Echocardiographic Cardiovascular Risk Stratification: Beyond Ejection Fraction

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Disclosures

- Financial – none
- Images – “borrowed”

Objectives

- Understand the concept of clinical risk stratification
- Learn about the application of echocardiography to cardiovascular risk stratification
- Review specific echocardiographic parameters and their clinical significance

Diagnosis: To Be, or Not To Be…

To evaluate…

- Abnormal EKG
- Murmur
- Chest pain
- Shortness of breath/dyspnea
- Lightheadedness/dizziness/presyncope/syncope
- Sepsis
- Stroke

…and diagnose or rule out…

- Cardiomyopathy
- Valvular disease
- Ischemia
- Heart failure
- Pericardial effusion
- Endocarditis
- Thrombus

Clinical Risk Stratification (Prognosis)

- “What are the risk/chances/odds that my patient will have XYZ-outcome?”

- Death
- Myocardial infarction
- Stroke / systemic embolism
- Congestive heart failure
- New onset atrial fibrillation
- Syncope
- Hospitalization
- Coronary revascularization (PCI or CABG)
- Valvular surgery or procedure
- Pacemaker / defibrillator

Risk Stratification

Clinical variables (the "H&P")

Age, Sex, Ethnicity
History of present illness / Symptoms
Past medical history / Comorbidities
Social history, Family history

Vital signs, Physical exam findings

EKG variables

Rhythm, Rate
Intervals, QRS

Imaging

Other testing

Laboratory variables
CBC, Chem, TFTs
FLP, A1C, BNP, hs CRP, Troponin

Pretest probability
Clinical decision making

“There’s just *so much* information in an echocardiogram.”

- Left ventricular size, structure and function
- Valvular stenosis and regurgitation

- Left atrium
- Right ventricular size, structure and function
- Hemodynamics
  - Inferior vena cava size
  - Left ventricular outflow tract VTI
- Aortic root

Technical Difficulties…

- "Echocardiography is operator dependent"
- Accuracy depends on…
  - Sonographer
  - Interpreting physician
  - Instrument
- Some findings can change significantly over short periods of time

Left Ventricle

- Size
- Structure
  - Wall thickness
  - Shape (aneurysm, spherical remodeling, pattern of hypertrophy, etc.)
- Systolic function
  - **EJECTION FRACTION**
  - Regional wall motion abnormalities
  - Paradoxical septal motion
- Diastolic function

- Tissue Doppler, strain, strain rate, etc.

Valvular Disease

- Regurgitation
- Stenosis
- Other (rheumatic, congenital, etc.)

- Mild, mild-moderate, moderate, moderate-severe, severe – a gradient of risk
- Findings, particularly for regurgitation, are dynamic

Recommendations for Chamber Quantification: A Report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, Developed in Conjunction with the European Association of Echocardiography, a Branch of the European Society of Cardiology

Members of the Chamber Quantification Writing Group are: Roberto M. Lang, MD, FASE, Michelle Bierig, MPH, RDCS, FASE, Richard B. Devereux, MD, Frank A. Flachskampf, MD, Elyse Foster, MD, Patricia A. Pellikka, MD, Michael H. Picard, MD, Mary J. Roman, MD, James Seward, MD, Jack S. Shanewise, MD, FASE, Scott D. Solomon, MD, Kirk T. Spencer, MD, FASE, Martin St John Sutton, MD, FASE, and William J. Stewart, MD

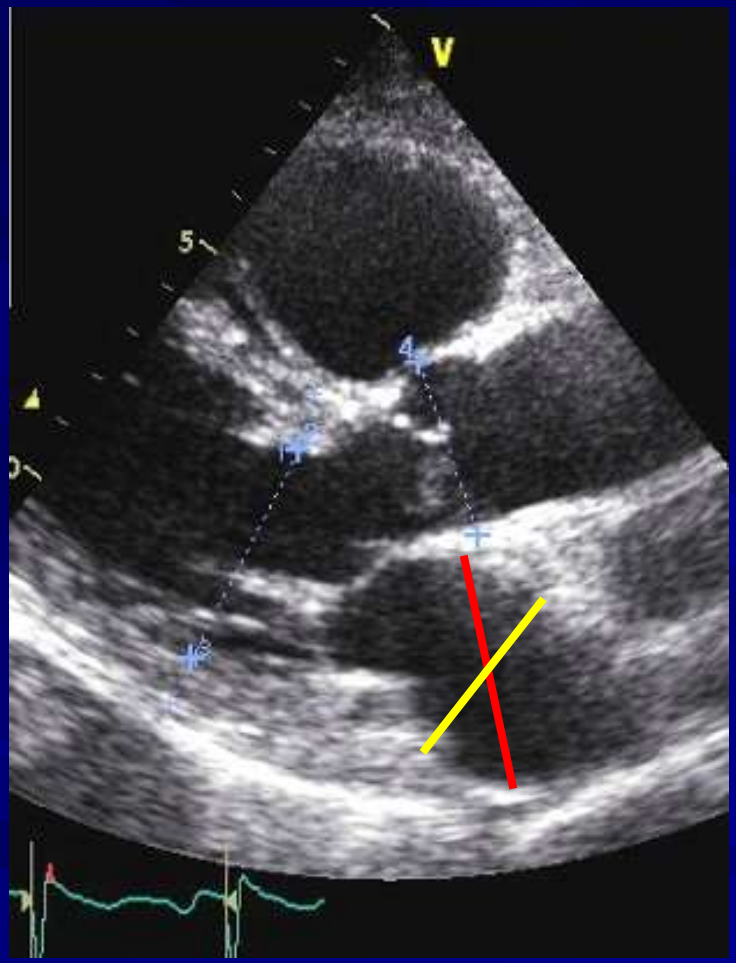
Quantification of cardiac chamber size, ventricular mass, and function ranks among the most clinically important and most frequently requested tasks of echocardiography. Standardization of chamber quantification has been an early concern in echocardiography and recommendations on how to measure such fundamental parameters are among the most often cited articles in the field.[1,2] During the last decades, echocardiographic methods and techniques have improved

monic imaging, fully digital machines, left-sided contrast agents, and other technologic advancements.

