Aortic Stenosis: Diagnostic Pearls for Beginners and Experts

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Aortic Stenosis

- Most common valve disease in western world
- Number of aortic valve replacements doubled in last decade
- Because of aging of the population, the number will double again in the next 20 years.

AS: Let's start with the basics

- History
- Physical
- EKG
- Chest X ray

AS: Let's start with the basics

- History
  - CHF
  - Angina
  - Syncope
- Physical
- EKG
- Chest X ray

AS: Let's start with the basics

- History
- Physical
  - Murmur: Harsh, rasping, crescendo-decrescendo, late peaking. Muffled S_2
  - Carotid shudder, delayed upstroke
- EKG
- Chest X ray

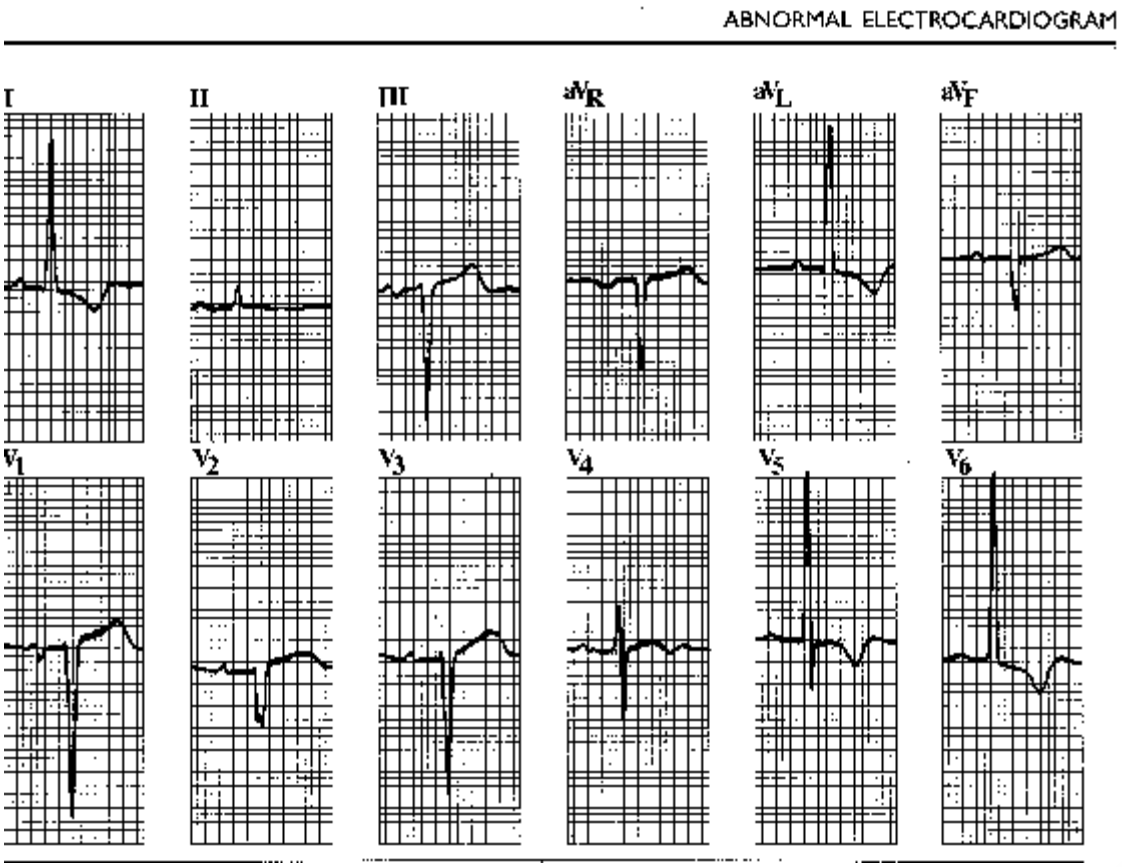
Now play the youtube.com

www.youtube.com/watch?v=Gbk2465HO98

AS: Let's start with the basics

- History
- Physical
- EKG
  - LVH
- Chest X ray

Left ventricular hypertrophy

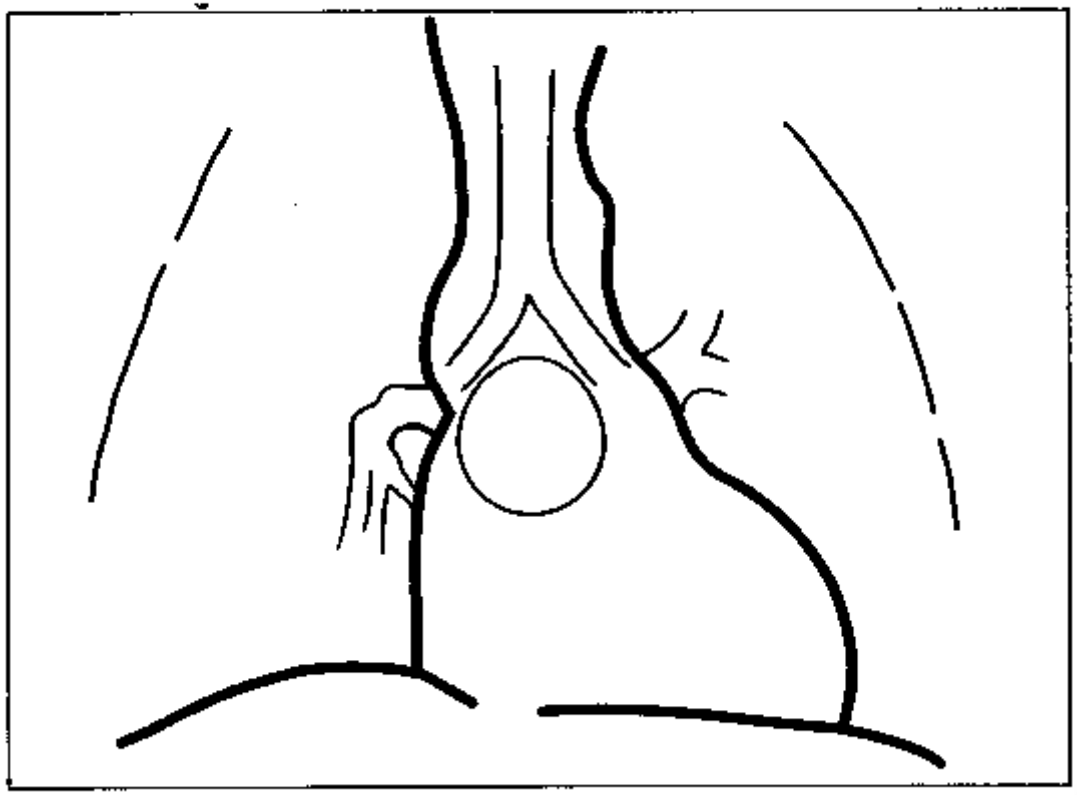


AS: Let's start with the basics

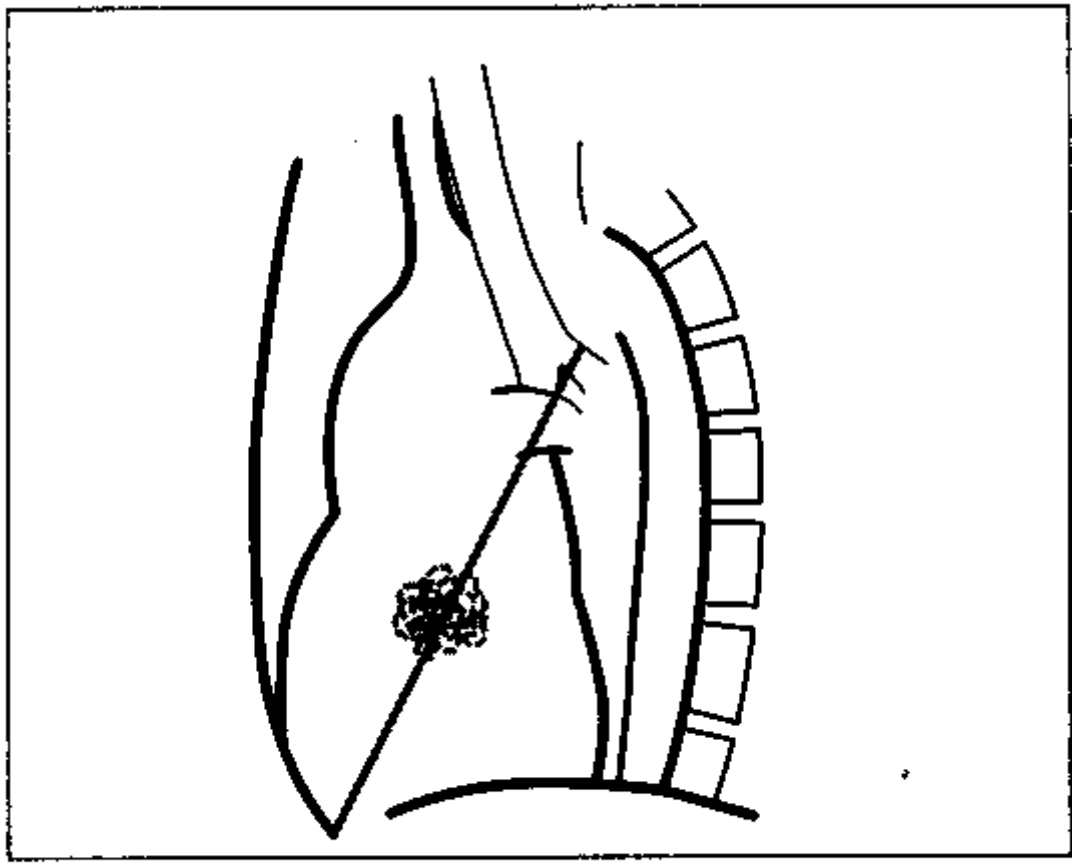
- History
- Physical
- EKG
- Chest X ray
  - Calcification of valve on lateral CXR
  - Finding of elastocalcinosis (Monckeberg's medial sclerosis)

