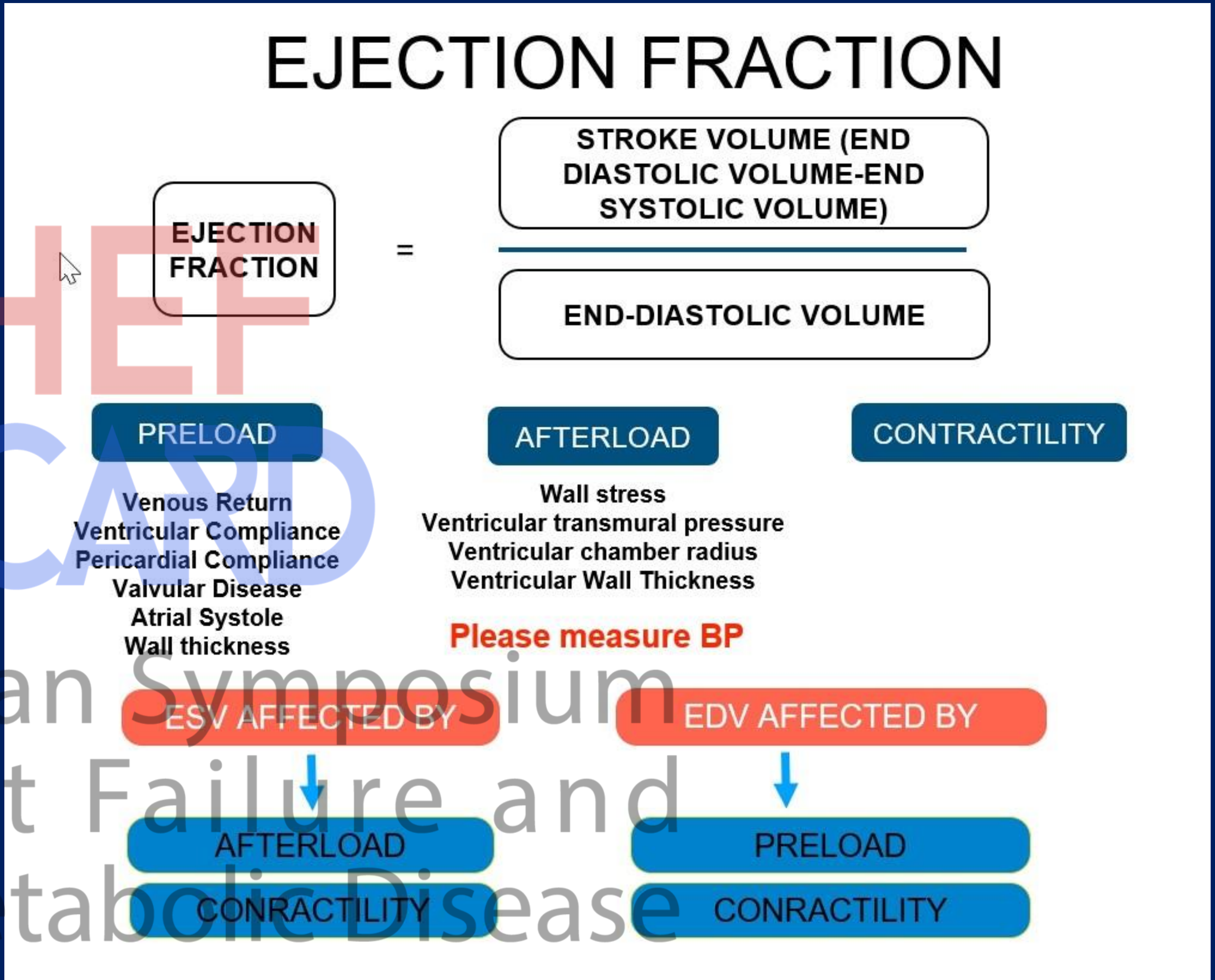


Framingham Heart Study

EF - Limitations

2D EJECTION FRACTION LIMITATIONS

PHYSIOLOGICAL	LOAD DEPENDENCY AFFECTED BY VERY HIGH OR LOW HEART RATE VALVULAR HEART DISEASE (MR, AS) SMALL LV INCREASE IN WALL THICKNESS (LVH)
TECHNICAL	IMAGE QUALITY AFFECTED BY LV GEOMETRY LBBB IRREGULAR RR(AF)



Oben Baysan, İlke Zehra Akyıldız. HVT Journal. 2019

Despite its limi
EF is still the Ki

The use of left ventricular eje
the diagnosis and managemen
A clinical consensus statemen
Failure Association (HFA) of t
Heart Failure Society of Ame
the Japanese Heart Failure So

European Journal of Heart Failure (20
doi:10.1002/ejhf.3646

The current classification of HF phenotypes based on LVEF ranges does not fully capture the disease complexity (role of comorbidities) and aetiology (e.g. ischaemic, genetic) and does not reflect the importance of LVEF trajectories.

The sub-classification of HF should be based on trajectories of LVEF over time, rather than discrete categories based on single measurements which are inherently limited by measurement imprecision.

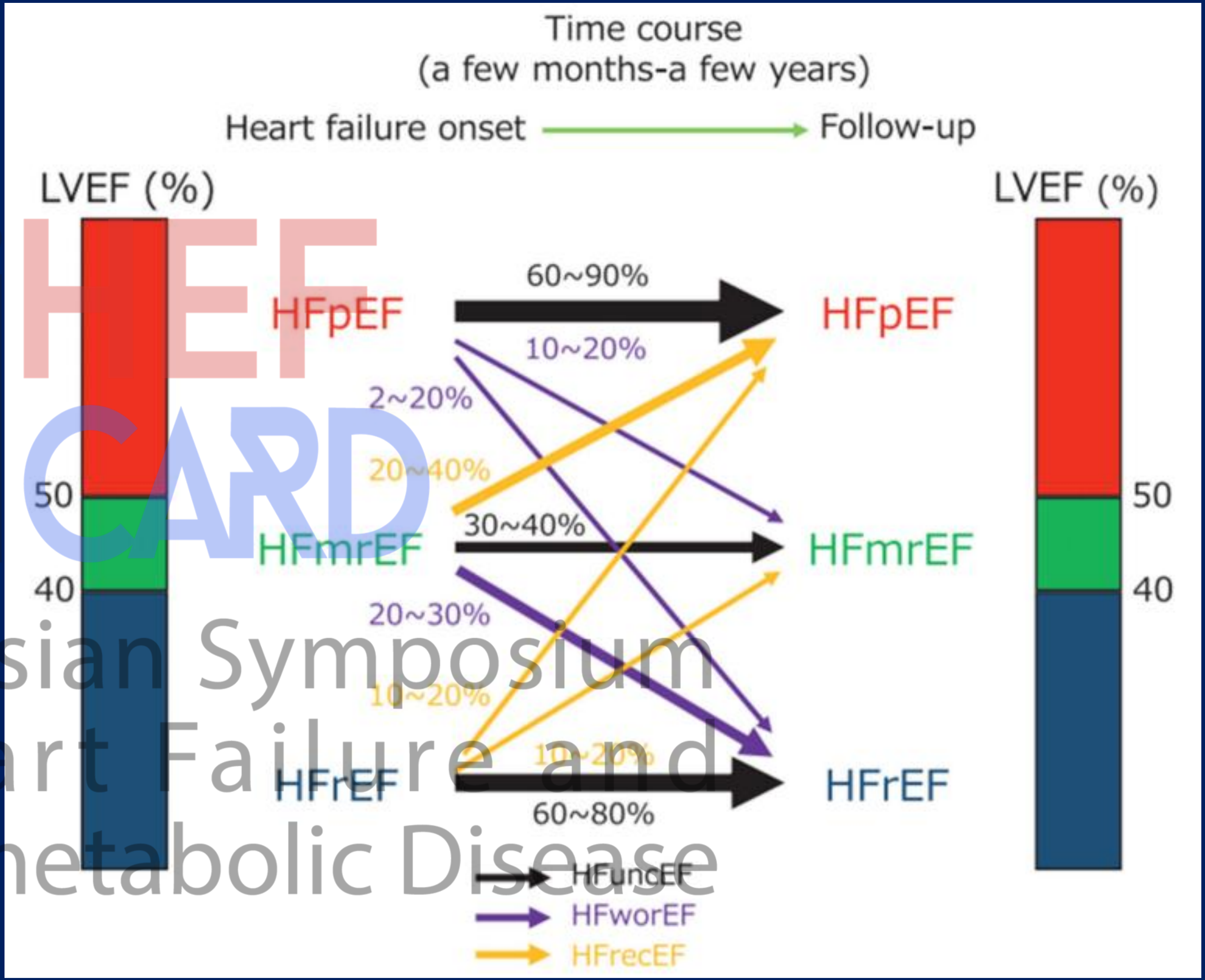
The diagnosis of HF is made by history, physical exam and markers of congestion (e.g. natriuretic peptides, chest X-ray). It is advised that, once the diagnosis is established, treatment initiation need not to wait for measurement of LVEF for agents such as loop diuretics, SGLT2is and MRAs or for the treatment of hypertension and other comorbidities.

The impact on LVEF and clinical outcomes of guideline-directed HF therapy varies across the range of LVEF. There are greater increases in LVEF and more pronounced clinical benefits of neurohormonal modulators the lower the LVEF, while SGLT2is and MRAs demonstrate efficacy across the whole spectrum of LVEF.

Future research should focus on characterizing myocardial tissue status, rather than refining LVEF categories, using novel imaging techniques and biomarkers, which can facilitate the identification of alternative therapeutic targets for HF patients across the spectrum of LVEF.

