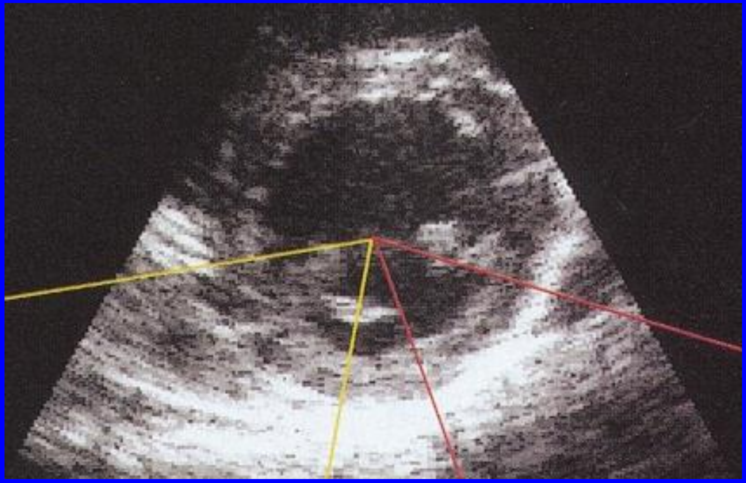
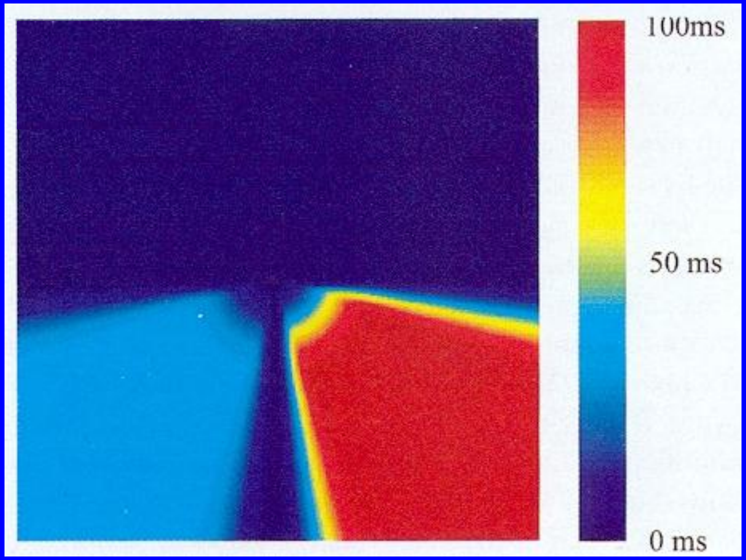
Quantifying LV function –
how good are we ?

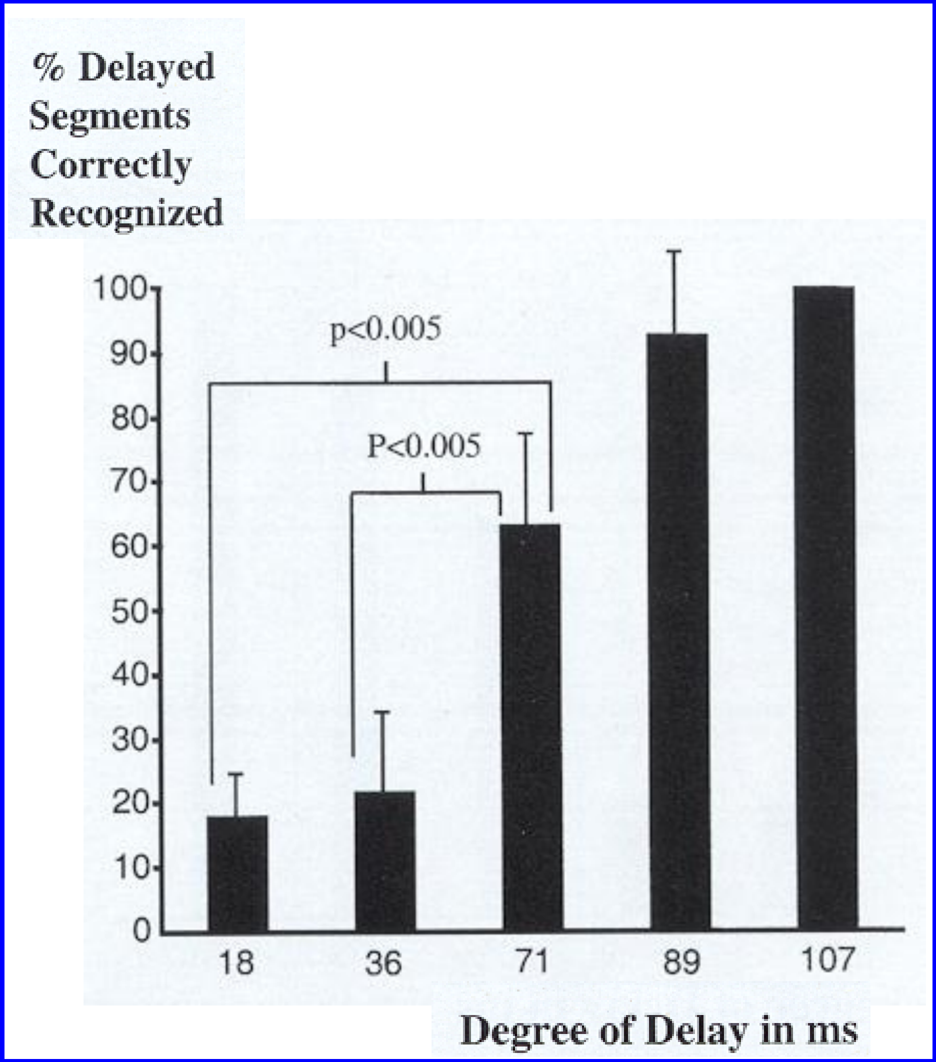
Professor Alan G Fraser
Wales Heart Research Institute
Cardiff University, U.K.

Support for research from Hitachi Aloka, & GE Ultrasound

Visual assessment of synchronicity
Computer-simulated regional delay

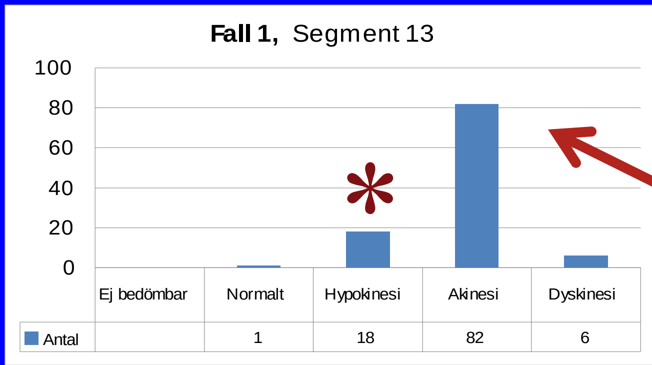


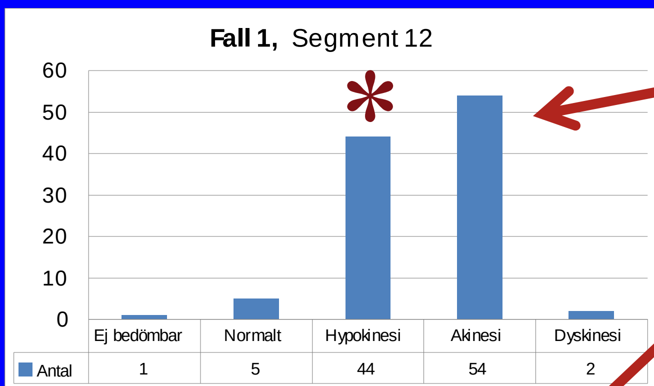


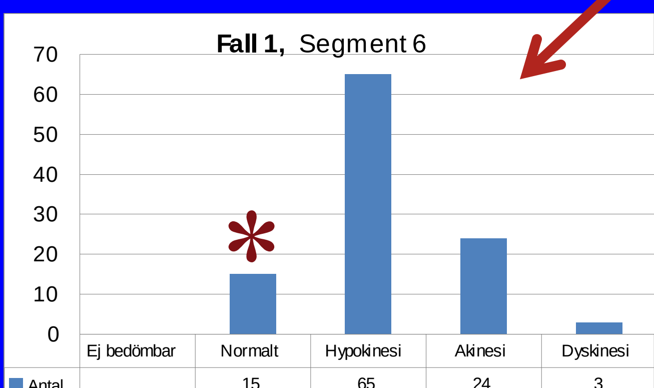


Kvitting et al, J Am Soc Echo 1999; 12: 698

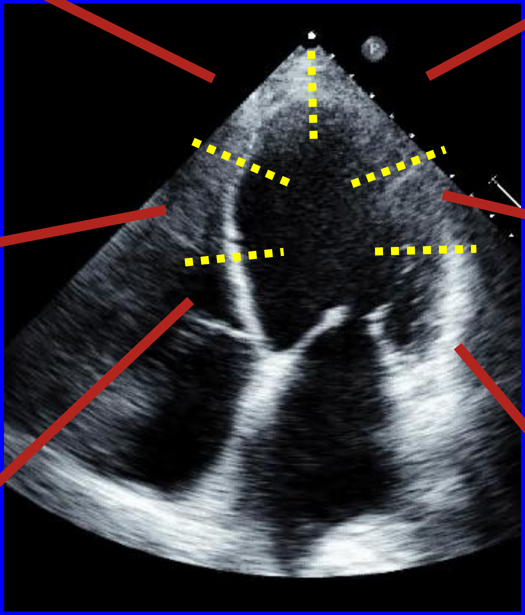
EQUALIS – Diagnosis of regional wall motion





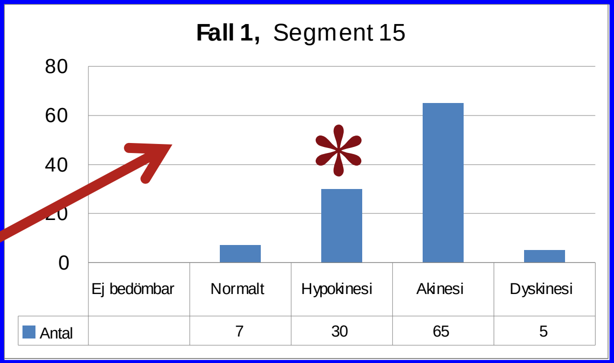


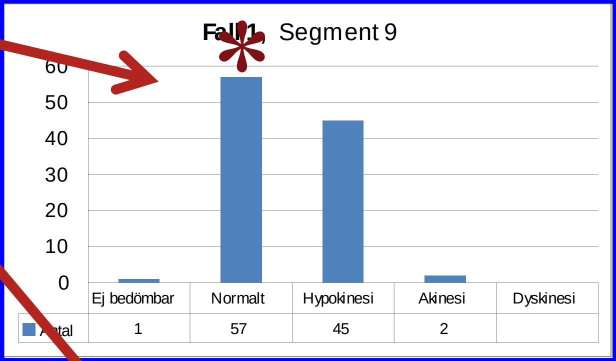
Echocardiography
Quality Control
Project: **Case #1**