Patient 4

CHEST X-RAY FILM



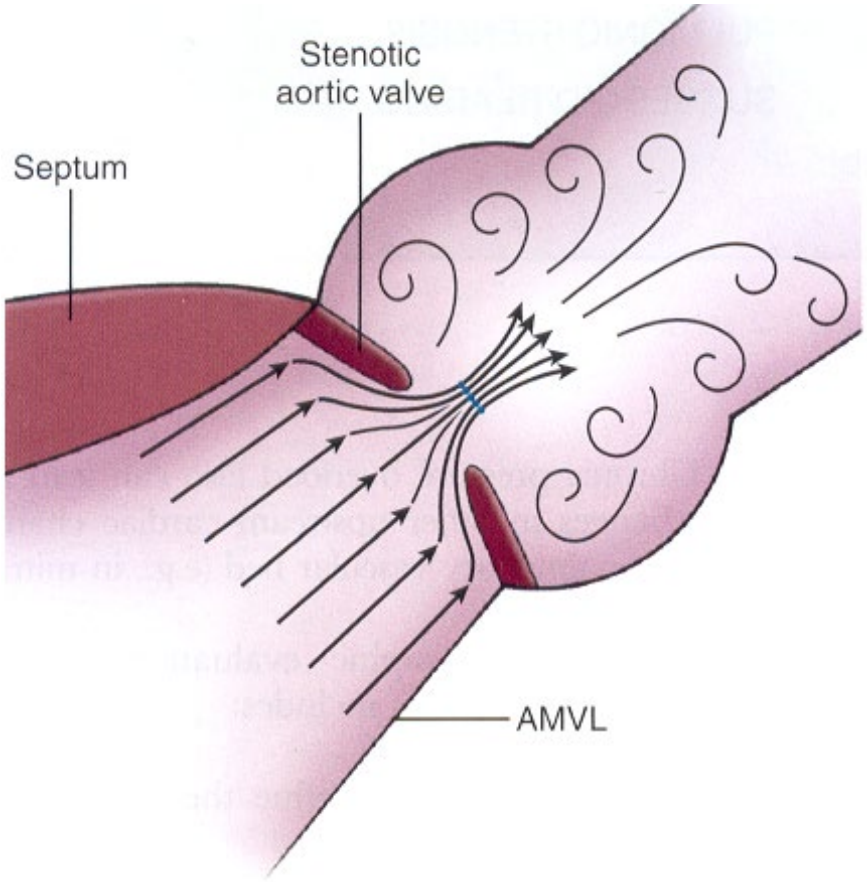
Patient 4

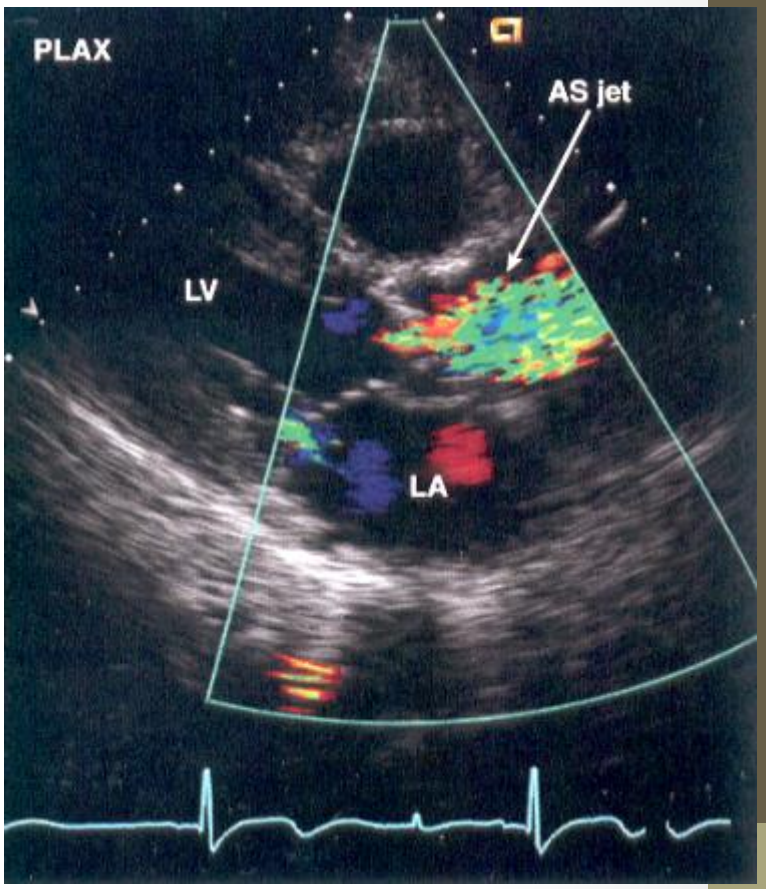


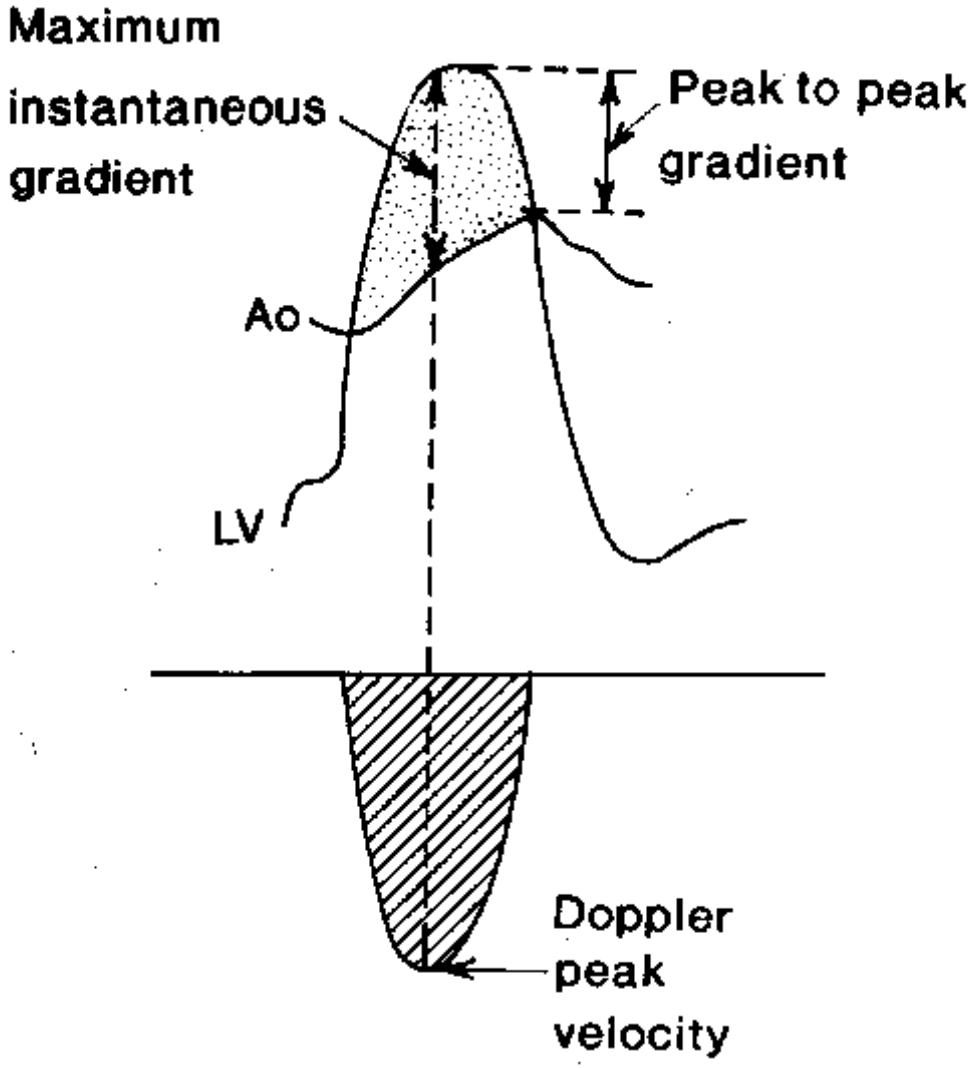
Left lateral view

Making the diagnosis by echocardiography

- Valve appearance
  - Leaflets – BAV? Trileaflet?
  - Calcification
  - Leaflet range of motion
  - Valve area by planimetry
- Doppler

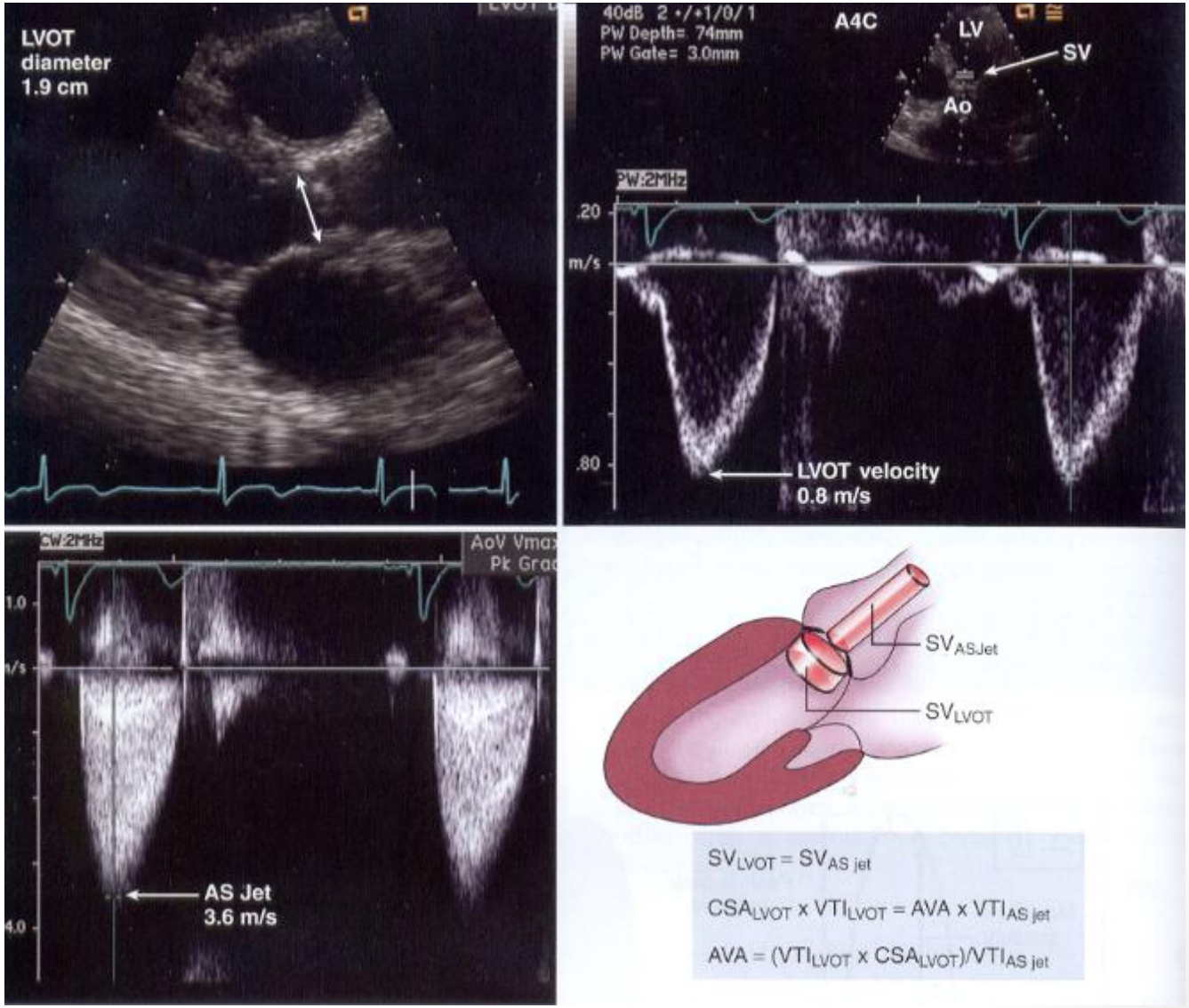

Stenotic
aortic valve
Septum
AMVL


PLAX
AS jet
LV
LA

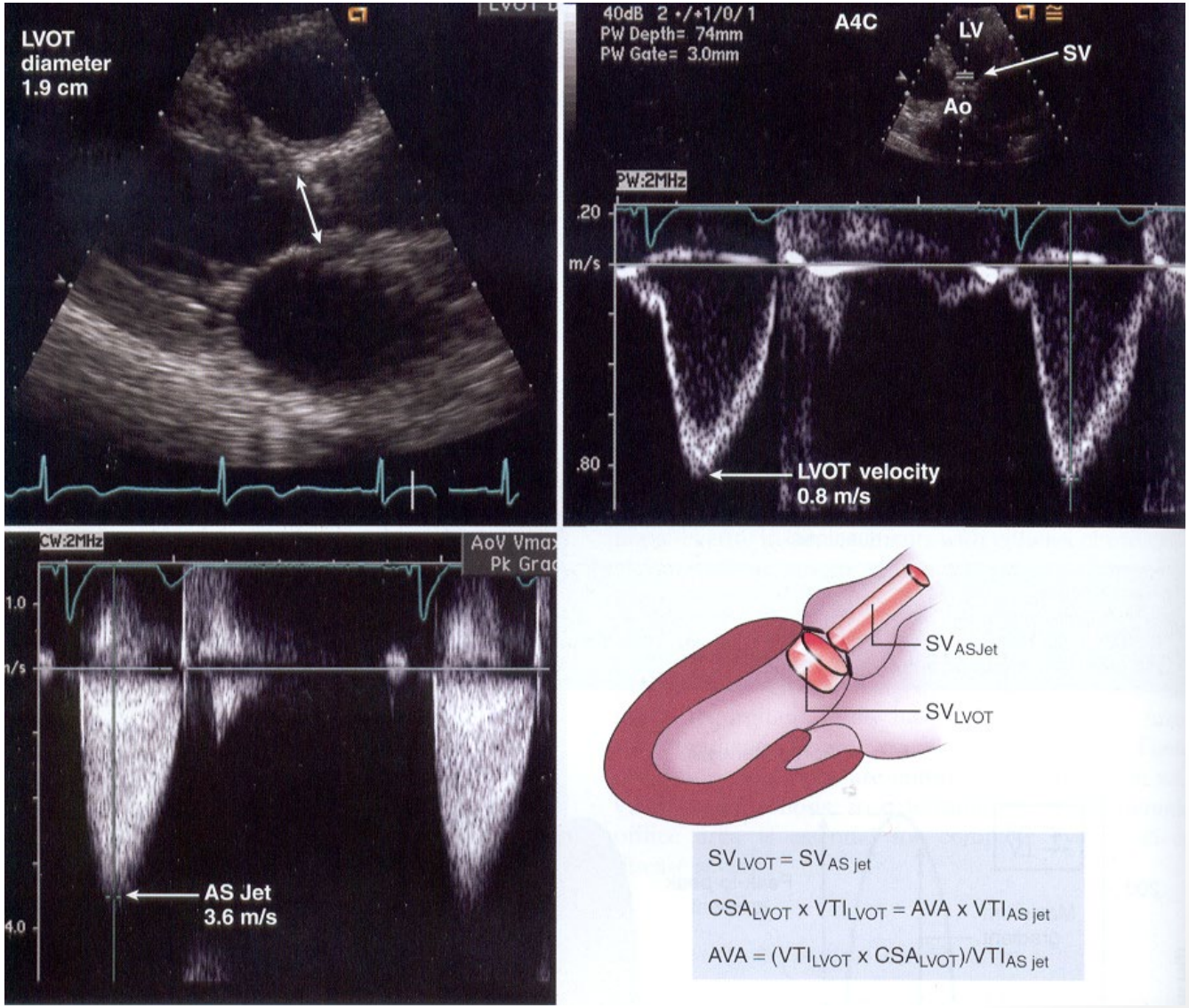


Bernoulli equation
Gradient = 4 x vel^2

Calculation of AVA



Calculation of AVA



Severe aortic stenosis

ACC/AHA 2006 guideline

- Peak aortic velocity $\geq$ 4 m/s (Peak gradient $\geq$ 64 mm Hg)
- Mean gradient $\geq$ 40 mm Hg
- Aortic valve area $\leq$ 1.0 cm^2

