Prediction of Left Ventricular Ejection Fraction Using Wall Motion Score Index

Validation in a Large Patient Population in Clinical Practice

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Disclosure

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Background

- Left ventricular ejection fraction (LVEF) is an important clinical and prognostic factor in pts with cardiovascular disease
- Echocardiography is the most common clinical imaging technique used to evaluate LVEF
  - Several quantitative techniques for measuring LVEF
  - LVEF – commonly assessed qualitatively (visual estimation)

    Visual estimation of LVEF – highly observer-dependent
- Wall motion score index (WMSI) – represents LV segmental Fx
  - WMSI = Σ wall motion scores / # of scores segments (16 segments)
  - Correlation between WMSI & LVEF – intuitive

    Not assessed in large pt populations in routine clinical practice

Objectives

- To evaluate the relation between WMSI and LVEF in a large pt population undergoing echocardiography in routine clinical practice
- To examine whether any additional echocardiographic parameters modify this relation
- To develop a formula that predicts LVEF according to:
  - WMSI
  - Additional interacting factors
- To validate this formula in a large pt population

Methods
Data Collection

- Computerized database – echocardiographic laboratory
- 2000 consecutive pts with Dx: "LV segmental wall motion abnormality"
- Collection of relevant data from echocardiographic reports
  - Demographics / body size
  - Heart rate / rhythm
  - Left ventricle
    - Size / wall thickness / remodeling
    - Coronary artery territory (LAD, non-LAD, multiple territories)
  - Valve dysfunction (> moderate)

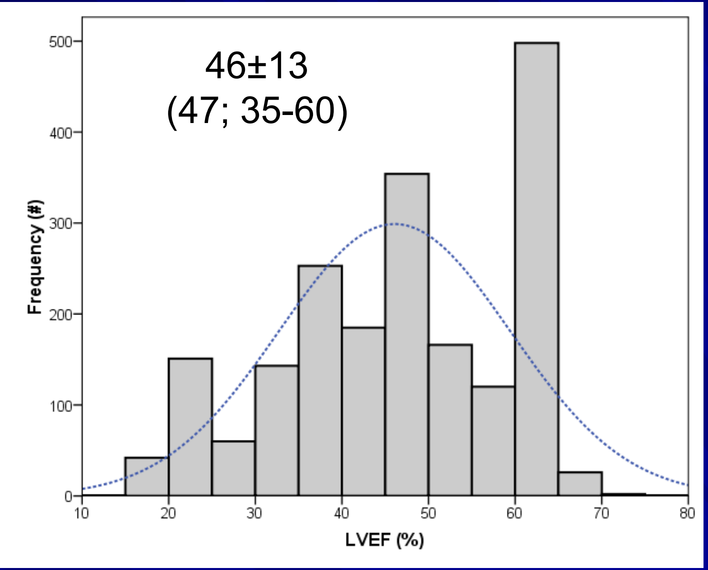
Statistical Analysis

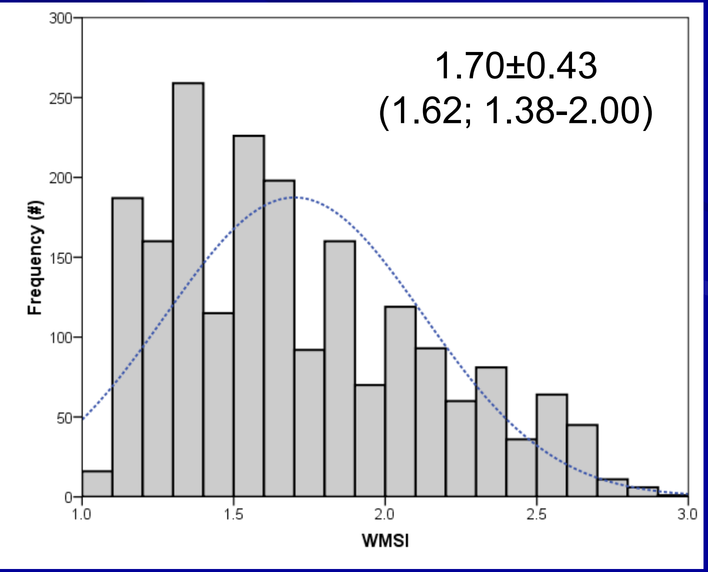
- Total population (n = 2000)
  - Correlation: WMSI ↔ LVEF
  - Modifiers of WMSI ↔ LVEF relationship (interactions)
- Test group (1st 1000)
  - Predictors of LVEF (WMSI + other predictors)
  - Multivariate linear regression analysis → regression equation
- Validation group (2nd 1000)
  - Calculation of "predicted LVEF" using regression equation
  - Relationship between predicted LVEF ↔ LVEF (original)
    - Correlation & Bland-Altman analysis
- ROC analysis
  - WMSI → LV dysfunction (ASE categories of LV dysfunction)