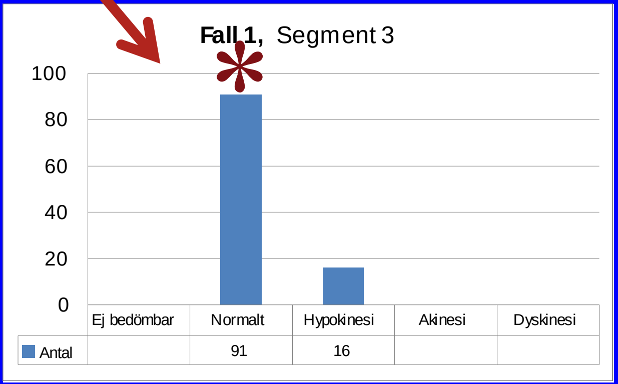


Independent reporting by 106 Swedish centres in 2008

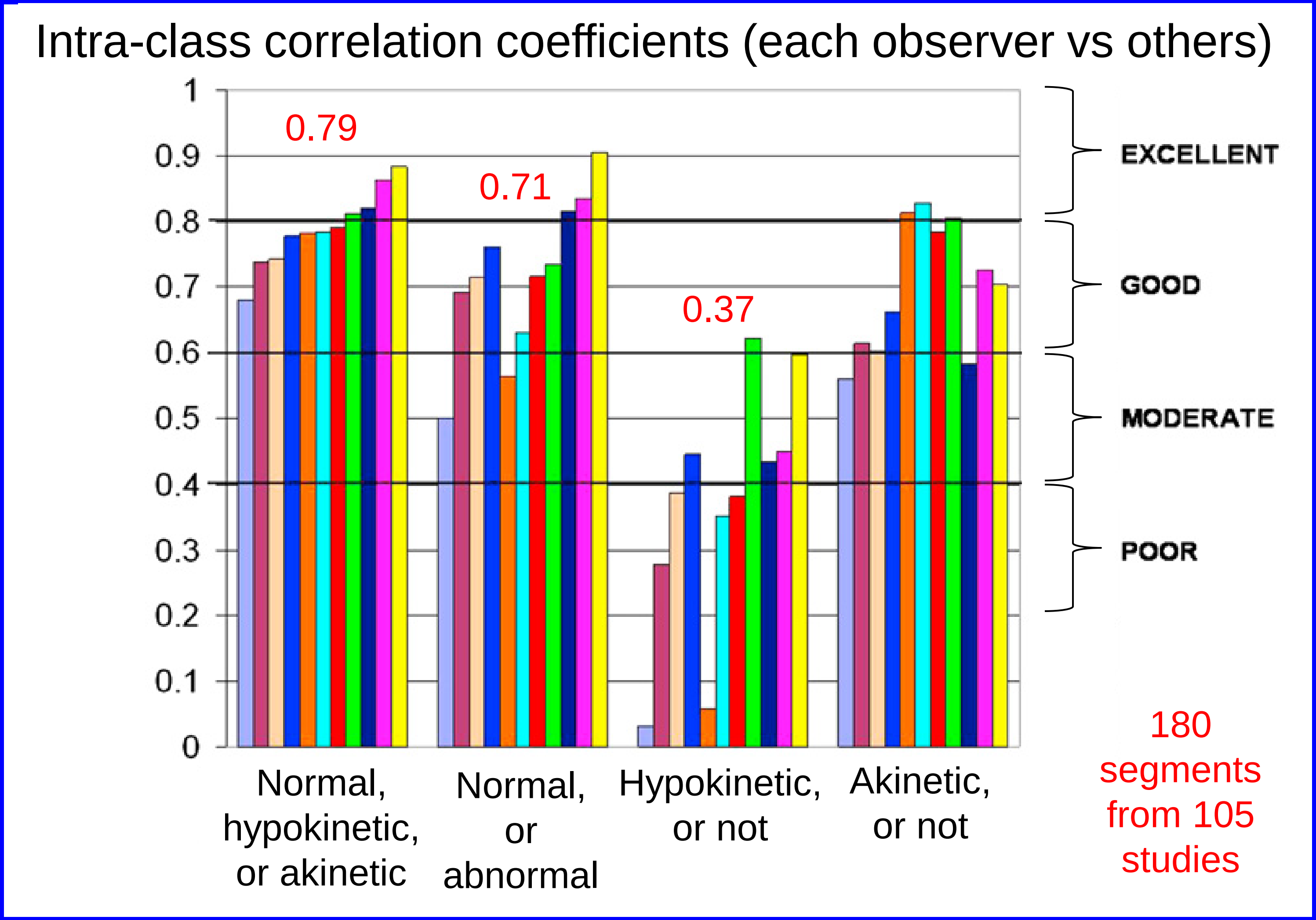
Courtesy of
Dr Odd Bech-Hansson







Inter-observer reproducibility of visual grading of regional wall motion – 11 experienced observers



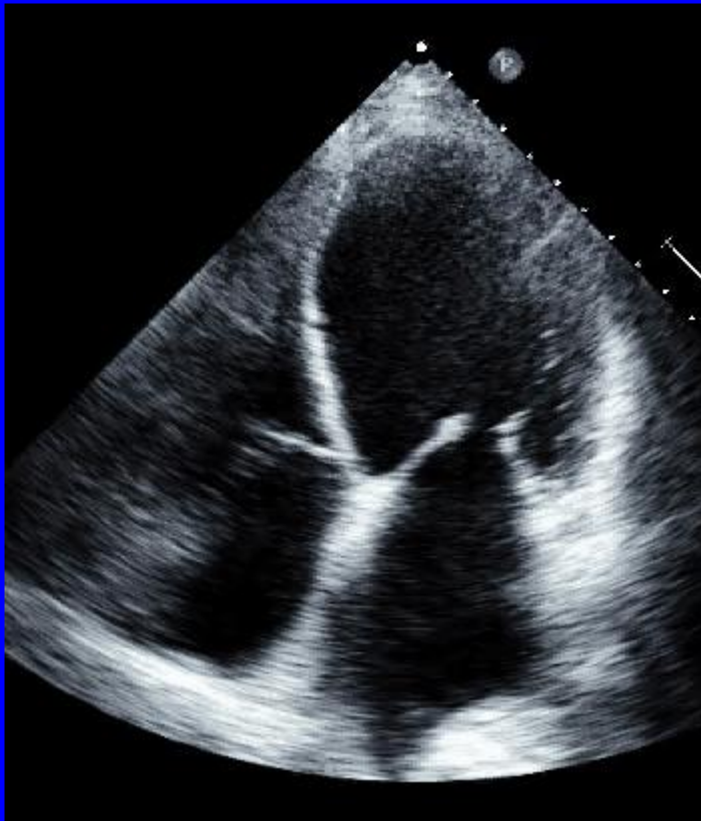
Blondheim DS et al, JASE 2010; 23: 258-64

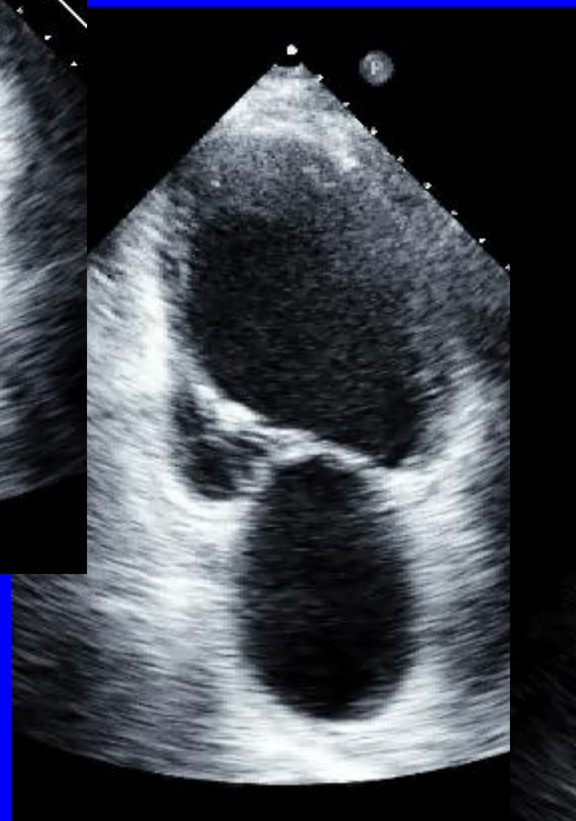
Limitations of wall motion scoring

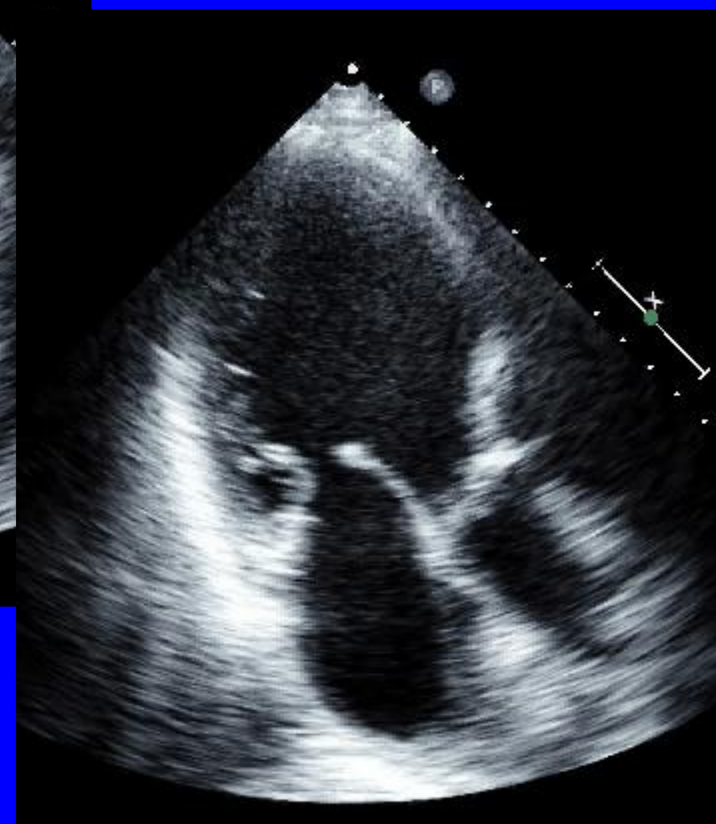
- Subjective interpretation of motion & thickening
- Learning curve, operator-dependent
- Sub-optimal reproducibility even in expert centres
- Insensitive for detecting single vessel disease
- Categorical outcomes, not a graded response
- Improved by LV opacification with echo contrast
- Remains a subjective diagnosis
- *So why is it still used in stress echocardiography ?*