Standard Indication for Surgery

- Typical symptoms of aortic stenosis
  - Chest pain
  - Shortness of breath with exertion
  - Syncope (usually with exertion)

- Echocardiographic evidence of severe aortic stenosis
  - Peak aortic velocity $\geq$ 4 m/s ($\geq$ 64 mm Hg)
  - Mean gradient $\geq$ 40 mm Hg
  - Aortic valve area $\leq$ 1.0 cm^2

When to order an echo for AS

- Sounds like mild AS every three years
- Moderate AS (Peak gradient > 35) annually
- Severe, but asymptomatic ASevery 6 months
- Measure a BNP with each echo when asymptomatic, severe AS, or when in doubt with at least moderate disease

The biggest problem with AS

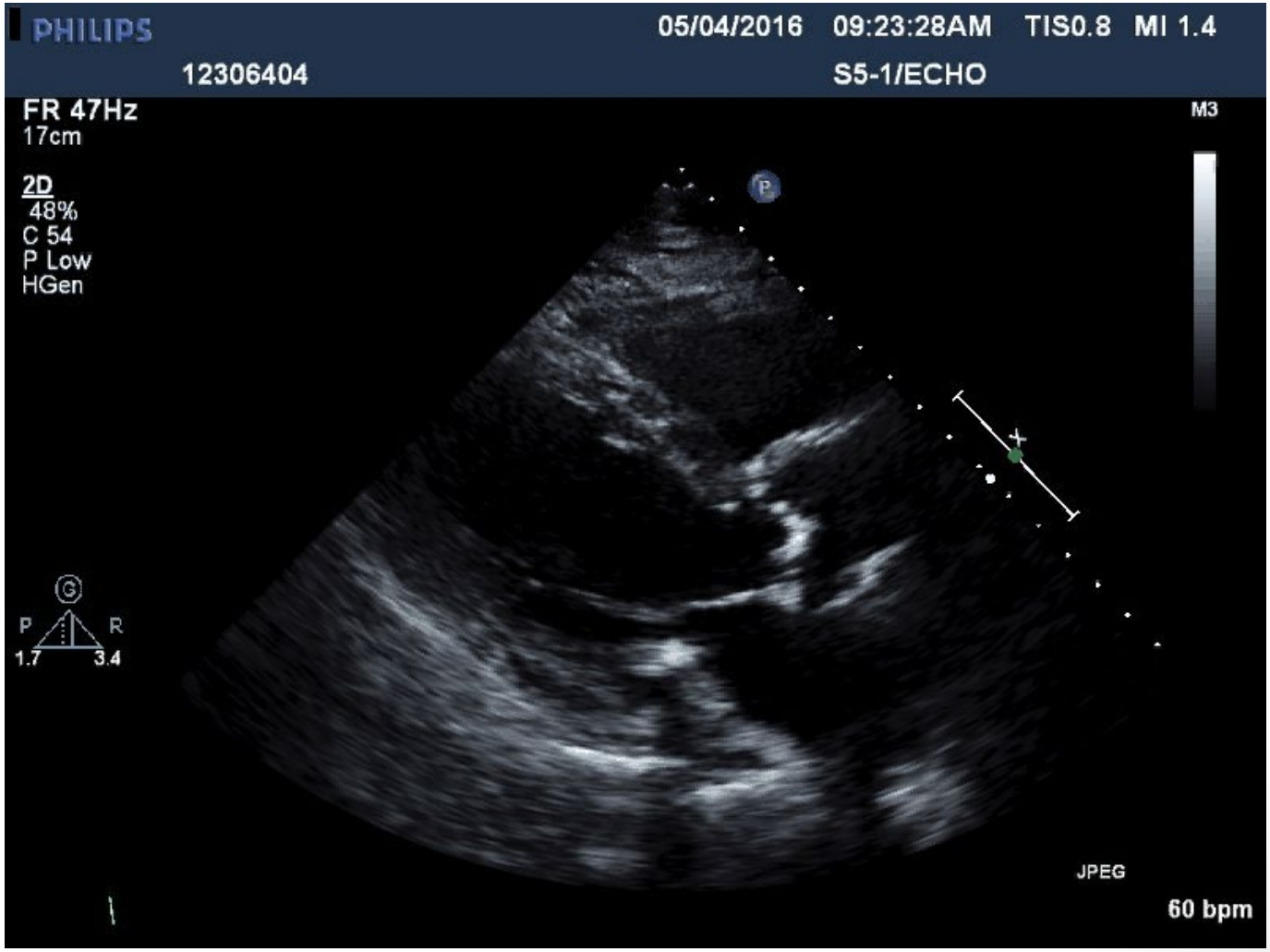
Now that we have the ability to replace the aortic valve by trans-catheter techniques, we have a new problem with the elderly patient:

Should we????

Consider: cognitive decline/dementia
frailty
psychosocial support

The best decisions are made with collaboration between the primary care physician, the cardiologist and the interventional (structural heart disease) specialist

Example of aortic stenosis



Severe aortic stenosis

ACC/AHA 2006 guideline

- Peak aortic velocity $\geq$ 4 m/s ($\geq$ 64 mm Hg)
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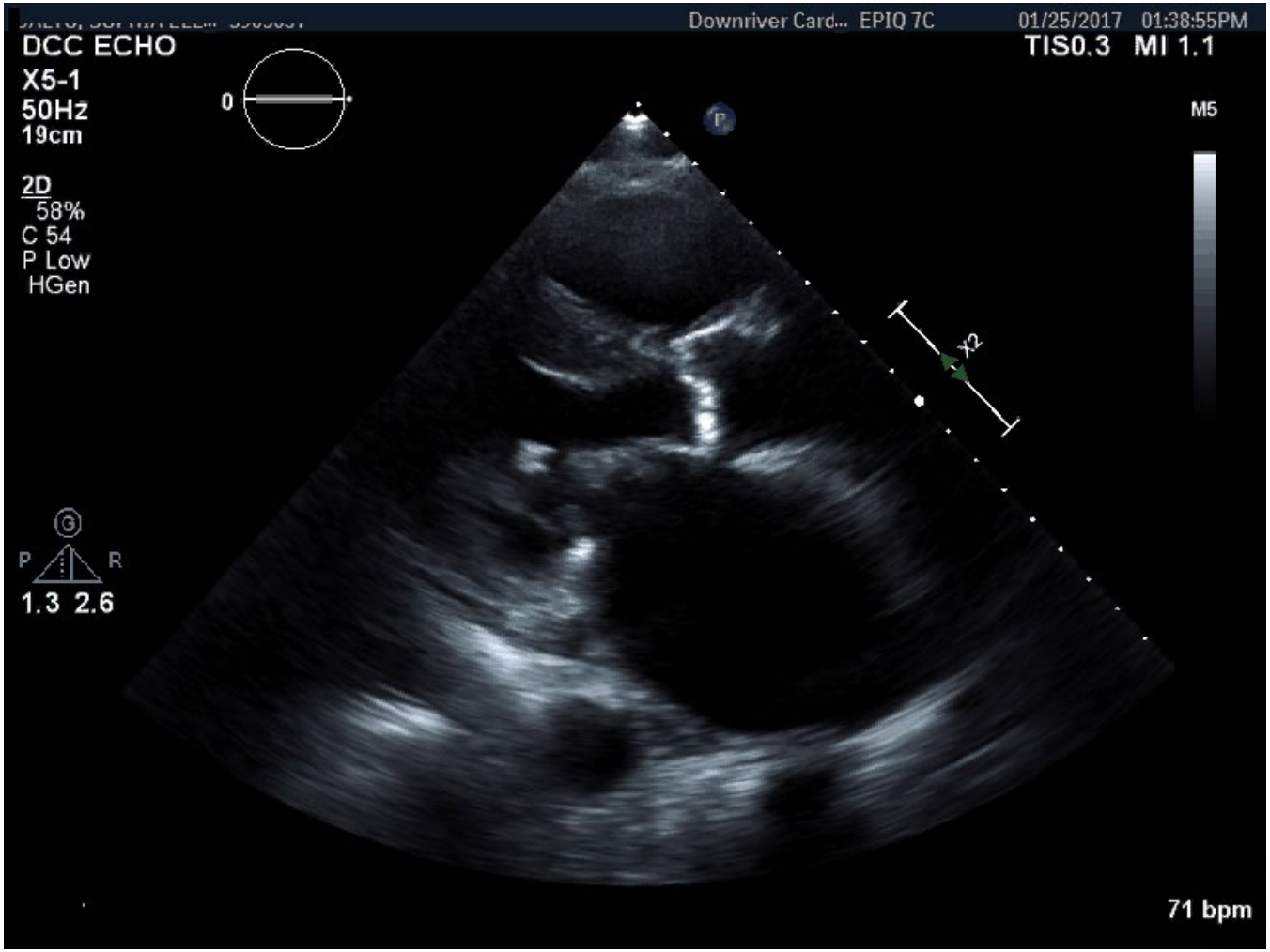
Severe aortic stenosis

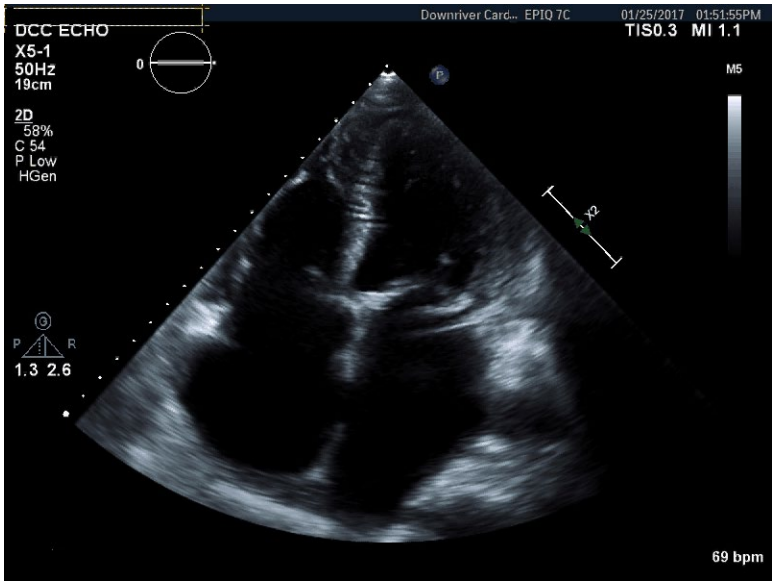
What about the AS patient with CHF?

