Lapland, Sarek National Park, Sweden

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GUIDELINES

Recommendations for chamber quantification ☆

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In preparation: "focussed update"

Relevant developments for update

- **new normative and prognostic data emerging, e.g. left atrial size**
- **obsolescence of M-mode**
- **increased and new use for particular measurements, e.g. aortic annulus for TAVI/TAVR, left atrial size for diastolic function and risk assessment**
- **new technologies: harmonic imaging, simultaneous biplane imaging, 3D imaging, tissue Doppler and strain imaging**

Left ventricle

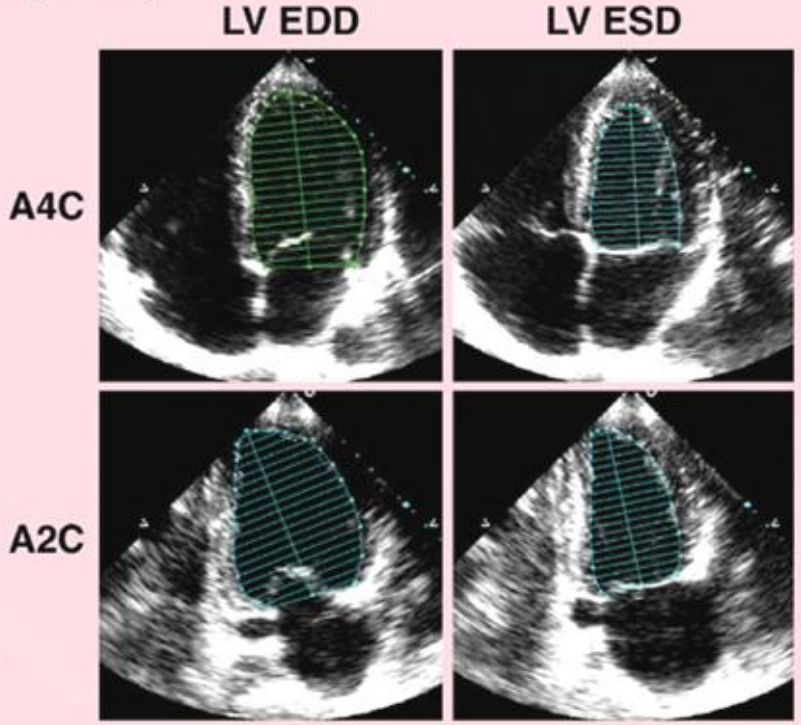
Size:

- **2D-guided measurements preferred over M-mode**
- **caliper on "interface between cavity and wall" (no "leading edge")**
- **volumes/EF from biplane mod. Simpson's rule (or, if apex not well imaged, area-length)**
- **nomograms for BSA, gender, age, race**
- **no "mild, moderate, severe" abnormality classification (just mean ± 2SD)**
- **3D volumes: not yet**

new normal for EF:
63 ± 5% (53 – 73)

LV Volumes

2-D measurements for LV volume calculations using the biplane method of discs, in the apical four-chamber (A4C) and apical two-chamber (A2C) views at end diastole (LV EDD) and at end-systole (LV ESD).

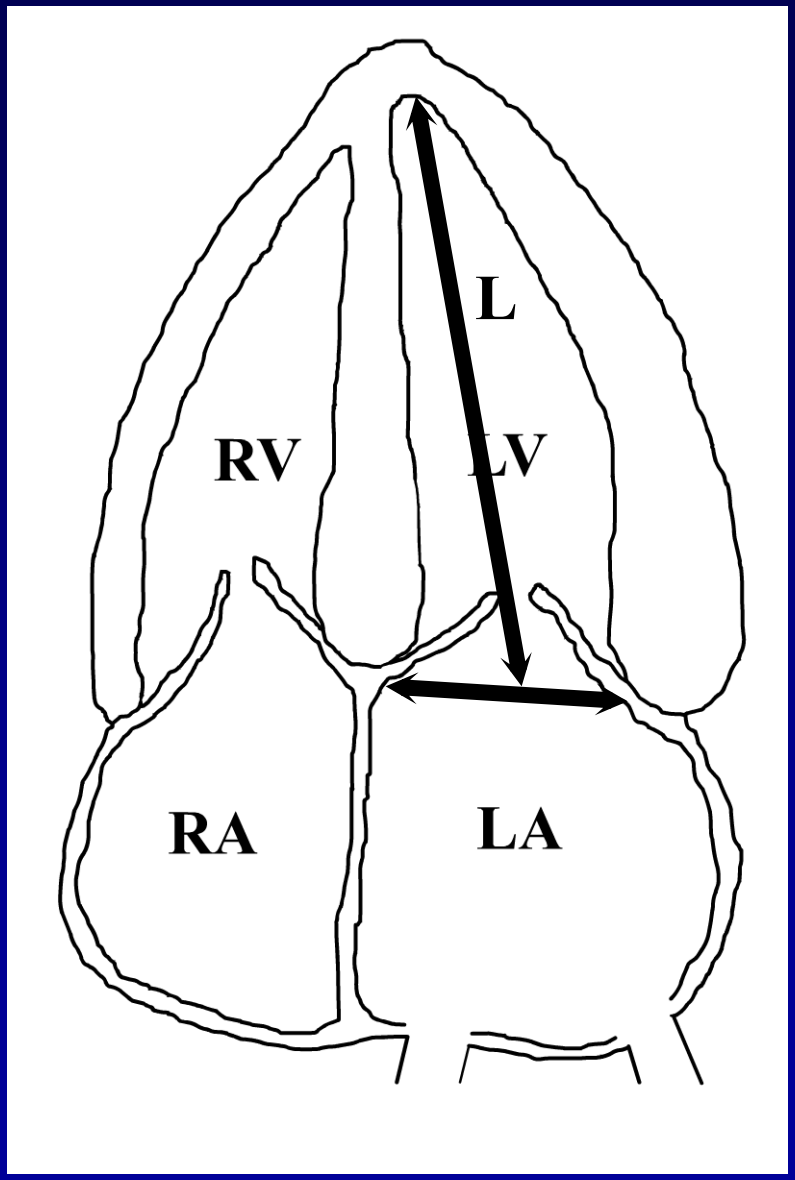


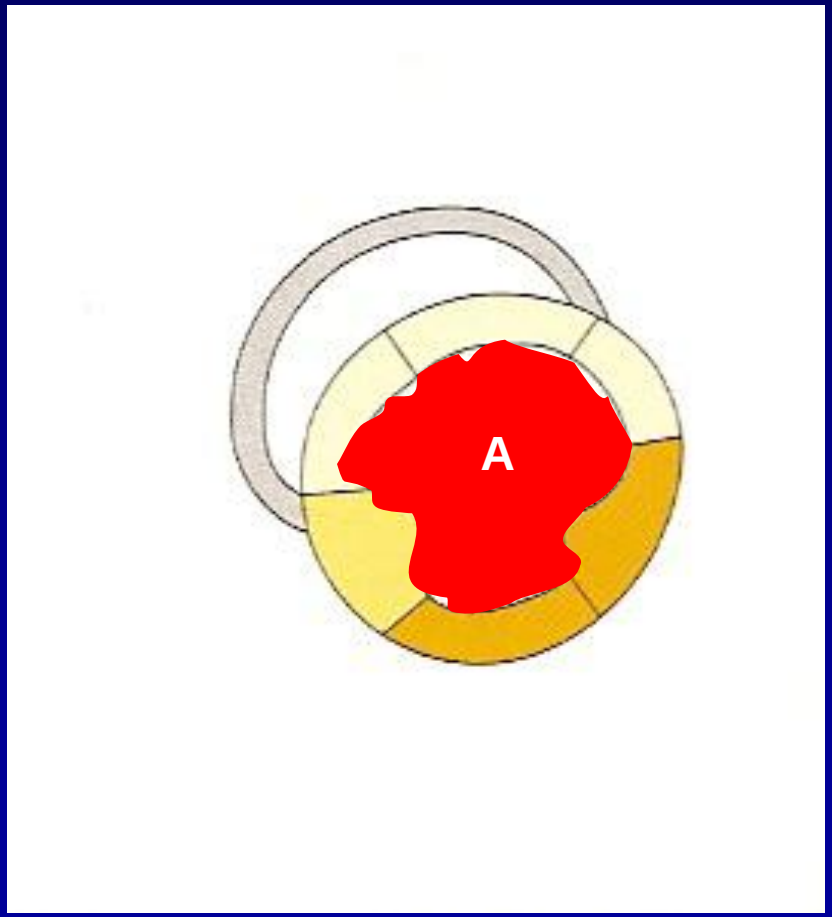
Ejection fraction = (EDV – ESV)/EDV

WOMEN and MEN

2D method	Reference Range	Mildly Abnormal	Moderately Abnormal	Severely Abnormal
LV diastolic volume/BSA (ml/m²)	35-75	76-86	87-96	≥ 97
LV systolic volume/BSA (ml/m²)	12-30	31-36	37-42	≥ 43
Ejection Fraction (%)	≥ 55	45-54	30-44	< 30