Results

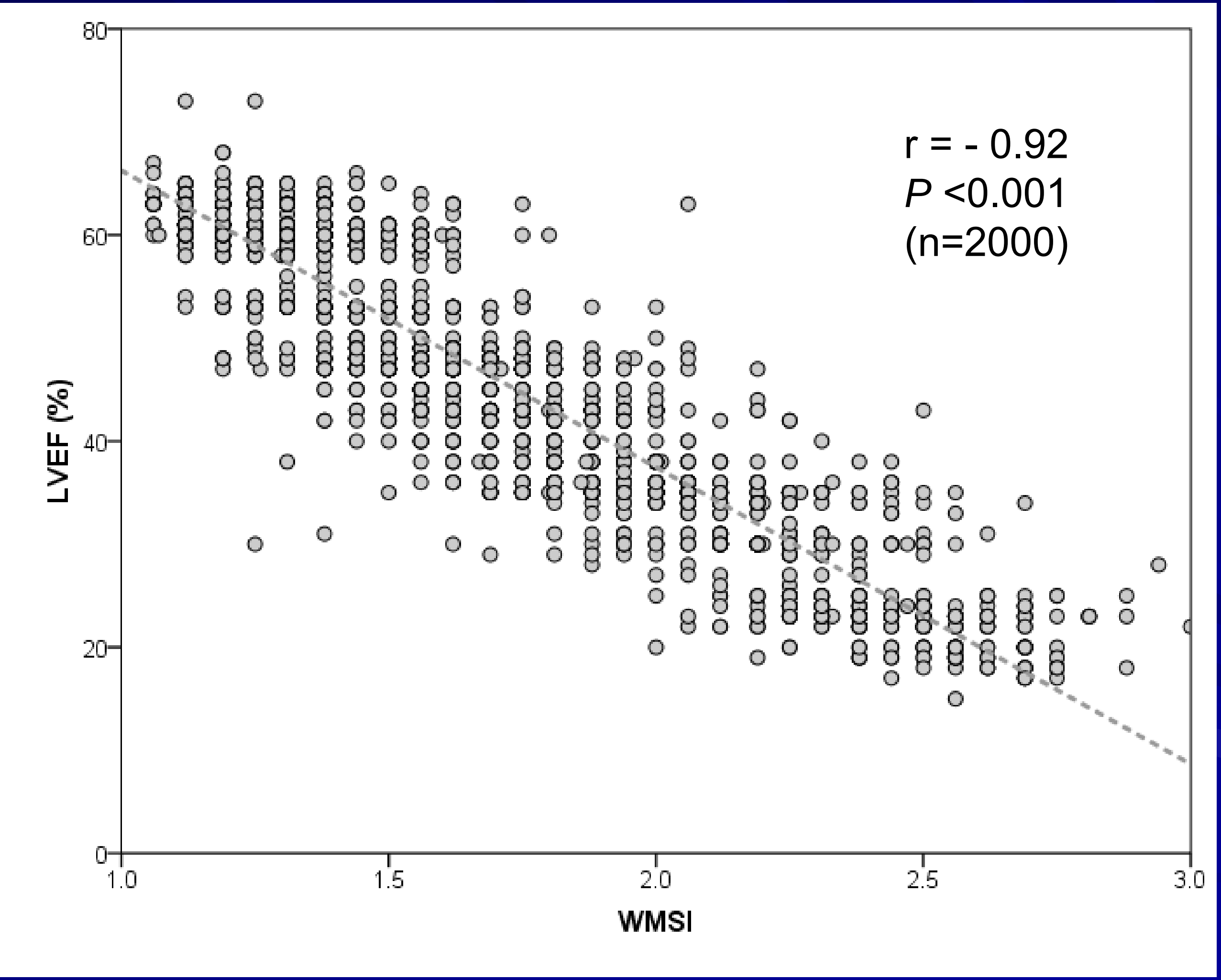
Total Study Population (n=2000)