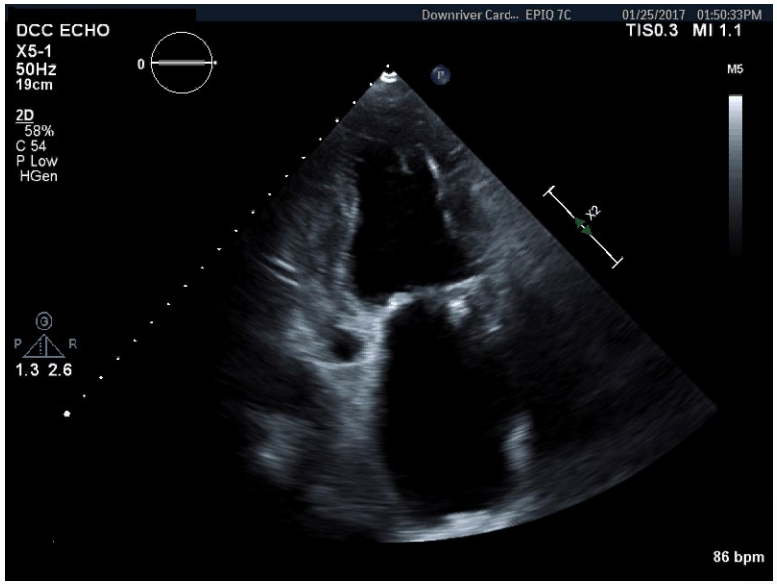
Severe AS, but the LV is too sick to generate a high gradient across the valve.

Patient ED, a 92 year old woman

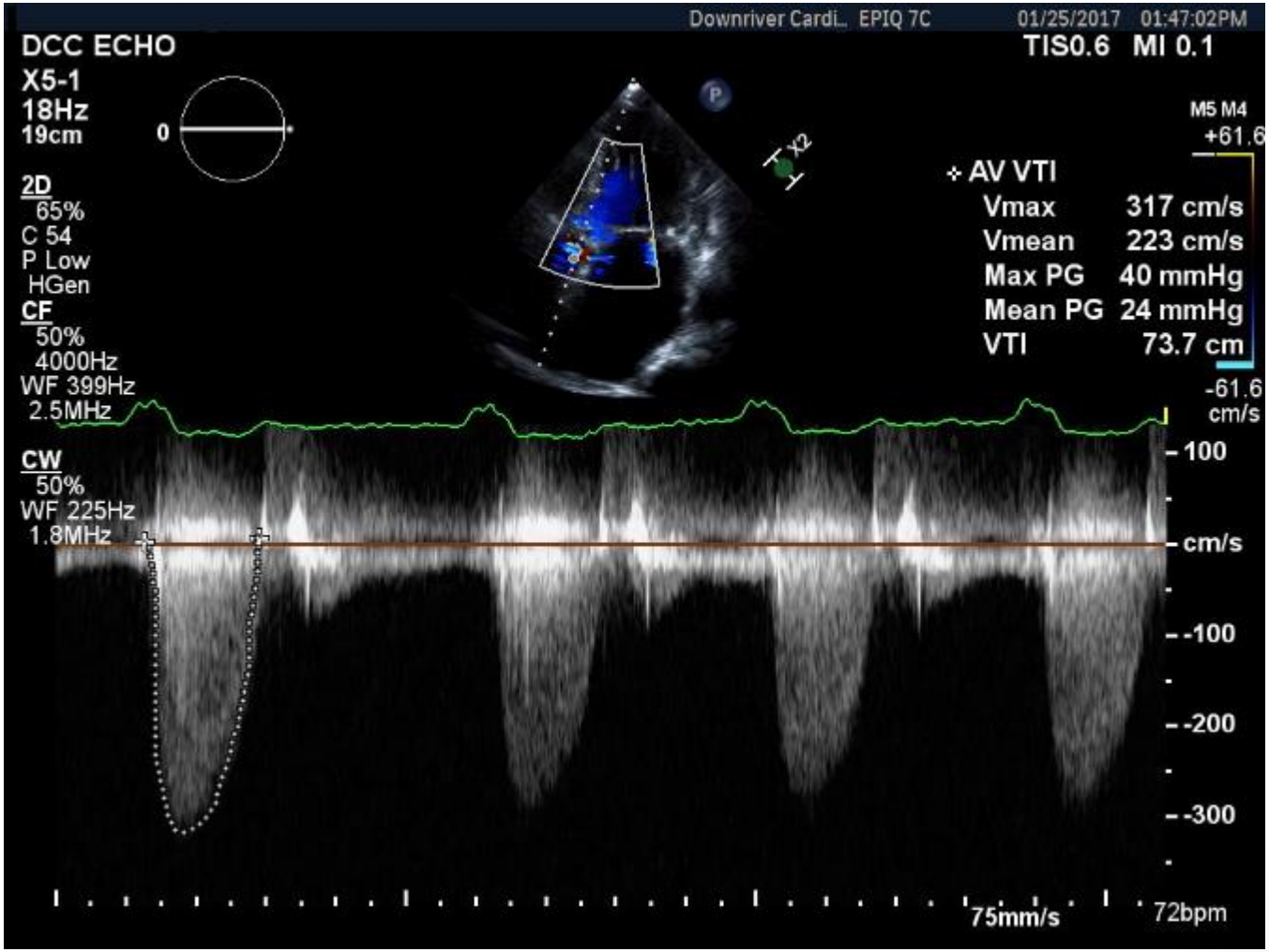


ED, a 92 y/o. LVEF = 41%





ED, Doppler of aortic valve



ED, a 92 y/o woman

- Peak aortic gradient 40 mm Hg
- Mean gradient 24 mm Hg

- Calculated aortic valve area 0.64 cm^2

- Dimensionless index 0.20

ED, a 92 y/o woman

• Peak aortic gradient	40 mm Hg	(≥ 64 mm Hg)
• Mean gradient	24 mm Hg	(≥ 40 mm Hg)
• Calculated aortic valve area	0.64 cm^2	(≤ 1.0 cm^2)
• Dimensionless index	0.20	(severe < 0.25)

Severe aortic stenosis

What about the AS patient with CHF?

Severe AS, but the LV is too sick to generate a high gradient across the valve.

Do dobutamine stress echo if in doubt

Severe aortic stenosis

Severe low gradient AS with decreased EF

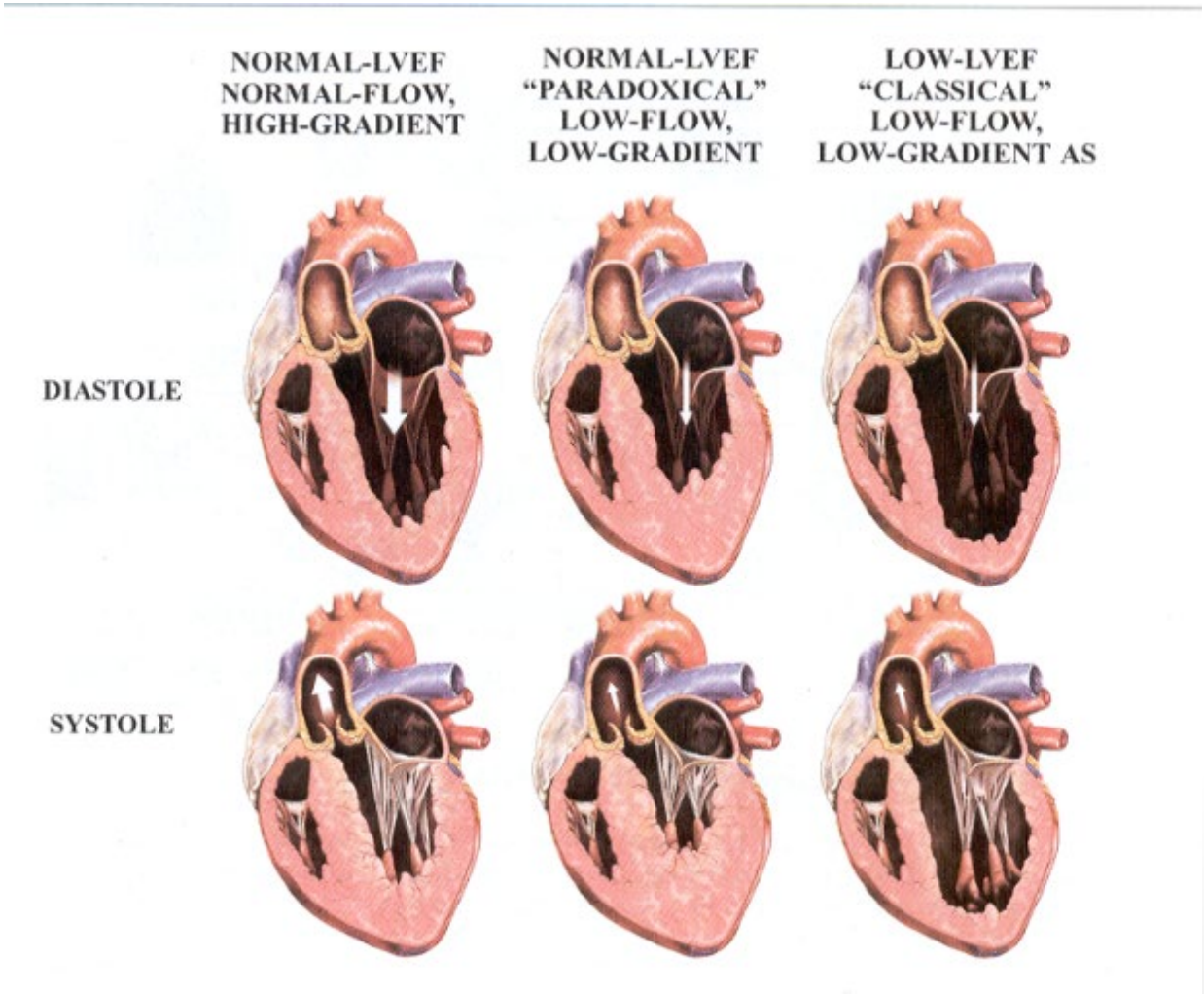
(Calculated valve area < 1.0 cm, but low gradient)

- Dobutamine stress test
  - Severe AS: with increase in contractility, the gradient across the valve increases, no change in AVA
  - Pseudosevere AS: with increase in contractility, the aortic valve opens more, the est. AVA increases and the gradient doesn't change much

New consideration

"Paradoxical" low gradient, severe aortic stenosis with normal LV ejection fraction.

Comparison of low flow, normal and depressed LVEF



New thinking

- In order to improve our assessment of aortic stenosis, we need to think in terms of AS as a systemic disease, with complex interactions between valvular, arterial and ventricular elements

Let’s consider 2 patients each with a gradient of 80 mmHg.