Alternative for LV volume calculation: Area length method V = A * L * 5 / 6





Left ventricle

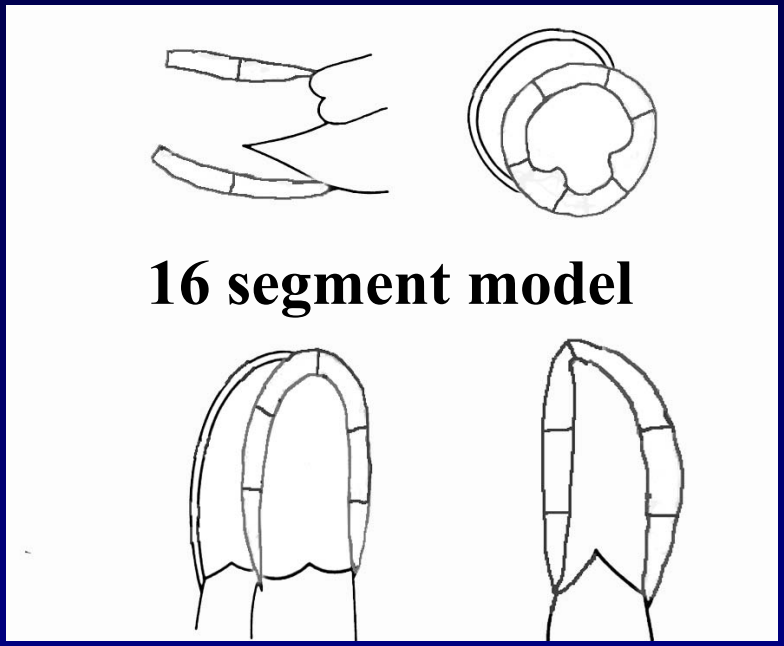
Global function:

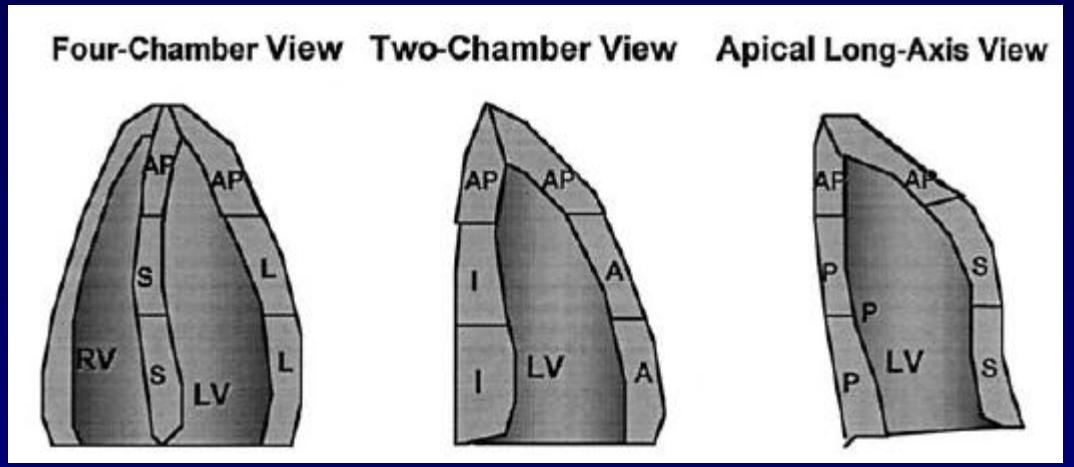
- **EF, fractional shortening (in concentric hypertrophy, midwall FS recommended)**
- **Global longitudinal strain (heterogeneous normal values)**

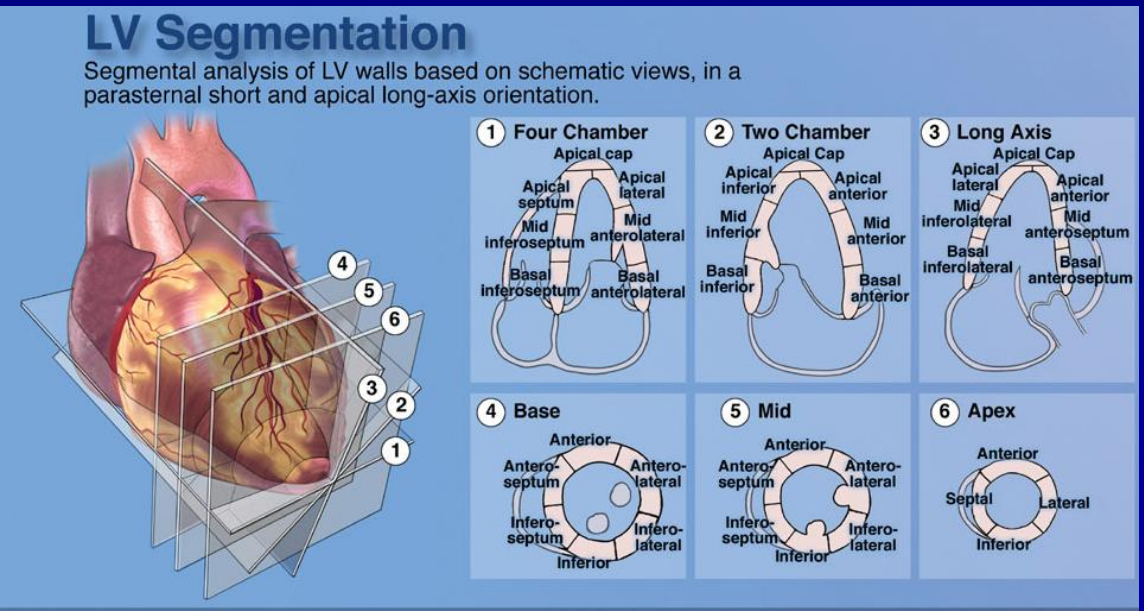
Regional function:

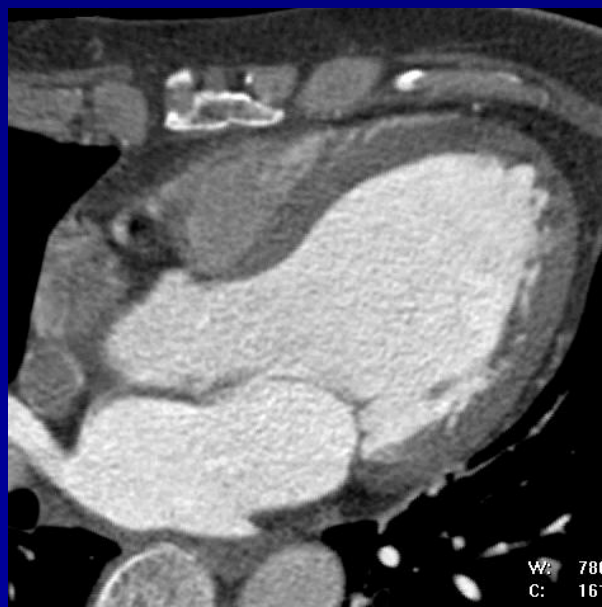
- **16 or 18 segment models preferred over 17-segment model**
- **wall motion score: no extra category for aneurysm**
- **regional longitudinal strain: (heterogeneous normal values)**
- **new post-systolic shortening (after aortic valve closure) in ischemic heart disease is a sign of ischemia**

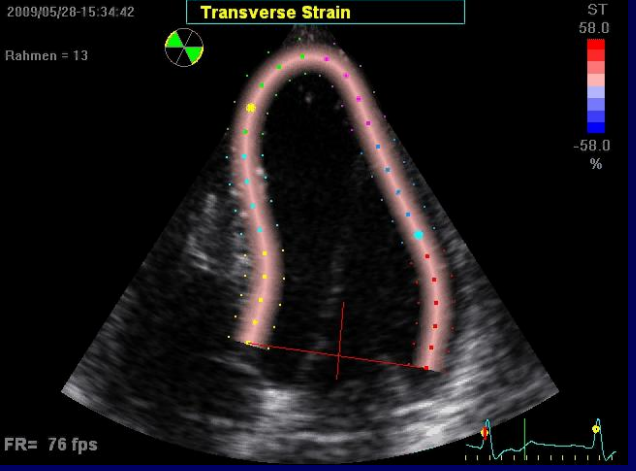
Left ventricular segmentation: 16/17/18 segments