- Age (yrs) 67±13
- Male 74%
- LV dilatation (qualitative)
  - Mild 24.6%
  - Moderate-severe 13.8%
- LVEDd (cm) 5.4±0.7
- LVH (qualitative) 24.2%
- HR (min^{-1}) 72±15
- Irregular heart rhythm 13.1%
- Coronary artery territory
  - LAD 9.4%
  - Non-LAD (RCA / LCx) 62.8%
  - Multiple territories 27.8%
- MR > moderate 7.8%





WMSI vs. LVEF



Linear Regression Analysis

Univariate Predictors of LVEF – Test Group (n=1000)

WMSI*	**$R^2 = 0.84$**	***P* <0.001**
LV size (cat)*†	$R^2 = 0.42$	*P* <0.001
LVEDd*	$R^2 = 0.37$	*P* <0.001
Territory*‡	$R^2 = 0.29$	*P* <0.001
RWT	$R^2 = 0.19$	*P* <0.001
LV mass	$R^2 = 0.11$	*P* <0.001
HR*	$R^2 = 0.03$	*P* <0.001
MR > moderate*	$R^2 = 0.03$	*P* <0.001
IV septum, PW	$R^2 = 0.01$	*P* = 0.002
Male*	$R^2 = 0.01$	*P* = 0.002
BMI	$R^2 = 0.006$	*P* = 0.03

- *Non-significant*
  - Age, BSA
  - Regular rhythm
  - LV wall thickness (qual)
  - AR > moderate

* Negative associations

† 1 = normal LV size; 2 = mildly dilated; 3 = mod-severely dilated (visual assess.)

‡ 1 = LAD; 2 = non-LAD; 3 = multiple territories

Multivariate Predictors of LVEF
Test Group (n=1000)

- Significant independent predictors ($\Delta R^2 > 0.01$):

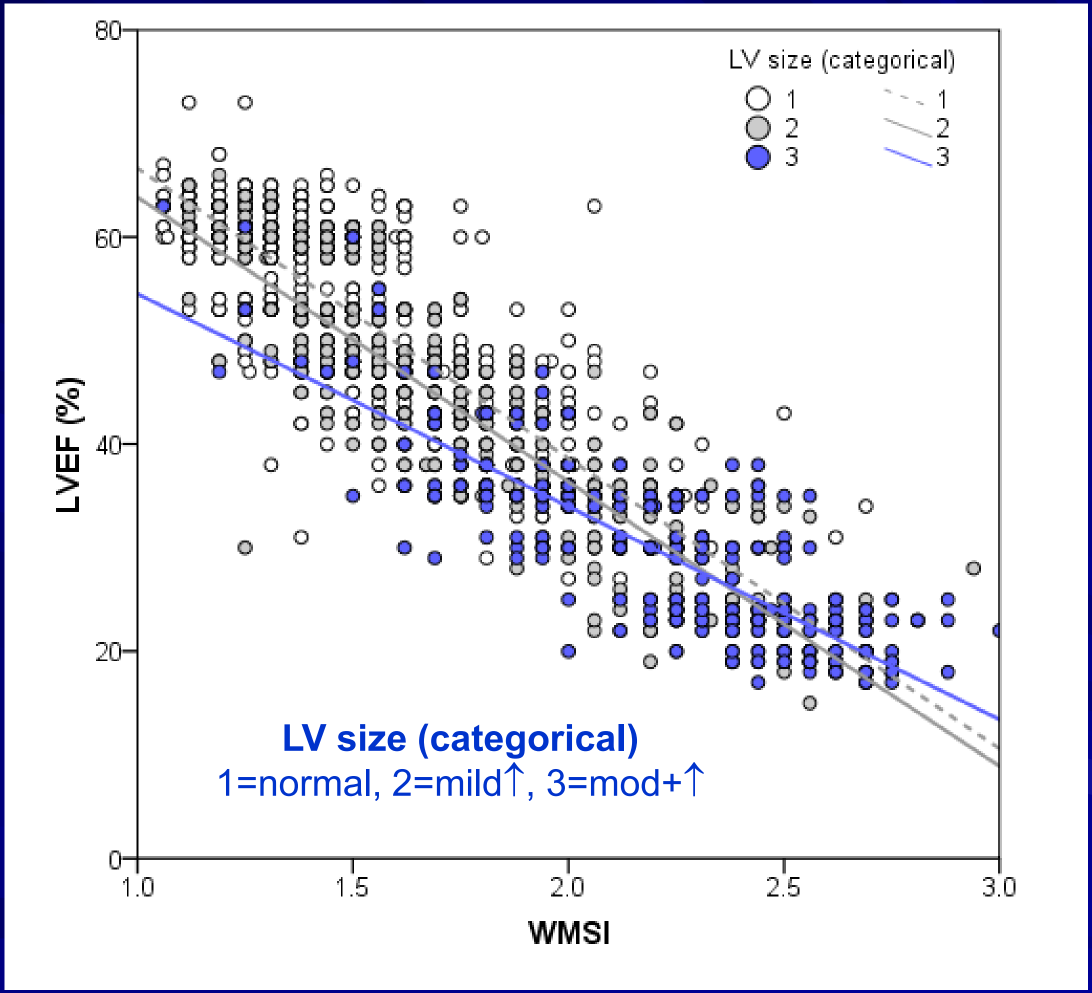
	Stand. coefficient (β)	*P* value
- WMSI	– 0.85	<0.001
- LV size (category)	– 0.11	<0.001