EQUALIS

Echocardiography Project





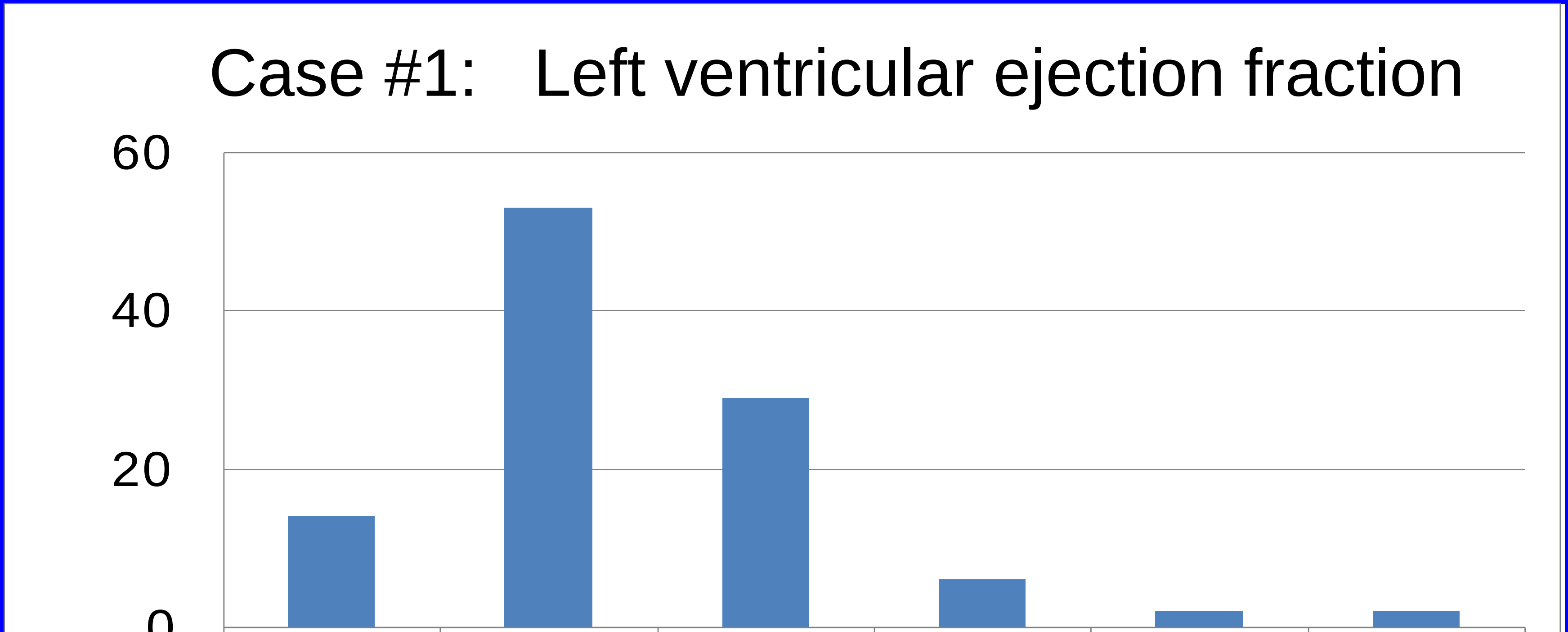


Case #1

Courtesy of
Dr Odd Bech-Hansson

EQUALIS Echocardiography Quality Control Project

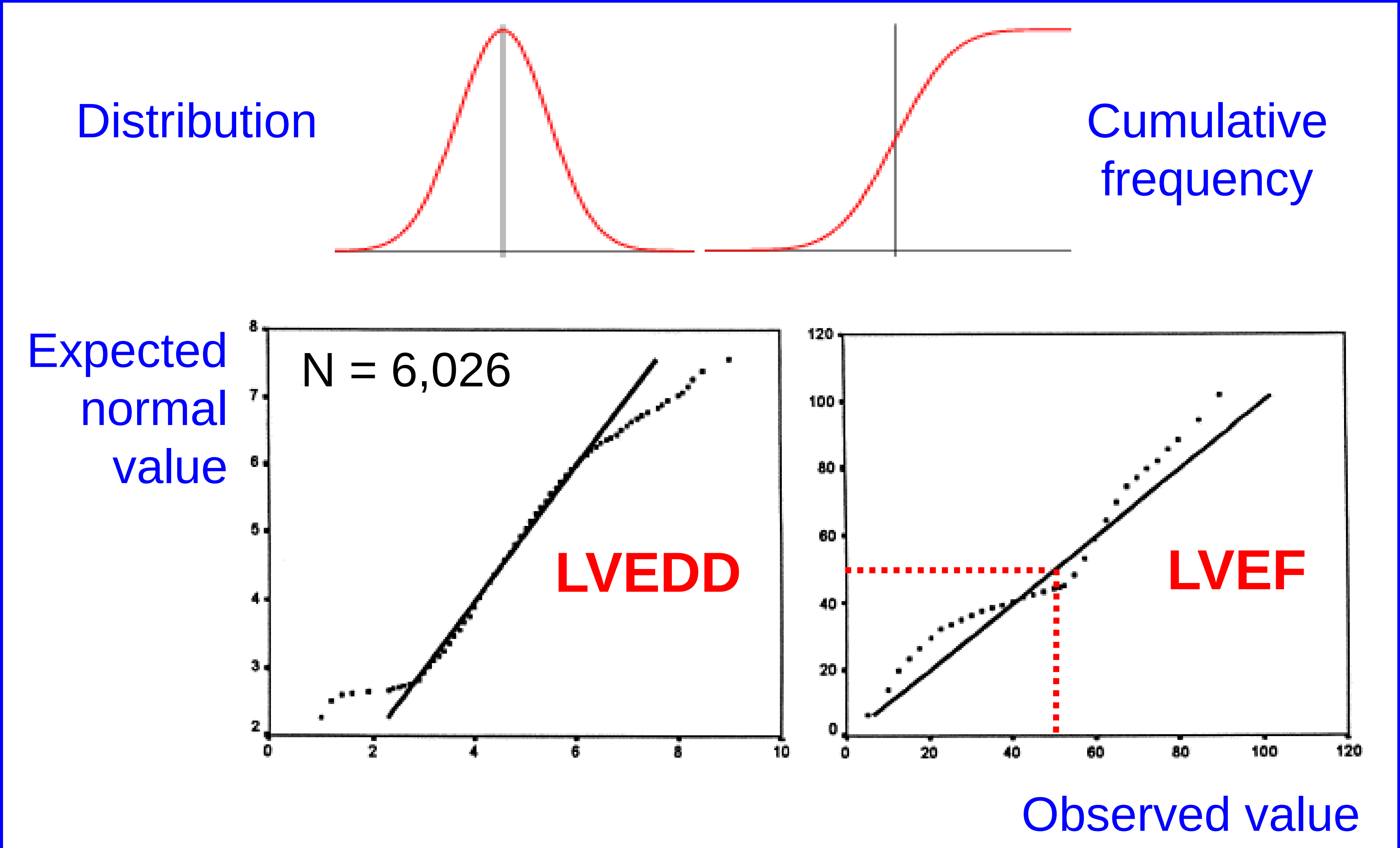
Independent analysis in 106 Swedish centres



	<20	20-29	30-39	40-49	50-59	>60
N	14	53	29	6	2	2

Simpson EF by 5 investigators: mean **34 %** (range 32-36 %)

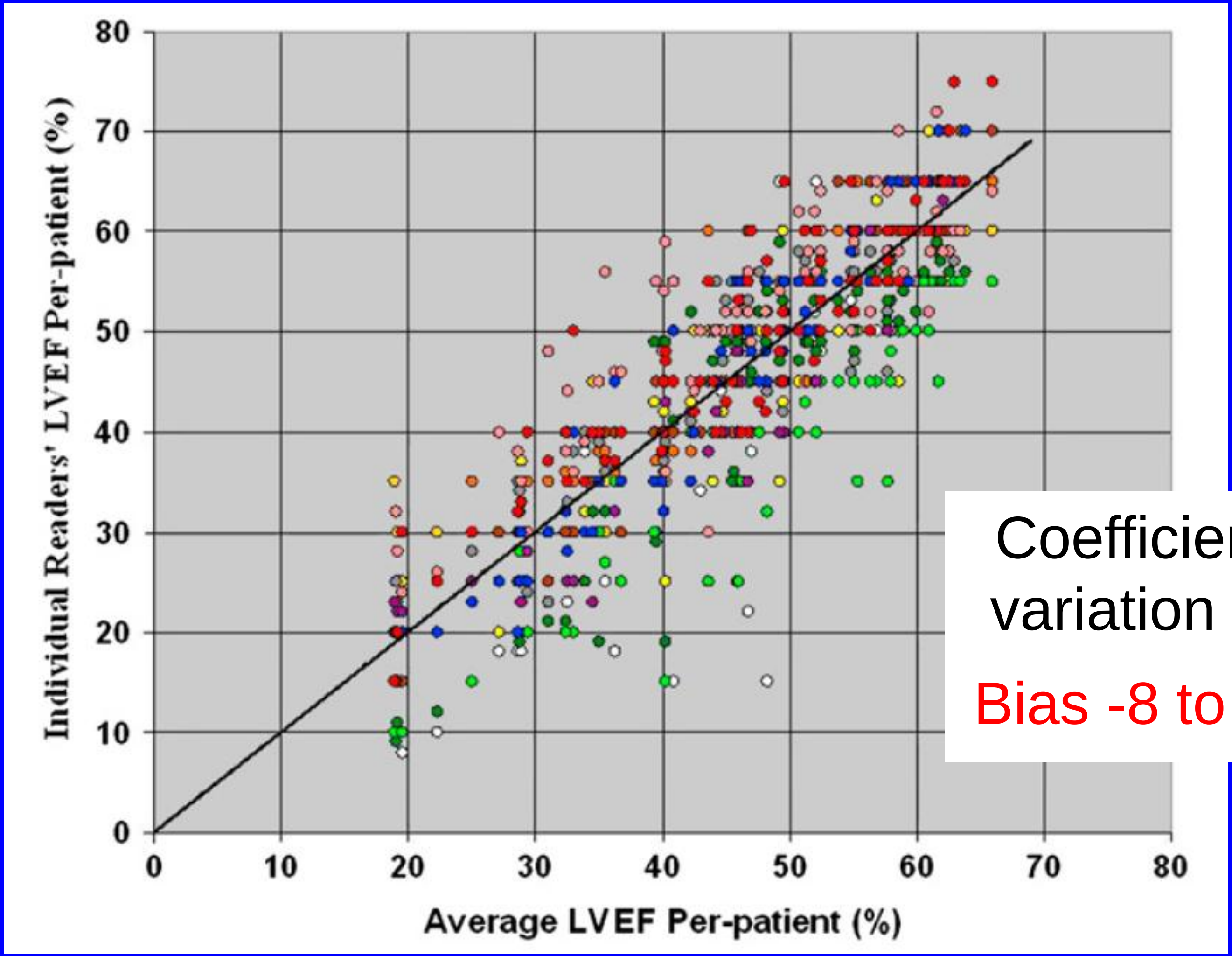
Observer bias in visual estimation of LVEF