Furthermore, echocardiography has become the dominant cardiac imaging technique, which, because of its portability and versatility, is now used in emergency, operating, and intensive care departments. Standardization of measurements in echocardiography has been inconsistent and less

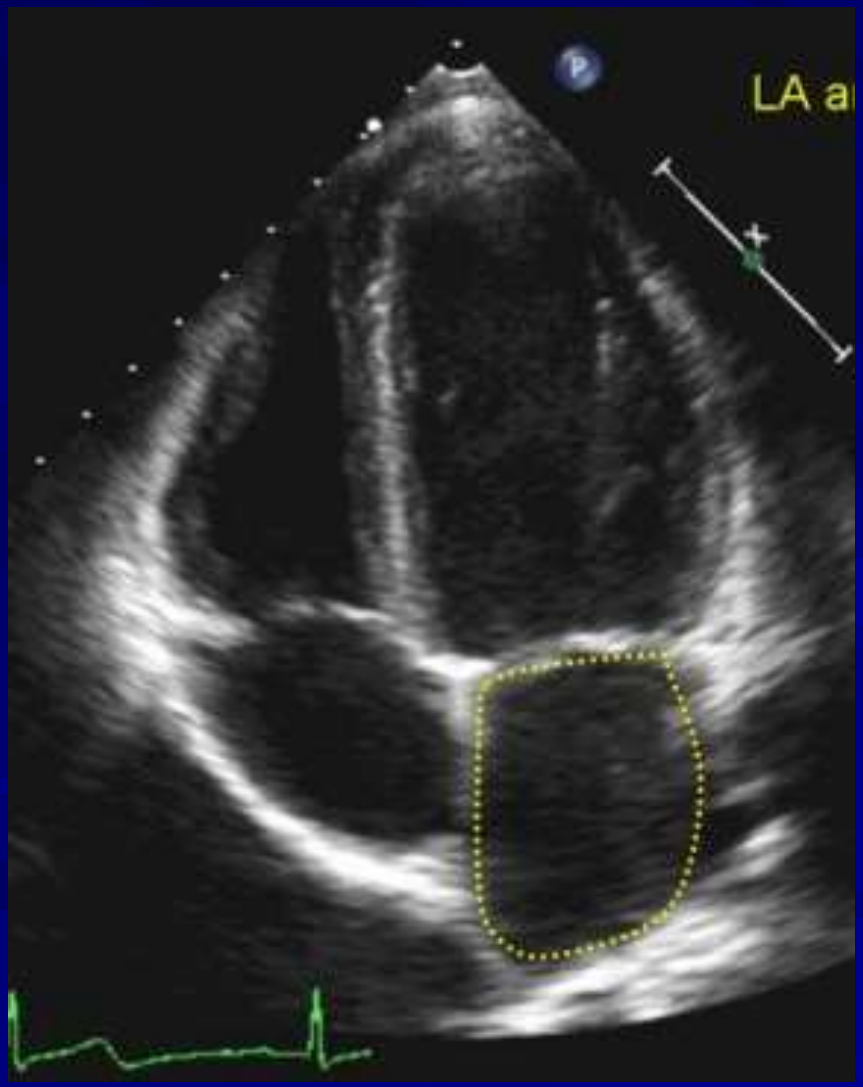
What is Normal?
(i.e., the Importance of Indexing)

Left Atrium: Diameter

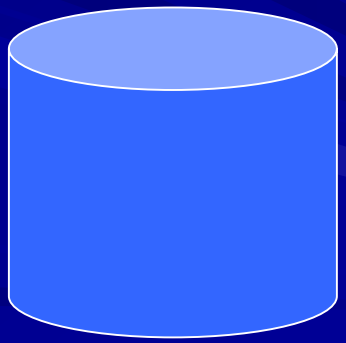


- 1 dimensional
- 2D preferred over M-mode
- Simple, easy, fast
- Overly simplistic

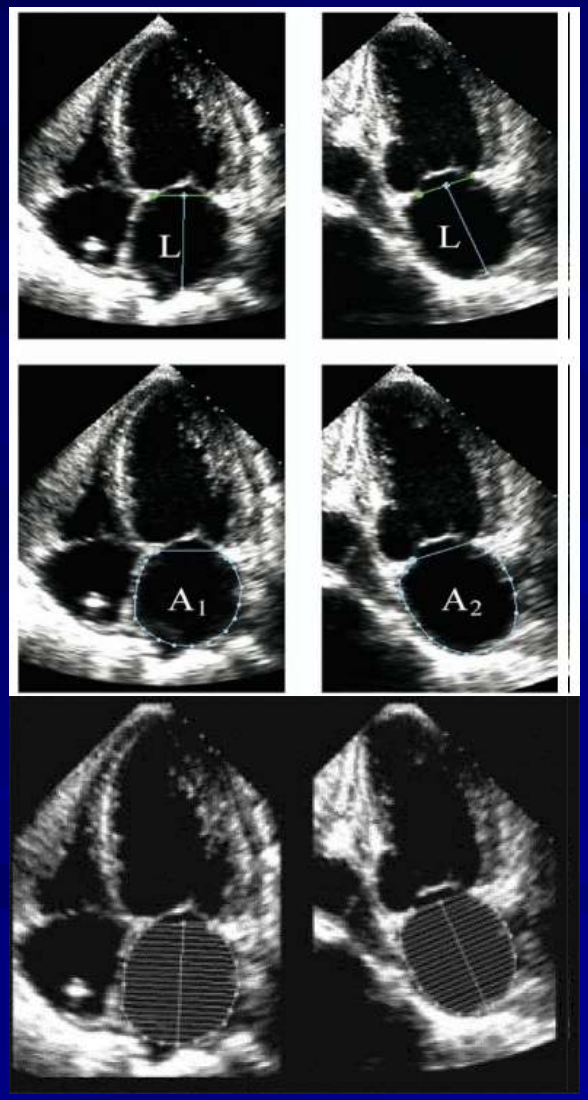
Left Atrium: Area



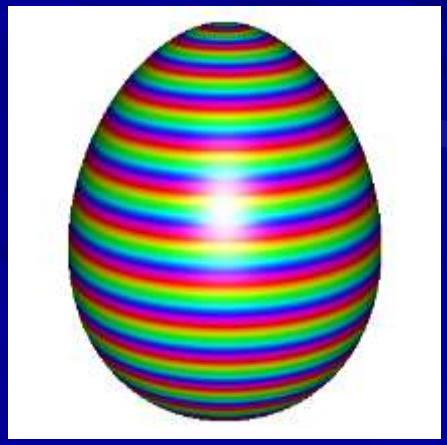
- Somewhat more accurate
- Simple, easy, fast
- Overly simplistic