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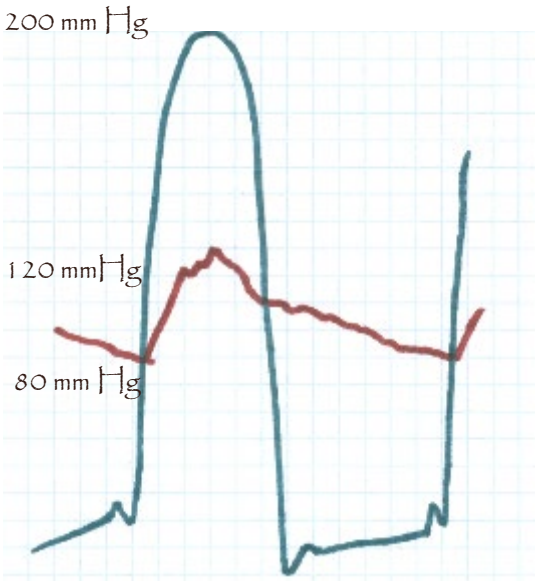

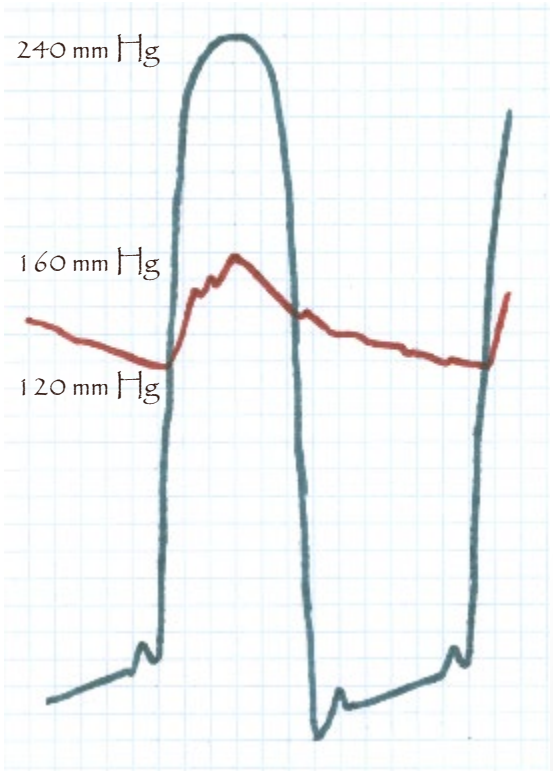

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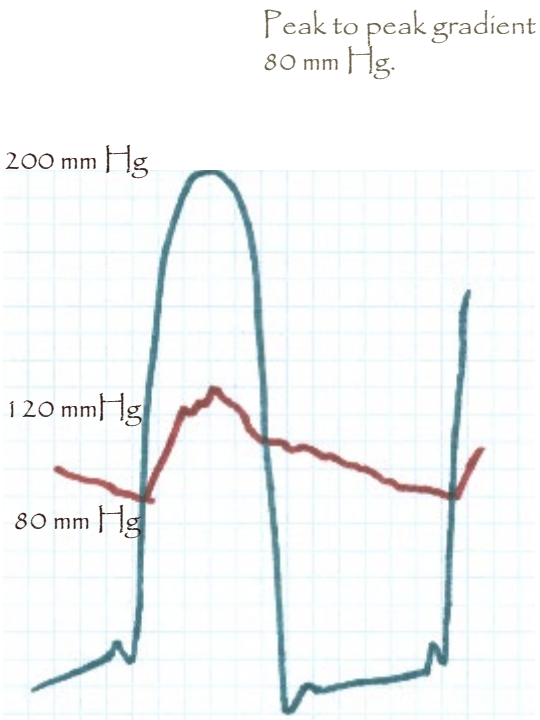

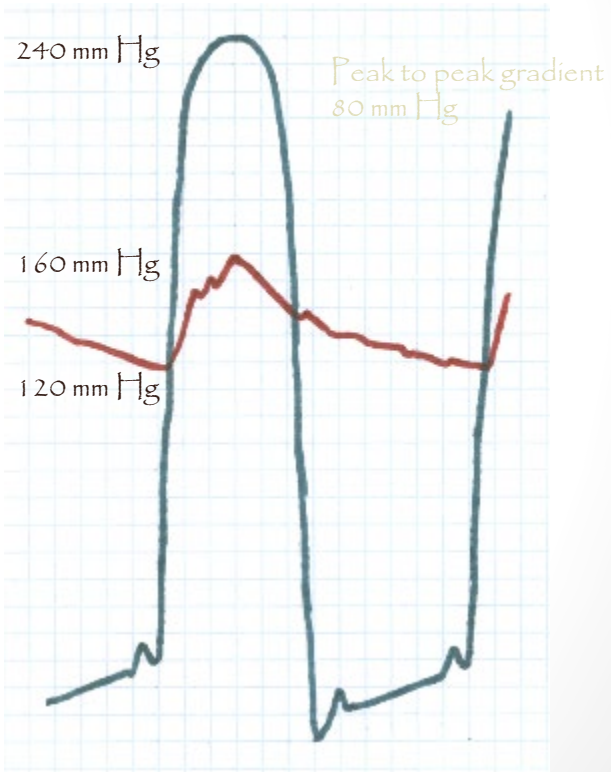

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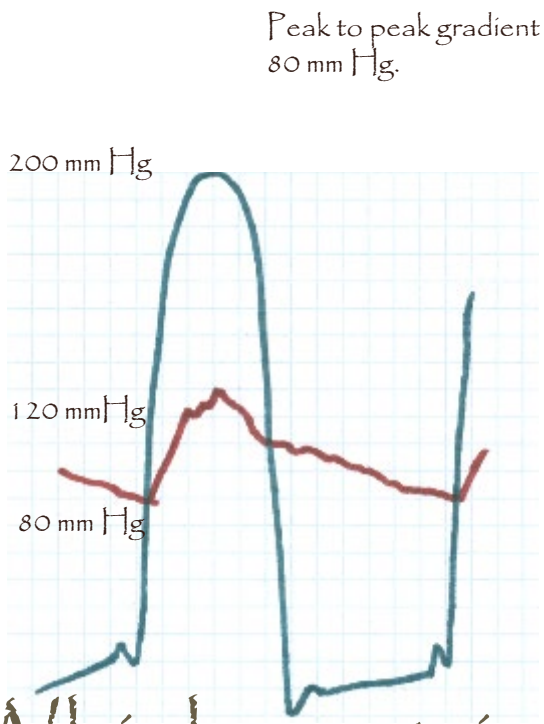

Which ventricle is working harder???

Let's consider 2 patients each with a gradient of 80 mmHg.

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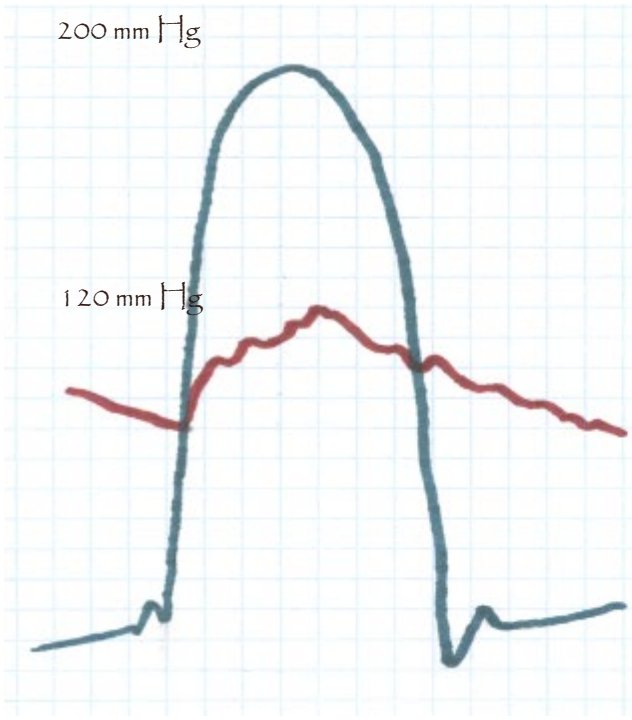
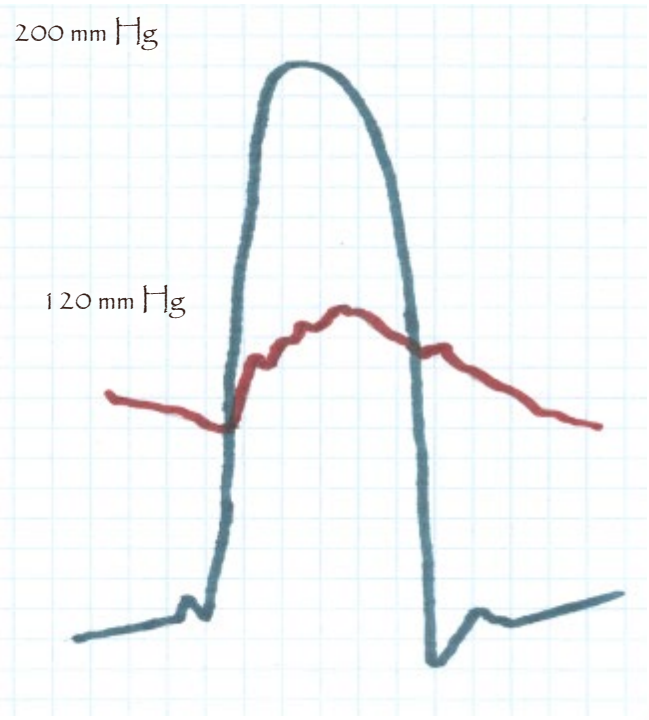


Stroke volume index 40 ml/M²



Stroke volume index 30 ml/M²

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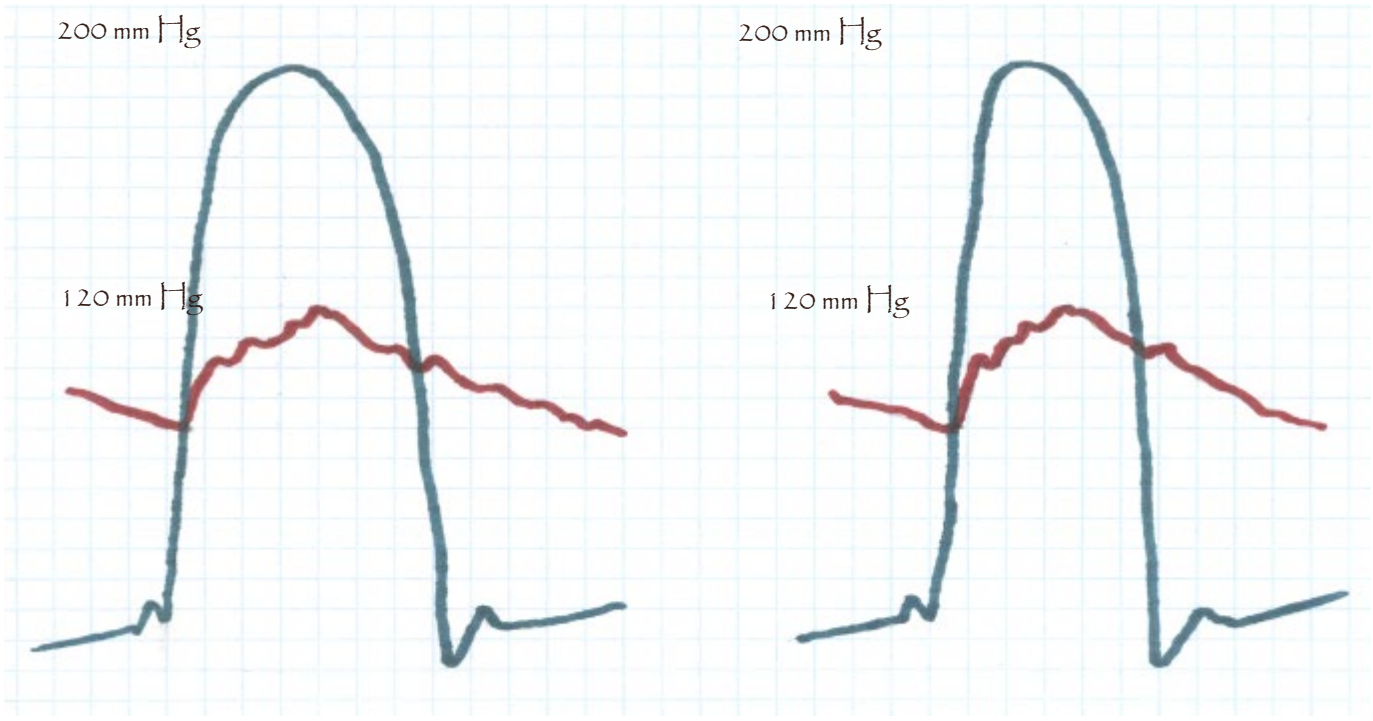


Stroke volume index 40 ml/M²

Stroke volume index 30 ml/M²

WHICH VENTRICLE IS SICKER???

Leveling the playing field

To assess how hard the ventricle is working:

Add the mean gradient to the systolic BP

To determine how healthy the ventricle is:

Calculate the stroke volume index from the measured 2 plane LVEF and LV volume, or the LVOT TVI.

Leveling the playing field

Add the mean gradient to the systolic BP

Calculate the stroke volume index from the measured 2 plane LVEF and LV volume or LVOT TVI.