Regression equation

LVEF = 95.1 – 26.9 x WMSI – 2.0 x LV size (cat)*

* 1 = normal LV size; 2 = mildly dilated; 3 = mod.-severely dilated (eyeballing)

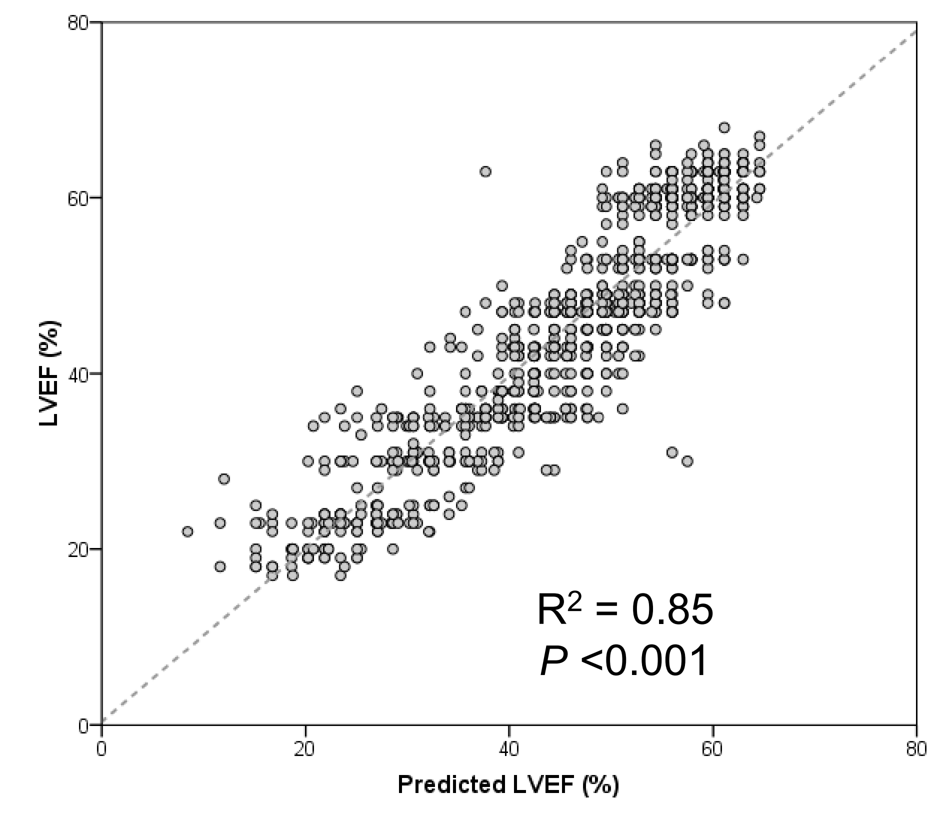