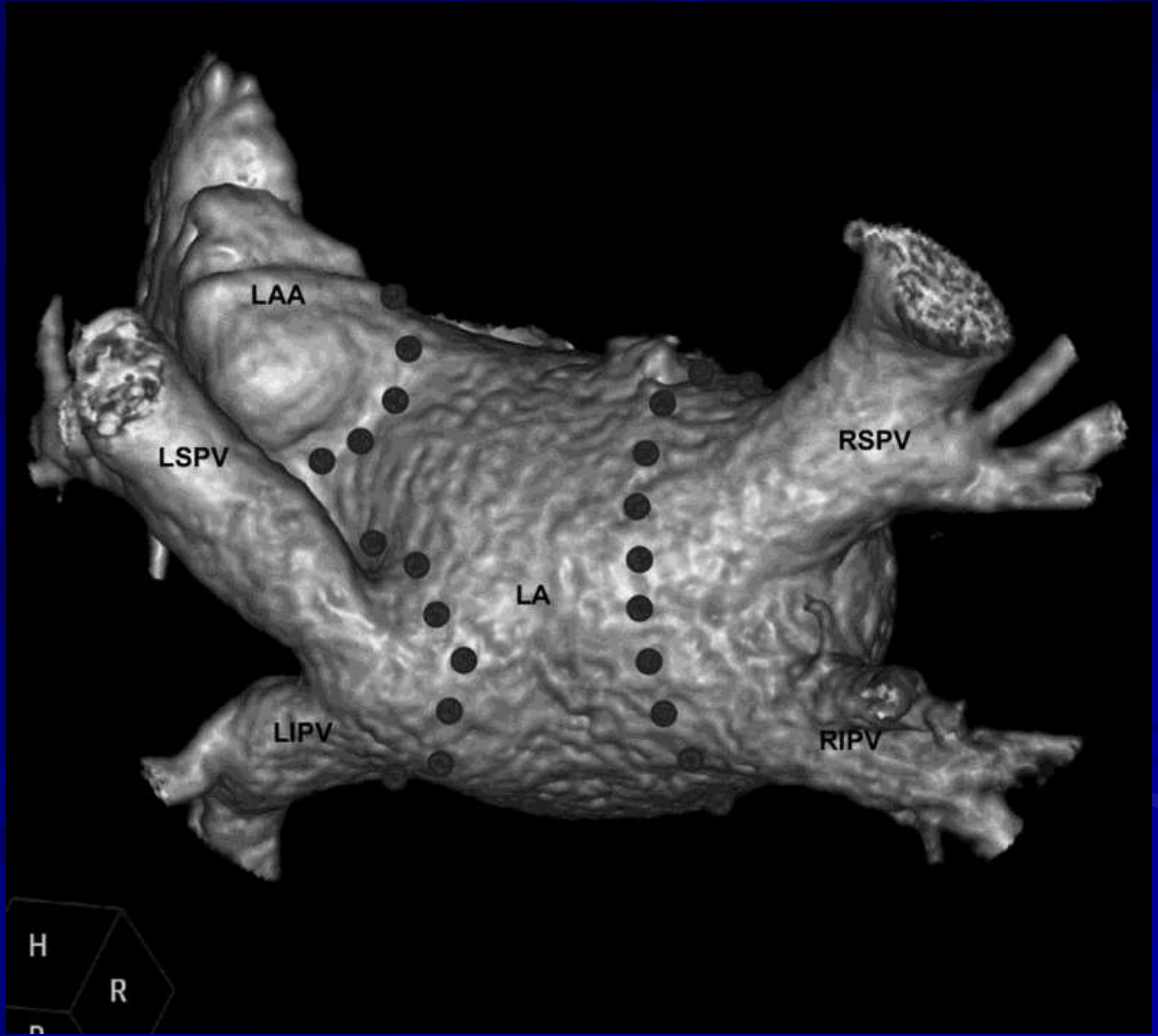


Left Atrium: Volume



- Ellipsoid (area-length) or Simpson's
- Biplane preferred over single plane
- More time consuming
- Still overly simplistic, but getting closer…