Berger AK et al, JACC 1999; 34: 1831

Visual assessment of LV ejection fraction

105 echo studies interpreted by 12 observers

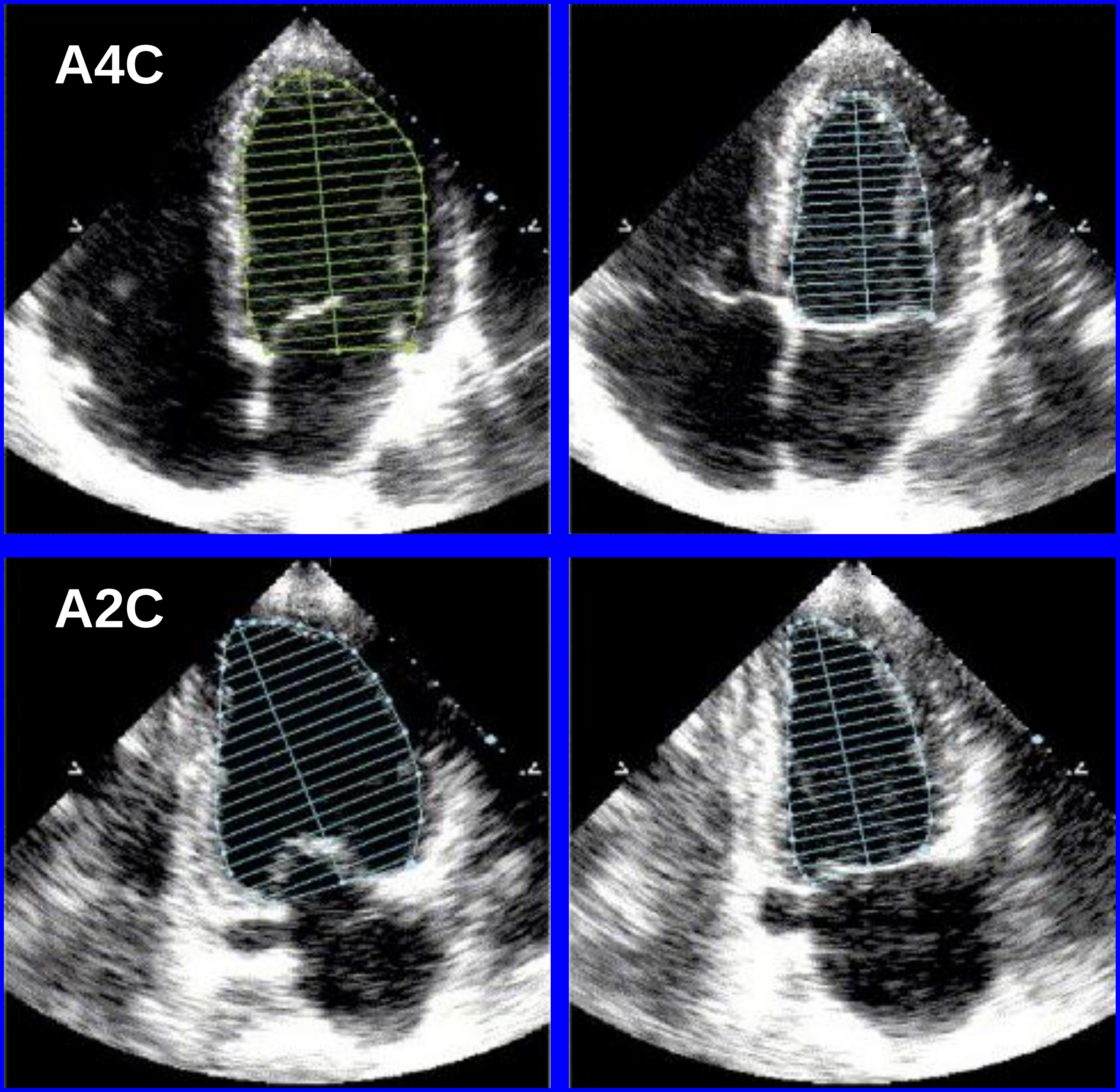


Coefficient of variation 11%

Bias -8 to +4%

Blondheim DS et al, JASE 2010; 23: 258-64

End-diastole End-systole



Modified Simpson's method of discs

Biplane planimetry

LVEDV
LVESV
SV
EF

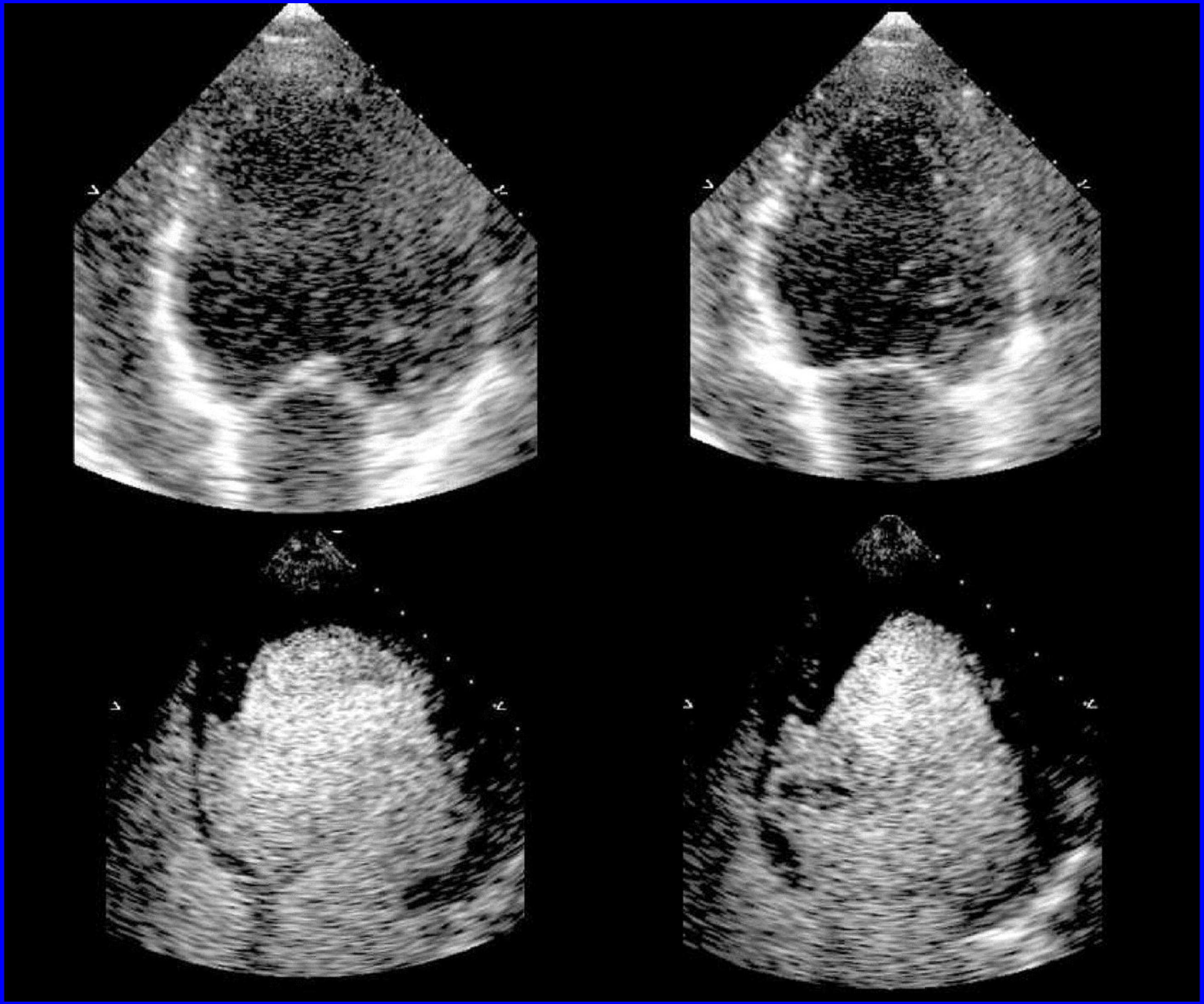
Systematic review of LV quantification by echo

Author	Method	Interobserver variability (1.96SD of differences)	Intraobserver variability
Senior	Simpson's rule	9%	6%
Jensen-Urstad	Simpson's rule	16%	NR
Tsujita-Koroda	Simpson's rule	21% (AQ)	13% (AQ)
		11% (H + AQ)	6% (H + AQ)
Yu	Simpson's rule	8% (echogenic)	11% (echogenic)
		12% (H)	6% (H)
		4% (C)	2% (C)
Berning	WMI	14%	NR
McGowan	WMI	20%	NR
van Royen	Subjective visual	17%	13%
Jensen-Urstad	Subjective visual	8%	NR
van't Hof	Subjective visual	15%	11%