Clinical advice, based on robust published evidence

Assessment of EF Trajectory is very important



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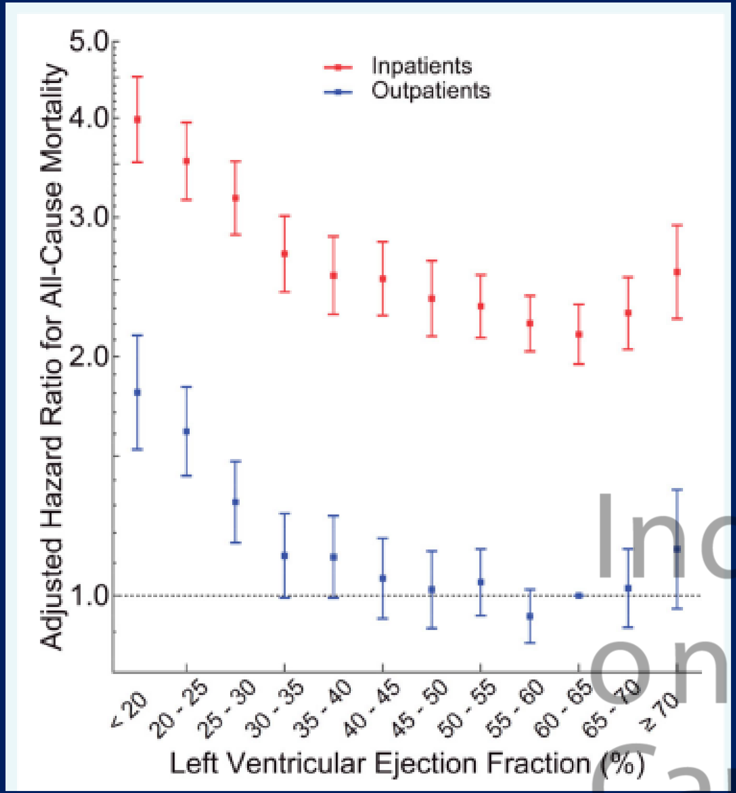
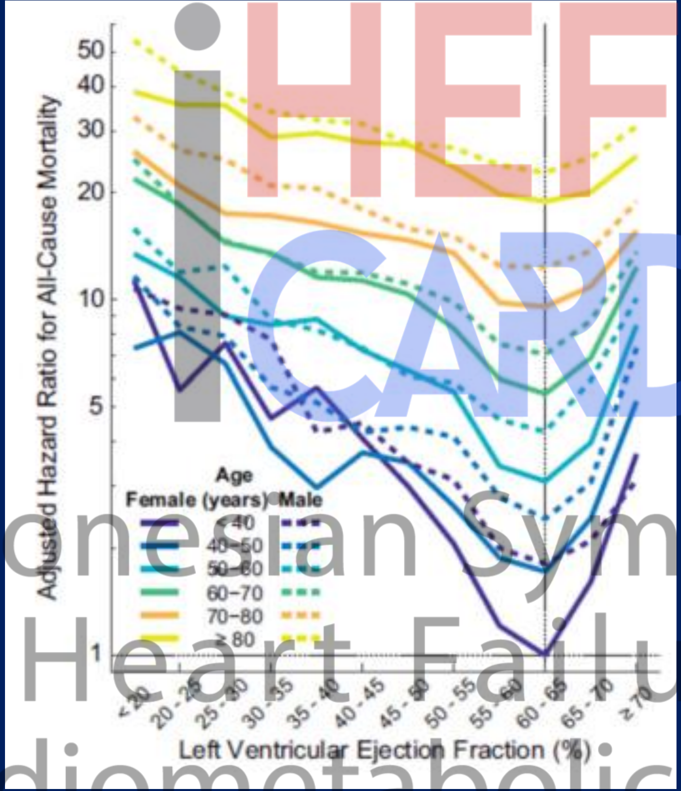
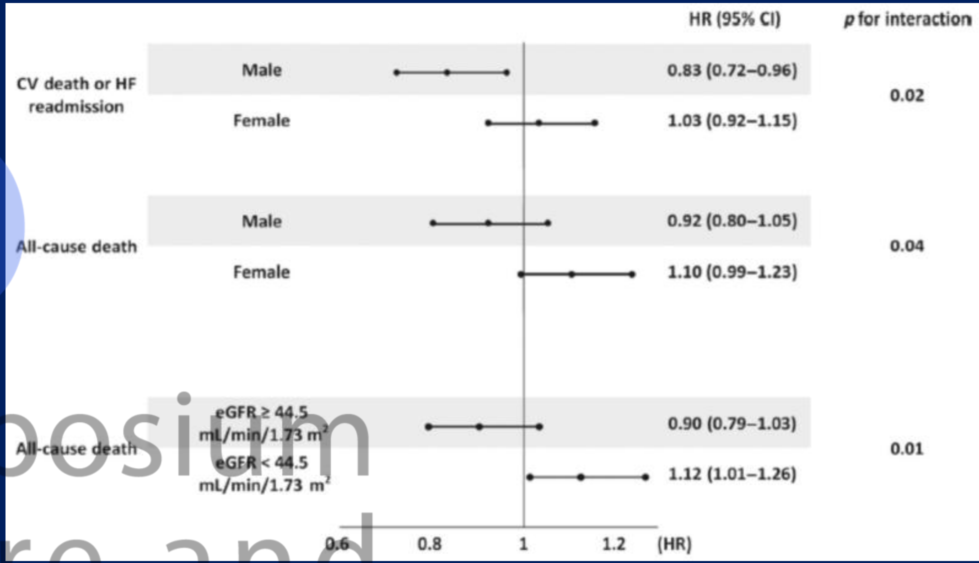
HF with Supranormal (sn) EF







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doi:10.1002/ejhf.3646

Supranormal EF is not benign condition!

Best Practice of Serial EF Measurement

- Strict consistency in:
  - Imaging modality
  - Vendor
  - Technique
  - Patient hemodynamics
- To ensure accurate detection of true clinical changes versus measurement variability

Modality: Echo → Echo

Technique:
Biplane → Biplane
3D → 3D

Same vendor and machine type?

Ensure similar hemodynamics conditions (attention to loading condition, use of inotropics, IABP etc.)

Measurement of EF

Measurement of EF

Table 1 Comparison of advantages and disadvantages between different techniques for measurement of ejection fraction

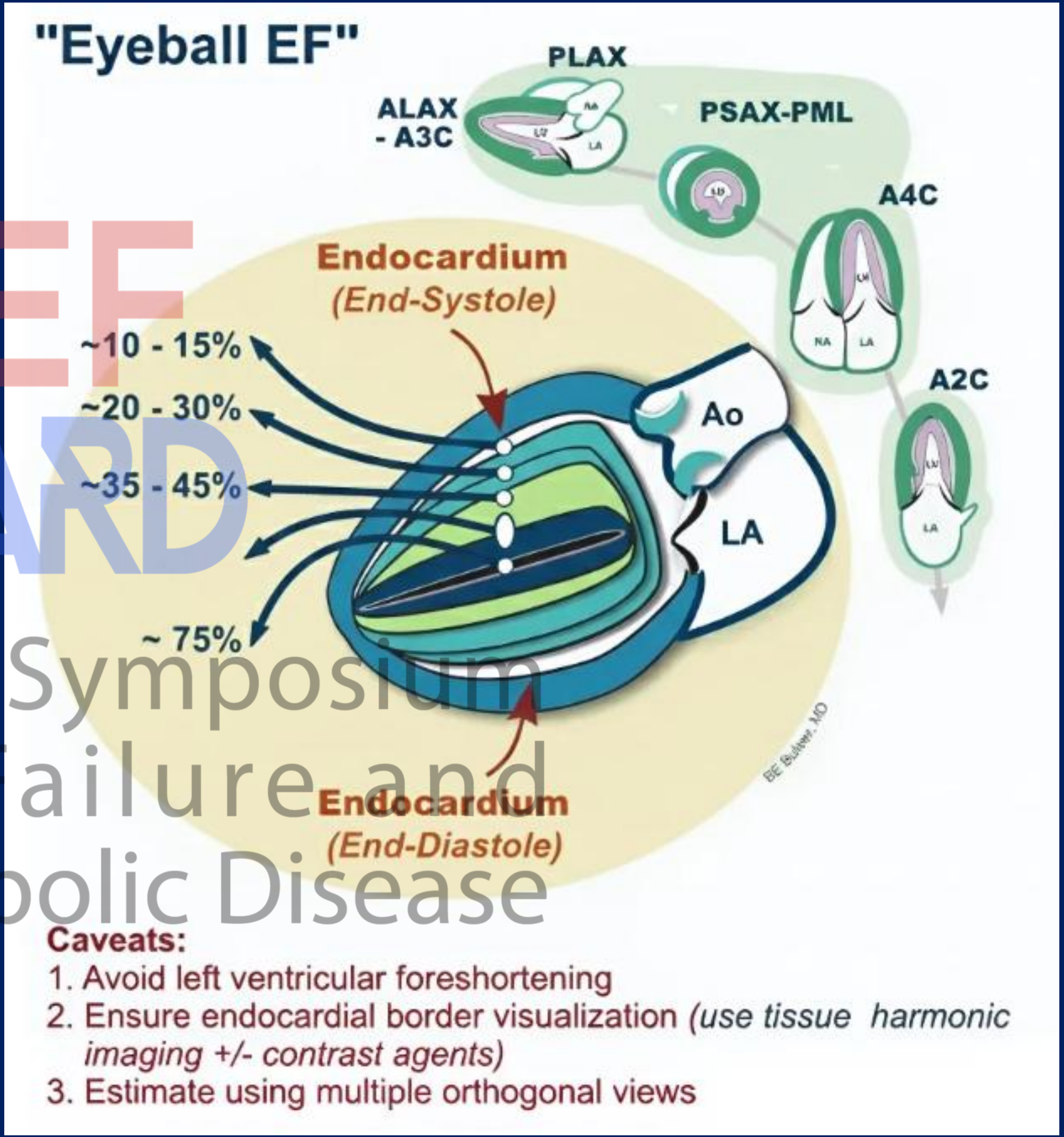
Methods	Availability	Assumptions	Reproducibility	Speed
Eyeball	Always	Dependent on observer skill	Low	Instant
M-mode	Widely used	Dependent on geometric assumptions	Low/modest	Quick
B-mode	Generally used	Minimizes mathematic assumptions	Low/modest	Needs tracing
3D	Readily available	Independent of geometric assumptions	High	Dependent on machine
AI	Not yet	Black box	High	Dependent on machine