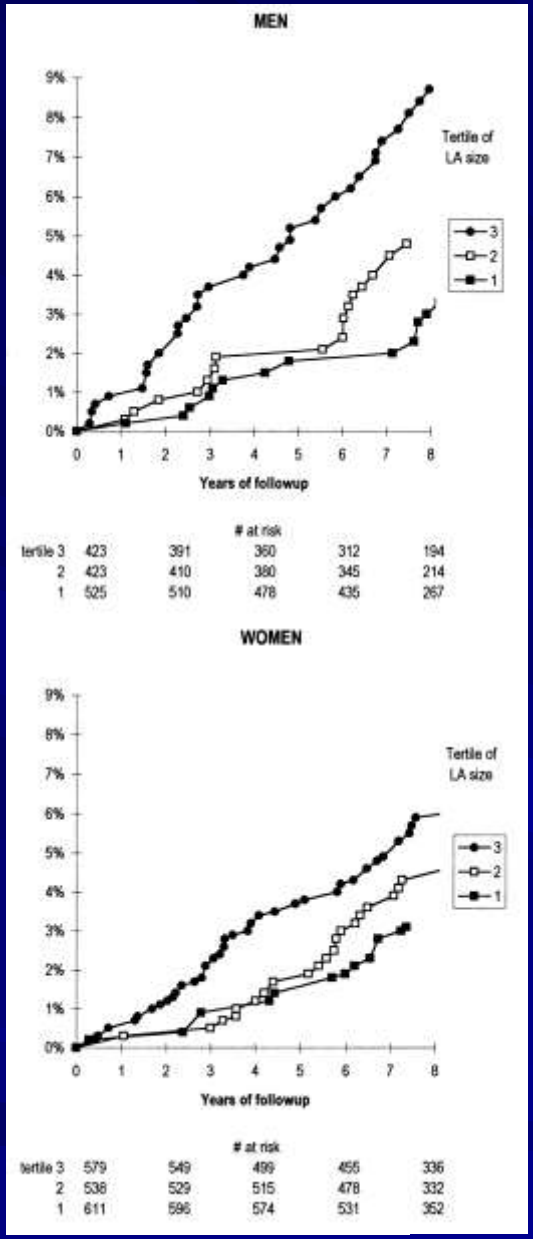

LAA
LSPV
RSPV
LA
LIPV
RIPV
H
R

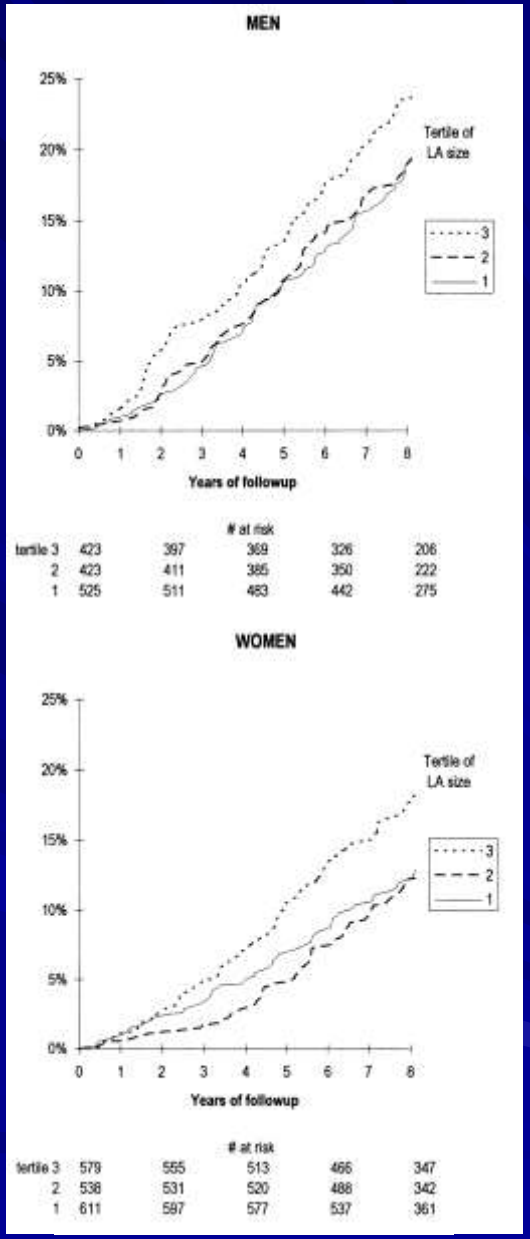
	Women			
	Reference range	Mildly abnormal	Moderately abnormal	Severely abnormal
Atrial dimensions				
LA diameter, cm	2.7–3.8	3.9–4.2	4.3–4.6	≥4.7
LA diameter/BSA, cm/m^2	1.5–2.3	2.4–2.6	2.7–2.9	≥3.0
RA minor-axis dimension, cm	2.9–4.5	4.6–4.9	5.0–5.4	≥5.5
RA minor-axis dimension/BSA, cm/m^2	1.7–2.5	2.6–2.8	2.9–3.1	≥3.2
Atrial area				
LA area, cm^2	≤20	20–30	30–40	>40
Atrial volumes				
LA volume, mL	22–52	53–62	63–72	≥73
LA volume/BSA, mL/m^2	***22 ± 6***	***29–33***	***34–39***	***≥40***

	Men			
	Reference range	Mildly abnormal	Moderately abnormal	Severely abnormal
Atrial dimensions				
LA diameter, cm	3.0–4.0	4.1–4.6	4.7–5.2	≥5.2
LA diameter/BSA, cm/m^2	1.5–2.3	2.4–2.6	2.7–2.9	≥3.0
RA minor-axis dimension, cm	2.9–4.5	4.6–4.9	5.0–5.4	≥5.5
RA minor-axis dimension/BSA, cm/m^2	1.7–2.5	2.6–2.8	2.9–3.1	≥3.2
Atrial area				
LA area, cm^2	≤20	20–30	30–40	>40
Atrial volumes				
LA volume, mL	18–58	59–68	69–78	≥79
LA volume/BSA, mL/m^2	***22 ± 6***	***29–33***	***34–39***	***≥40***

So What?

- Increased LA size is a marker of severity and chronicity of LV diastolic dysfunction, increased LA (and LV) filling pressures, and risk for…
  - Atrial fibrillation – incidence and recurrence
  - Heart failure – hospitalization and death
  - Stroke
  - Death after myocardial infarction
  - Death
- Advancing age alone does not independently contribute to LA enlargement; the indexed volume from childhood onward in normal healthy patients does not change significantly
- Sex differences in LA volume can largely be accounted for by the differences in body surface area between men and women





Benjamin E J et al. "Left Atrial Size and the Risk of Stroke and Death." Circulation. 1995;92:835-841