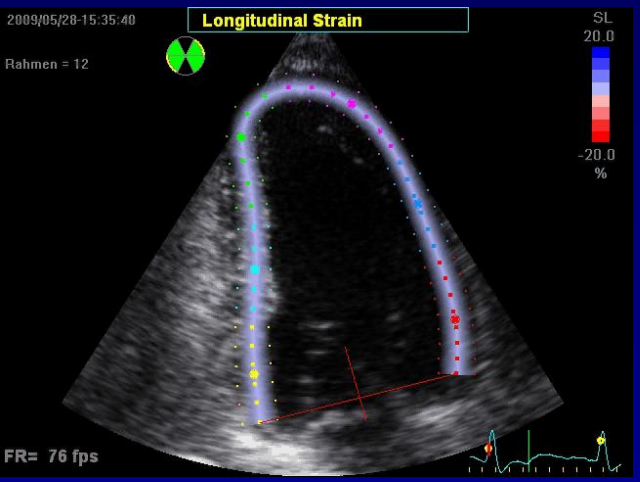


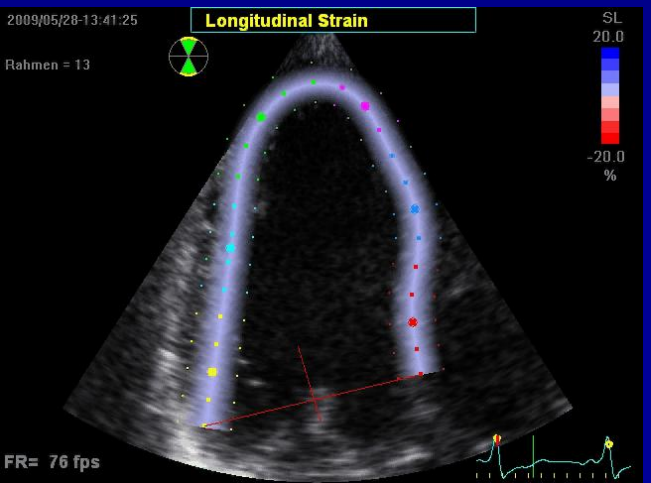


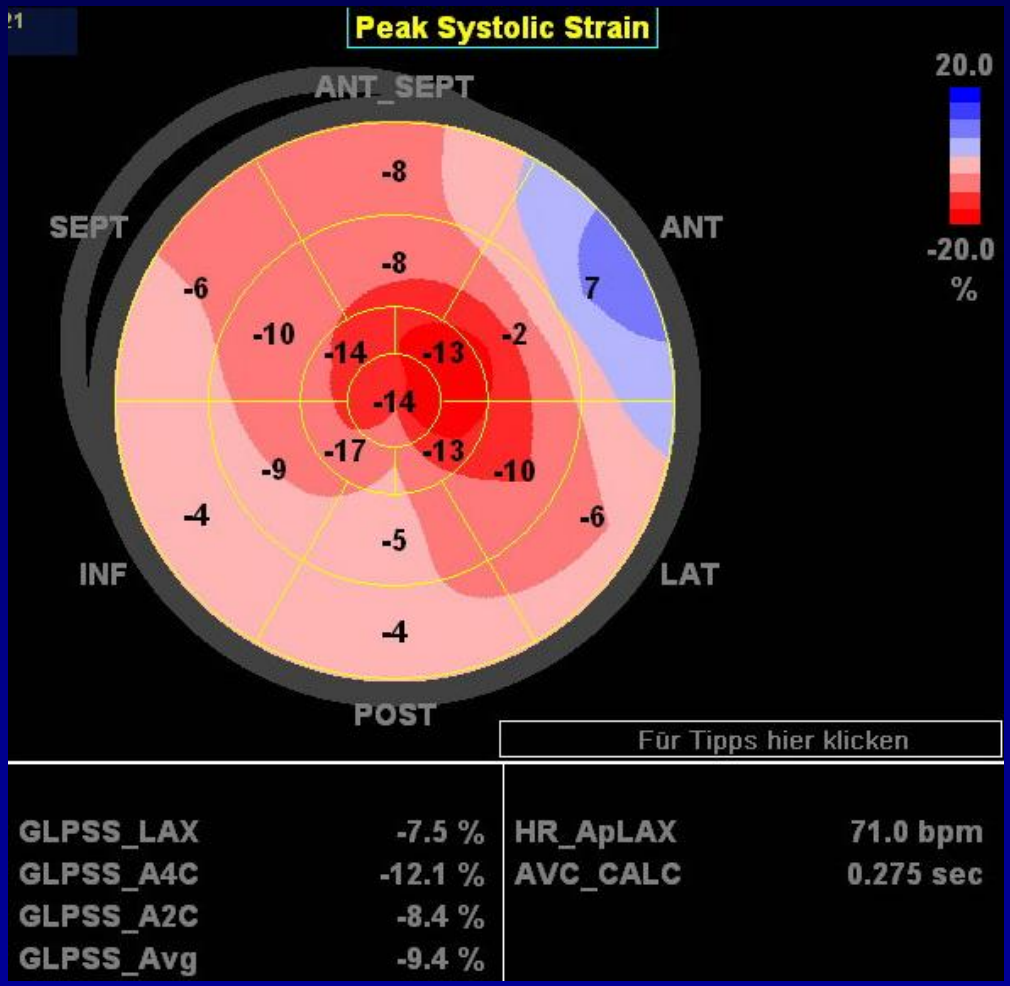






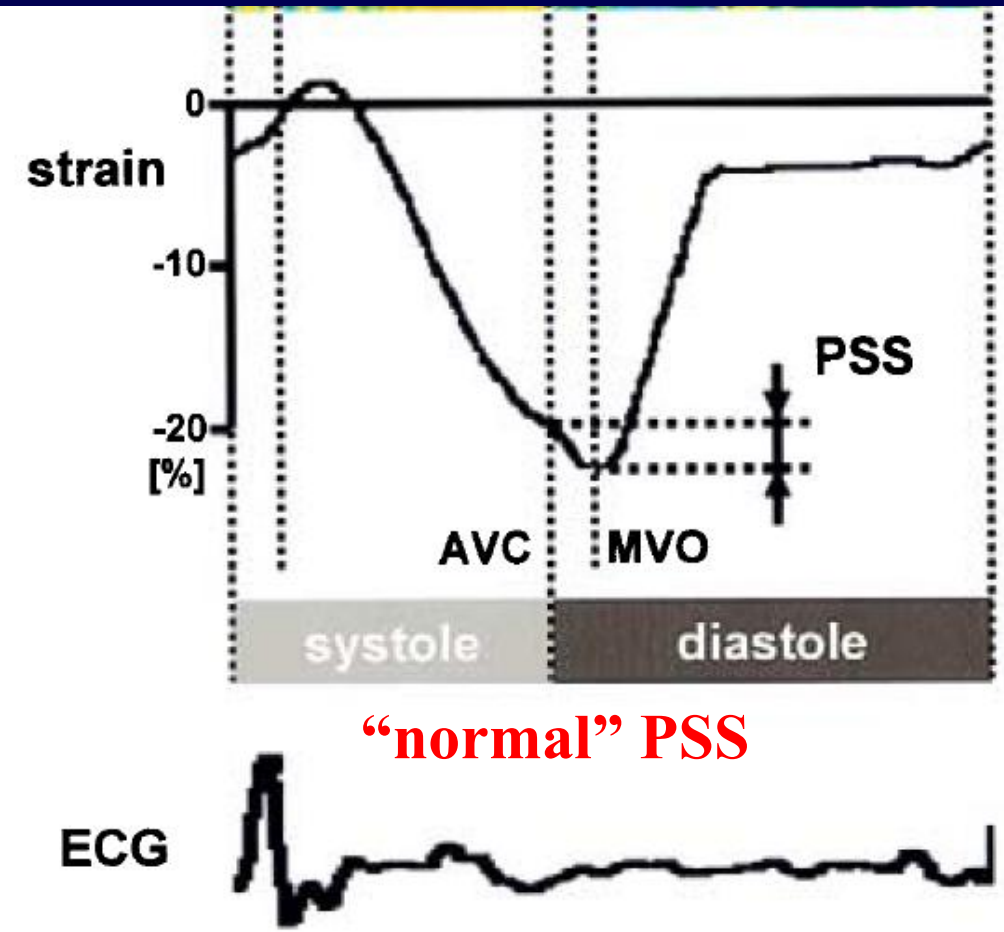




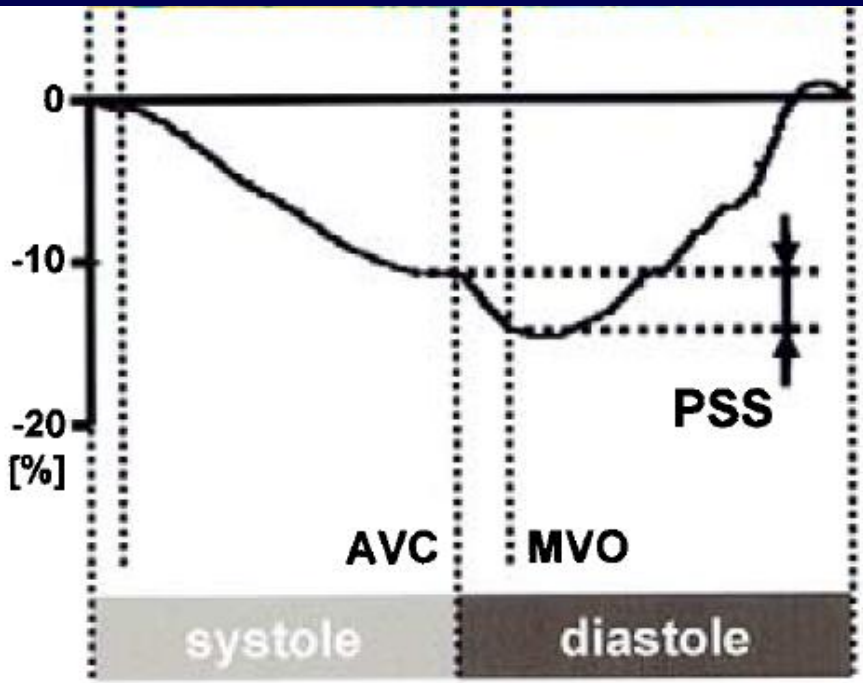


global (long.) strain -9%

Post-systolic shortening



"normal" PSS

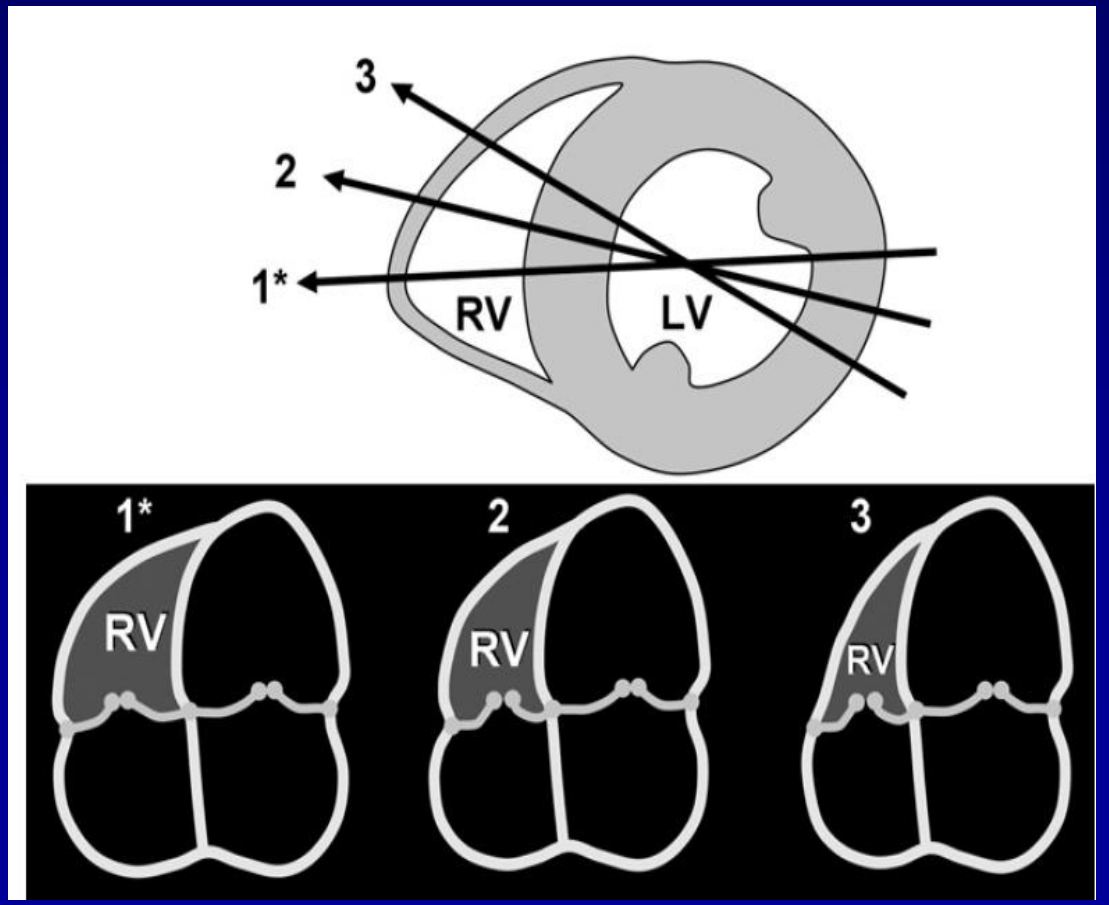


pathologic PSS > 30%

Voigt JASE 2003;16:415

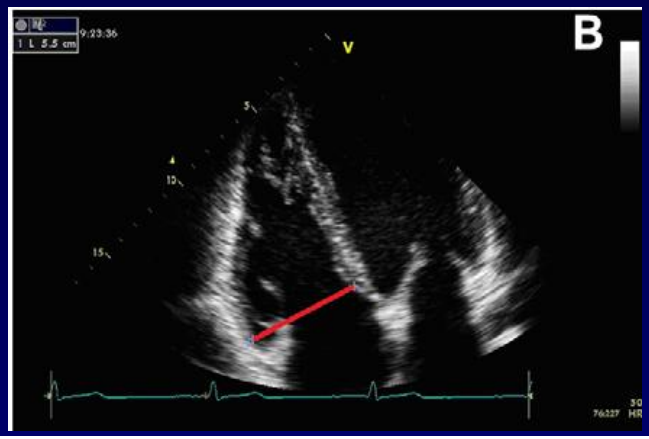
Right ventricle

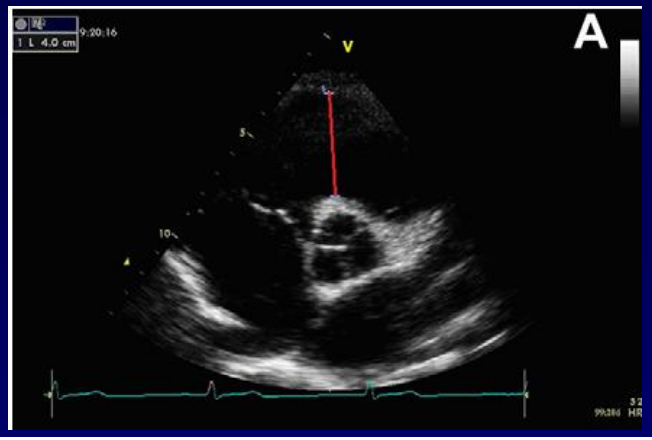
