Aortic Stenosis

Echocardiographic Evaluation of Hemodynamic Severity

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mayo

DISCLOSURE

Relevant Financial Relationship(s)

None

Off Label Usage

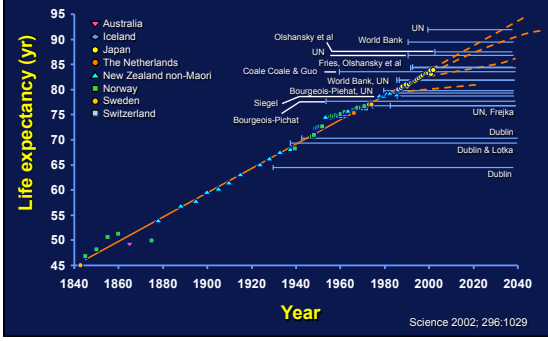
None

VHD in the 21th century

A re-emerging public-health problem

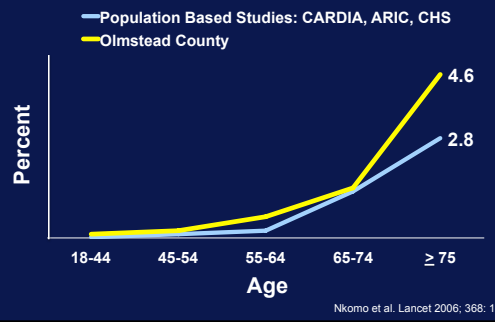
- Increasing prevalence
- Mostly degenerative
- **Affecting the elderly**
- Requiring new approaches

Aging of the Human Race
Survival: 3 months / year since 1840



Science 2002; 296:1029

Prevalence of Aortic Stenosis
Moderate to Severe

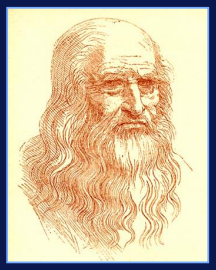


Nkomo et al. Lancet 2006; 368: 1005–11

VHD in the 21th century
A re-emerging public-health problem

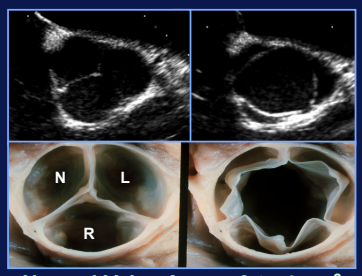
- Increasing prevalence
- Mostly degenerative
- Affecting the elderly
- Requiring new approaches

Leonardo da Vinci - 1513



www.reportajes.org/.../02/leonardo-da-vinci.jpg

Normal Aortic Valve

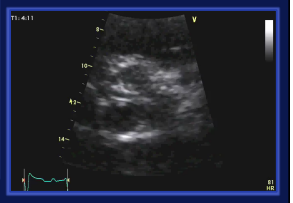


Normal Valve Area = 3 to 4 cm^2

N = non-coronary cusp; L = left coronary cusp; R = right coronary cusp

Michelena HI, Mankad S, Sarano ME. Atlas of Echocardiography, 2009

The earliest description of calcific aortic stenosis 1647



Lazarus Riverius 1589-1655

A Parisian Shoemaker named Carolus Rayger died suddenly (1672)

- reported by Bonetus in 1679
- "Sepulchretum" – aortic valve of "bone"

2014 AHA/ACC Guideline for the Management of Patients with Valvular Heart Disease

A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines

Developed in Collaboration With the American Association for Thoracic Surgery, American Society of Echocardiography, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons

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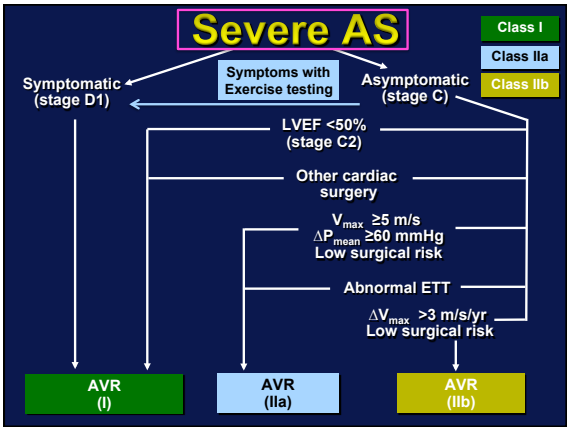
Many of the recommendations are now (Level of Evidence B)