Case – 66 yo W with palpitations

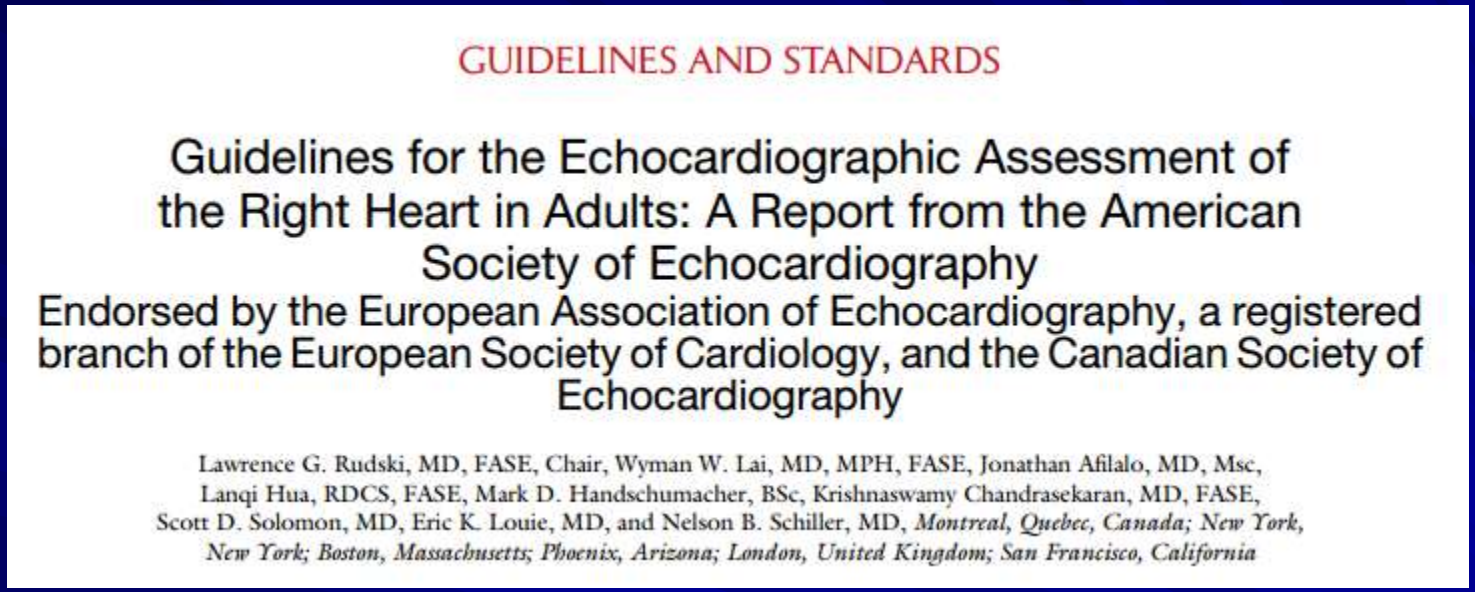
- 66 yo African American woman with mild palpitations described as “fluttering” most often at night when trying to sleep, sometimes during the day when sitting quietly at her desk, two or three times a week for the last six weeks – no other symptoms – sent by PMD
- Admits to increased stress at work, considering retirement
- PMH: HTN, overweight
- Married, two grown children
- Administrative assistant
- Never smoked, exercises by walking around the neighborhood 30-45 minutes three times a week with husband
- PE – normal VS, BMI 30, II/VI HSM @ LLSB
- EKG – NSR, possible LAE, NSTTs
- PMD performed routine labs (CBC, Chem, TFTs) – all normal

Case

- Possible diagnoses
  - Stress-related (benign)
  - Primary arrhythmias – **atrial fibrillation**
  - Secondary arrhythmias (due to other underlying disease, i.e cardiomyopathy)
  - Other medical problem (hyperthyroidism, anemia, etc.)

- Echo? Holter? Event monitor? Xanax?

Right Ventricle: Neglected



GUIDELINES AND STANDARDS

Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography

Endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography

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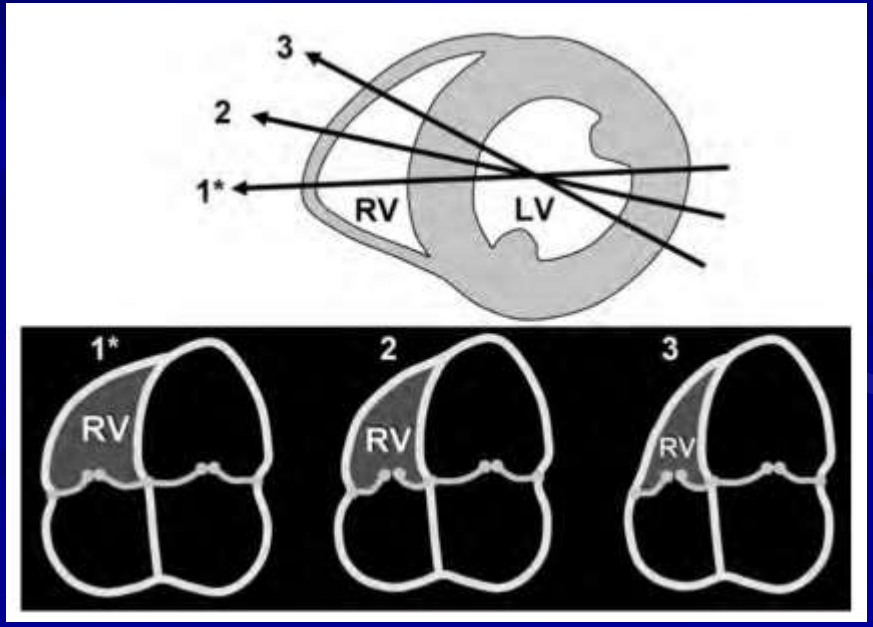
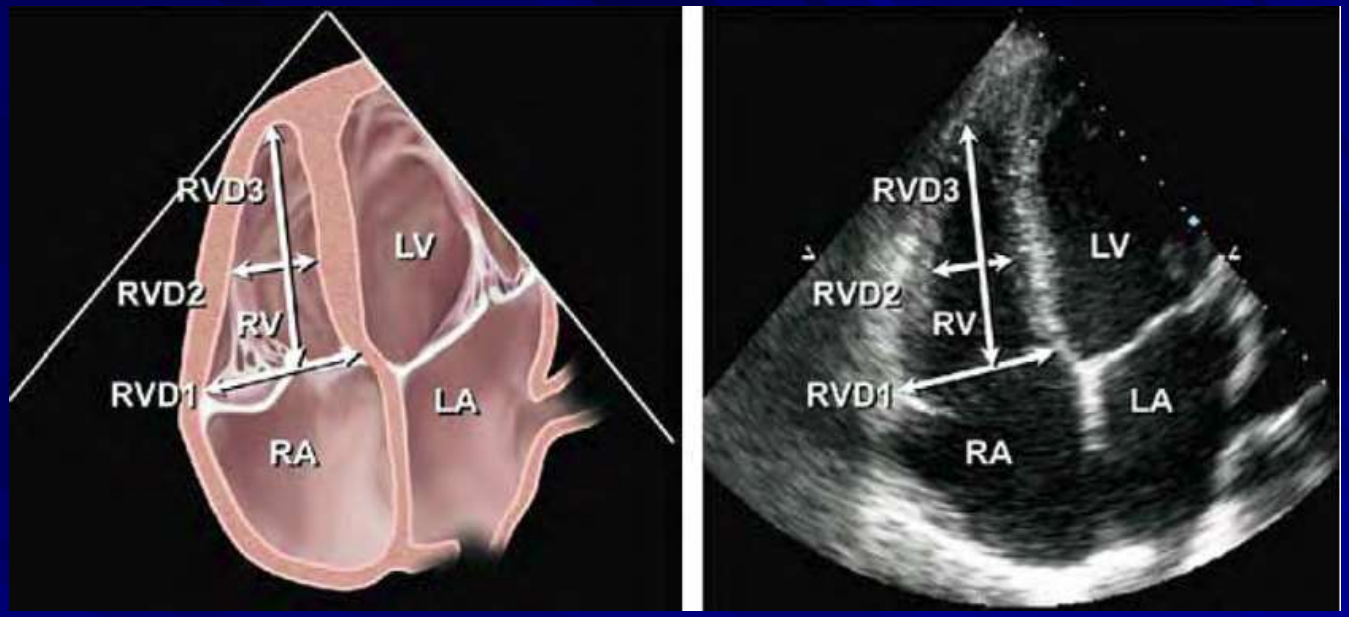
- Size
- Wall thickness
- Systolic function