Divide the sum of BP + mean gradient by the stroke volume index

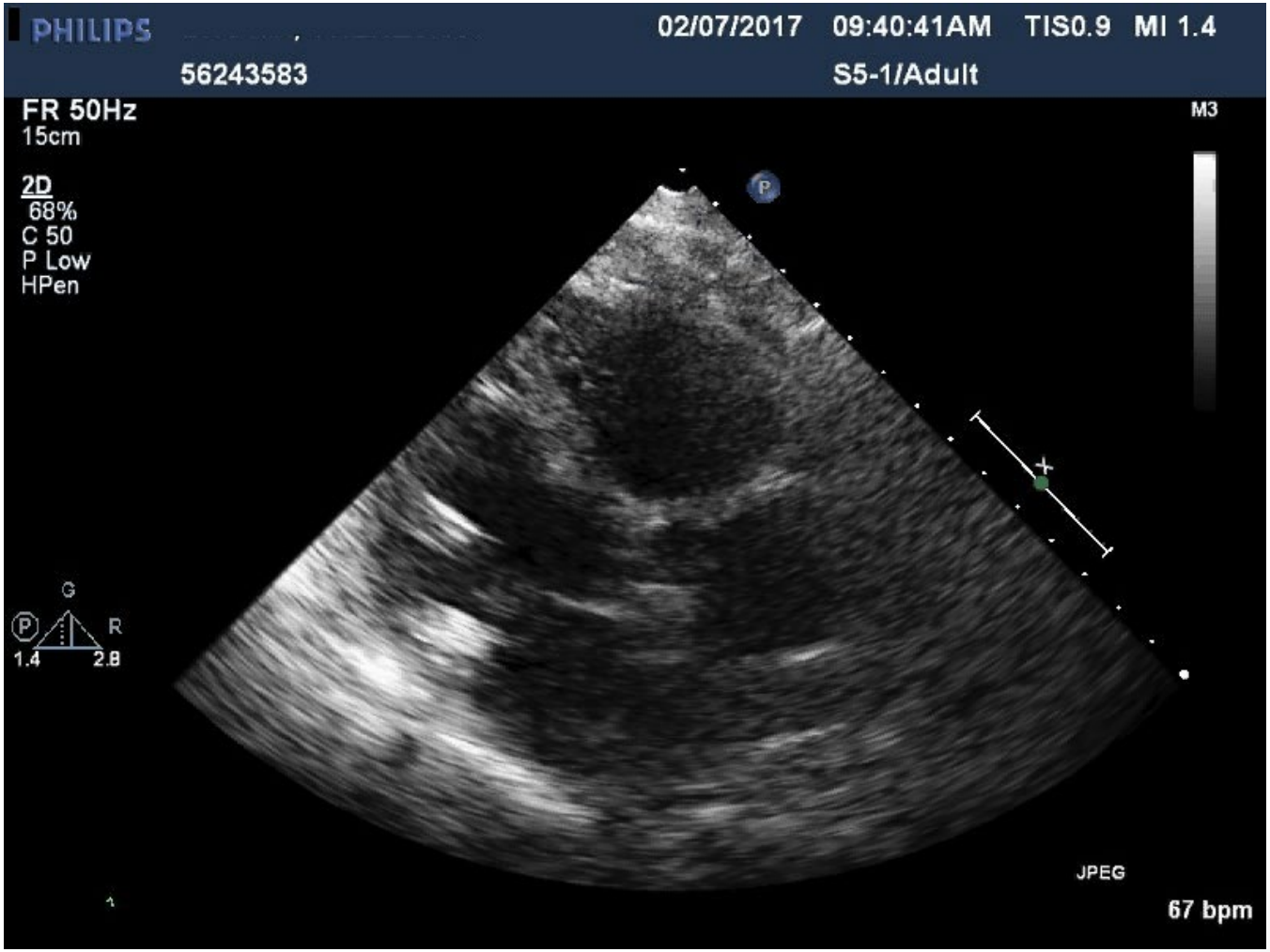
Z = BP + grad/ SVI. Normal < 3.5

Aortic impedance and prognosis

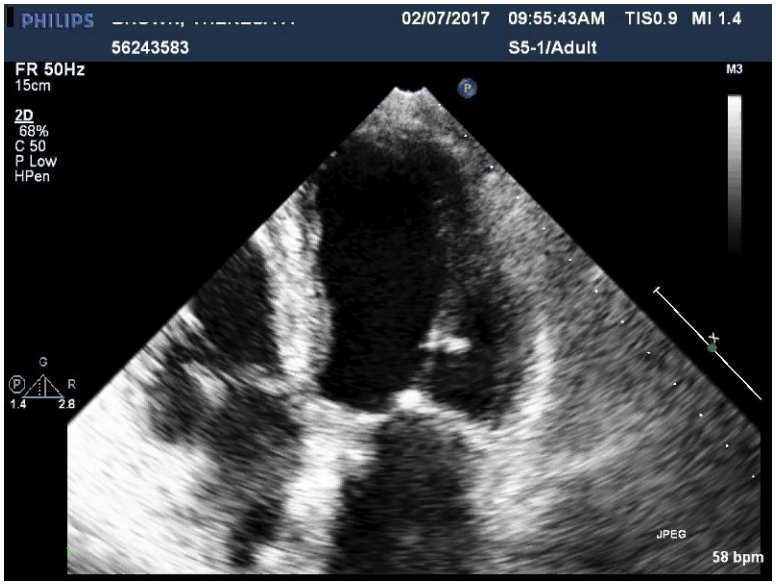
- Quebec Heart & Lung Institute, 544 Asymptomatic patients with mod AS, jet velocity > 2.5 m/s
- Four year survival
  - Z > 4.5 65 +/- 5%
  - Z 3.5 – 4.5 78 +/- 4%
  - Z < 3.5 88 +/- 3%

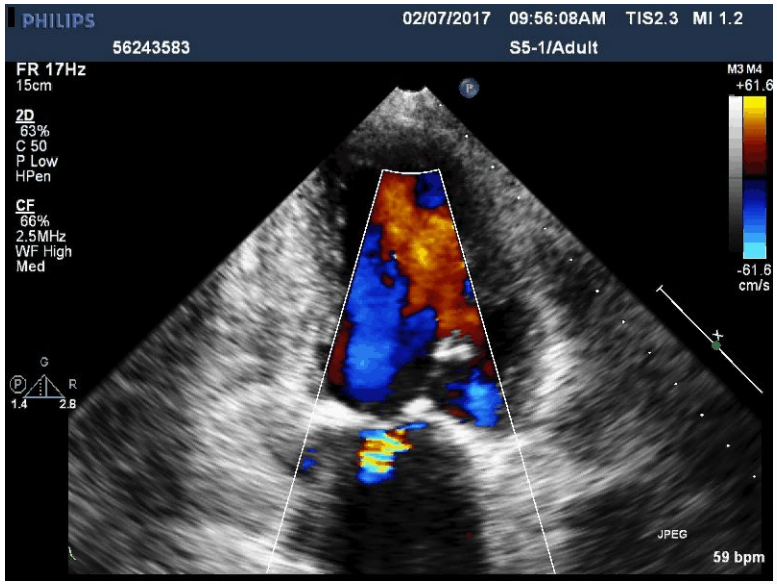
Hachicha et al., JACC 2009; 54: 1003-11

Case, TB, an 84 year old woman who needs surgery

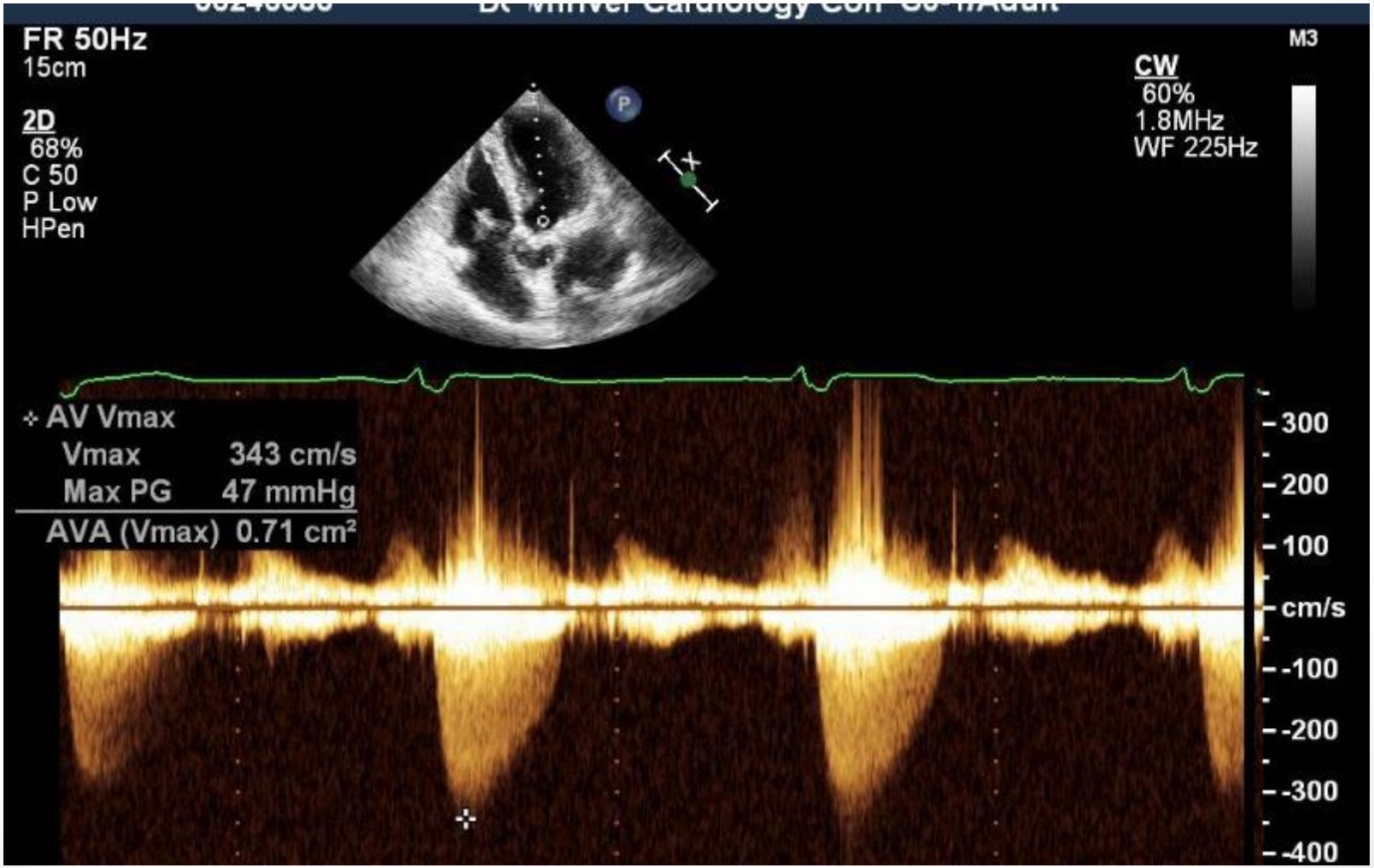


Case, TB, an 84 year old woman who needs surgery

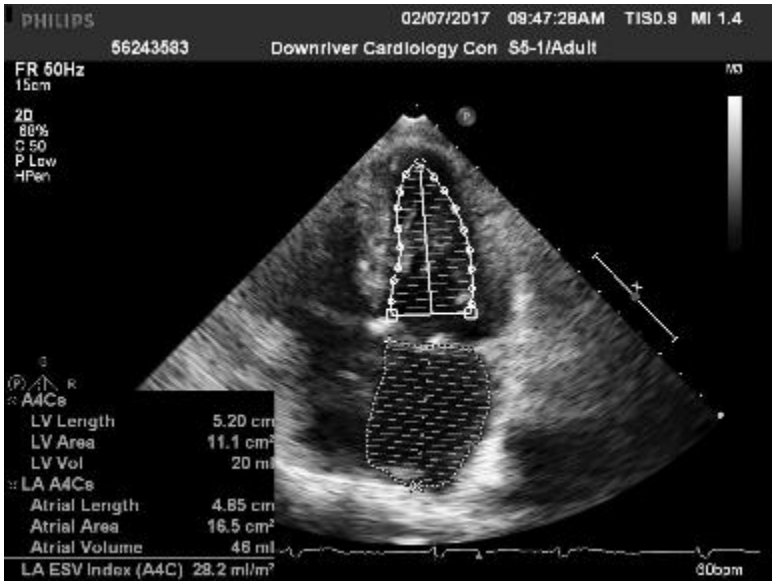


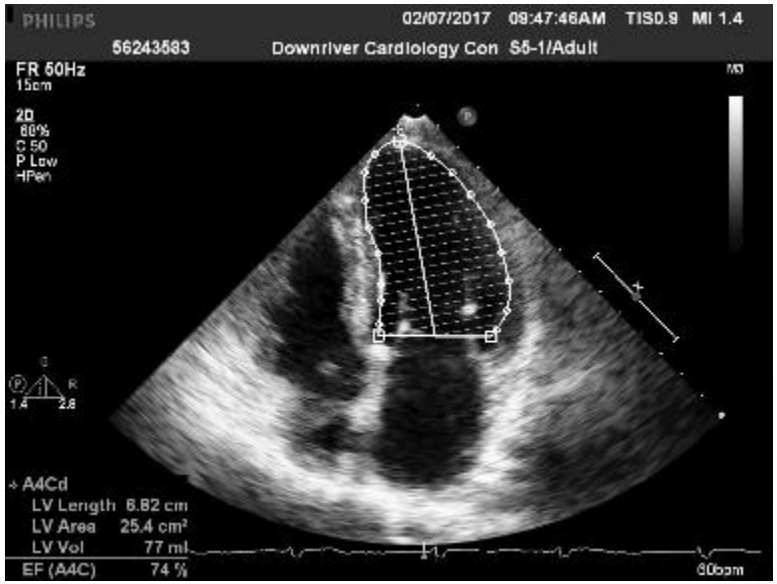


TB


FR 50Hz
15cm
2D
68%
C 50
P Low
HPen
CW
60%
1.8MHz
WF 225Hz
M3
AV Vmax
Vmax 343 cm/s
Max PG 47 mmHg
AVA (Vmax) 0.71 cm²
300
200
100
cm/s
-100
-200
-300
-400