Stages of Progression of Valvular Heart Disease

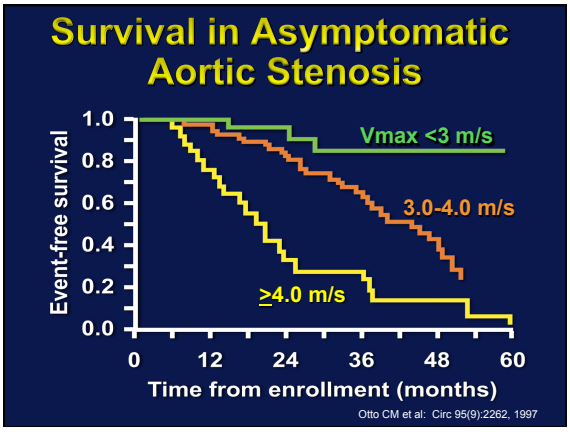
Stage	Definition	Description
A	At risk	Patients with risk factors for the development of VHD



Aortic Stenosis
Hemodynamic Severity

	Aortic V_{max} (m/s)	Mean Gradient (mmHg)	Valve Area (cm^2)	Valve Area Index (cm^2/m^2)
Mild	2.0-2.9	<20	>1.5	>0.8
Moderate	3.0-3.9	20-39	1.1-1.5	0.7-0.8
Severe	≥4.0	>40	≤1.0	≤0.6

Nishimura, et al, 2014



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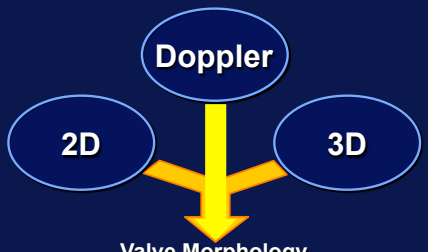
Echocardiographic Evaluation of Aortic Stenosis



Valve Morphology
Vmax, Valve Area and Gradient
Ventricular Size & Function, RVSP

Blood Flow Velocity

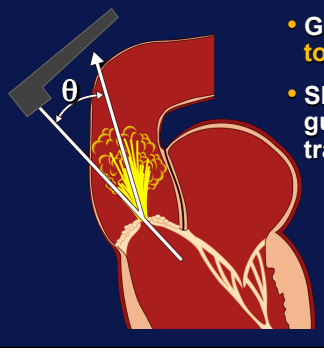
Christian Andreas Doppler
1803 - 1853

Positive Frequency Shift

$(fr-fo) = 2fo \; v \; (\cos\theta) \; / \; c$

C= average speed of sound in tissue (1540m/sec)

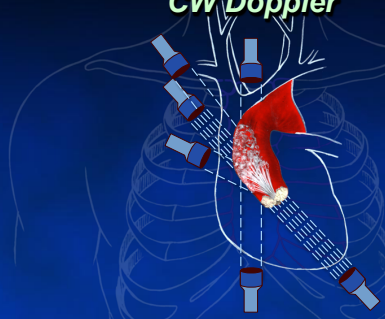
Importance of Doppler Angle



- Goal: parallel to flow
- Skilled in non-guided CW transducer

Aortic Stenosis

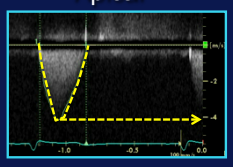
CW Doppler



Aortic Stenosis

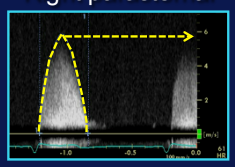
CW Doppler

Apical



V_{max} = 4.1 m/s
TVI = 92 cm
MG = 34 mmHg

Right parasternal



V_{max} = 4.8 m/s
TVI = 148 cm
MG = 68 mmHg

Buzz Miller MD

Echocardiographic Evaluation of Aortic Stenosis

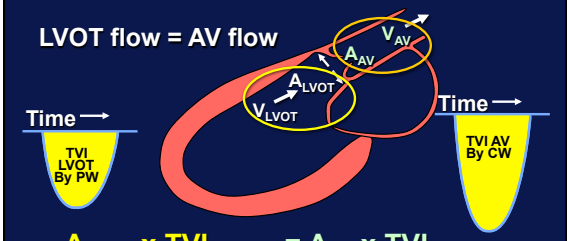
Rule #1:

CW Doppler from multiple windows

Aortic Valve Area

Continuity Equation

LVOT flow = AV flow



$A_{LVOT} \times TVI_{LVOT} = A_{AV} \times TVI_{AV}$

$A_{AV} = (A_{LVOT} \times TVI_{LVOT}) / TVI_{AV}$

AV area

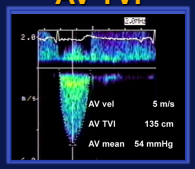
=

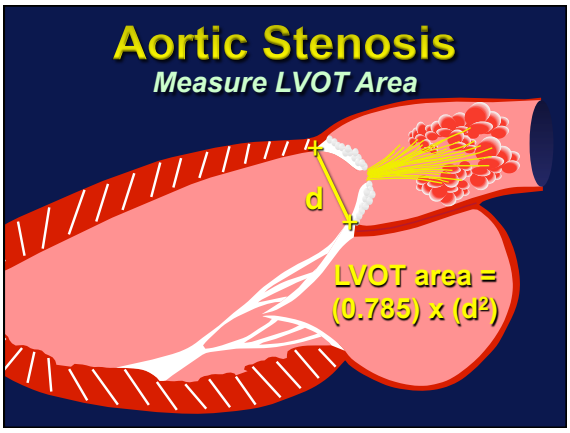
LVOT area

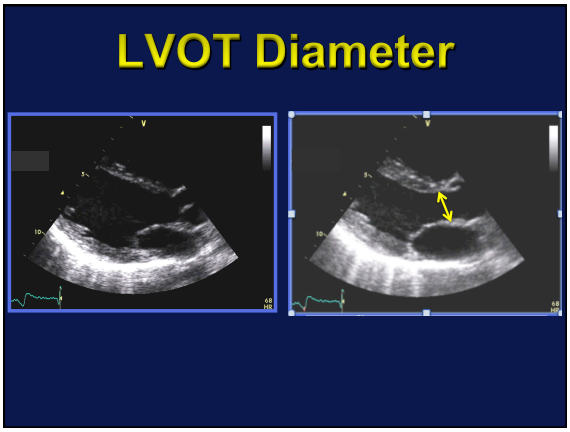
LVOT TVI

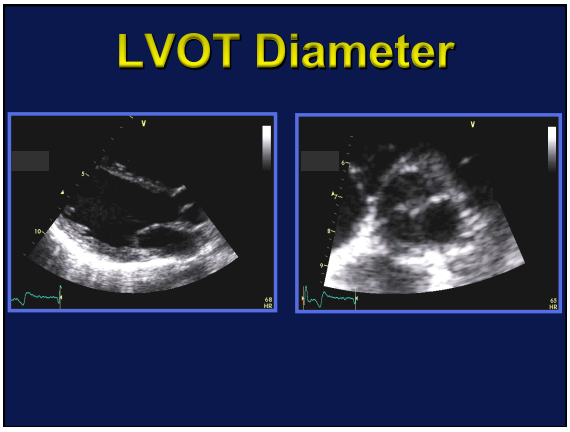
STROKE VOLUME

AV TVI

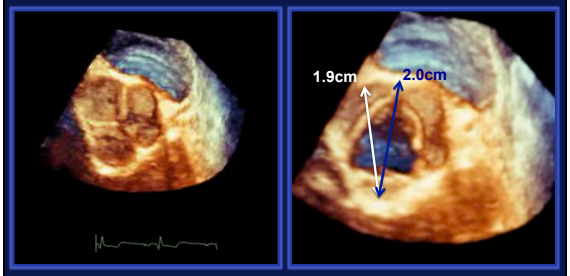



Aortic Stenosis
Measure LVOT Area
d
LVOT area =
(0.785) x (d²)


