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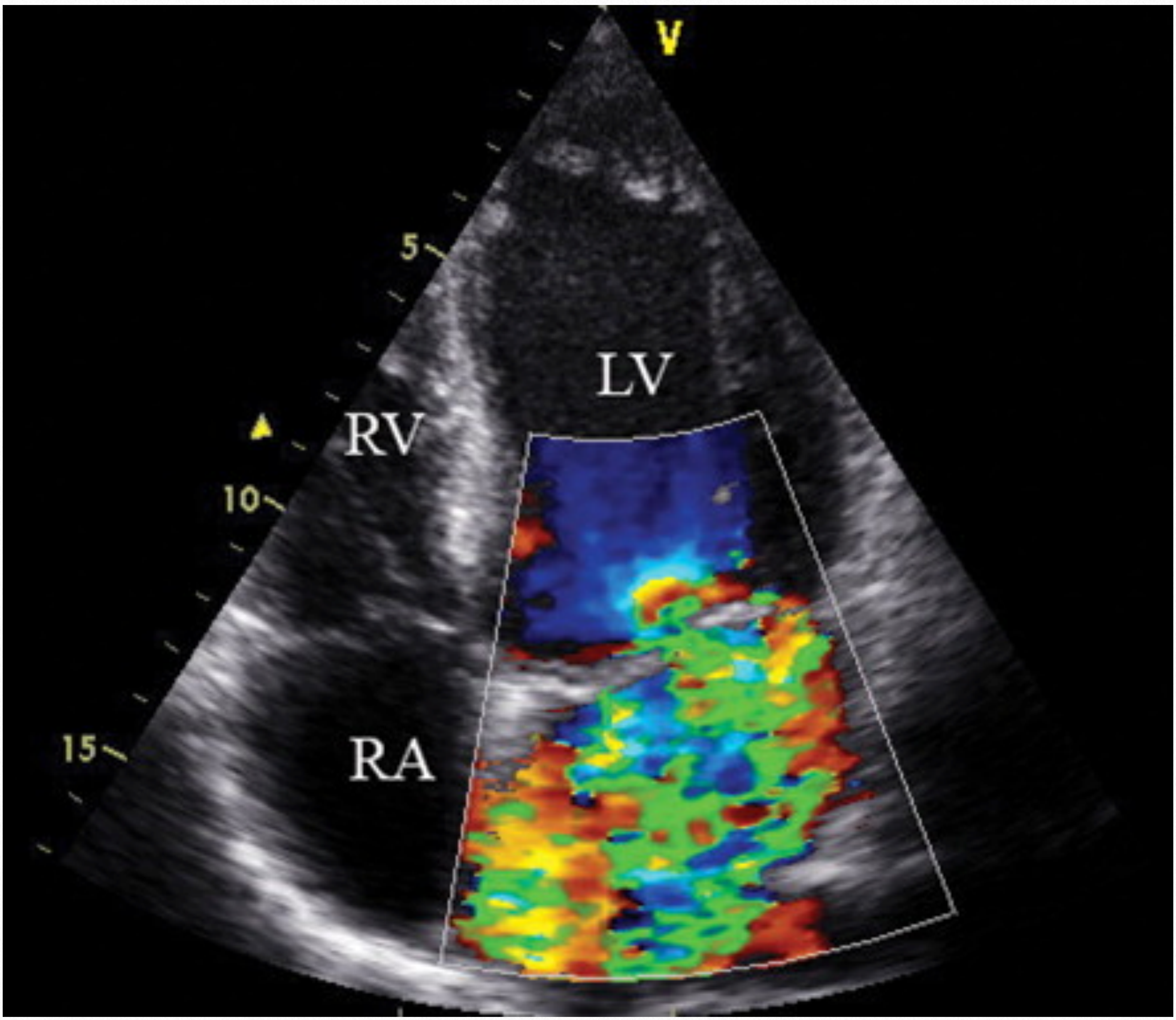
Cardiac Ultrasound: Evaluation of Cardiac



<u>III. CARDIAC:</u> Ultrasound is an excellent modality to assess cardiac function/abnormalities. Surface ultrasound can provide an excellent minimally invasive tool to determine the mechanisms of the patient's current hemodynamic status. Each subsection will cover a cardiac ultrasound technique used to answer these questions.