LV size → WMSI ↔ LVEF Relationship

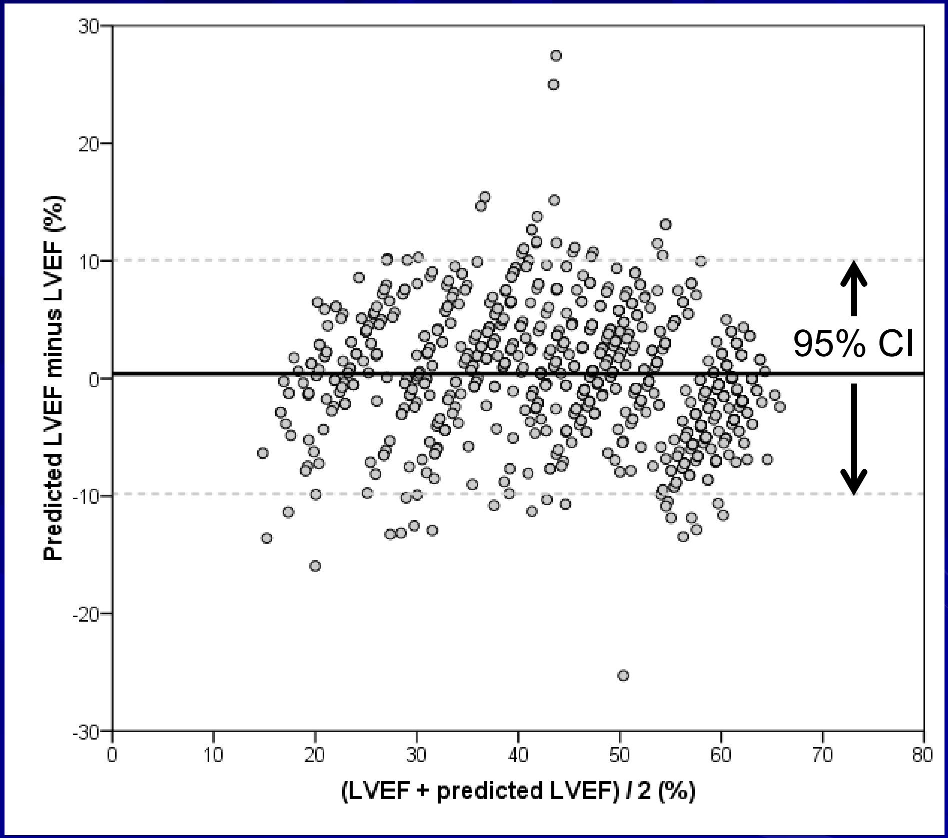


Results

Prediction of LVEF (Regression Equation)

Validation Group (2nd n=1000)