LVOT Diameter


LVOT Diameter

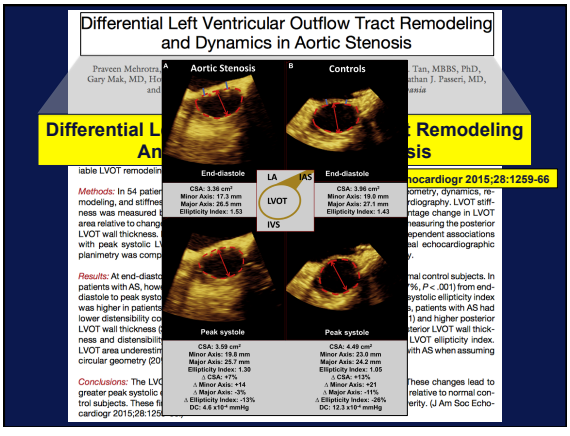
LVOT Diameter



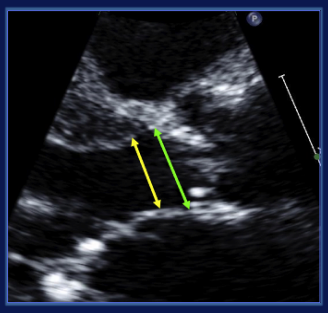
Echocardiographic Evaluation of Aortic Stenosis

Rule #2:

When measuring the LVOT diameter you should see the base of the anterior or right coronary cusp but may not clearly see the posterior cusp.



Where To Measure the LVOTd?
At the Annulus or Below the Annulus?



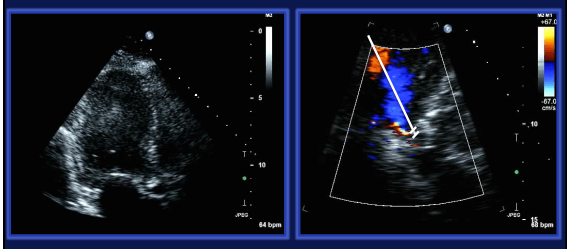
LaBounty et al. JACC Cardiovasc Imaging 2014;7:1065-6
Image from Piberot et al. J Am Soc Echocardiogr 2015;28:1267-69

Echocardiographic Evaluation of Aortic Stenosis

Rule #2a:

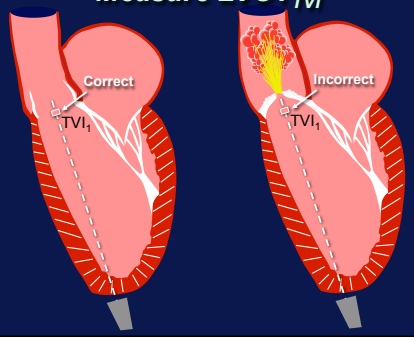
When measuring the LVOT diameter this measurement should be made at the level of the annulus at peak systole.

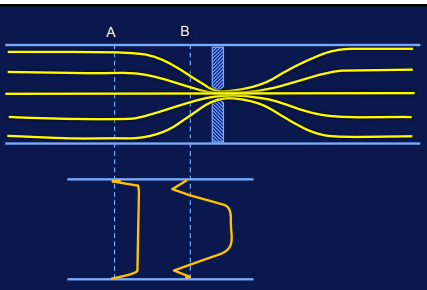
Aortic Stenosis
Measure $LVOT_{TVI}$



Aortic Stenosis

Measure $LVOT_{TVI}$



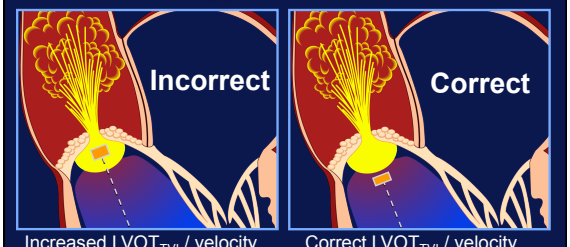


If as in the LVOT, the flow proximal to the obstruction is accelerated, the velocity profile at level A is flattened. Velocities representing the spatial mean velocity should therefore be recorded at this level.