The RV dimensions are … best estimated from a RV-focused apical 4-chamber view....indexing should be considered only at the extremes of BSA. …a diameter >42 mm at the base …indicates RV dilatation. Similarly, longitudinal dimension >86 mm indicates RV enlargement.

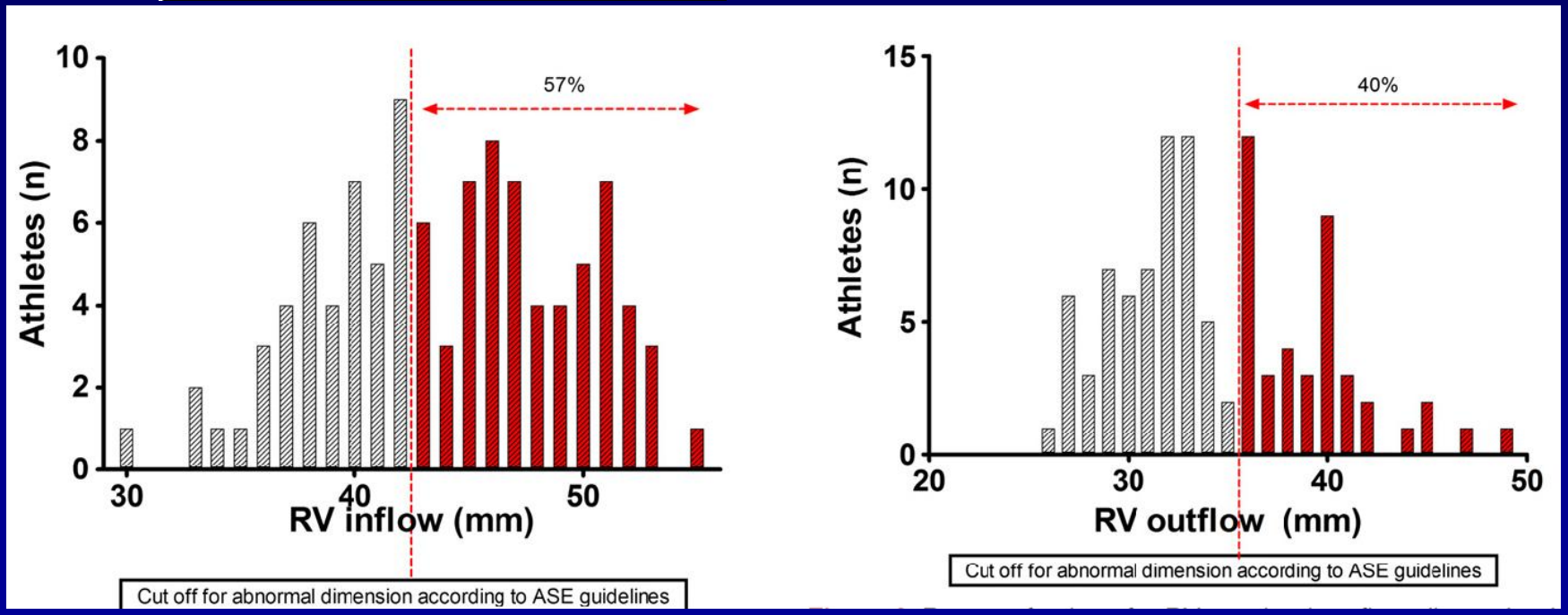


The "RV focussed" view (LV apex at center, maximal RV diameter)

Overlap in RV size between athletes and ARVC







Furthermore, 28% of the population had values greater than the proposed "major criteria" for ARVC.