3D 3-dimensional, *AI* artificial intelligence

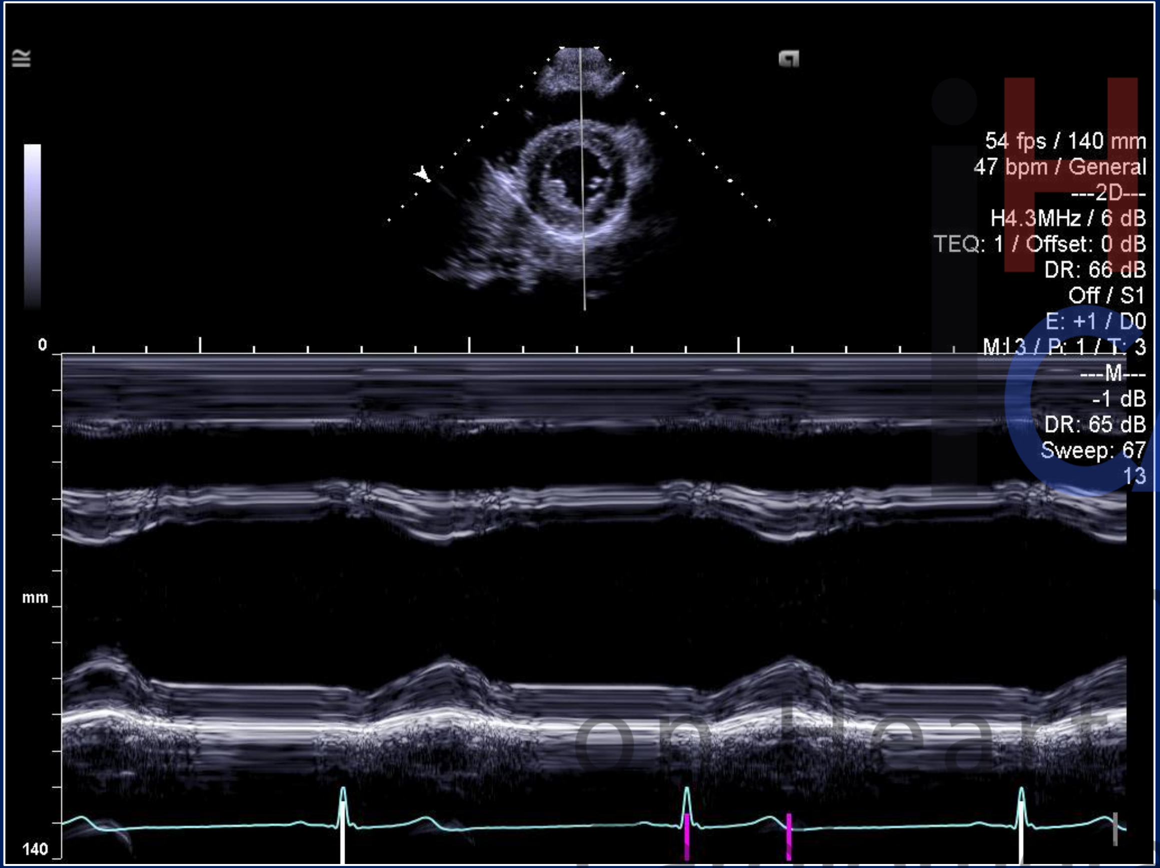
Journal of Medical Ultrasonics (2022) 49:35–43
https://doi.org/10.1007/s10396-021-01116-z

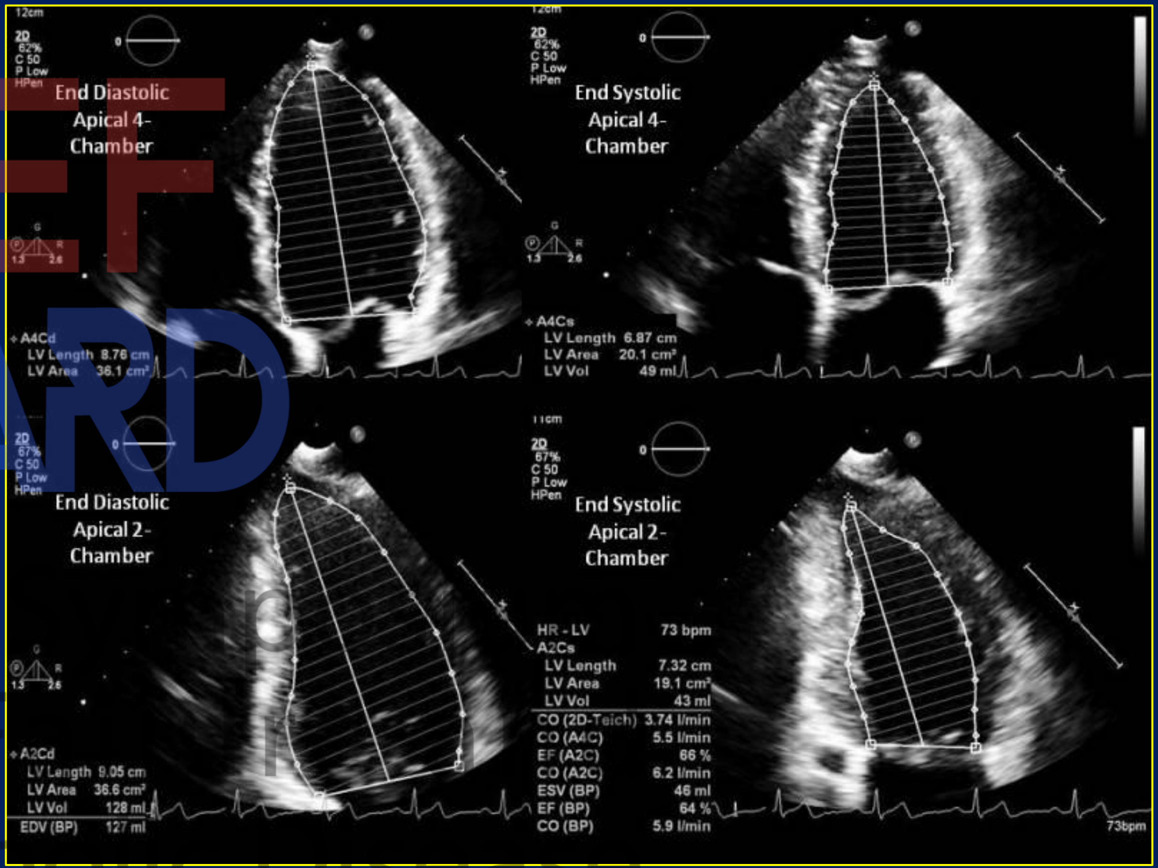
Eyeball EF

- Not pure approximate based on previous experience
- There is also “rules” that should be met



Methods for EF Measurements – M-mode & Biplane





M-mode EF: Quantitative, fast,
Cons: geometrical assumptions, not reliable, not recommended by current guidelines

Biplane EF: recommended and most feasible
Cons: Apex frequently foreshortened, Endocardial dropout, Blind to shape distortions not visualized in the apical two- and four-chamber planes

Biplane EF: Step-by-Step

Step 1: Optimize Your Images

- Ensure no foreshortening: Make sure the left ventricular (LV) apex is perfectly centered at the top of the sector and the image reveals the true, longest dimension of the ventricle.
- Focus the field: Narrow the sector width to display only the LV, the mitral valve, and roughly a third of the left atrium. This will improve frame rate and spatial resolution

Biplane EF: Step-by-Step

Step 2: Measure the Apical 4-Chamber (AP4) View

- End-Diastole (Max Volume): Freeze the clip at the frame where the LV cavity is at its largest (usually right after the QRS complex, just before the mitral valve opens).
- Trace the Endocardium: Trace the inner border of the myocardium. Exclude papillary muscles and trabeculations, as they are part of the cavity itself, not the wall.
- End-Systole (Min Volume): Scroll to the frame where the LV cavity is at its smallest (when the ventricle is fully contracted). Repeat the exact same endocardial trace

Biplane EF: Step-by-Step

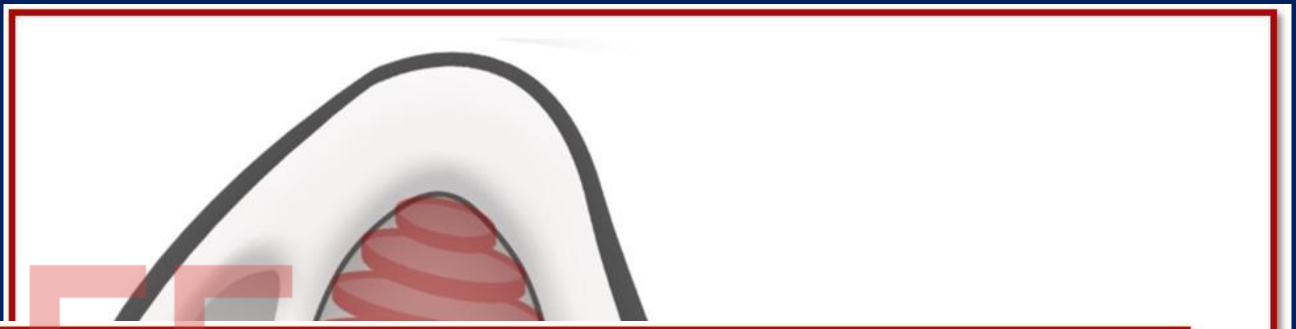
Step 3: Measure the Apical 2-Chamber (AP2) View