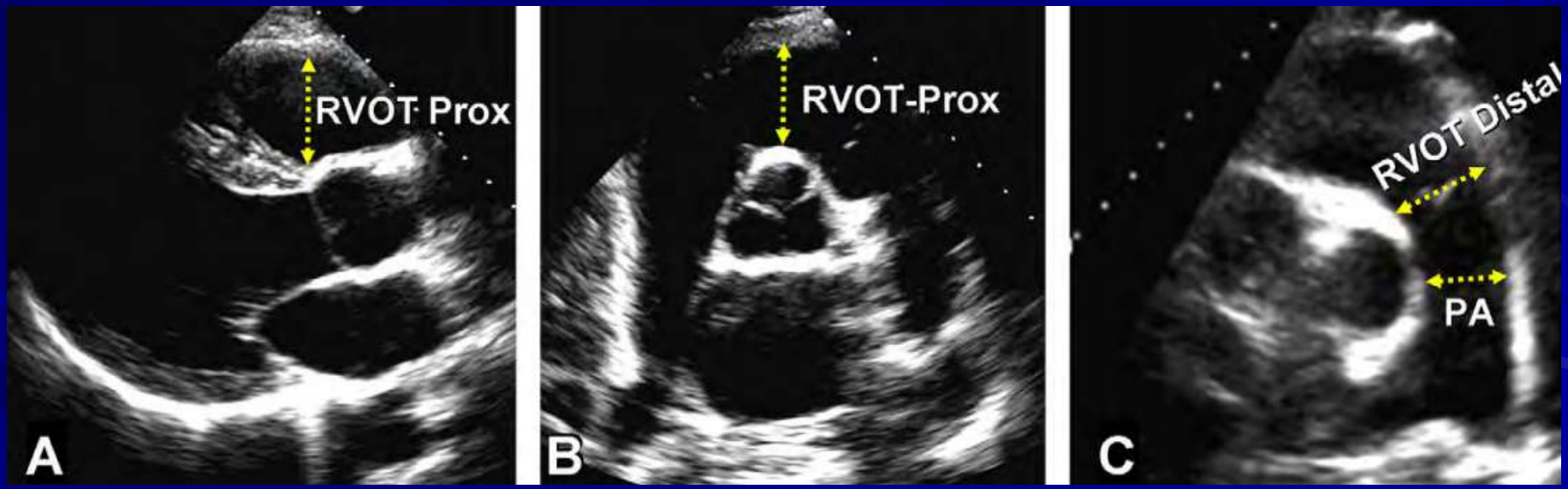
- Diastolic function
- Tissue Doppler, strain, strain rate

RV Size and Function: Qualitative "method" (i.e. eyeball it)

- **Size**
  - Mild – smaller than LV, not reaching the apex
  - Moderate – similar to LV, sharing the apex
  - Severe – larger than LV, apex-forming
- **Function**
  - Wall motion
  - "TAPSE"




RVD3
RVD2
RVD1
RV
LV
LA
RA
RVD3
RVD2
RVD1
RV
LV
LA
RA


RVOT Prox
RVOT-Prox
RVOT Distal
PA
A
B
C

So What?

- The RV is not just a conduit, it provides the entire cardiac output… to the lungs
- Size and function have prognostic implications on:
  - Congenital heart disease
  - Pulmonary embolism
  - Pulmonary arterial hypertension
  - Myocardial infarction
  - Left sided systolic heart failure

Hemodynamics: IVC

Table 3 Estimation of RA pressure on the basis of IVC diameter and collapse

Variable	Normal (0-5 [3] mm Hg)	Intermediate (5-10 [8] mm Hg)		High (15 mm Hg)
IVC diameter	≤2.1 cm	≤2.1 cm	>2.1 cm	>2.1 cm
Collapse with sniff	>50%	<50%	>50%	<50%
Secondary indices of elevated RA pressure				• Restrictive filling • Tricuspid E/E′ > 6 • Diastolic flow predominance in hepatic veins (systolic filling fraction < 55%)

- Size ~ right atrial pressure
- ASE recommends:
  - 0.5 to 3 cm proximal to hepatic vein
  - Sniff and quiet respiration
  - Can also use short axis view (cross section) to rule out translation of the IVC into another imaging plane
  - Dilated IVC may be normal in young athletes
  - Not reliable in mechanically ventilated patients (<1.2 cm accurately identifies hypovolemic patients)

So What?