TB, an 84 year old woman who needs surgery





TB, an 84 year old. Summary

- LV EF 74%

Aortic valve area 0.6 cm^2

- Peak gradient 47 mm Hg
- Mean gradient 27 mm Hg

TB, an 84 year old. Summary

- LV EF 74%
- Aortic valve area 0.63 cm^2
- Peak gradient 47 mm Hg
- Mean gradient 27 mm Hg
- Stroke volume 77 ml
  -20
  50 ml
- Systolic blood pressure BP 126/58

TB, an 84 year old. Summary

- LV EF 74%
- Peak gradient
- Mean gradient
- Stroke volume

Aortic valve area 0.63 cm^2

47 mm Hg

27 mm Hg

77 ml

-20

50

BSA 1.63 M^2

SVI = 50/1.63 = 31

Systolic blood pressure

BP 126/58

TB, an 84 year old. Summary

- LV EF 74%
- Peak gradient
- Mean gradient
- Stroke volume

Aortic valve area 0.6 cm^2

47 mm Hg

27 mm Hg

77 ml
-20
50 ml

BSA 1.63 M^2

SVI = 50/1.63 = 31

Systolic blood pressure

BP 126/58

Z Score $\frac{126 + 27}{31}$ (how hard the LV is working) (how well the LV holds up)

= 4.9

Aortic impedance and prognosis

- Quebec Heart & Lung Institute, 544 Asymptomatic patients with mod AS, jet velocity > 2.5 m/s
- Four year survival
  - Z > 4.5 65 +/- 5%
  - Z 3.5 – 4.5 78 +/- 4%
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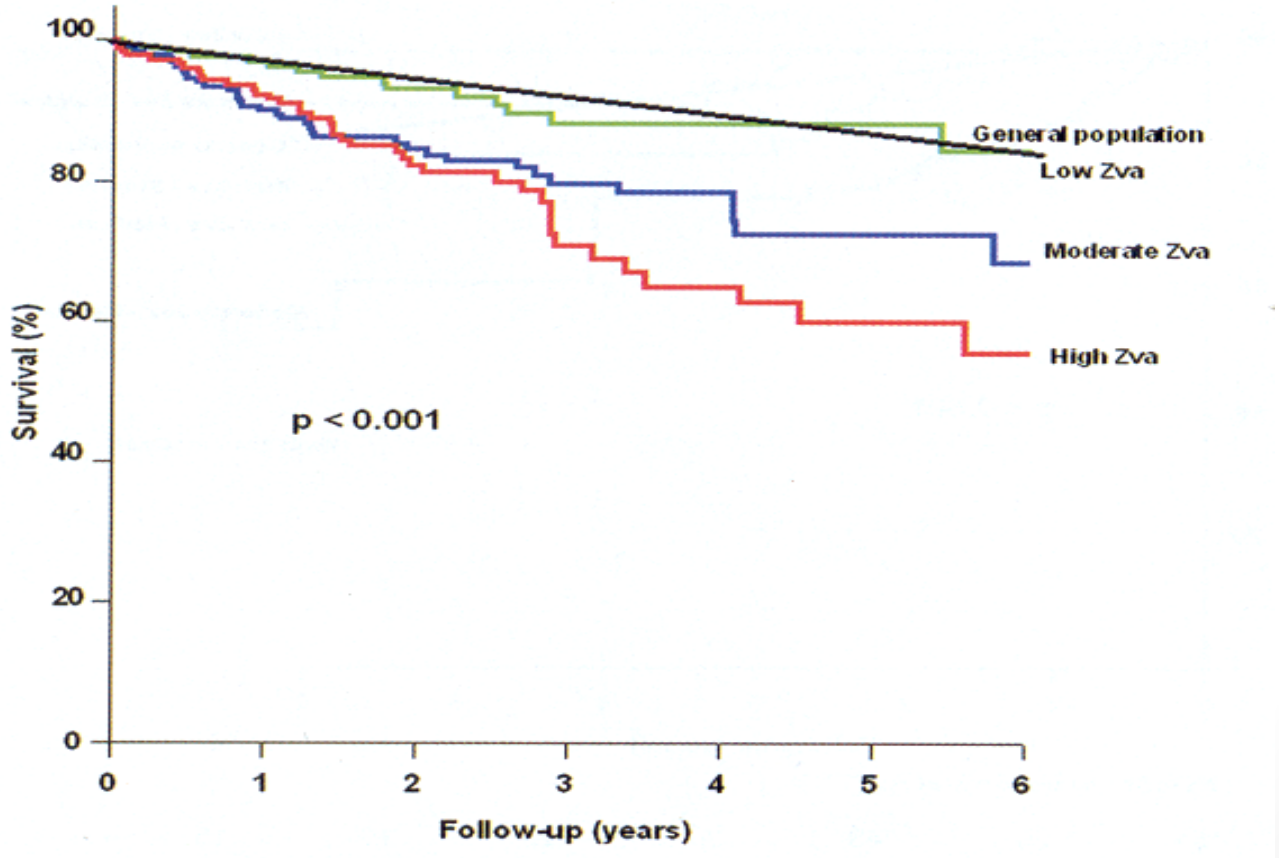
Aortic impedance and prognosis



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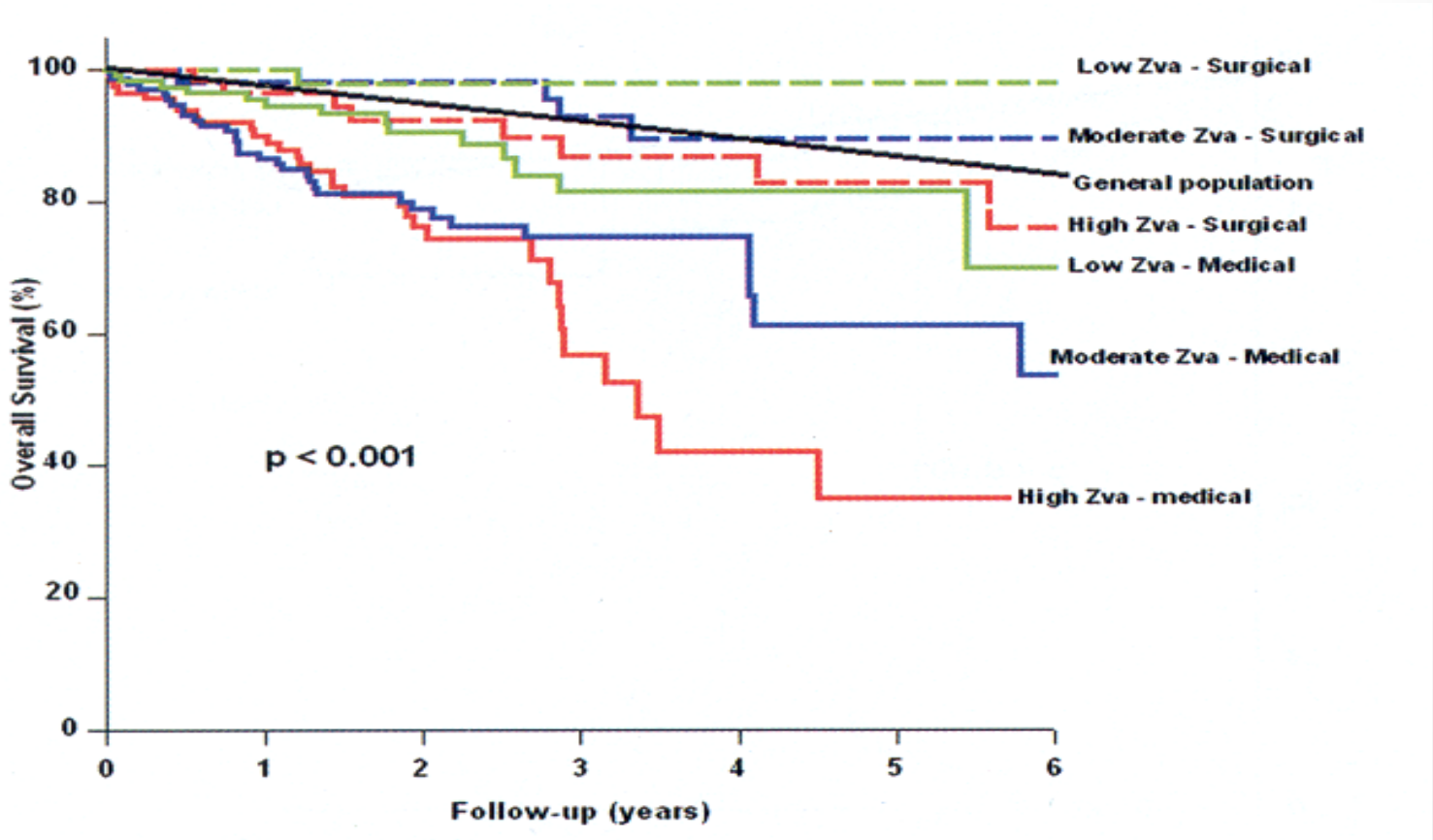

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Aortic impedance: implications

- There may be a paradoxical patient with low gradient severe AS with normal EF.
- These patients are more likely to be elderly women with advanced disease.
- Unlike the valve area itself, the Z score can be modified to some degree – control blood pressure, improve stroke volume.

Aortic impedance: implications

- The ease with which the Z score is implemented in a busy lab depends on how echoes are done prior to that point: routine recording of BP, routine measurement of 2 plane LVEF, calculation of SVI from LVOT TVI.