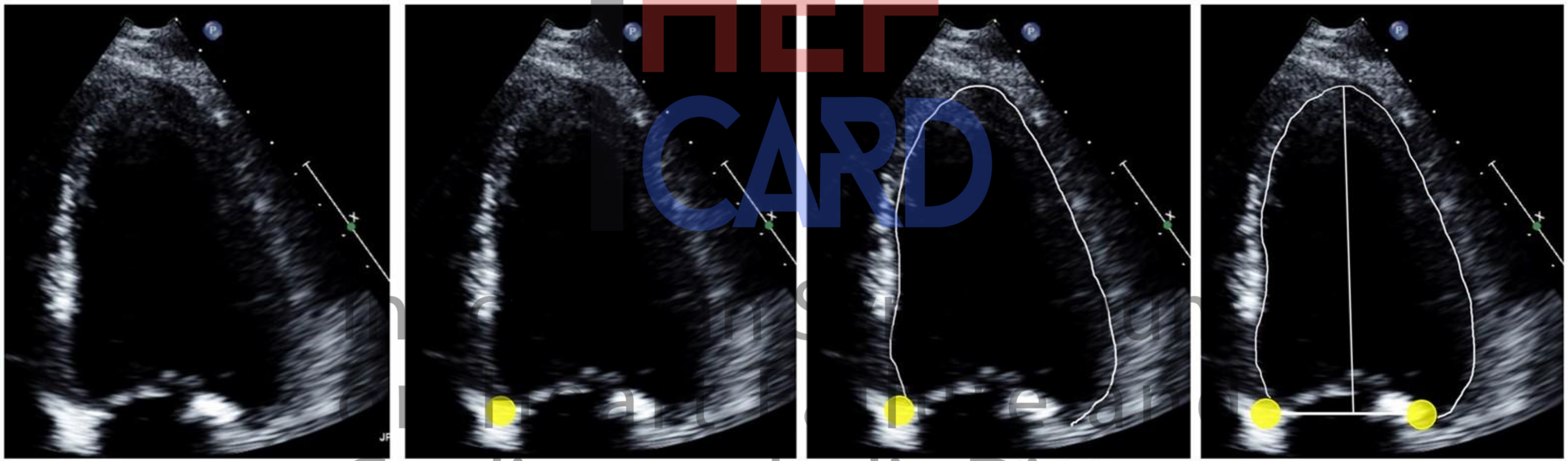
- Rotate the ultrasound probe 90 degrees to obtain the AP2 view.
- Repeat the process from Step 2, taking an endocardial trace at both end-diastole and end-systole.
- Again, trace from one side of the mitral annulus to the other, making a straight line at the mitral plane.

Step 4: Calculate the Ejection Fraction

- The ultrasound system's software will use the summation of disks algorithm to estimate the End-Diastolic Volume (EDV) and End-Systolic Volume (ESV) from the AP4 and AP2 planes

Biplane EF: Step-by-Step



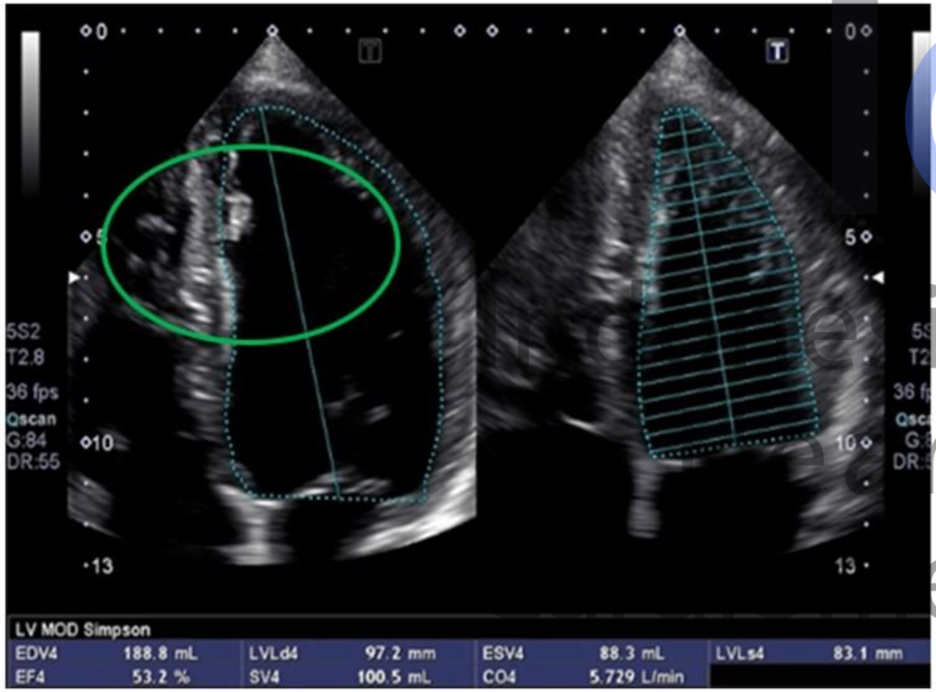


Step 1: Zoom & Focus Image on LV Cavity	Step 2: Place & set cursor on MV annulus	Step 3: Trace blood-tissue interface along endocardial border	Step 4: Set cursor to complete tracing; machine will create straight line to connect original cursor

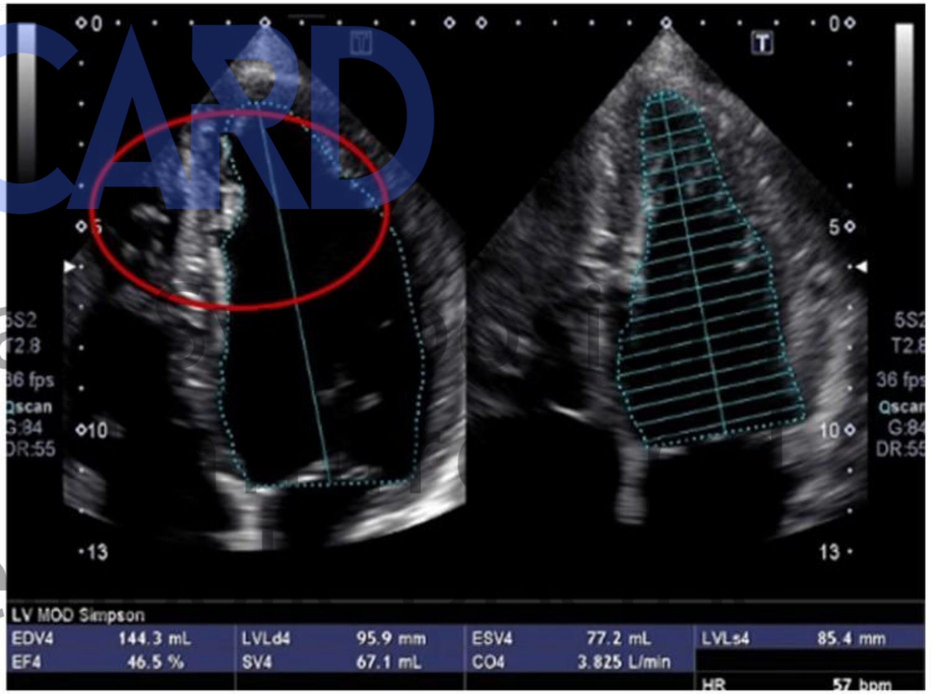
CARDIOSERV
INSPIRING EXCELLENCE IN IMAGING