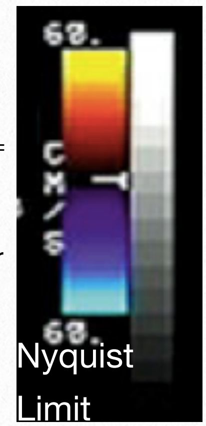
<u>C Doppler Evaluation of Cardiac Valves:</u>

The apical window is used for routine doppler examination of patients for evaluation of valvular heart disease. This is because, in this view, the Doppler beam is parallel as possible to the direction of assumed blood flow through the mitral, tricuspid valves, and aortic valves. Let's remind ourselves of the different doppler modes used to assess the cardiac valves in this window.

Continuous Wave Doppler is a doppler modality in which there is a *<u>constant</u>* ultrasound signal being sent, and there is a constant part of the piezoelectric crystal that is able to receive the ultrasound signal. The benefit is that there is no limitation to velocity measurement. However, the trade off is that we lose the ability to obtain depth (or location) identification. A continuous wave doppler will show the highest velocities **anywhere** along the continuous wave ultrasound plane. As it pertains to assessment of cardiac valves, continuous wave doppler **is used to assess for stenosis of the cardiac valves.** This is because, as stated above, it is only modality that allows one to detect the high velocity blood flow across the valve with stenosis.

Pulsed Wave Doppler is a Doppler modality in which the transducer *<u>alternates</u>* transmission and reception of ultrasound. The benefit is that the user can identify a location in the US plane to sample the velocities and the direction generated in that precise location. However, while defining a specific location, the range of velocities measured (**called the Nyquist limit)** is limited. The closer the sample volume is located to the transducer, the higher the maximum velocity can be detected, or in other words, the wider the range of the Nyquist limit. For our purposes, we will **use pulsed wave Doppler to assess for DIASTOLIC DYSFUNCTION** (discussed in another chapter).

Color 2-D Doppler is really a modified version of pulse wave doppler in which multiple lines of pulse wave Doppler are used to produce a color *doppler* pattern over the 2 D ultrasound image, allowing one to assess the degree of regurgitation across the cardiac valves. The colors displayed correspond to the *<u>direction of flow</u>* depending if the returning signals cause either a positive or negative doppler shift (toward or away from the transducer). The brightness of the color represents the intensity of the echoes, and sometimes other colors are added to indicate the range of doppler velocities. One can adjust this range or Nyquist Limit, to detect velocities in a certain range. Remember: BLUE COLOR = BLOOD FLOW MOVING AWAY FROM THE TRANSDUCER, AND RED COLOR = BLOOD FLOW MOVING TOWARDS THE TRANSDUCER. (B.A.R.T - Blue-Away/ Red-Towards). When using color Doppler you will see the color profile on the top right of the screen and the range of velocities that they represent. Again, this range is the **Nyquist limit. A good rule of thumb is to keep the Nyquist limit at 60cm/sec when evaluating for valve regurgitation.** Another important point regarding color doppler on a 2-D ultrasound image is that the size of your doppler window will directly affect the ultrasound image. By increasing the window size, the frame rate is decreased which will result in a poorer quality window.



Vena Contracta is an important concept to understand in order to help quantify the severity of regurgitation. Vena contracta is the narrowest region of a jet that occurs just below the orifice of a regurgitant valve as assessed by color flow mapping during echocardiography. Vena contracta is smaller than the regurgitant orifice and is characterized by high velocity, laminar flow (color change in color doppler). Even though the measurement of the vena contracta is less dependent on technical factors, small errors in measurement can be multiplied due to the relatively small values of the vena contracta width. Measurement of vena contracta is useful in assessing the severity of mitral, tricuspid, and aortic regurgitation.

