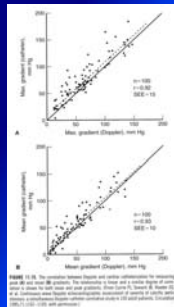


Aortic Stenosis

Background

- Aortic stenosis
 - “Gold Standard” - catheterization – Derivation of valve area using peak and mean pressure gradients
 - Doppler assessment –
 - Validated in vitro, and in clinical situations
 - echocardiographic/catheterization correlation



Amerson W, & Ryan T. *Foxeinstein's Echocardiography*. Philadelphia 2003

Defining Severity of Aortic Stenosis

	Stenosis			
	Normal	Mild	Moderate	Severe
Mean Gradient (mmHg)	0	<25	25-40	>40
Peak Gradient (mmHg)	0	<35	35-60	>60
Valve Area (cm ²)	3.0-4.0	1.6-3.0	1.0-1.5	<1.0

Bernard RD et al. JACC 2000;48:34

Background

- Doppler assessment
 - Depends on the ability to accurately record and quantify the maximal aortic jet velocity through the valve orifice
 - Requires use of multiple echocardiographic windows
 - Use both imaging and non-imaging (Pedoff) transducers
 - After jet velocity is accurately recorded and quantified assumptions are made to then translate the measured gradient into an aortic valve area.

Pitfalls

- Assumptions inherent in assessing valve area severity
 - Normal left ventricular function
 - Regular rhythm
 - Physiologic cardiac output
 - No significant aortic regurgitation
 - Reliable and reproducible data
- When are some or all of these factors missing in a given patient?
 - Unfortunately - frequently

Avoiding the Pitfalls

- Pitfalls in gradient measurement due to:
 - Variations in cardiac physiology
 - Incorrect data collection/interpretation
- Continuity equation – used to report aortic valve area
- May generate over or under estimation of aortic stenosis severity

Pitfalls

- Variations due to cardiovascular physiology
 - Low cardiac output - decreased flow
 - Decreased flow across aortic valve yields lower gradient during systole thus causing underestimation of aortic stenosis severity - CHF with decreased LVEF
 - Increased cardiac output/valvular flow
 - High output states – anemia, sepsis, etc.
 - Aortic insufficiency - moderate to severe
 - Pressure recovery
 - In certain situations (especially prosthetic aortic valves, more severe stenoses and small aortic roots), Doppler derived gradients may overestimate severity of stenosis

Pitfalls – Technical

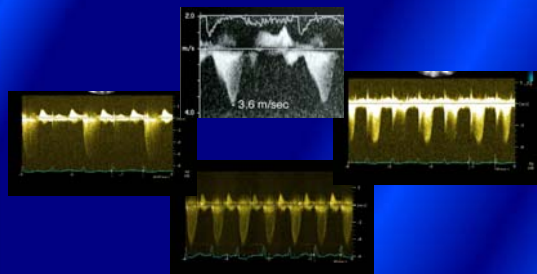
- Pitfalls in data collection
 - Must record the highest velocities in order to assure that the doppler recording is nearly parallel to flow and use non imaging (Pedoff) transducer for greatest sensitivity of Doppler signals
 - Requires excellent sonographer technique



Ameling W, & Ryan, T. Faganbaum's Echocardiography, Philadelphia 2003

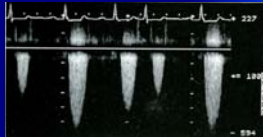
Technical Pitfalls

- Aortic stenosis may be mistaken for
- Mitral insufficiency
 - Hypertrophic obstructive cardiomyopathy
 - Tricuspid insufficiency



Pitfalls - Technical

- Arrhythmia
 - Atrial fibrillation - Should use average of five or 10 beats depending on the degree of irregularity of arrhythmia
 - PVCs - Avoid PVC or post PVC beats
- Presence of subaortic stenosis (HOCM or membranous subaortic stenosis) will increase the LVOT velocity and further increase the velocity across the aortic valve



Amendong W. & Ryan, T. *Echocardiography* Philadelphia 2010

Continuity equation

Based on the conservation of flow from aortic outflow tract through the aortic valve

- $TVI_{LVOT} \times Area_{LVOT} = TVI_{AV} \times Area_{AV}$
- $Area_{AV} = TVI_{LVOT} \times Area_{LVOT} / TVI_{AV}$
- Advantages
 - Independent of flow (i.e. can be used with aortic insufficiency, high or low cardiac output states)
- Disadvantages
 - Requires three measurements including left ventricular outflow tract velocity, aortic valve flow velocity and left ventricular outflow tract diameter (a squared measurement)
 - LVOT flow and diameter must be measured at same location

Continuity equation

- Continuity equation tips
 - Measure left ventricular outflow tract **velocity** at same levels as left ventricular outflow tract **diameter**-very important
 - From apical approach, move sample volume up until turbulence is encountered then move cursor back until laminar flow is seen and note distance from aortic valve.
 - Measure left ventricular outflow tract diameter at the same level
 - Note on report location where diameter and velocity were recorded for future study correlation for stenosis progression