Common Pitfalls

Do not include trabeculations and papillary muscle in endocardial tracing



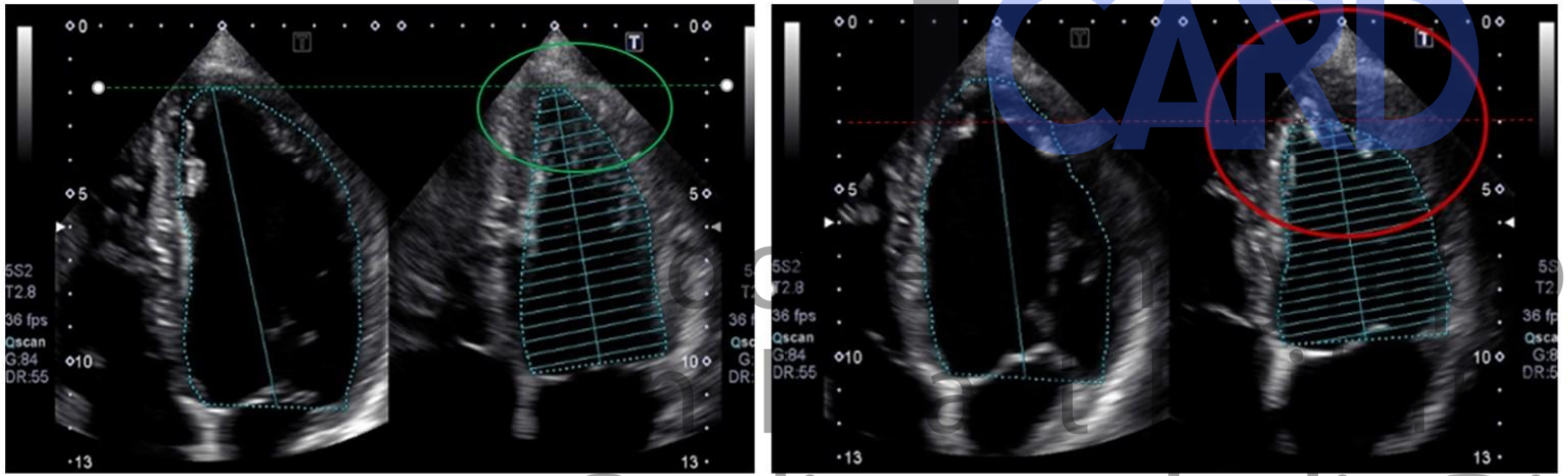
Correct



Incorrect

Common Pitfalls

Avoid foreshortening LV apex

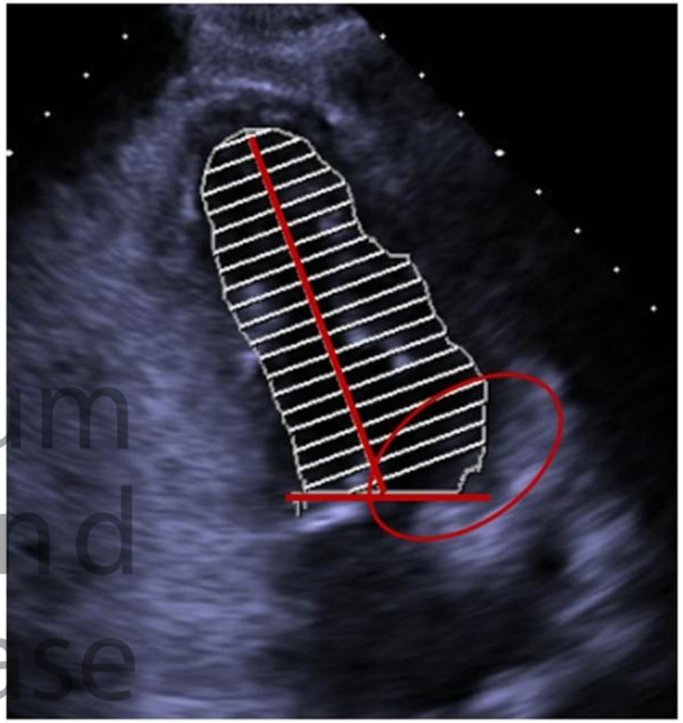


Correct

Incorrect

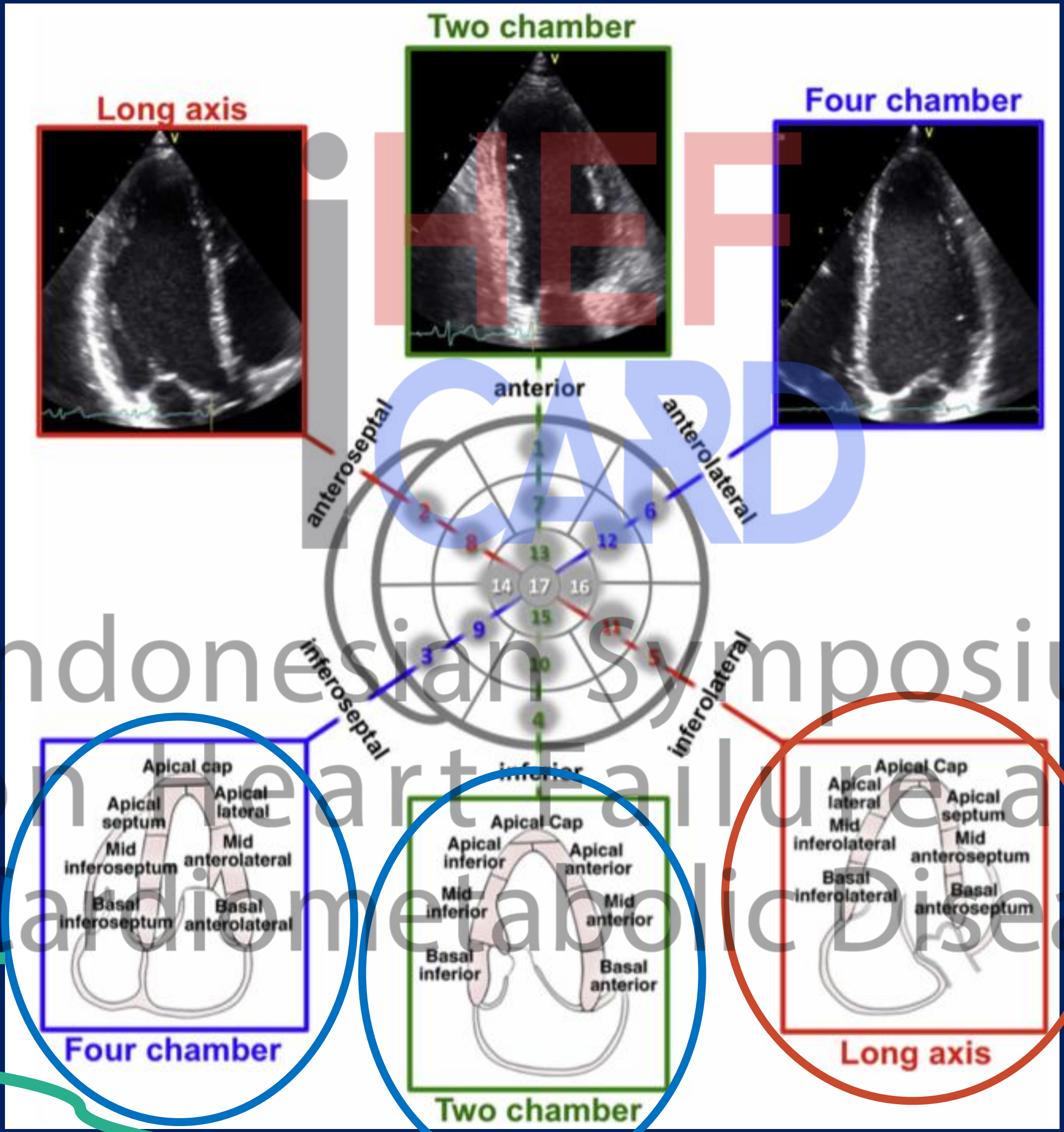
Apex should be in same location for diastole & systole

Length must be 90° angle from base width



Circle area highlights 'dead space' that was not calculated into area—underestimating the volume.

Limitations

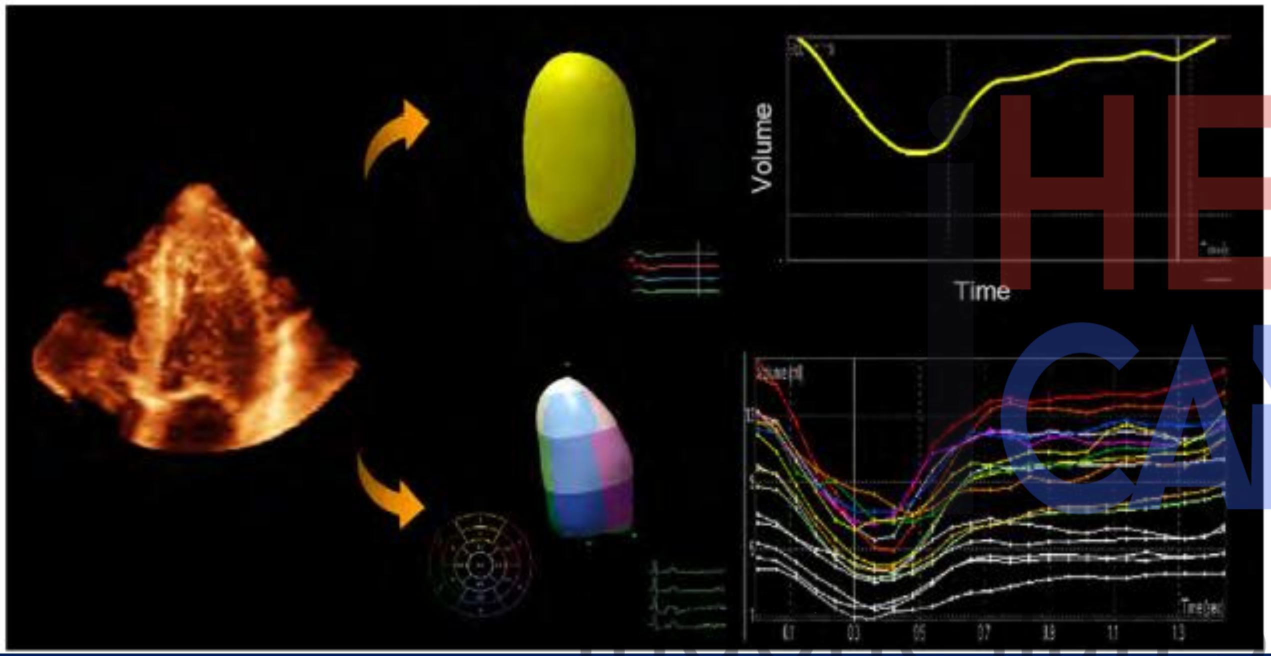


M-mode EF

Biplane EF

2015 ASE/EAE Guidelines on Chamber quantification

Methods for EF Measurements - 3D/4D



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

No geometrical assumption, unaffected by foreshortening, more accurate and reproducible compared to other imaging modalities