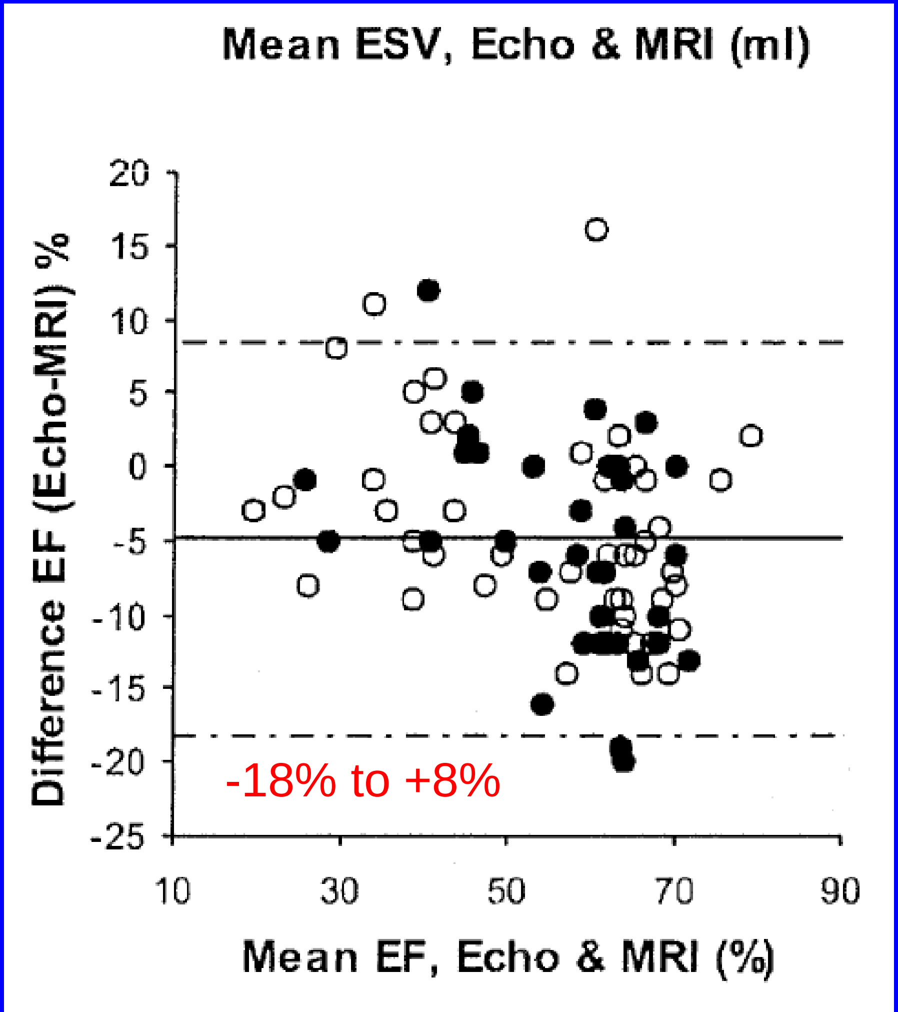
McGowan JH et al, Am Heart J 2003; 146: 388-97

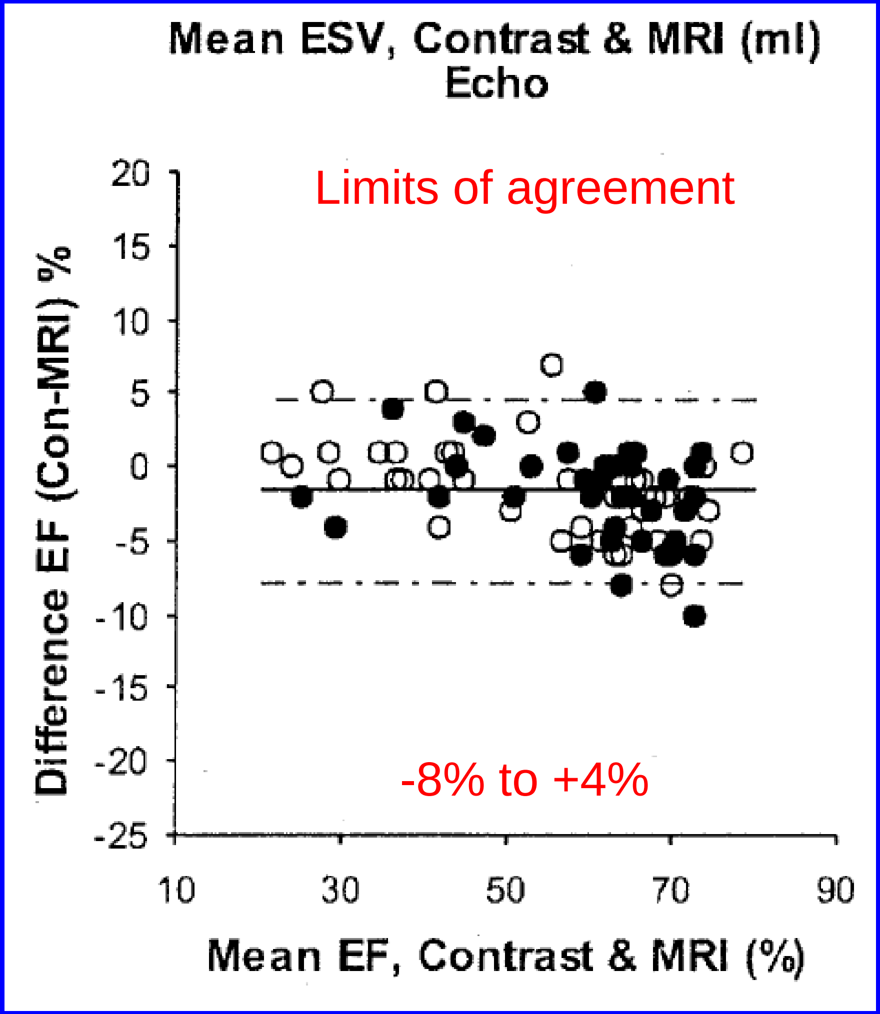
Contrast echo enhancement of LV borders

Recommended if <80% of endocardium not seen



Accuracy of contrast echo to quantify LV function, compared to magnetic resonance imaging (n 110)





Malm S et al et al, JACC 2004; 44: 1030-5

Non-invasive measurement of global LV function

Comparison of imaging modalities

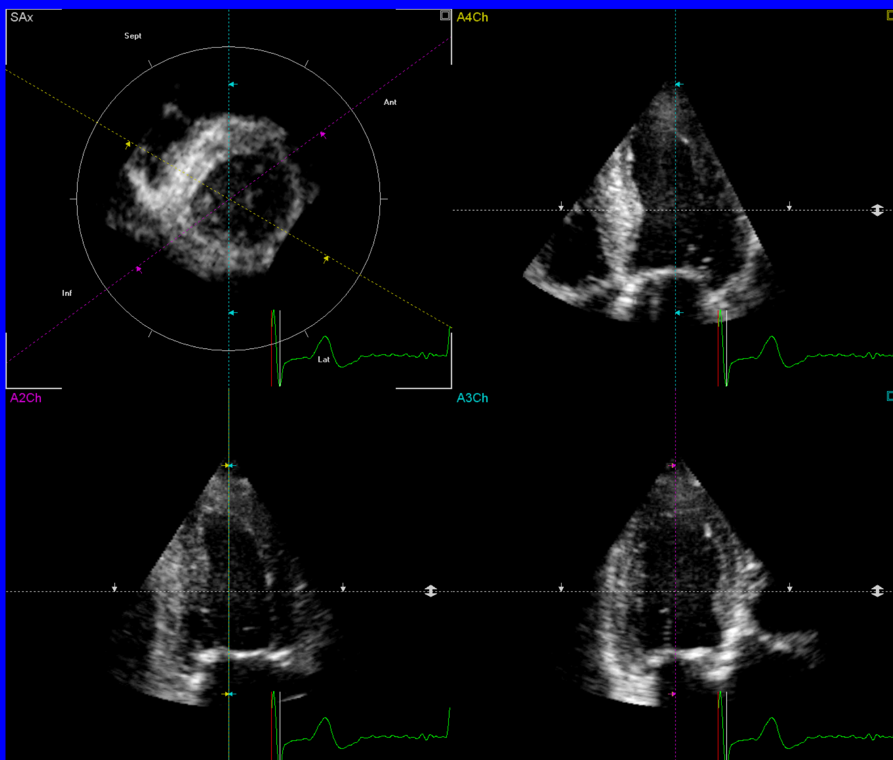
	End-diastolic volume (ml)	End-systolic volume (ml)	Ejection fraction (%)	*n*
Cineventriculography, biplane	187 ± 105	90 ± 84	56.2 ± 18.3	100
Magnetic resonance imaging, SAX	174 ± 50	84 ± 45	54.1 ± 12.9	55
Unenhanced echocardiography	115 ± 53	62 ± 48	50.9 ± 15.3	115
Contrast-enhanced echocardiography	147 ± 60	73 ± 56	54.6 ± 16.8	115

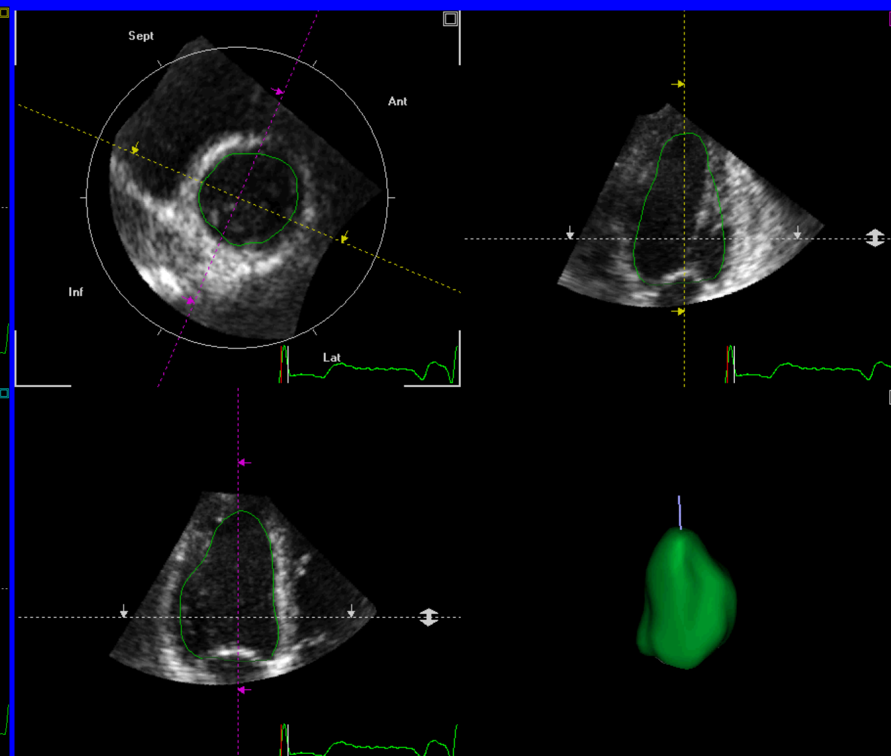
Hoffmann R et al, Eur Heart J 2005; 26: 607-16