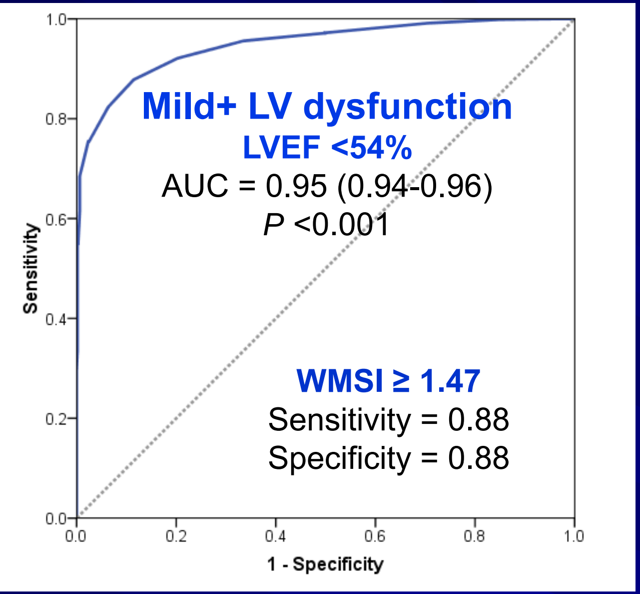


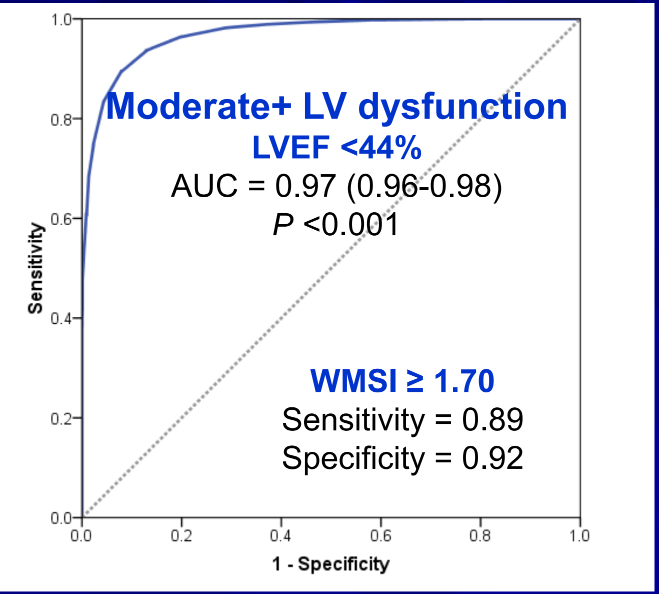
Correlation

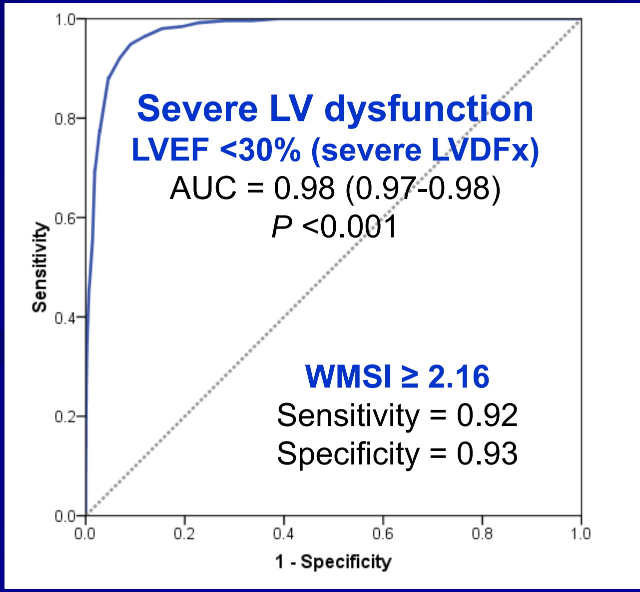
Bland-Altman analysis

- Mean ΔLVEF (%) = 0.4 (95% CI -9.8-10.1)
- Mean absolute ΔLVEF (%) = 4.0 (0.1-11.5)

Prediction of Qualitative LV Dysfunction – WMSI







Summary

- WMSI correlates strongly with LVEF
  - This correlation – modified by LV size
- LVEF can be predicted using a regression equation
  - Combining WMSI & estimated LV size
- Regression equation – high accuracy
  - Validation in a large group of pts
- LV dysfunction (categories) can be predicted using WMSI cutoffs

A new tool for estimating left ventricular ejection fraction derived from wall motion score index.

Lebeau R, Di Lorenzo M, et al.

- 243 TTE and radionuclide angiography (RNA) performed
- First 150 patients established a correlation

  between LV WMSI and RNA EF.

  Regression equation (RNA LVEF=92.8-25.8 x WMSI)
- Correlated well with RNA EF (r=0.86) in 93 pts.

The Canadian journal of cardiology 2003 ;19(4):397–404.