In patients with good image quality, 3DE-based EF measurements are **accurate** and **reproducible** and should be used when **available** and **feasible**

2015 ASE Recommendations on Cardiac Chamber Quantification

EF is still the King of LV systolic function..
But we should keep Improving

Strain and Myocardial Work

Accurate measurement of LV systolic function

- Diagnosis
- Therapeutic strategies
- Prognostic marker

Contemporary methods for of LV systolic function

- Ejection fraction and GLS
- Myocardial Work

LV Systolic Function Evaluation

- Ejection fraction by Teich, Simpson biplane and 3D
  - Prognostic parameter in numerous studies
  - Volume based measurement, interobserver variability, load dependent
  - Do not reflect myocardial work or oxygen demand
- Global Longitudinal Strain
  - May evaluate subtle myocardial dysfunction
  - Less angle-and operator-dependent method
  - Increasing the afterload may decrease GLS
  - Variations in afterload and blood pressure can affect strain
  - Do not reflect myocardial work or oxygen demand

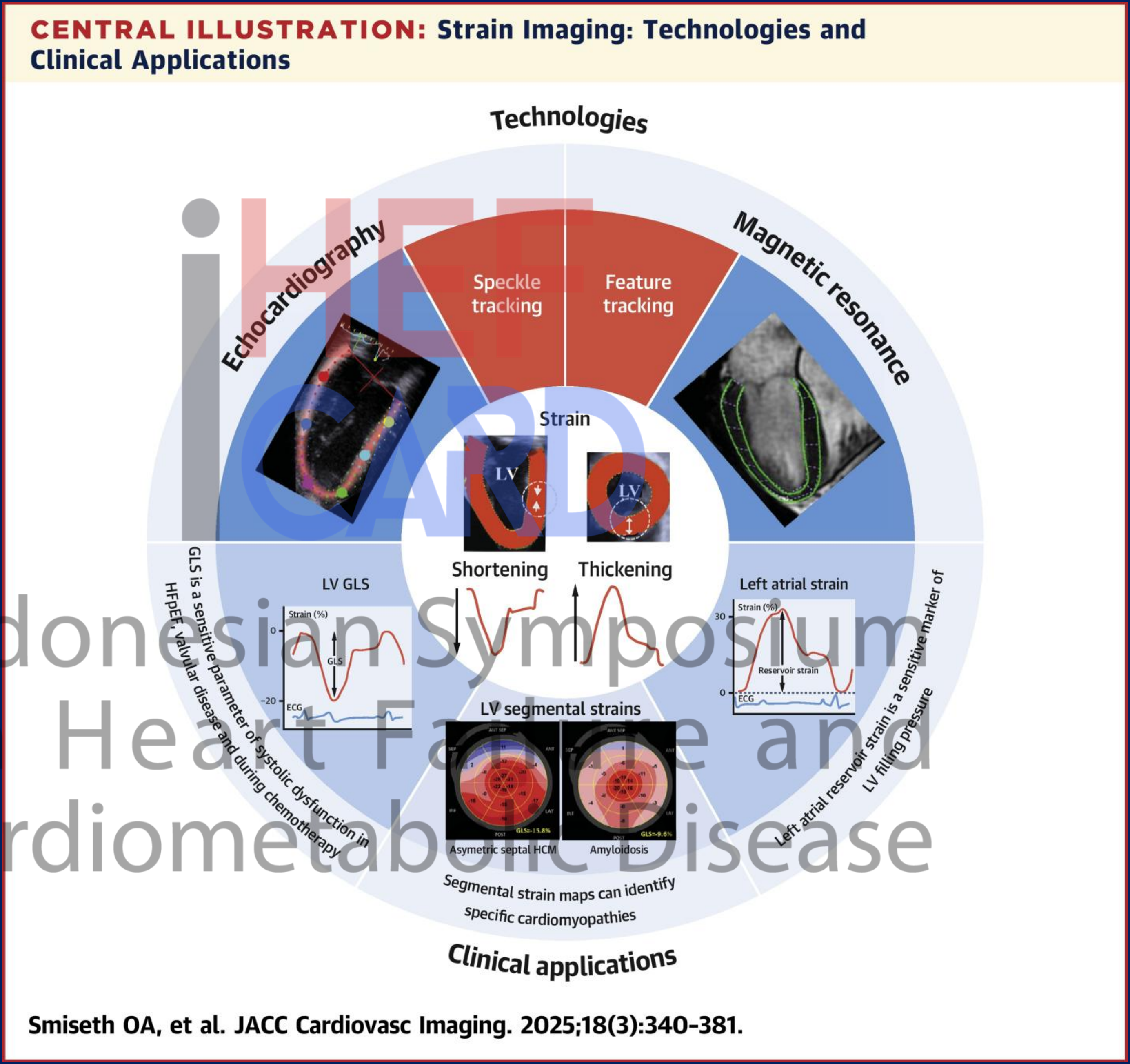
Clinical Applications of Strain Echocardiography: A Clinical Consensus Statement From the American Society of Echocardiography Developed in Collaboration With the European Association of Cardiovascular Imaging of the European Society of Cardiology

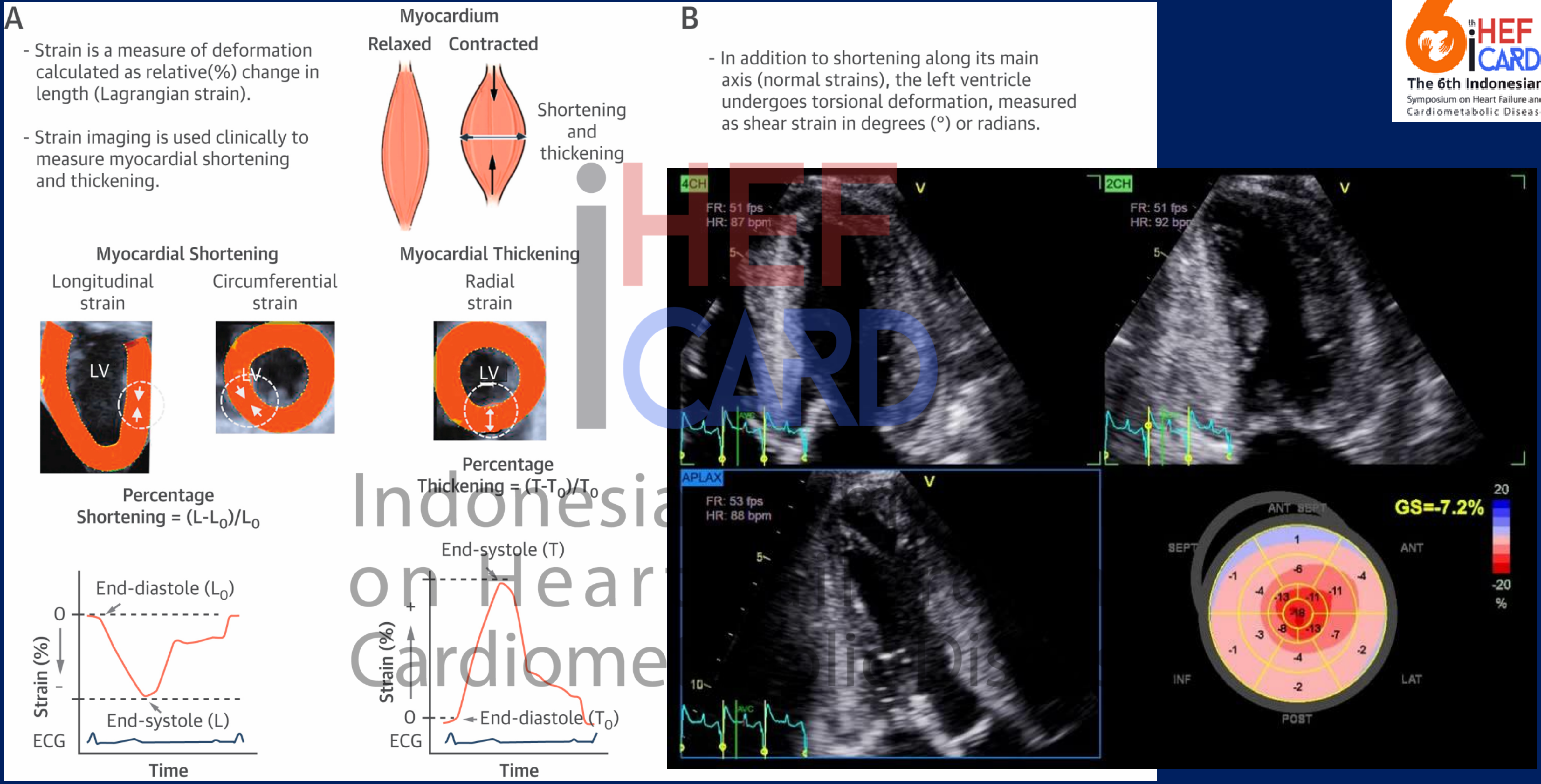
Table 1 Endorsed clinical indications for strain utilization