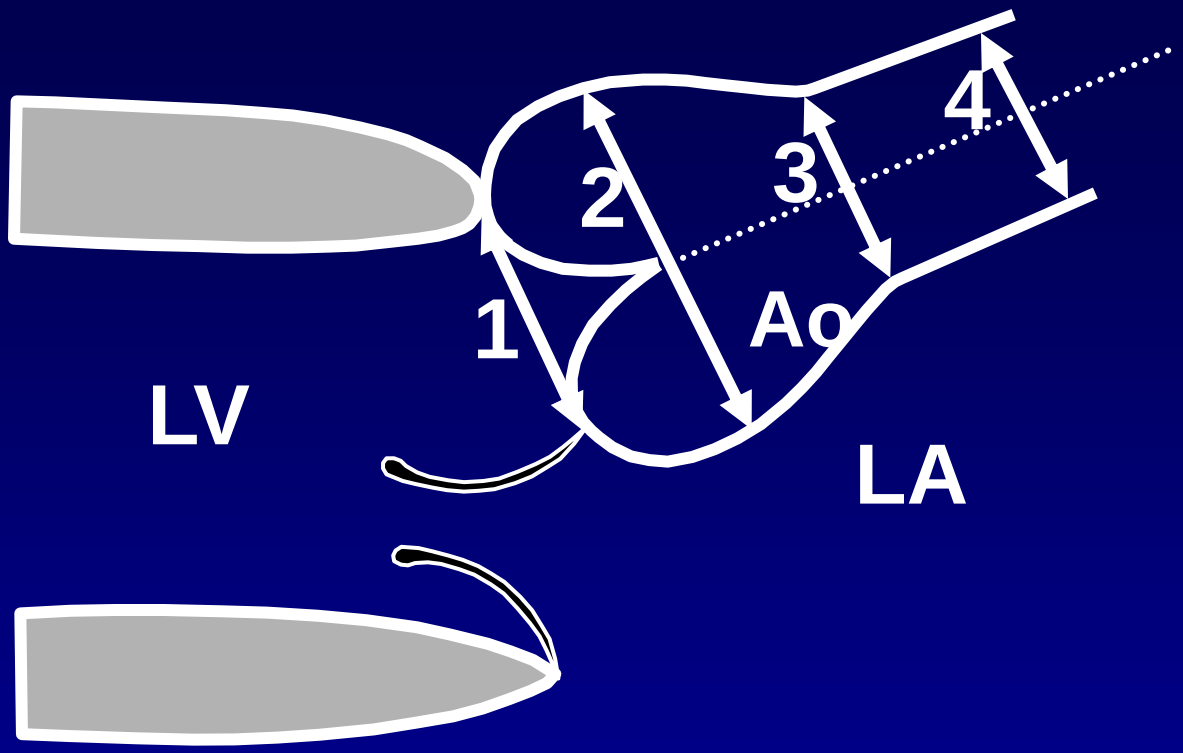
Oxborough JASE 2012;25:263

Recommended functional RV parameters:

- TAPSE (≥ 17 mm) or
- fractional area shortening (≥ 35%) or
- S' or (≥ 9.5 cm/s) or
- 3D ejection fraction (≥ 45%)

(+ estimate of systolic pulmonary pressure)

Aortic root diameter

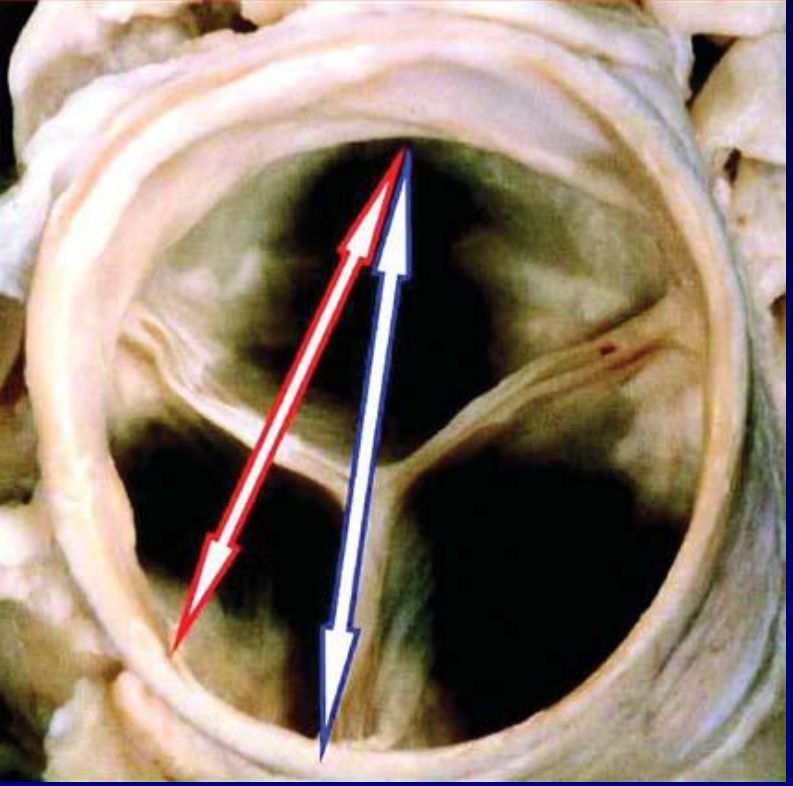


- **where to measure ?**

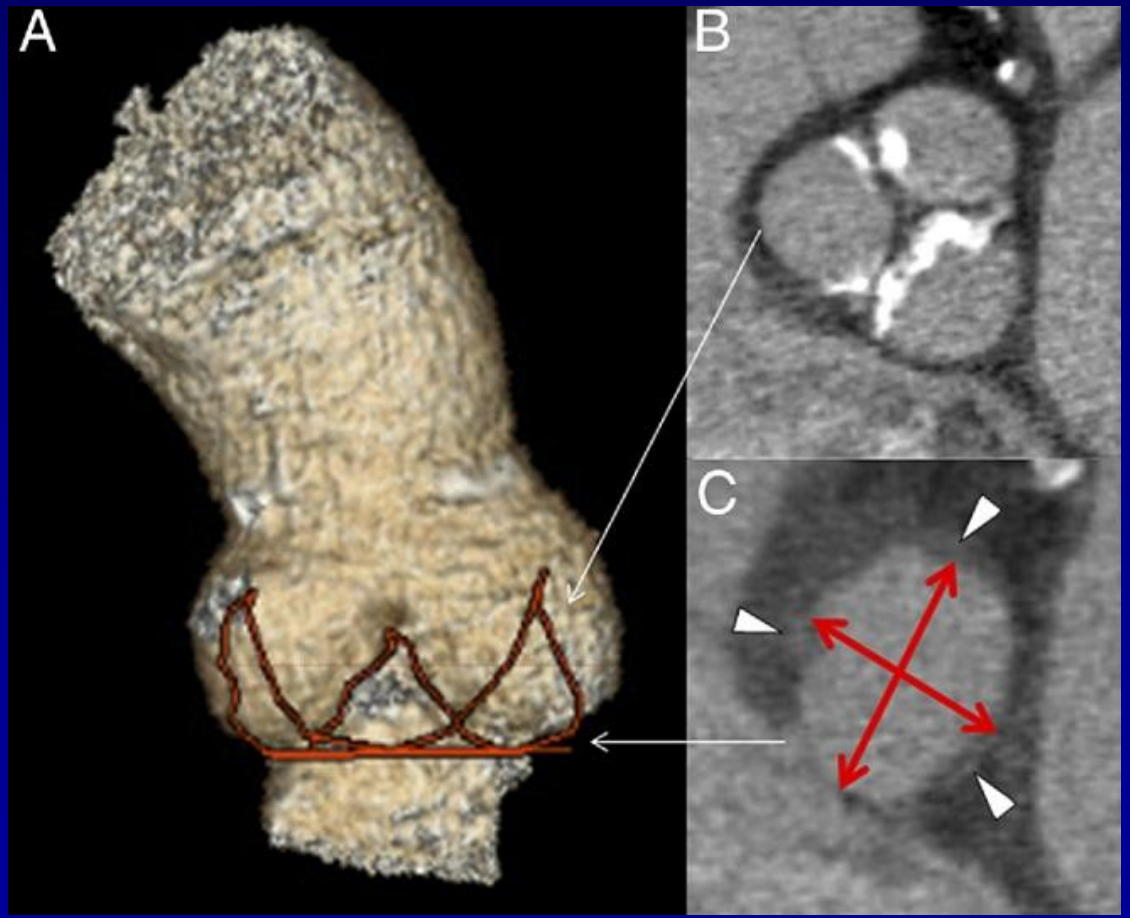
Sinus Valsalvae, tubular ascending aorta ?