Three dimensional echocardiography

Real-time 3D echocardiography *avoids foreshortening* of the LV

Real-time 3D echocardiography *allows automated quantification*

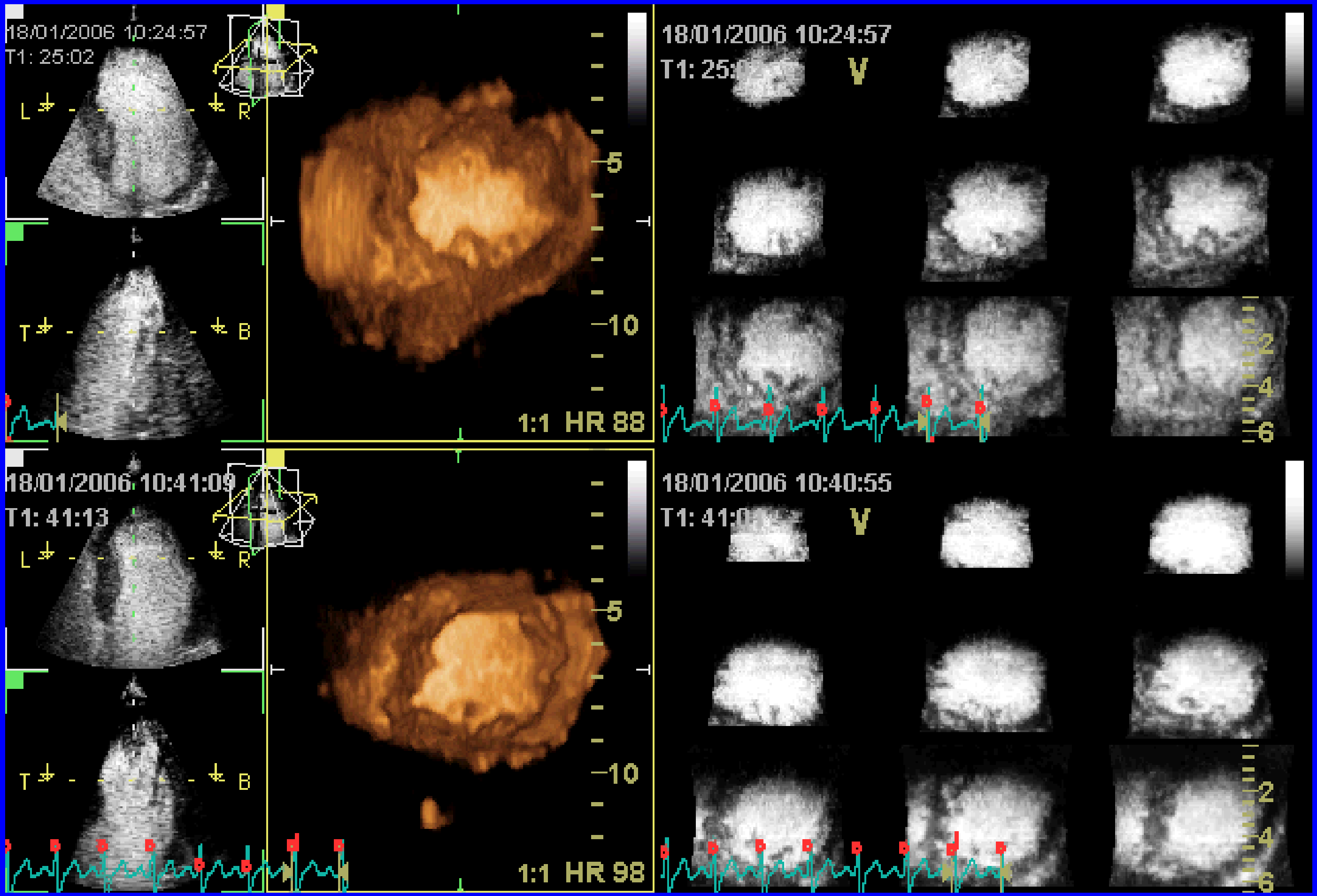




Courtesy of Luigi Badano

Contrast echo to improve LV cavity opacification

Real-time 3D stress echocardiography



LA Brodin

Utility of contrast for LV opacification

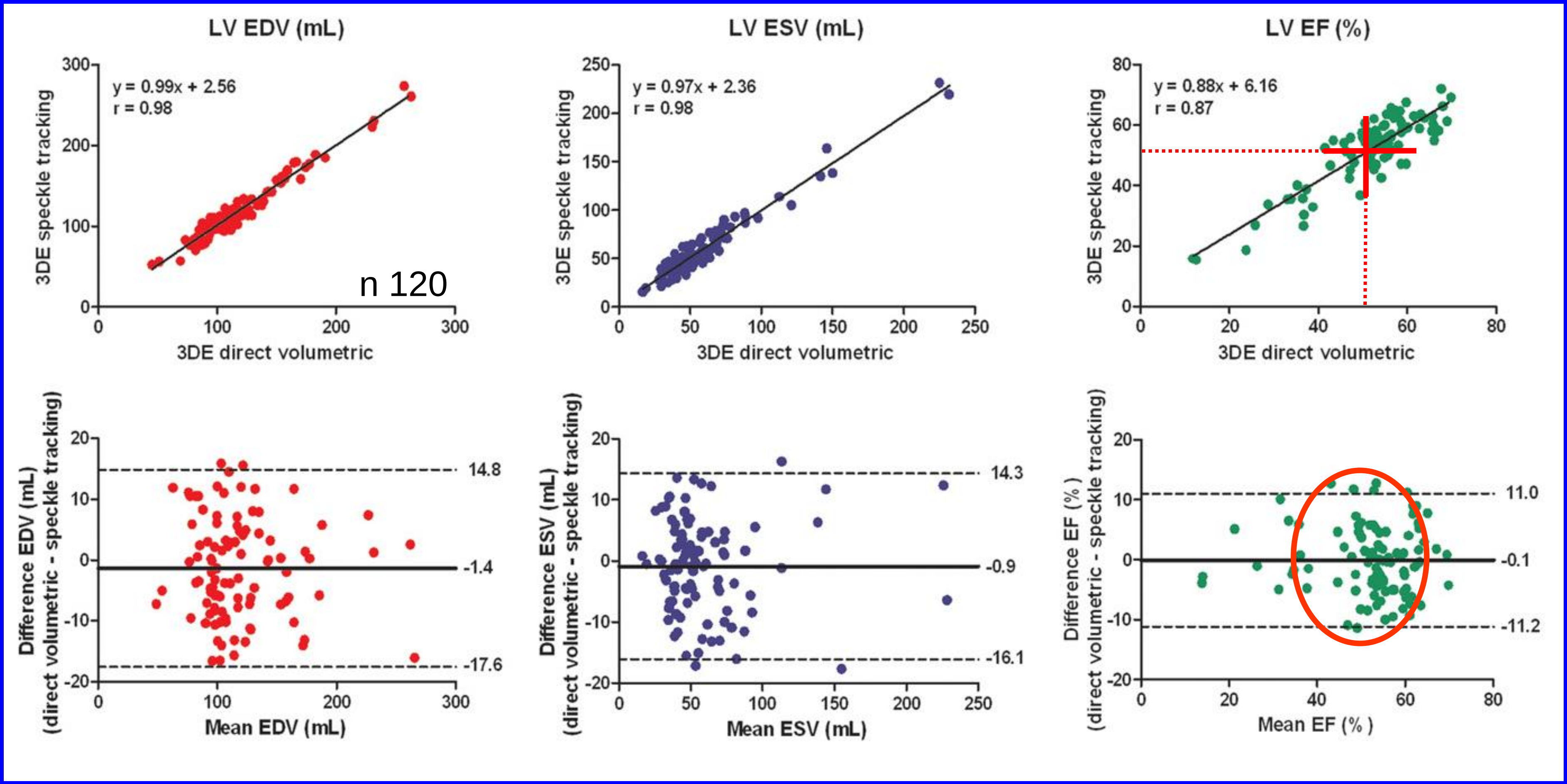
Real-time 3D stress echocardiography

	RT3D	+ LVO
Segments analysable	76%	90%
Image quality index	2.2	3.1
Diagnosis of ischaemia		
by territory (n=108)	79%	88%
kappa	0.26	0.59
by patient (n=36)	72%	89%
kappa	0.43	0.77

Nemes A et al, Am J Cardiol 2007; 99: 275-8

Quantification of LV function: inter-machine comparison

Volumetric 3D (Philips iE33) *vs* speckle 3D (Toshiba Artida 4D)



“comparable & reproducible” “interchangeable .. in daily clinical practice”

Kleijn SA et al, Am J Cardiol 2011; 108: 1038-44

Diagnostic imaging – ***the choice***

- QUALITATIVE

  Subjective

  Insensitive

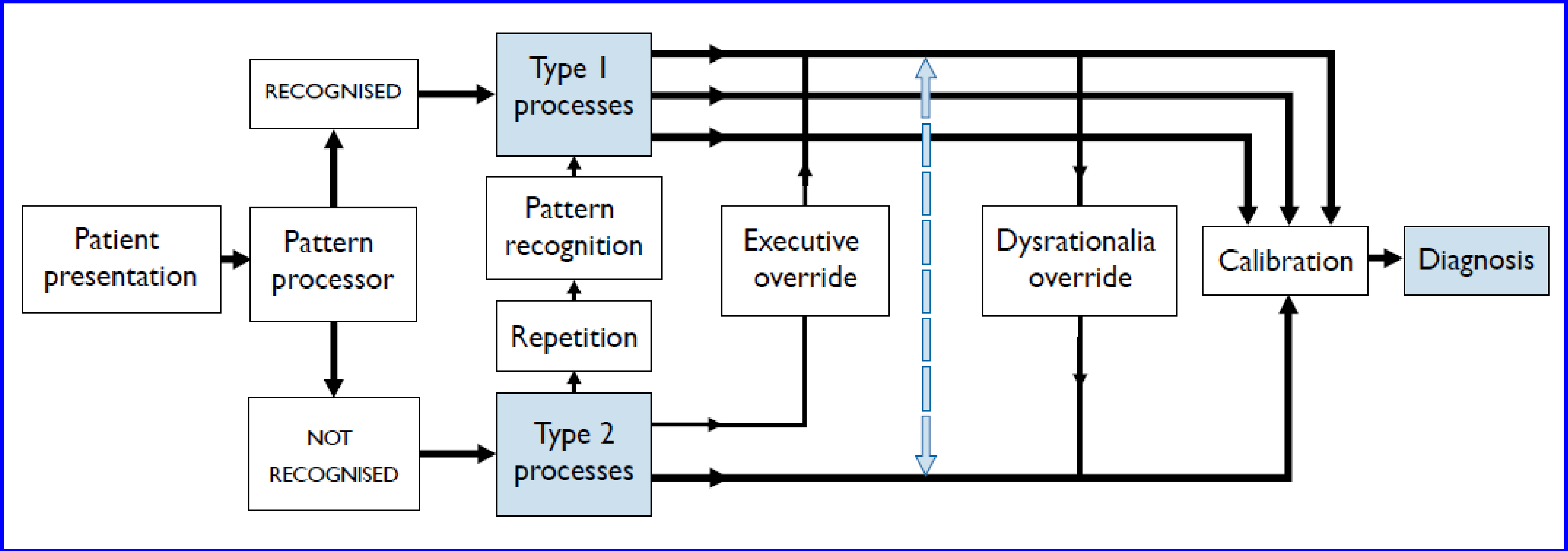
  Imprecise

  Variable

  Categorical

  Quick

Cognitive psychology – models of diagnostic reasoning



Type 1	**Intuitive**	**Type 2**	**Analytical**
	Heuristic		Deductive
	Reflexive		Deliberate
	Fast		Slow
	Vulnerable to bias		Consistent
	Prone to error		Scientific