Clinical scenarios in which strain may be appropriate	Type of strain and consensus advice		Clinical value
Acute and chronic MI	LVGLS	+++	Diagnosis and prognosis
	RVFWLS	+++	Diagnosis and prognosis
	LASr	++	Prognosis
	LVMD	++	Prognosis
	LVMW	–	Not enough evidence
Cardio-oncology	LVGLS	+++	Diagnosis and prognosis
	RVFWLS	++	Prognosis
	LASr	++	Prognosis
	LVMD	–	Not enough evidence
	LVMW	–	Not enough evidence
Valvular heart disease ≥ moderate severity single or multiple lesions	LVGLS	+++	Prognosis
	RVFWLS	+++	Prognosis
	LASr	++	Prognosis
	LVMD	–	Not enough evidence
	LVMW	–	Not enough evidence
Undifferentiated cardiomyopathy	LVGLS	+++	Diagnosis and prognosis
	RVFWLS	+++	Diagnosis and prognosis
	LASr	+++	Diagnosis and prognosis
	LVMD	++	Prognosis
	LVMW	–	Not enough evidence
Acute and chronic HF	LVGLS	+++	Diagnosis and prognosis
	RVFWLS	+++	Diagnosis and prognosis
	LASr	+++	Diagnosis and prognosis
	LVMD	++	Diagnosis and prognosis
	LVMW	–	Not enough evidence
CRT	LVGLS	+++	Diagnosis and prognosis
	RVFWLS	+++	Diagnosis and prognosis
	LASr	++	Prognosis
	LVMD	–	Not enough evidence
	LVMW	–	Not enough evidence
Athlete's heart	LVGLS	+++	Diagnosis and prognosis
	RVFWLS	+++	Diagnosis and prognosis
	LASr	++	Diagnosis and prognosis
	LVMD	++	Diagnosis and prognosis
	LVMW	–	Not enough evidence
PH	LVGLS	+++	Diagnosis and prognosis
	RVFWLS	+++	Diagnosis and prognosis
	LASr	++	Diagnosis
	LVMD	–	Not enough evidence
	LVMW	–	Not enough evidence
Stress echocardiography	LVGLS	++	Diagnosis and prognosis
	RVFWLS	++	Diagnosis and prognosis
	LASr	++	Diagnosis
	LVMD	–	Not enough evidence
	LVMW	–	Not enough evidence
Adult CHD	LVGLS	++	Prognosis
	RVFWLS	++	Diagnosis and prognosis
	LASr	–	Not enough evidence
	LVMD	–	Not enough evidence
	LVMW	–	Not enough evidence

Thomas et al. JASE. 2025

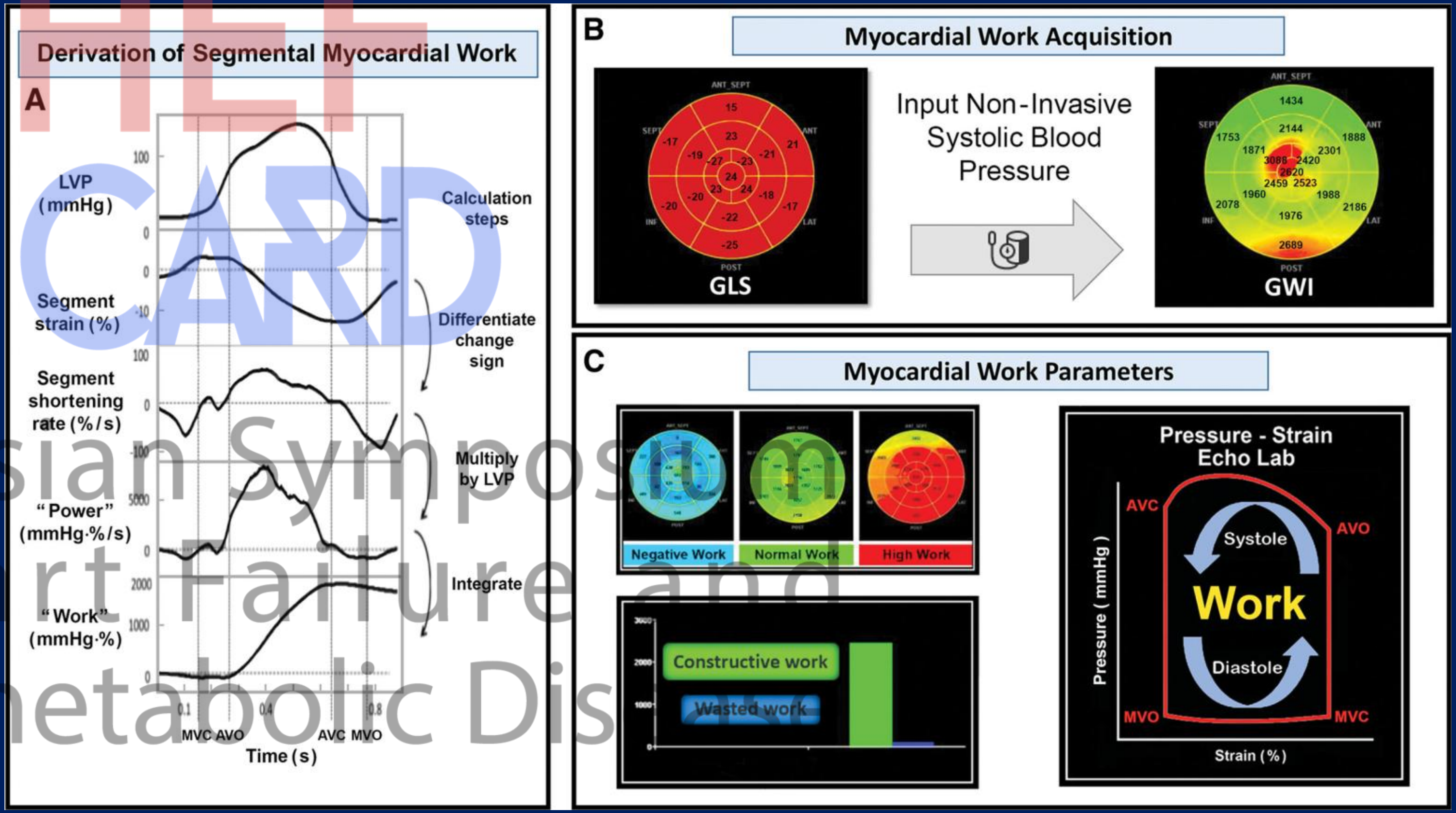
LV Strain


CENTRAL ILLUSTRATION: Strain Imaging: Technologies and Clinical Applications
Technologies
Echocardiography
Speckle tracking
Feature tracking
Magnetic resonance
Strain
LV
LV
Shortening
Thickening
LV GLS
Strain (%)
0
GLS
-20
ECG
GLS is a sensitive parameter of systolic dysfunction in HFpEF, valvular disease and during chemotherapy
Left atrial strain
Strain (%)
30
Reservoir strain
0
ECG
Left atrial reservoir strain is a sensitive marker of LV filling pressure
LV segmental strains
Asymetric septal HCM
Amyloidosis
Segmental strain maps can identify specific cardiomyopathies
Clinical applications
Smiseth OA, et al. JACC Cardiovasc Imaging. 2025;18(3):340-381.

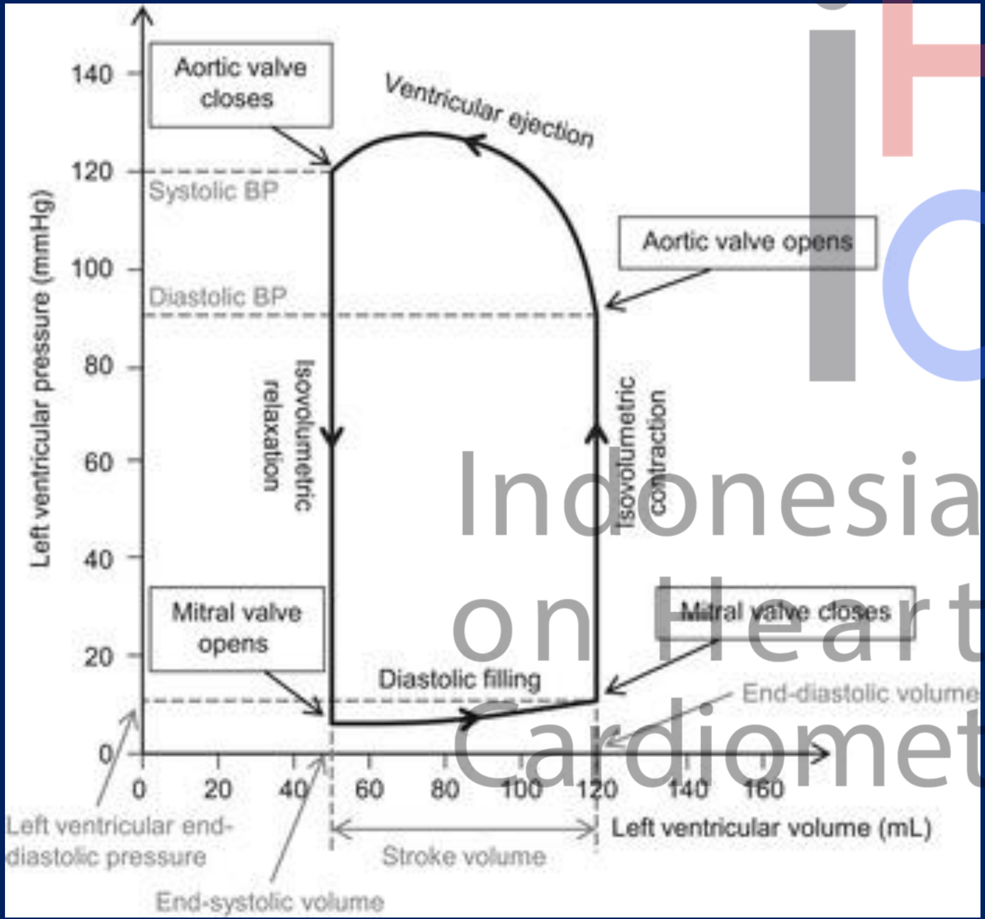


Smiseth et al. JACC CV Imaging 2024.