Skjaerpe T: Circulation 72(4), 10/85

Aortic Stenosis

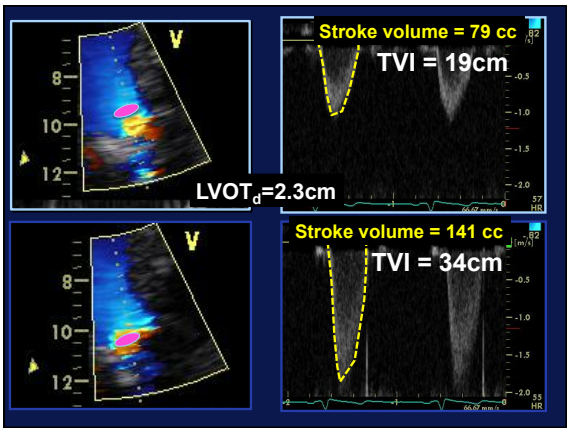
Measure $LVOT_{TVI}$: Sample Volume Position

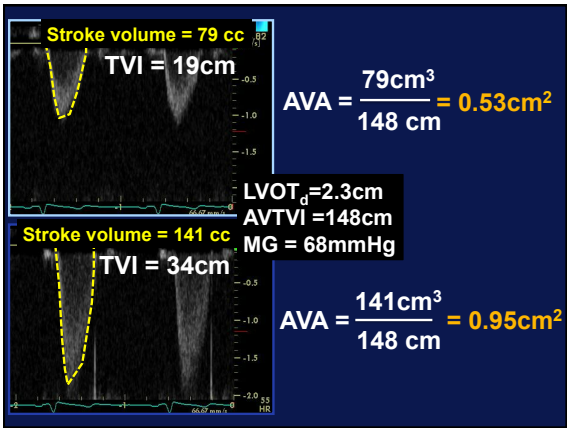


Increased $LVOT_{TVI}$ / velocity

Correct $LVOT_{TVI}$ / velocity

Normal LVOT TVI: 18-22 cm

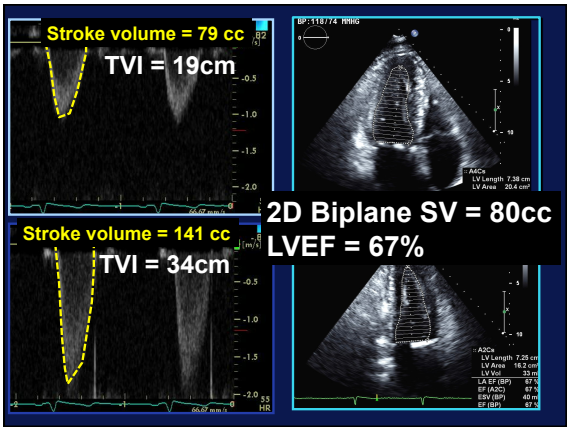




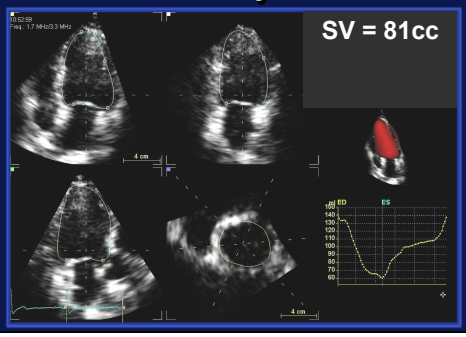
Echocardiographic Evaluation of Aortic Stenosis

Rule #3:

When measuring the $LVOT_{TVI}$ the pulsed wave sample volume should be placed in the blue flow.



3D Echocardiography
Stroke Volume & Ejection Fraction



Echocardiographic Evaluation of Aortic Stenosis

Rule #4:

Check for concordance between Doppler with 2D &/or 3D calculations of stroke volume and compare to LV size and ejection fraction.

Echocardiographic Evaluation of Aortic Stenosis

Rule #5:

Check for concordance between the calculated valve area and mean gradient or explain discordance.

Echocardiographic Evaluation of Aortic Stenosis