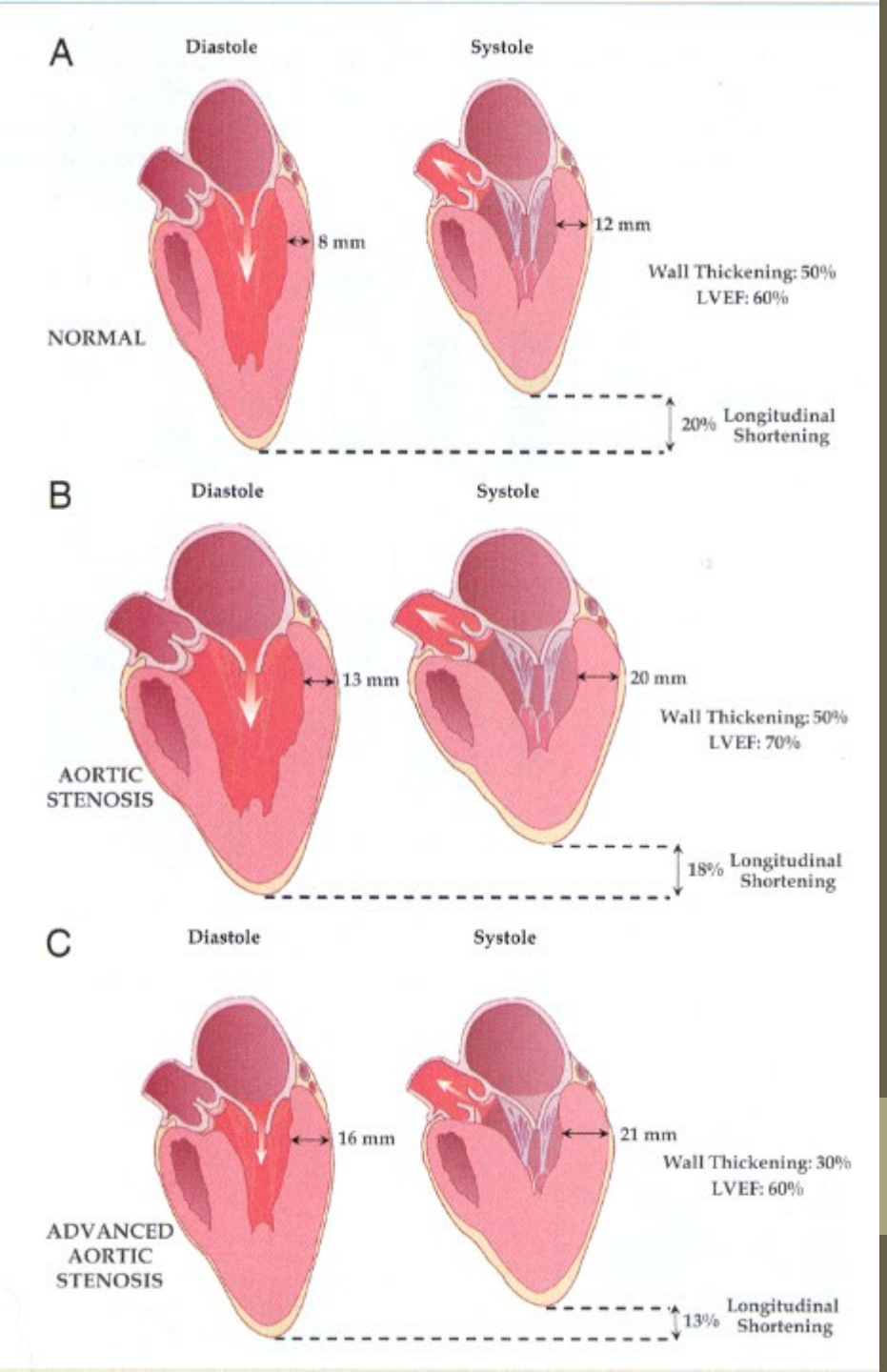
Additional challenges

- Assess LV geometry, intrinsic LV function
- Identify myocardial damage
  - MRI for fibrosis
  - BNP
- Exercise the patient to unmask symptoms

Let's look more at the "paradoxical" problem

- How can you have a normal left ventricular ejection fraction and have LV systolic dysfunction?

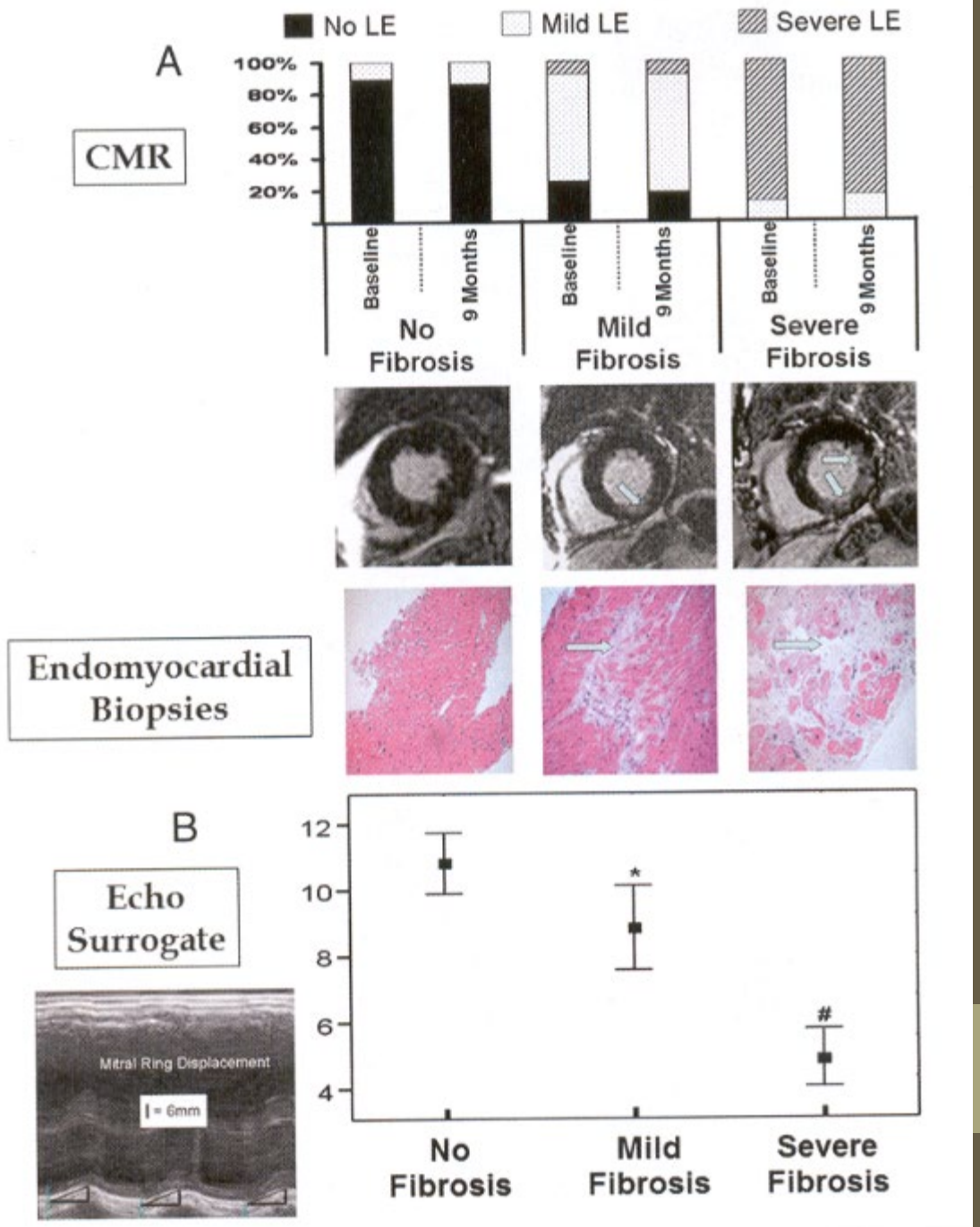
Superiority of Longitudinal Shortening Over LVEF



Measurement of Longitudinal Shortening

- Longitudinal strain imaging
- Mitral ring displacement

Assessment of myocardial fibrosis



New Classification
Severe Aortic Stenosis

New Classification of Severe Aortic Stenosis, Normal EF

- Normal flow/ High gradient
- Normal flow/ Low gradient

- Low flow/ High gradient
- Low flow/ Low gradient

New Classification of Severe Aortic Stenosis, Normal EF

- **NF/LG** 31%. ***Best prognosis***. Preserved longitudinal myocardial function. Lower BNP. 3 year event free 66 ± 9%. Lower LA area index

- **NF/HG** 52%. Mean grad > 40.
  3 year event free rate 33 ± 7%. High BNP.

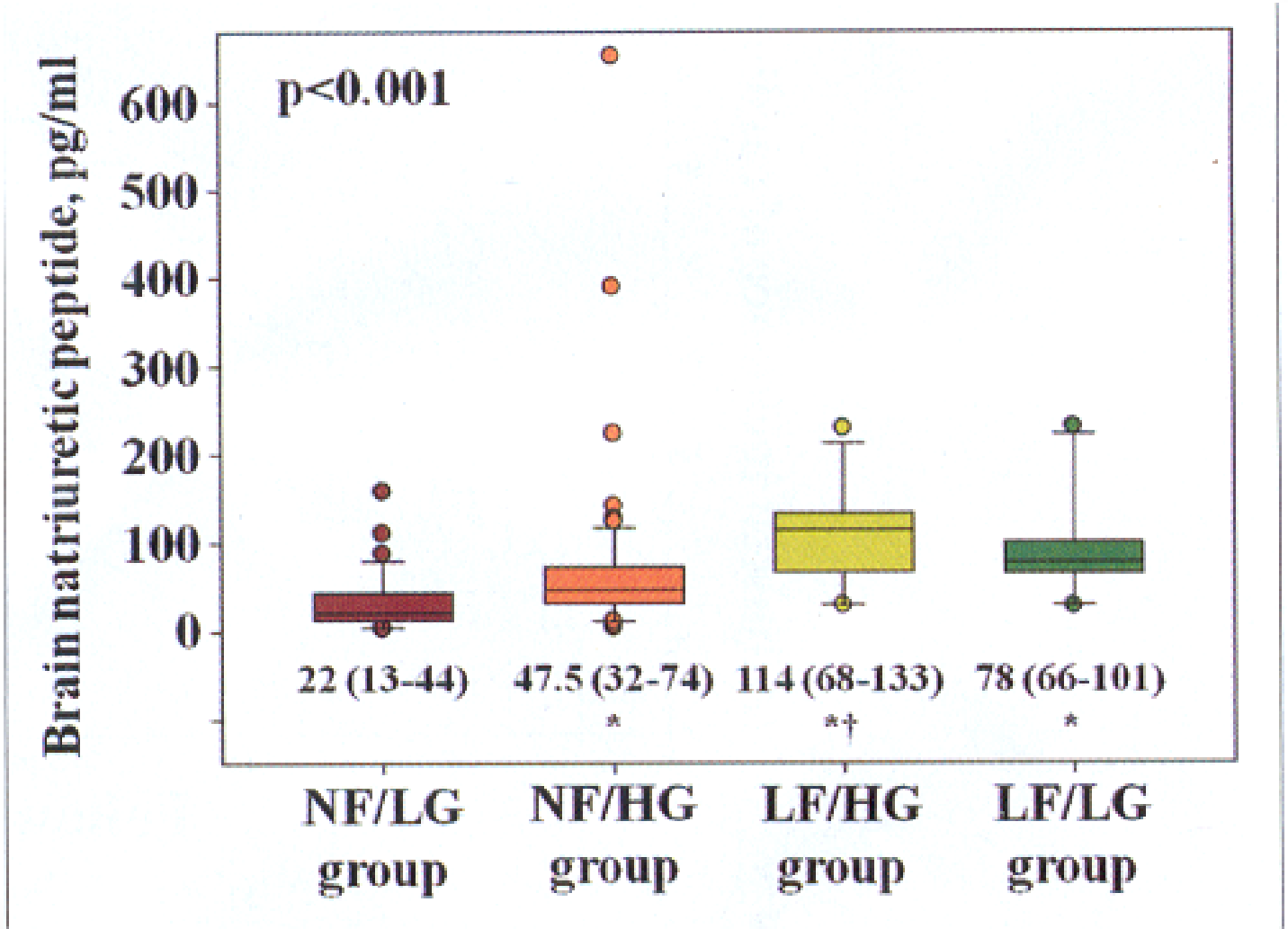
New Classification of Severe Aortic Stenosis, Normal EF

- **LF/HG** 15% SVI < 35 ml/m^2 in spite of normal EF. Decreased longitudinal deformation. Highest BNP.

- **LF/LG** 7% mean grad < 40, SVI < 35 ml/m^2 , preserved EF, AVA < 1.0 cm^2. Pronounced LV concentric remodeling, small LV cavity, intrinsic myocardial dysfunction. ***Dismal prognosis.***

New Classification of Severe Aortic Stenosis, Normal EF

Lancellotti, et al. *JACC*, 2012; 59: 235-43



New thinking about AS

- Move beyond peak gradient and aortic valve area as key markers to define the severity of aortic stenosis
- Incorporate measures of vascular load (valve impedence)
- Assess LV geometry, LV function and myocardial damage (including BNP)
- Do stress test if in doubt about symptoms