Myocardial Work



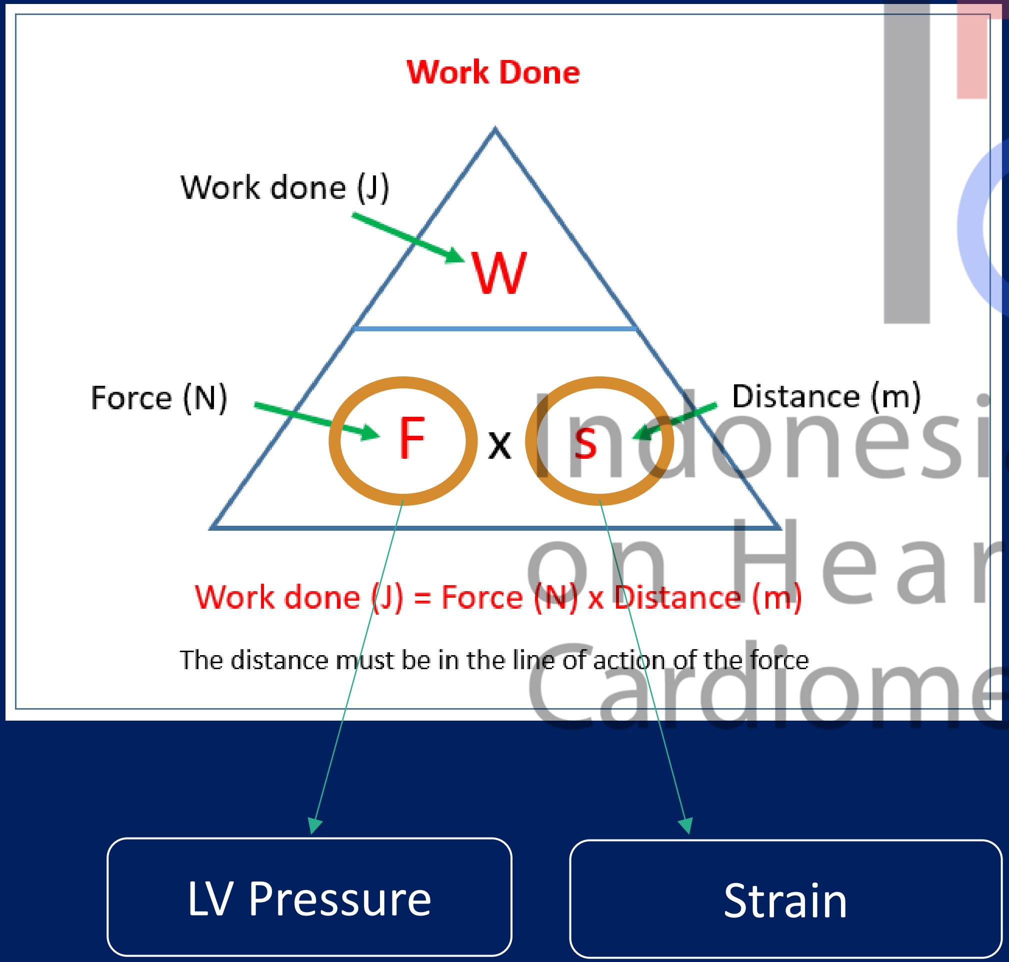
LV Systolic Function Evaluation



Pressure-Volume Loop

- Reflects the myocardial oxygen consumption and eventually the LV performance
- Measured with invasive methods → lack of use of this method in routine clinical practice

Myocardial Work (MW)



- Myocardial work = LV pressure applied over strain
- Measures the LV pressure–strain relationship through a noninvasive method
- Incorporates both LV afterload and deformation
- Does not calculate the actual LV work but is a valid approximation of it.
- Less load-dependent

Myocardial Work (MW)

- Russel et al. were the first to develop this tool to assess segmental and global myocardial work
- LV pressure–volume loop correlated well with the pressure–strain loop (PSL) in various cardiac pathologies
- PSL also correlated with segmental glucose metabolism measured by FDG-PET

Pressure - Strain Loop (PSL)

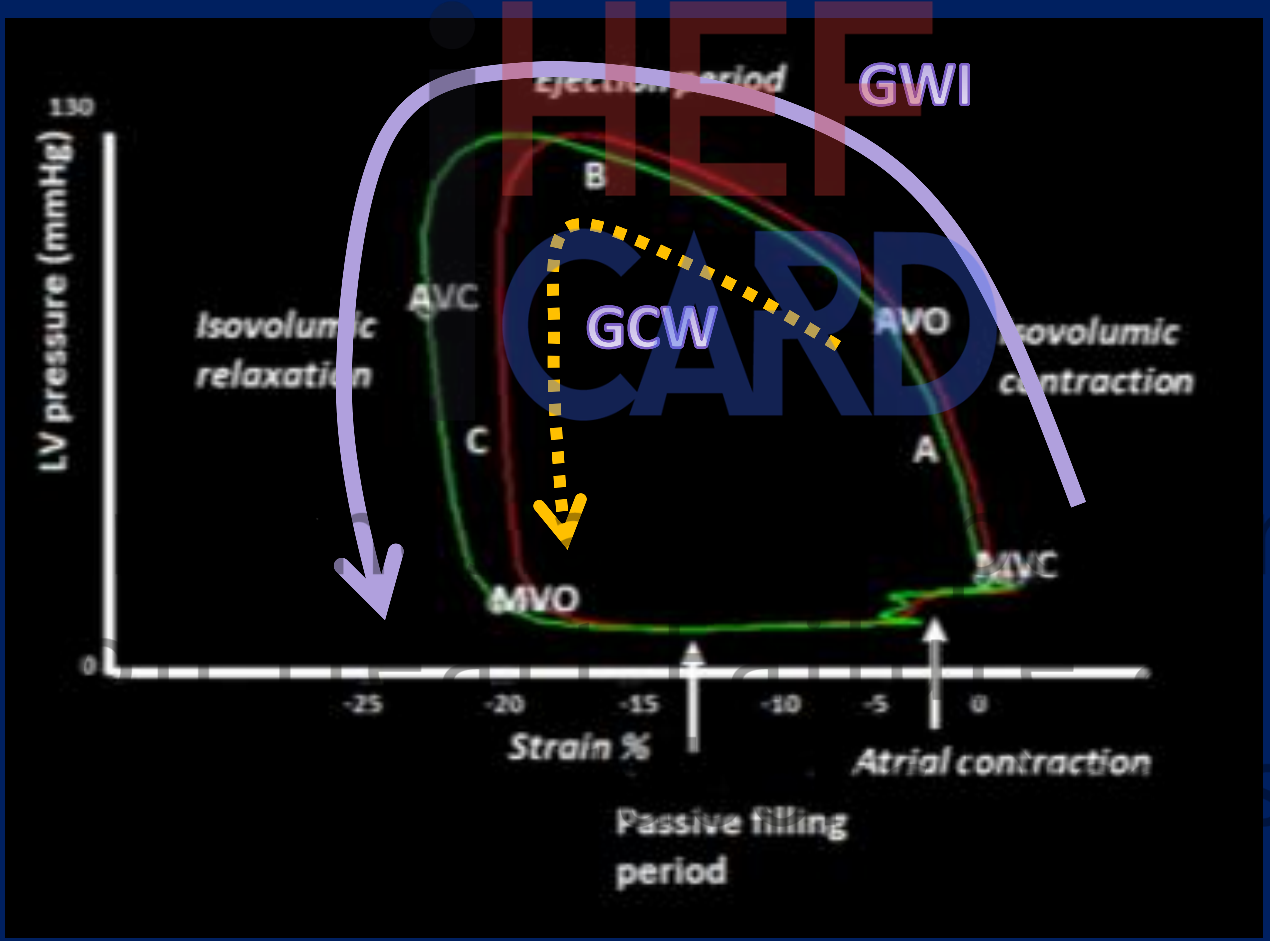
Global work index (GWI) represents the area of the loop from mitral valve closure (MVC) to mitral valve opening (MVO).

Global constructive work (GCW) reflects the work that contributes to pump from aortic valve opening (AVO) to MVO

- shortening of the myocytes during systole
- lenghtening during isovolumic relaxation

Global wasted work (GWW) represents the work that does not contribute to ejection:

- elongation of myocytes during systole
- shortening against a closed AV



Global work efficiency = Fraction of GCW to GCW + GWW

Take Home Messages

- EF remains the cornerstone of LV systolic assessment, despite its known limitations.
- Guideline-directed EF measurement is essential to ensure accurate, high-quality clinical decisions.
- Advanced modalities (e.g., global longitudinal strain, myocardial work) offer valuable incremental value in specific clinical scenarios


thank you
danke
gracias
obrigado
merci
dziękuję
tesekkür ederim
ngiyabonga
شكراً جزيلاً
謝謝
спасибо
Баярлалаа
рахмат
bedankt
sukriya
kop khun krap
go raibh maith agat
mochchakkeram
grazie
arigatô
takk
dakujem
terima kasih
ありがとう
감사합니다
мерси
хвала
tapadh leat
dank je
hvala
mauruuru
köszönöm
kiitos
dankie
enkosi
sobodi
dêkuji
faafetai lava
vinaka
blagodaram
welalin
tack
mersi
barka
paldies
grazzi
matondo
misaotra
mahalo
asante
manana
obrigada
tenki
murakoze
trugarez
dhanyavadagalu
shukriya
diolch
rahmet
xièxie
ευχαριστώ
najis tuke
kam sah hamnida
didi madloba
sagolun
mesi
djiere dieuf
mamnun
chokrane
chnorakaloutioun
gràcies
sulpay
tanemirt
dhanyavad
nandri
nanni
bayarlalaa
gràcie
akun dankon
spas
tau
дякую
spasibi