Dimensionless index

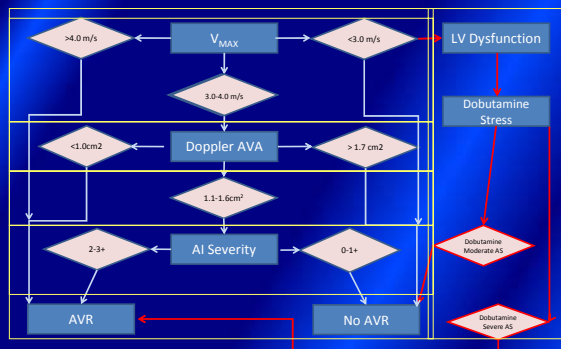
- Ratio of VTI of LVOT to the VTI of the stenotic jet
- < 0.25 is consistent with severe aortic stenosis

Dobutamine Echo Responses Aortic Stenosis With LV Dysfunction and Low Resting Gradients

Low cardiac output causing underestimation of stenosis severity
Dobutamine stress echocardiographic evaluation

Baseline			Low Dose			Mid Dose			Interpretation
LVOT Velocity	AV Jet Velocity	AV Pl. Gradient	LVOT Velocity	AV Jet Velocity	AV Pl. Gradient	LVOT Velocity	AV Jet Velocity	AV Pl. Gradient	
0.6	3.0	36	0.9	4.0	64	1.1	5.0	100	Severe AS with LV Dysfunction
0.6	3.0	36	0.8	3.2	41	1.1	3.4	46	Moderate AS with LV dysfunction
0.6	3.0	36	0.6	3.0	36	0.6	3.0	36	AS with LV dysfunction and no myocardial viability

Flow Chart for AS in Consideration for AVR



Aortic Insufficiency

- Color Flow
 - Measurement of Vena Contracta
 - PLA vs. Apical
 - Apical more subject to entrainment and is dependent on lateral (as opposed to axial) resolution thus tends to overestimate jet width
 - Short axis
 - Best view to estimate jet morphology and to assess severity with color flow
 - » Make sure you are just below the valve, not in LVOT!
 - Jet size affected by
 - Nyquist limit
 - Color gain settings
 - Eccentric vs. central jet

Aortic Insufficiency

Aortic Insufficiency

- CW
 - Doppler sampling off axis to jet flow
 - Will record lower velocities and shorter pressure half-time (and faster deceleration slope)
 - AI severity will be overestimated
 - Dependant on:
 - Acuity of onset
 - LVEDP
 - Blood pressure

Aortic Insufficiency

- Solutions
 - Multiple measurements
 - Apical overestimates jet width
 - Assess patient status
 - Unusually high or low BP
 - Hemodynamically unstable
 - Use regurgitant fraction calculation
 - In presence of trace or mild MR or TR (use as reference valve)
$$RF = (CSA_{AV} \times TVI_{AV}) - (CSA_{MV} \times TVI_{MV}) / (CSA_{AV} \times TVI_{AV})$$
$$RF > 60\% = \text{Severe AI}$$

Mitral Insufficiency

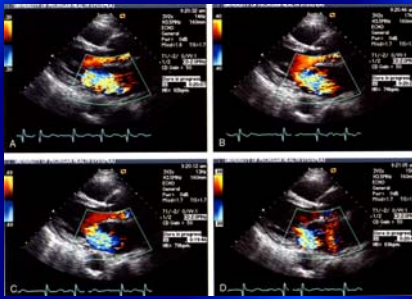
Mitral Insufficiency

- Eccentric jet
 - More eccentric, the more will underestimate severity of MR
- Late systolic mitral insufficiency (e.g. MV prolapse)
 - Color flow may occupy a large portion of LA, although only during a small portion of systole
- Color gain, color map and Nyquist limit settings – may over- or underestimate severity
- Low CO
- Low SBP

Mitral Insufficiency

- Solutions
 - Use PV Flow
 - Pay attention to CW jet density, timing, etc
 - Assess LA and LV sizes
 - Assess hemodynamic state of patient at time of study (BP, unstable hemodynamic state)
 - Look at the color map

Mitral insufficiency – Effect of Nyquist Limit



Tricuspid Insufficiency

Tricuspid Insufficiency

- Severe Tricuspid insufficiency in presence of elevated right atrial pressure and/or right ventricular dysfunction
 - May significantly underestimate severity due to high right atrial pressure limiting flow velocity from right ventricle (i.e. color jet appears smaller esp. with high Nyquist limit)
- Solutions
 - Pay careful attention to right atrium, RAP and right ventricular systolic function

Summary

- Although there are many pitfalls, in most situations the standard approach to valve function is reliable especially if data is obtained by experienced sonographers.
- Experienced echocardiographers and clinicians should assess whether Doppler data and two dimensional imaging correlate with the patient's clinical presentation. They generally will be able to determine the true clinical importance of the various valvular lesions.
- When data is not consistent or data does not match the clinical presentation, one must take a critical look at the data and/or consider repeating the study, taking care to avoid the many pitfalls associated with assessing of valvular stenosis or insufficiency.

Summary

- In situations where there is significant left ventricular systolic dysfunction, the addition of dobutamine infusion will help assess both the severity of aortic stenosis as well as left ventricular functional reserve.
- Use of the "Dimensionless index"
(VTI_{LVOT}/VTI_{AV}) < 0.25 will indicate severe aortic stenosis in most patients.