Evaluation of Valve Function

Step 1: Evaluate 2 D image of valve structure and motion (movement, calcification, etc)

Step 2: Apply Color Doppler Window over the desired area to include the entire valve and the area of comparison (*are of backflow*) to assess regurgitation.

Mitral Valve = Left Atrium

Aortic Valve = Left Ventricular outflow Tract

Tricuspid Valve = Right Atrium

Step 3: Compare the area of the regurgitant jet to the area of comparison (see above)

Step 4: Use Doppler to Assess for Stenosis

Step 5: If possible take measurements of vena contracta

PLEASE SEE HANDOUT ON APICAL WINDOWS FOR INFORMATION ON: Patient Position, Probe Type, and Prove Position.

Colour Doppler Indicators of Mitral Regurgitation Severity

	Mild	Moderate	Severe
Colour Doppler Jet area (cm^2) (Nyquist 50-60cm/s)	<4		>10
Ratio of jet area to left atrial area (%)	<20		>40
Vena contracta width (cm)	<0.3		>0.7

Assessment of Tricuspid Regurgitation

	Mild	Moderate	Severe
Colour Doppler Jet area (cm^2) Nyquist 50-60cm/s	<4		>10
Ratio of jet area to left atrial area (%)	<20		>40
Vena contracta width (cm)	<0.3		>0.7

Assessment of Aortic Regurgitation

Mild	Moderate	Severe
Central Jet, width < 25% of LVOT		Central Jet, width ≥ 65% of LVOT
Vena contracta < 0.3 cm		Vena contracta > 0.6cm

Estimation of valve area.

As discussed in chapter 4 the doppler flow pattern across cardiac structures can be traced and this tracing results in the velocity time integral or VTI. Remember that one can view VTI as a summation of all the reflected velocities of blood flow during that cardiac cycle. In chapter 4 we discussed how this parameter represents the patients stroke volume assuming that the doppler flow pattern is obtained from an *area without pathology*. This relationship is from the following equation: Stroke Volume = VTI X area of flow measurement. To go one step further one can estimate the outflow area of one cardiac valve by knowing the VTI of the flow across the unkown area and the area and VTI of a known area. To put this in an equation Area 1 x VTI 1 = Area 2 x VTI 2. Thus by knowing the VTI at two different areas and the area of one area you can calculate for the area or pathology. This is most commonly done to determine the valve area of the pathologic aortic valve (Aortic stenosis). Specifically for this scenario one would get a VTI signal across the LVOT (using PW) and then across the aorta (using CW). Then one would measure the diameter of the LVOT and determine its area. Finally one would plug these three variables in to the above equation to solve for the aortic valve area.

Estimation of Pulmonary Artery Systolic Pressure (PASP): Doppler ultrasound can also be used to estimate PASP. To do this your patient has to have some degree of tricuspid regurgitation (TR). This is because the assessment of the velocity of TR relates to the PASP. One can think of this in the following way: From the right ventricle blood will flow with the same velocity across the pulmonic valve (forward flow) as it will across the tricuspid valve (TR).   From a velocity sample the ultrasound machine can identify a pressure (Bernoulli's principle: Pressure = 4 x velocity^2). So from these points this is how one can calculate an estimate of PASP.

Step 1: Identify a tricuspid regurgitation jet (from the apical 4 chamber view).

Step 2: Use continuous wave doppler across the TR jet and capture the doppler waveform.

Step 3: Measure the peak systolic velocity of the waveform. The machine will automatically calculate the pressure of this velocity using Bernoulli's principle.

Step 4: Add this pressure value to the estimate of right atrial pressure (done from examining the IVC diameter)