- **how to measure ? leading, trailing edge ?**

- **when to measure ? diastole, systole ?**

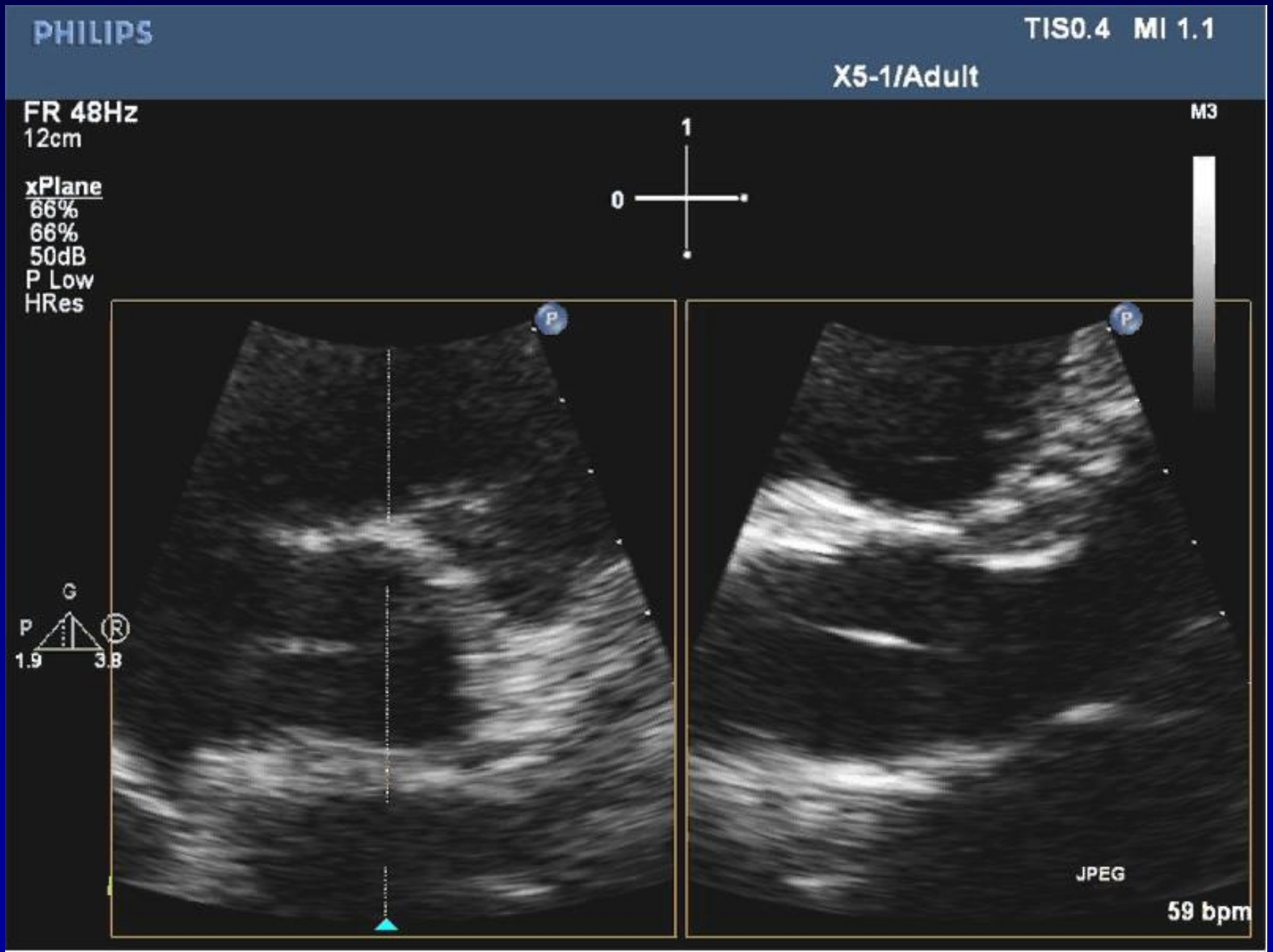


Piazza
Circ CV Interv 2008;1:74

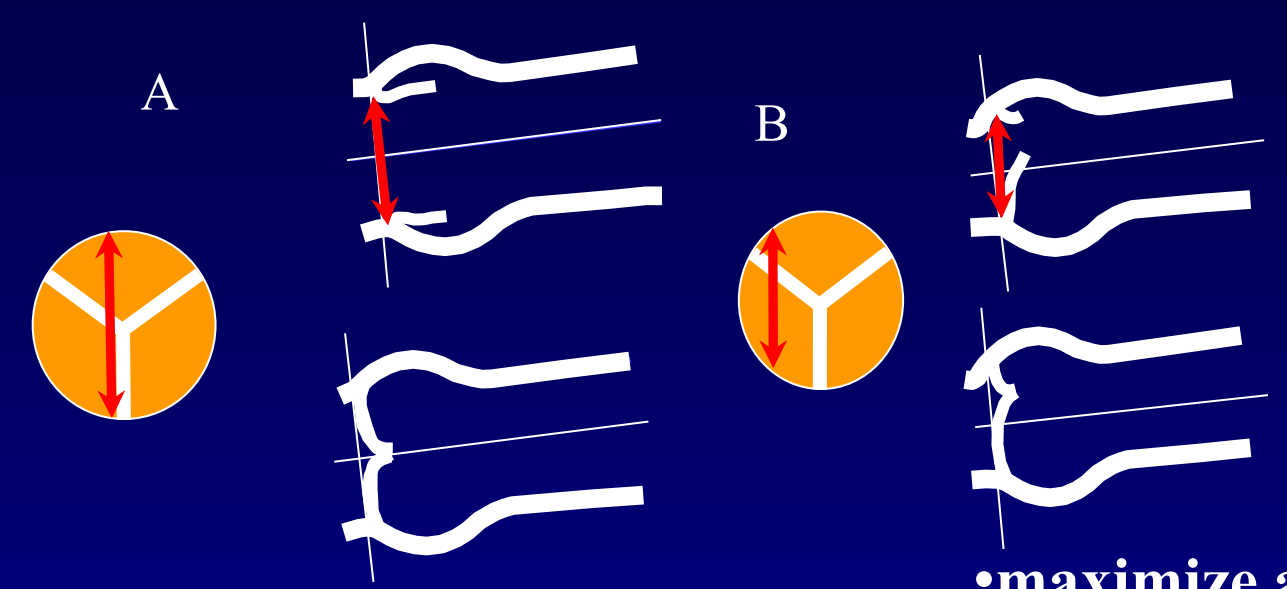


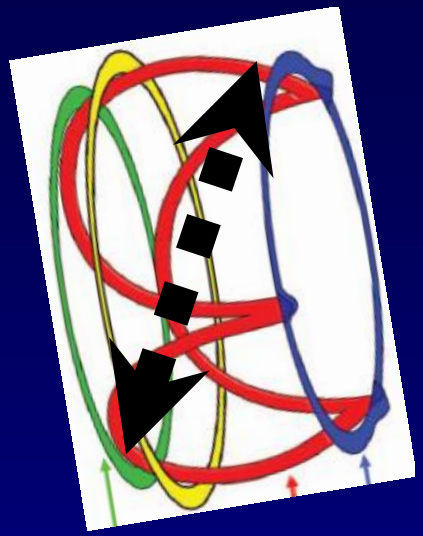
Messika-Zeitoun
JACC 10;55;186

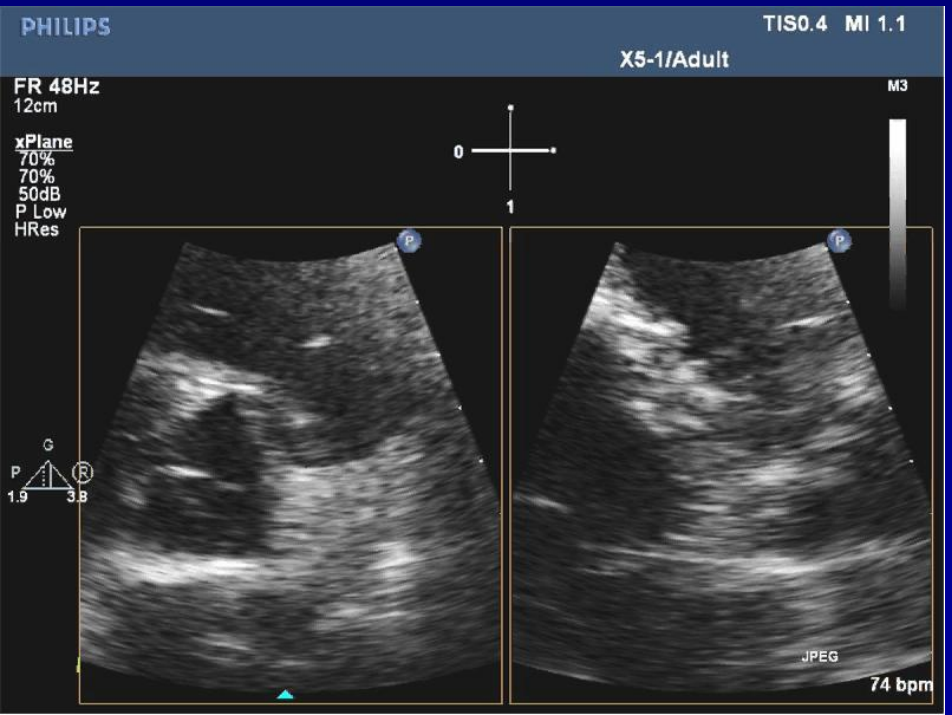
Simultaneous imaging in orthogonal planes (“x-plane”)