- Rapid assessment of volume status
- PASP = RVSP + RAP
- Systemic Vascular Resistance (SVR) =

$$\frac{\text{MAP} - \text{CVP (RAP)}}{\text{CO}}$$

- Non-invasive pulmonary artery (Swan-Ganz) catheterization

Hemodynamics: LVOT VTI

- Not only for AS...
- Can use LVOT VTI to estimate CO
- Poor CO is half the diagnosis of cardiogenic shock
- Also useful to identify high CO

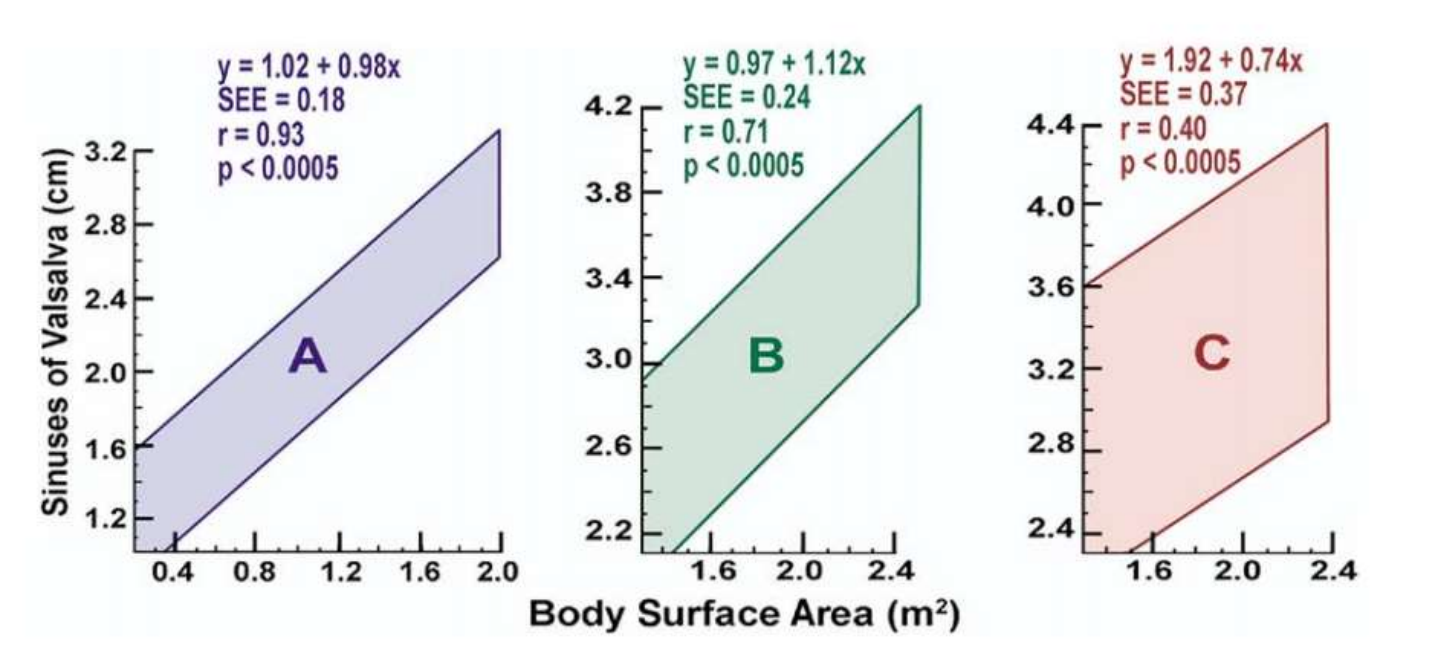
INTERMACS Official Shorthand

Category	Shorthand	Life Expectancy
1. Critical Cardiogenic Shock	"Crash & Burn" →	Hours
2. Progressive Decline	"Sliding Fast" ↘	Days to Weeks
3. Stable but Inotrope Dependent	"Stable but Dependent"	Weeks
4. Recurrent Advanced Heart Failure	"Frequent Flyer"	Weeks to Months if baseline is restored
5. Exertion Intolerant	"Housebound"	Weeks to Months
6. Exertion Limited	"Walking Wounded"	Months if nutrition and activity maintained

Source: INTERMACS quarterly statistical report released June 2, 2009

Aortic Root

- TTE - parasternal long axis
- TEE provides much more complete exam
- Aortic root diameter at the sinuses of Valsalva is related most strongly to BSA and age
- 2D more accurate than M-mode (which underestimates)



So What?

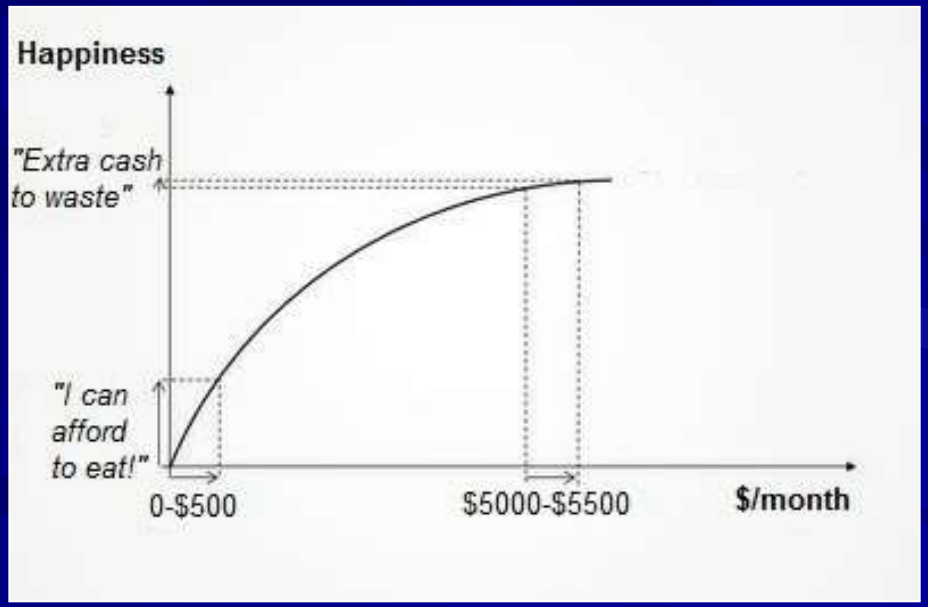
- Aortic root dilatation associated with…
  - Bicuspid aortic valve
  - Marfan's
  - Aortic regurgitation
  - Risk for aortic dissection
  - Risk for aortic rupture
- TTE allows for identification and surveillance of at-risk patients