Croskerry P et al, J Roy Coll Physicians Edin 2011; 41: 155-62

Diagnostic imaging – ***the choice***

- QUALITATIVE

  Subjective

  Insensitive

  Imprecise

  Variable

  Categorical

  Quick

- QUANTITATIVE

  Objective

  More sensitive

  Precise

  Reproducible

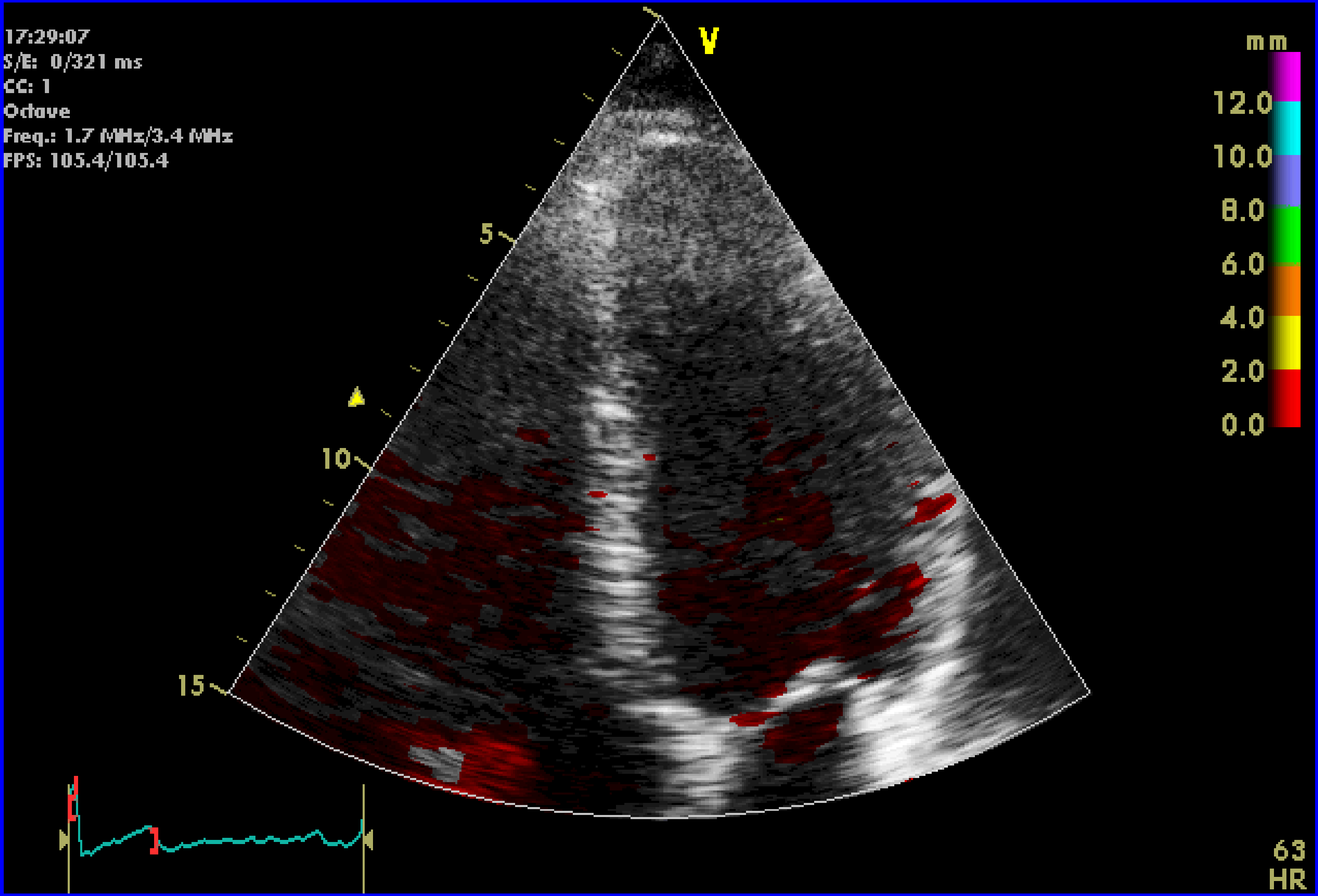
  Continuous

  Time-consuming

How could we improve diagnostic accuracy ?

.. by exploiting computing and information technology

- Normative databases
- Compare each patient to normal values that reflect age, gender, BMI, and risk factors
- Automated quantification / analysis
- Integrated clinical decision aids, algorithms
- Parametric visual displays of quantitative data
  - *measurements, significance levels, z scores*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CC: 1
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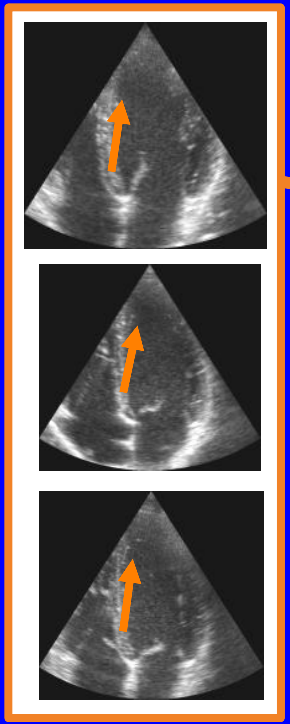
63
HR

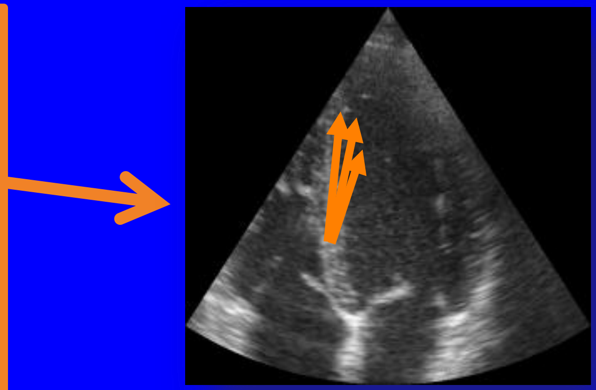
A new concept for diagnosis: a statistical atlas