off-axis images of aortic annulus/valve/root



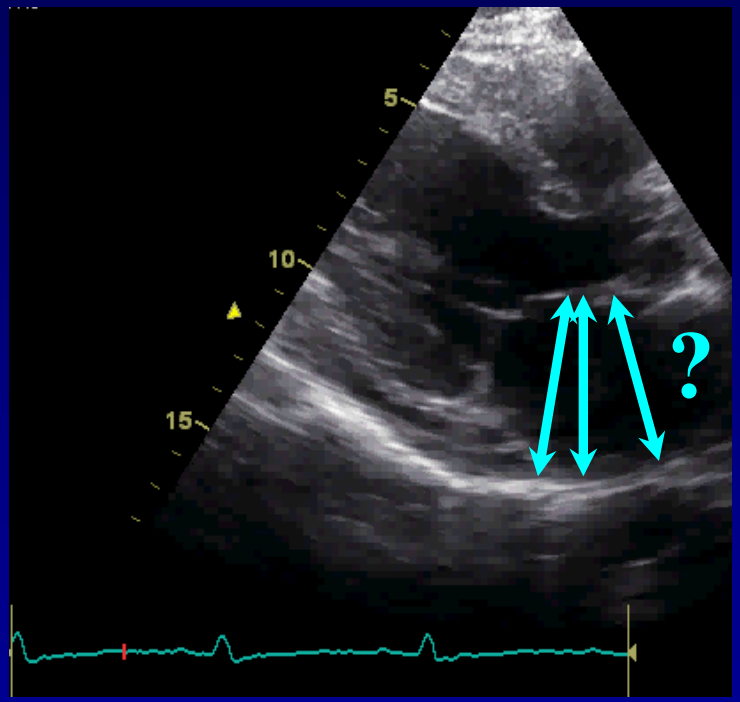




- maximize aortic diameter
- look for central valve closure
- look for ∅ perpendicular to LAX
- from and to cavity/wall interface
- measure annulus in systole, other aortic diameters in diastole

Left atrial size

"The recommended linear dimension is the LA antero-posterior measurement ...using M-mode or preferably 2D imaging... AP linear dimension should not be used as the sole measure of LA size."



Recommended:

- **mod.biplane Simpson rule or area-length**
- **"single plane LA volumes ...can be used as a simpler tool for measuring the LA volume in the majority of patients**

Left atrial size

present upper normal cut-off: ≤ 32 mL/m^2

Table 1. Echocardiographic Determination of LAV in Normal Subjects (n = 124)

	Total*	Cutoff†	Ma
2D LAVImax, ml/m^2	24.1 ± 6.0	36	24.9

Wu JACCCVImg 2013, epub

Mean LAVi was 32.2 ± 9.0 mL/m^2 (range = 15.8–69.9 mL/m^2) in the pooled population and was larger in athletes than in non-athletes (38.9 ± 9.6 mL/m^2 vs. 28.4 ± 5.8 mL/m^2, respectively, $P < 0.0001$).