EUROPEAN SOCIETY OF CARDIOLOGY®
European Journal of Echocardiography (2010) **11**, 125–130
doi:10.1093/ejechocard/jep177

Novel wall motion score-based method for estimating global left ventricular ejection fraction: validation by real-time 3D echocardiography and global longitudinal strain

Vittorio Palmieri[1]*, Cesare Russo[2], Antonietta Buonomo[1], Emiliano A. Palmieri[1], and Aldo Celentano[1]

- EF of 63% if all segments were normal, 49% if all were mildly hypokinetic, 35% if all were moderately hypokinetic and 21% if all were severely hypokinetic.
- 40 random patients

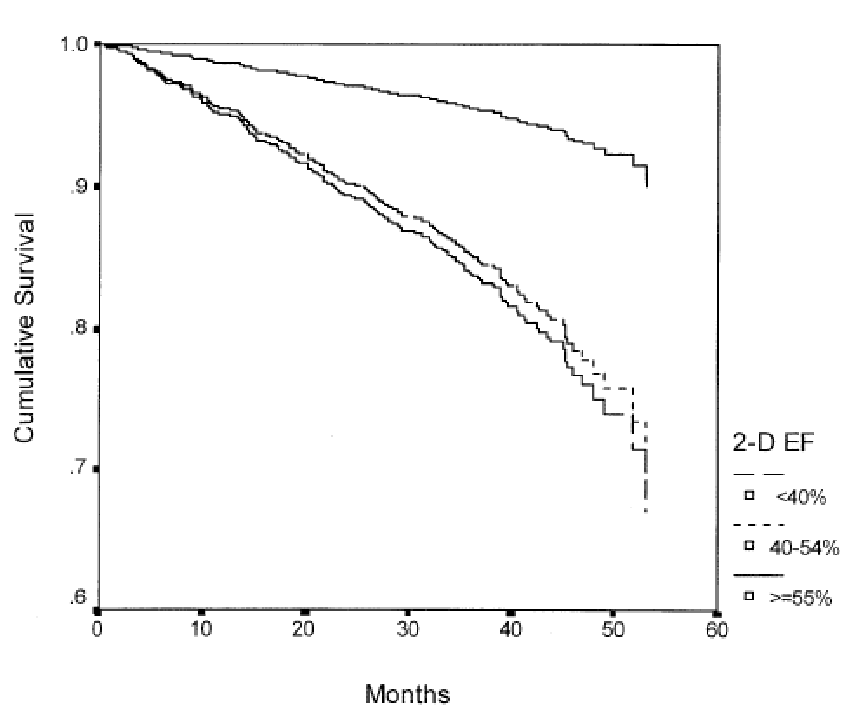
Table 3 Reliability analysis and regression equations

Items	Intraclass correlation coefficients		P-value
	Value	95% confidence interval	
WMSI-EF vs. 3D based EF	0.94	0.89–0.97	<0.001
WMSI-EF vs. Biplane EF	0.94	0.89–0.97	
Biplane EF vs. 3D-EF	0.94	0.88–0.97	
	Regression equations		**Constant (%)**
	B (β)	**r^2; standard error of estimates (%)**	
WMSI-EF predicting 3D-EF	0.86 (0.95)	0.89; 6.2	6
WMSI-EF predicting 2D-EF	0.84 (0.96)	0.91; 5.4	9
Biplane EF predicting 3D-EF	0.98 (0.95)	0.90; 6.1	−1

Prognostic implications of ejection fraction from linear echocardiographic dimensions: The Strong Heart Study

Richard B. Devereux, MD,[a] Mary J. Roman, MD,[a] Vittorio Palmieri, MD,[a] Jennifer E. Liu, MD,[a] Elisa T. Lee, PhD,[b] Lyle G. Best, MD,[c] Richard R. Fabsitz, MA,[d] Richard J. Rodeheffer, MD,[e] and Barbara V. Howard, PhD[f] *New York, NY, Timber Lake, SD, Bethesda, Md, Washington, DC, and Rochester, Minn*

- EF of 63% if all segments were normal, 49% if all were mildly hypokinetic, 35% if all were moderately hypokinetic and 21% if all were severely hypokinetic.



Freedom from cardiovascular death (*vertical axis*), adjusted for covariates described in the text, is similarly lower in SHS participants with mildly reduced EF (40%–54%) or severely reduced EF (<40%) compared to those with normal EF from 2-D echocardiographic wall motion scores.