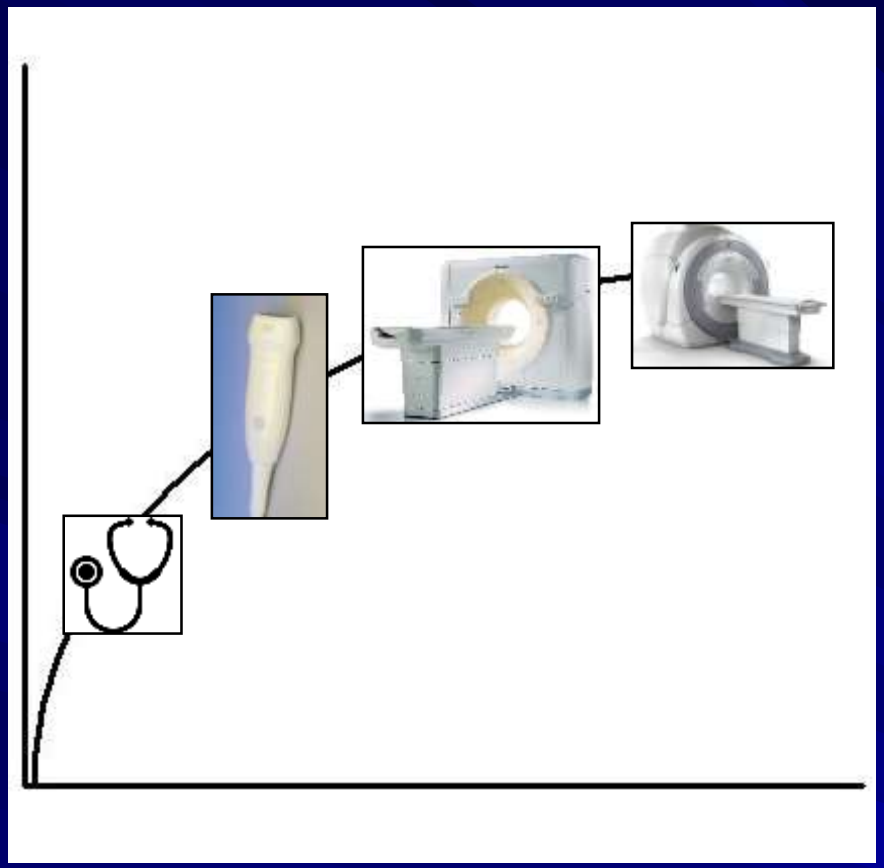
Technical Difficulties…

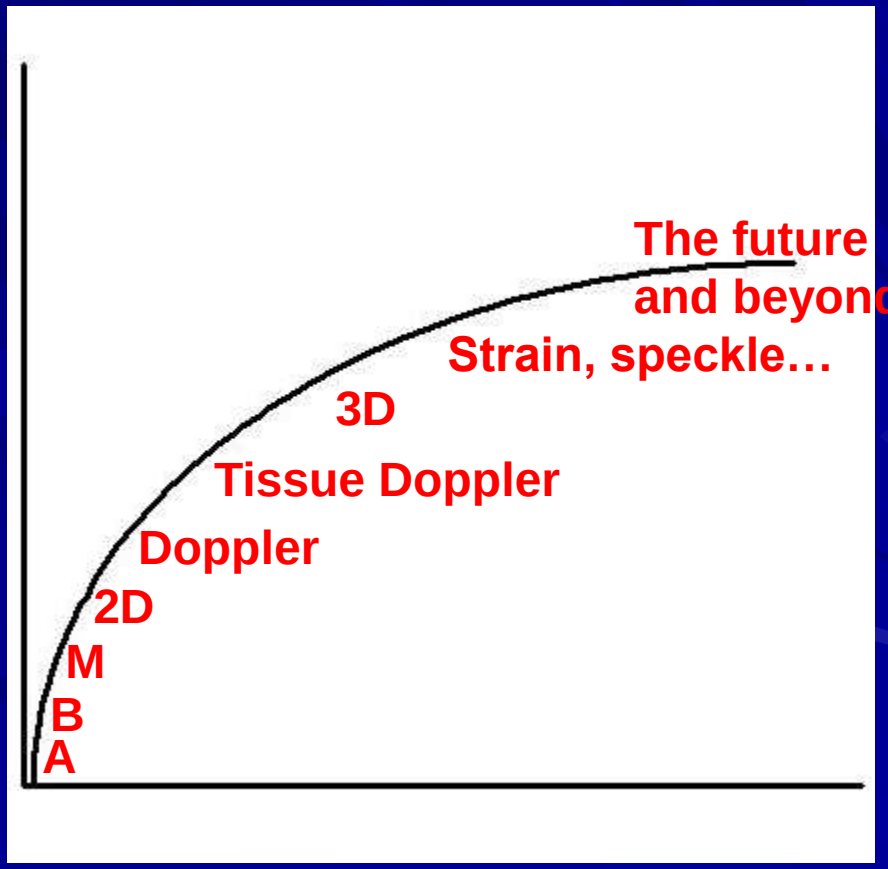
- Recommendations (requests / pleas!):
  - Make linear measurements using 2D, not M-mode
  - Use Simpson's method to estimate LVEF
  - Use left atrial volume > left atrial area > left atrial diameter
  - Index to body surface area

Clinical Echocardiography in 2014

- Despite rapidly advancing knowledge and technology, medicine (and the universe) still obeys the Law of Diminishing Marginal Utility or Return






The future
and beyond!
Strain, speckle…
3D
Tissue Doppler
Doppler
2D
M
B
A

Conclusions

- There *really is* “so much” information in an echocardiogram
  - there is more to the left ventricle than just EF
  - there is more to the heart than just the left ventricle
  - there is more to the echocardiogram than just the heart
  - (there is more to the patient than just the echocardiogram)
- Echocardiography will remain a workhorse of clinical cardiology