Nistri EJE 2011;12:826

final cut-off for LA size will probably be ≥ 36 mL/m2

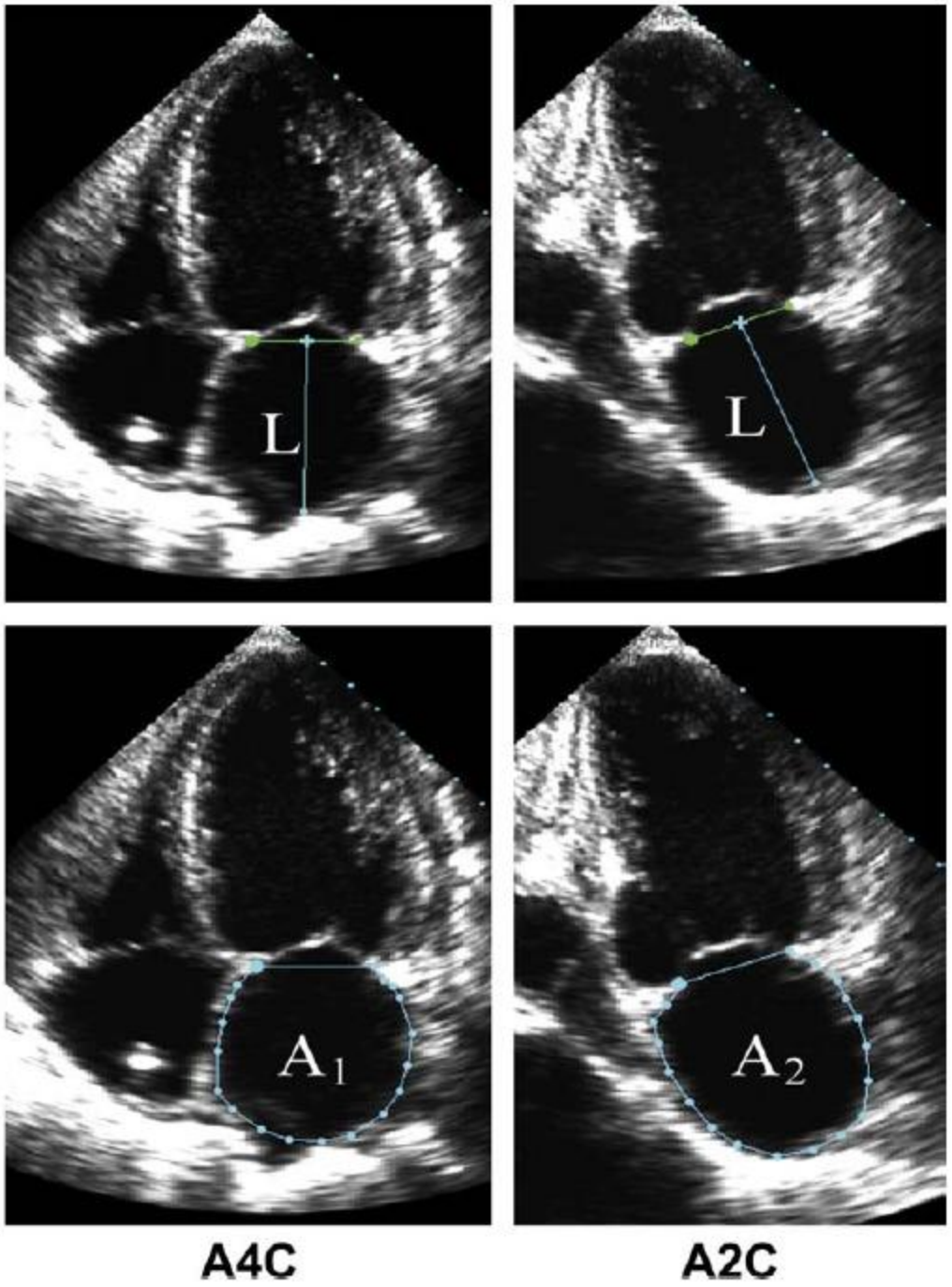
Summary

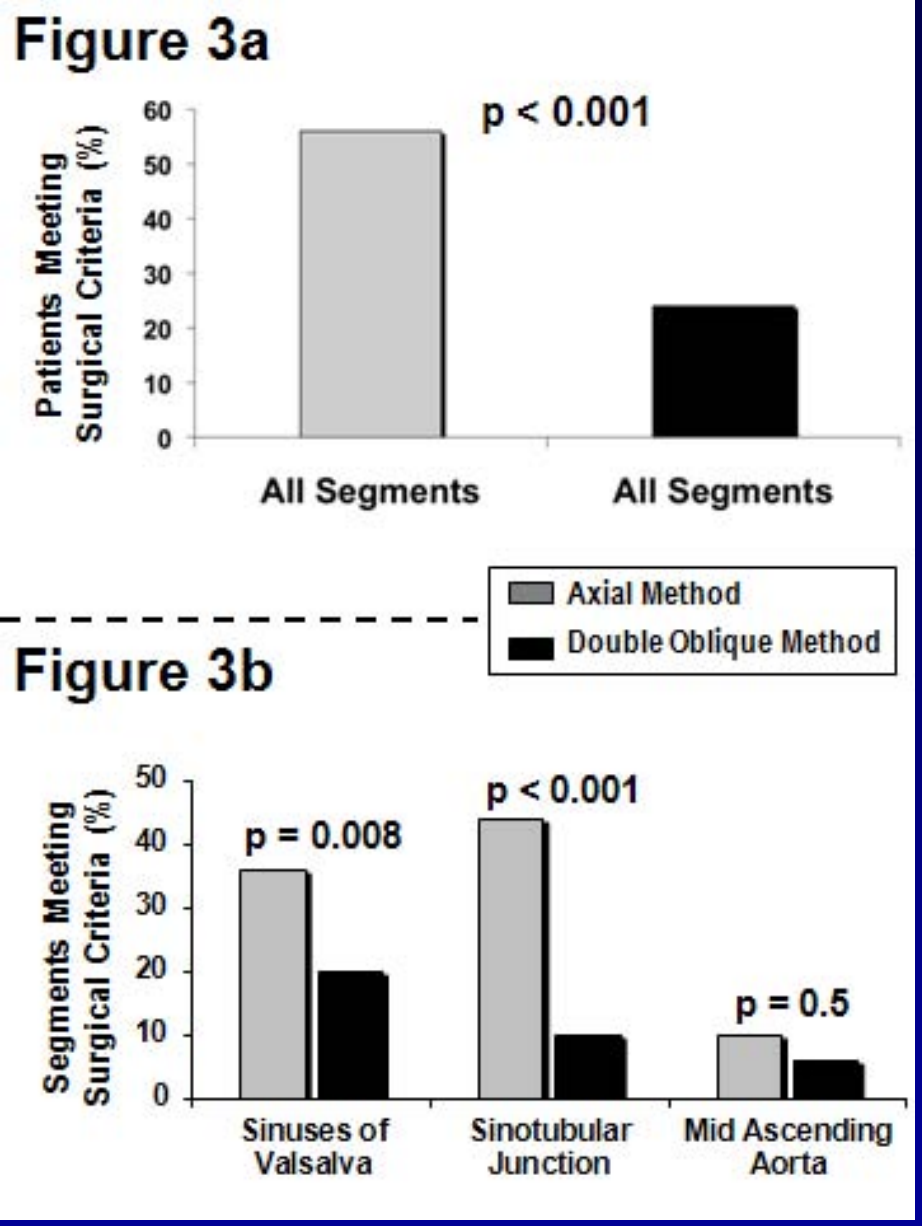
- **2D measurements preferred; border cavity/blood**
- **GLS and post-systolic shortening introduced for LV function**
- **RV focussed view emphasized, overlap in size between cardiomyopathy and athletes**
- **aortic root: biplane adjustment of 2D planes recommended; ∅ annulus in systole, other ∅ in diastole**
- **left atrial size: cut-off will increase > 32 mL/m^2**
- **normal values difficult to provide in new 3D and strain due to vendor dependency**

Left Atrial Volume =

$$8/3\pi[(A_1)(A_2)/(L)]^*$$

* (L) is the shortest of either the A4C or A2C length

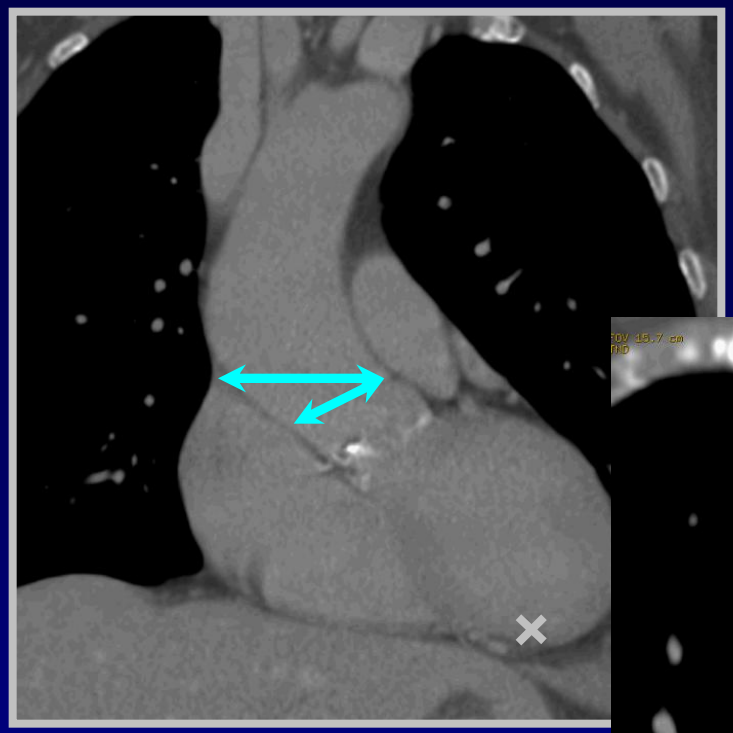


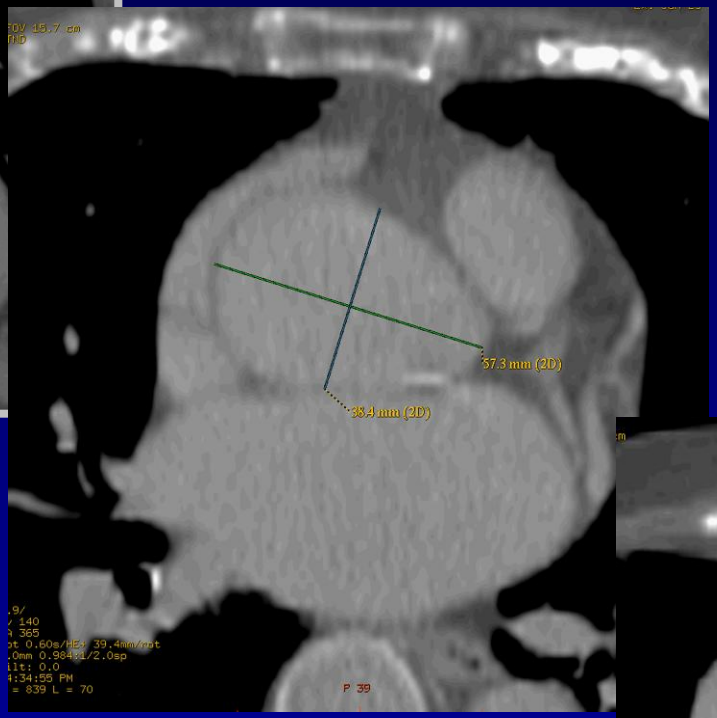


Durchmesser der Aorta
Bedeutung
der Orientierung der Untersuchungsebene

Mendoza et al. *Ann Thorac Surg* 2011;92:904-912

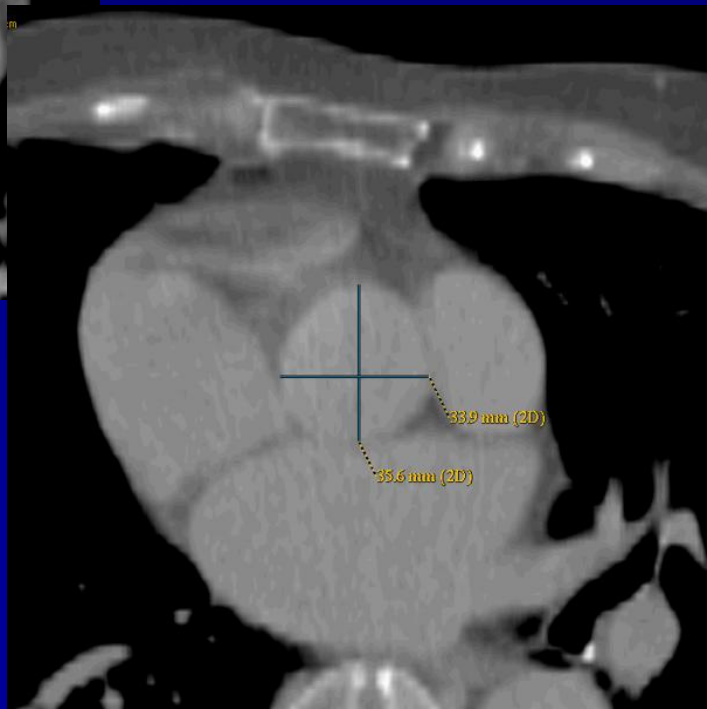
Importance of “double-oblique” vs. axial measurement of aorta for CT





max. 57 mm

max 36 mm



Mendoza *Ann Thorac Surg* 2011;92:904