A prospective comparison of echocardiographic wall motion score index and radionuclide ejection fraction in predicting outcome following acute myocardial infarction

G I W Galasko, S Basu, A Lahiri, R Senior

- 120 consecutive patients treated with thrombolysis following AMI
- Confirmed the very close correlation between WMSI and RNV EF

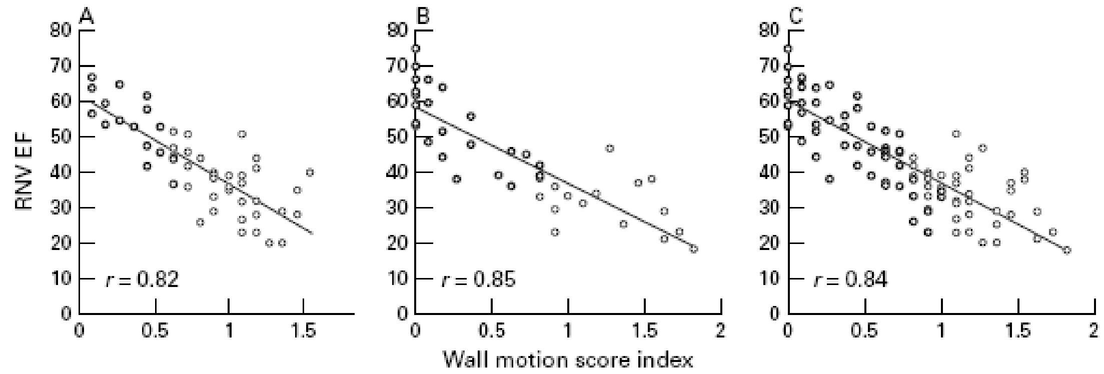


Figure 1 Scatter plot of radionuclide ventriculographic ejection fraction (RNV EF) compared with echocardiographic wall motion score index (WMSI) (A) in 120 patients pre-discharge after myocardial infarction, (B) in 85 patients six months after myocardial infarction, and (C) in all 205 patients combined.

Heart (British Cardiac Society) 2001 ;86(3):271–6.

Rapid Estimation of Left Ventricular Ejection Fraction in Acute Myocardial Infarction by Echocardiographic Wall Motion Analysis

Berning J. · Nielsen J.R. · et al

- Using radionuclide ventriculography (RNV) and contrast ventriculography measurements of LVEF for comparison.
- ECHO-LVEF from 41 patients correlated well with the reference methods ($y = 1.5x – 14.7$, $r = 0.93$; linear regression analysis; 95 % confidence limit for a single determination of ECHO-LVEF was 17.2)

Cardiology 1992;80:257–266

Usefulness of the severity and extent of wall motion abnormalities as prognostic markers of an adverse outcome after a first myocardial infarction treated with thrombolytic therapy.

Carluccio E, Tommasi S, et al

- Most powerful predictor of a subsequent event was a resting WMSI ≥1.50 before discharge.
- In patients with a first AMI who underwent thrombolysis wall motion abnormalities are important independent predictors of cardiac events.

The American journal of cardiology 2000;85(4):411–415.

Determinants of ΔLVEF

- Logistic regression – predictor(s) of absolute ΔLVEF >10%:
  - Single significant predictor – LVEF

OR = 0.75 per 10% LVEF

(95% CI 0.61-0.93; *P* <0.01)

Study Limitations

- Retrospective analysis using a prospectively collected database
- Referral bias – pts undergoing echocardiography in a tertiary medical center
- Comparison of 2 qualitative techniques (visual assessment)
  - WMSI $\leftrightarrow$ LVEF
  - Reflects common clinical practice
- Additional qualitative parameters analyzed (LV size / wall thickness)
  - Secondary analyses using quantitative LV parameters (LVEDd, LVM)
- Relatively small subgroups of pts with pure involvement of LAD territory

Conclusions

- WMSI can be used to predict visually-estimated LVEF in routine clinical practice
- Calculation of LVEF via WMSI may be used for “cross-checking” of standard visual assessment of LVEF
  - A method for quality-control of visual LVEF assessment?