An average heart with population variability

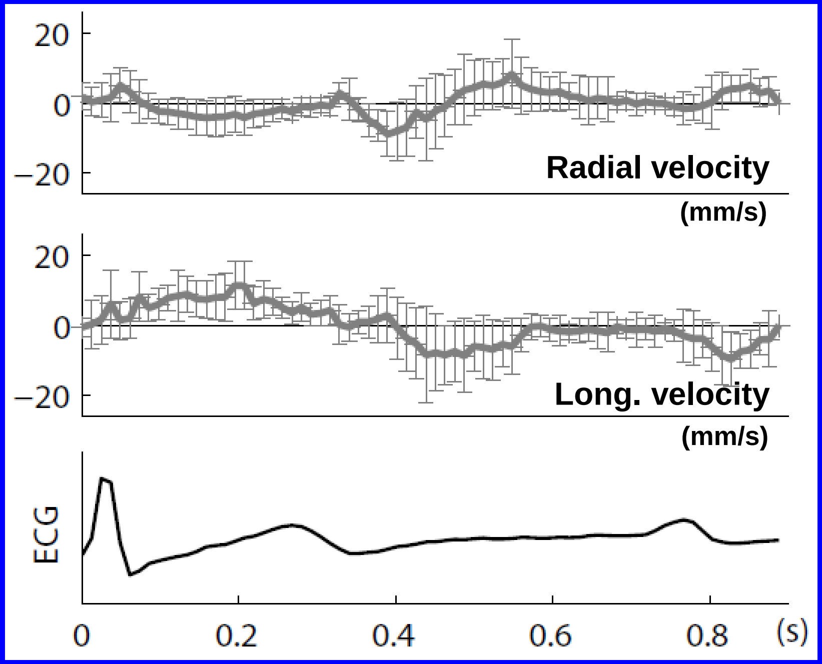


Healthy subjects

Atlas



Derived from fully automated 3D/4D analysis of velocity using tracking technique

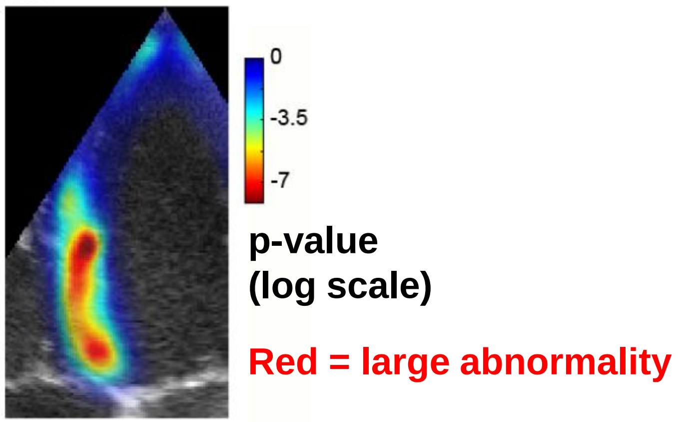


Temporal display of mean velocities with variance, at a particular location

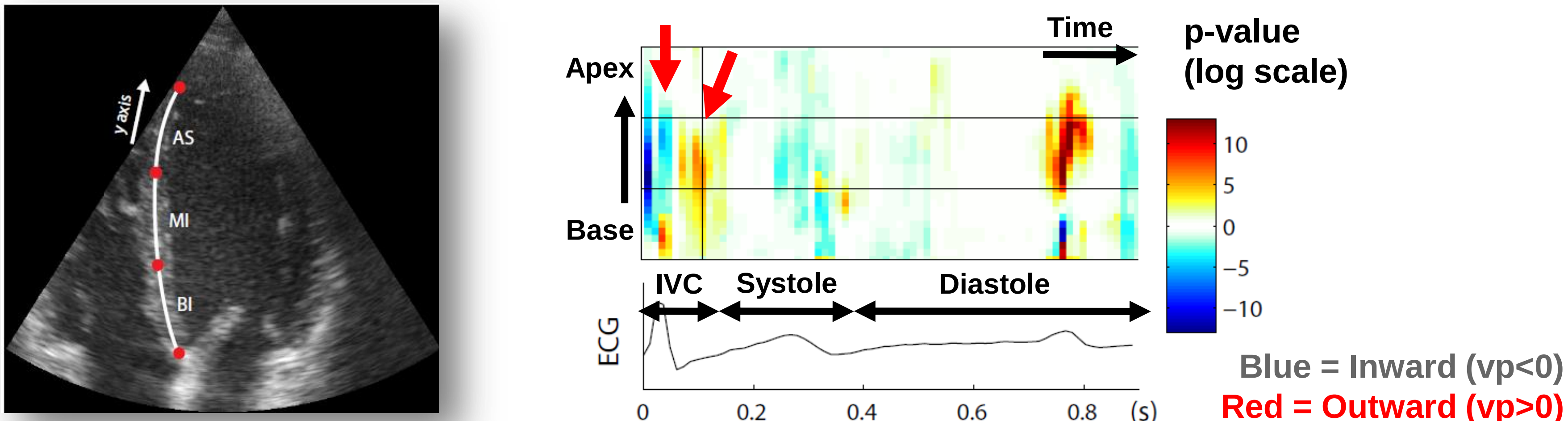
Duchateau N et al, Med Image Analysis 2011; 15: 316-28

Parametric displays of statistically abnormal myocardial motion

Local maps at fixed time t

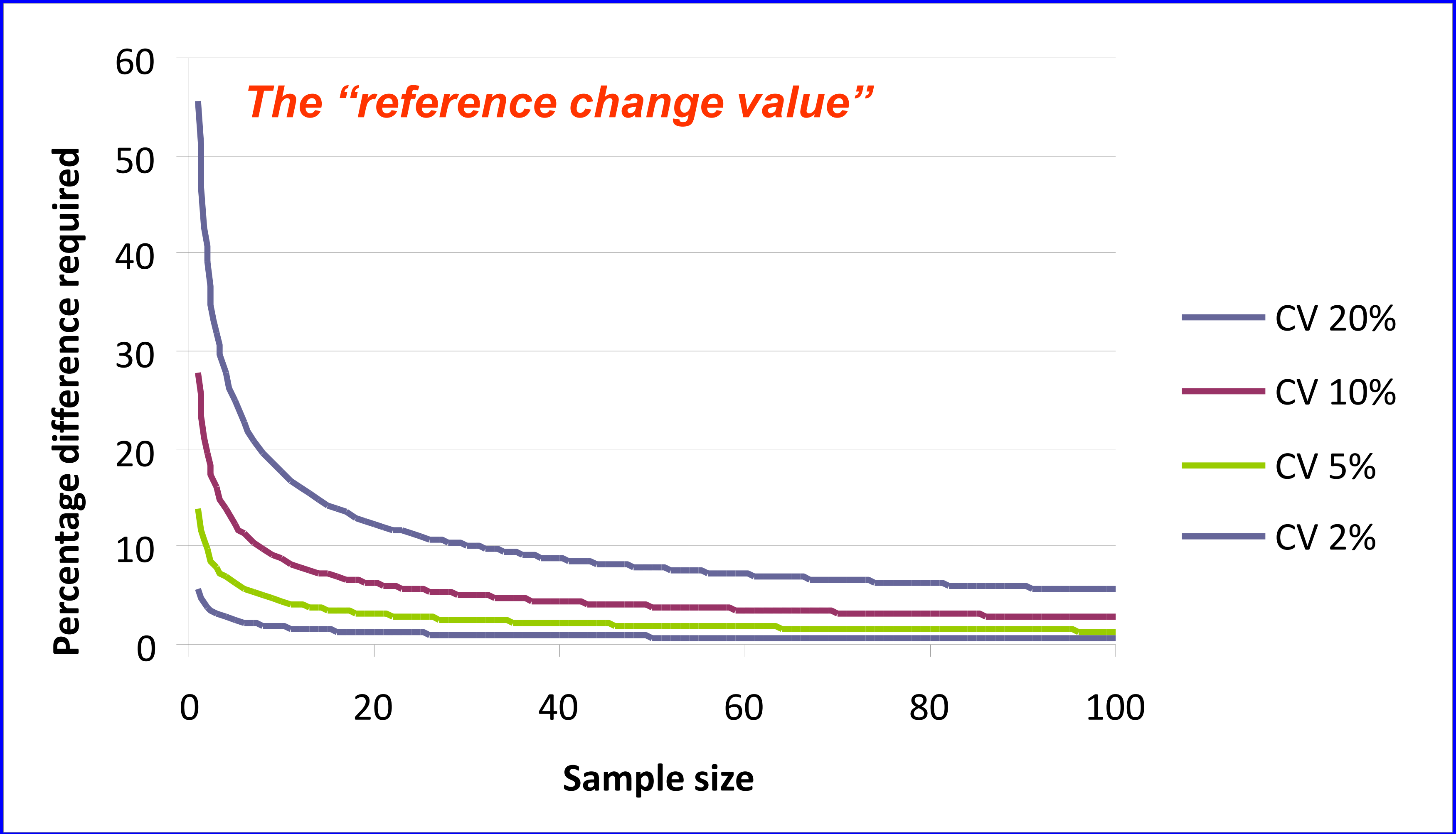


Spatiotemporal maps of abnormality



Duchateau N et al, Med Image Analysis 2011; 15: 316-28

The implications of reproducibility



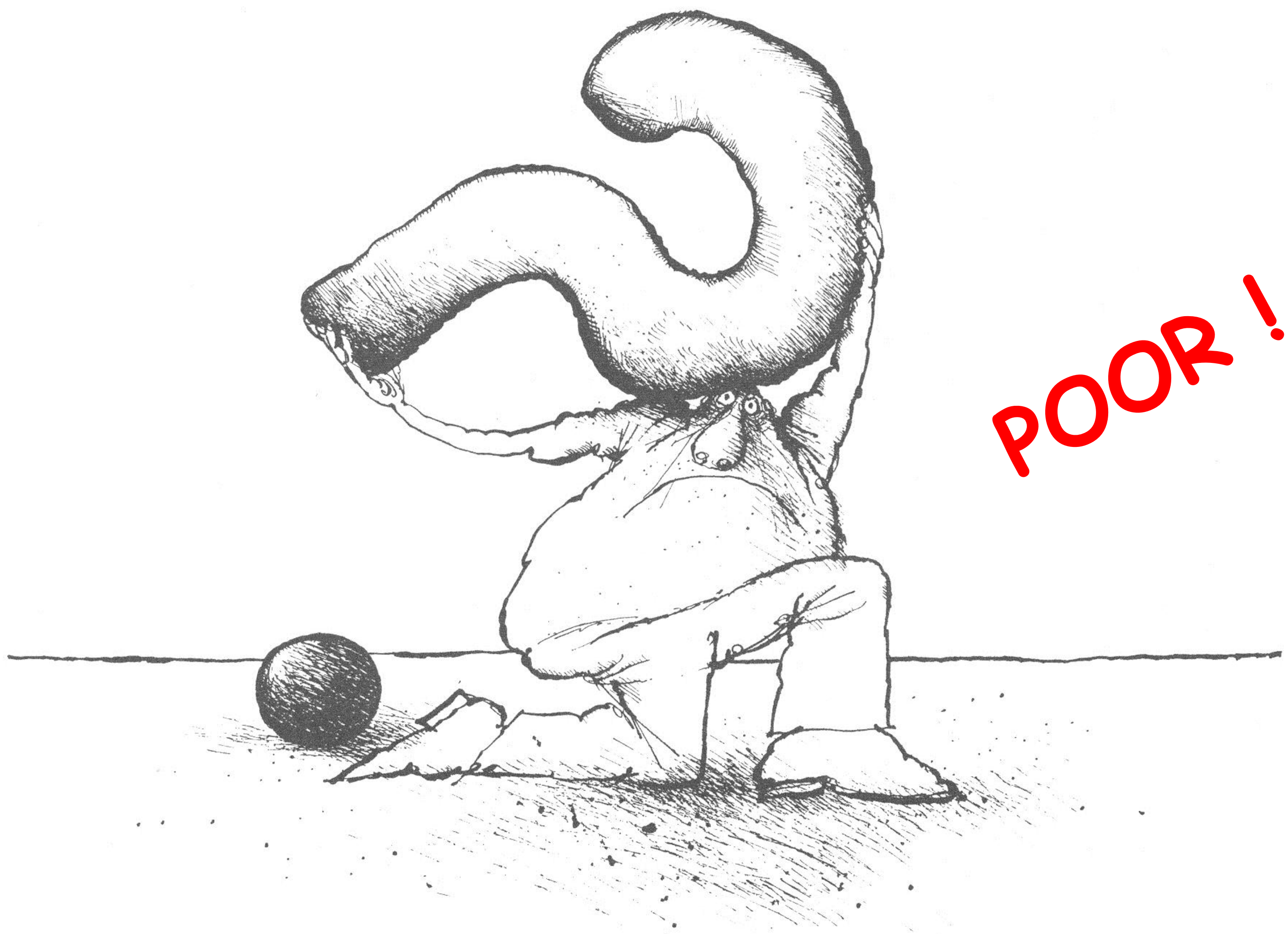
Courtesy of Professor Frank Dunstan

Statistical power by sample size & reproducibility

Significant differences that can be demonstrated

Number of subjects per sample	Coefficient of variation				
	2%	5%	10%	20%	30%
1	6	14	28	55	83
10	2	4	9	18	26
20	1	3	6	12	19
50	1	2	4	8	12
100	1	1	3	6	8

How good are we at quantifying LV function ?



POOR !

Each echo lab needs its own quality control