Doppler Tissue Imaging

Conventionally, PW and CW Doppler modalities are used to determine the velocity and direction of blood flow through the heart and great vessels over the cardiac cycle. However, Doppler Tissue Imaging (DTI) or Tissue Doppler Imaging (TDI) is used to record the velocities within the myocardium and at the corners of the mitral and tricuspid annuli. While the principles of DTI are essentially the same as conventional PW Doppler, there are important differences between these techniques. Conventional PW Doppler assumes the velocity of blood flow by measuring high-velocity, low-amplitude signals from moving RBCs. Therefore, when using this modality, filters are set to detect velocities between 15 to 100 cm/s and amplitudes between 0 to 15 dB. Conversely, myocardial velocities are much slower and amplitudes are much higher; therefore, when using DTI filters are set to detect low velocities (< 20 cm/s) and high amplitudes (> 40 dB).

DTI velocities may be displayed as Doppler signals recorded from a specific sample volume site, as colour-encoded M-mode and as colour-encoded 2D mode (Fig. 5.13). Most commonly, the DTI examination is performed via spectral Doppler as this modality readily displays quantitative velocity information.

Display Differences between PW and CW Doppler

PW Doppler signals are described by the degree of spectral broadening and by the presence or absence of a spectral window. As such, the appearance of the PW Doppler spectrum can be used to distinguish laminar and turbulent flow (Fig. 5.14). Spectral broadening is defined by the spectral width or 'thickness' of the Doppler spectrum. In the presence of laminar flow, the majority of RBCs are moving at similar velocities. Therefore, a small range of Doppler shifts are represented resulting in a narrow band of spectral signals being displayed. As flow becomes turbulent, there is a greater variation in blood flow velocities which produces a larger range of Doppler shifts. This results in increased spectral broadening on the spectral display. Spectral broadening may also be increased by using excessive Doppler gain and by widening of the sample gate such that a wider range of velocities are displayed. Spectral window refers to the 'clear' area under the spectral trace. In the presence of laminar flow, there is a large spectral window because the majority of RBCs are moving at similar velocities. As flow becomes turbulent, spectral broadening occurs and the spectral window size is diminished or eliminated. Importantly, with CW Doppler, there is no spectral window and spectral broadening occurs even in the presence of laminar flow (Fig. 5.15). This occurs because a large range of velocities are encountered along the entire path of the ultrasound beam.

Doppler Gain

The Doppler gain function adjusts the degree of amplification of received Doppler signals. The Doppler gain should be adjusted to optimally display the entire Doppler spectrum without excessive background noise.

Velocity Scale and Baseline Shift

The velocity scale adjusts the maximum velocity that can be displayed. When using PW Doppler, this scale is limited by the sampling rate (Nyquist limit). The baseline is the horizontal line on the spectral display representing zero Doppler shift. Traditionally, spectral Doppler signals are displayed so that positive Doppler shifts (blood flow toward the transducer) are displayed above the zero baseline while negative Doppler shifts (blood flow away from the transducer) are displayed below the zero baseline. Both the velocity scale and baseline are adjustable; an optimal adjustment is when the signal of interest or the signal to be measured fills the display. Importantly, when there is regurgitation it is crucial to display the forward flow as well as the regurgitant jet as this provides indirect clues to the severity of regurgitation (see Chapter 13).

Wall Filters

Wall filters or low velocity reject functions allow the elimination of low Doppler shifts that typically occur due to motion of the cardiac valves or heart walls. Wall filters should be set sufficiently high to eliminate low Doppler shifts but not so high that the beginning and end of flow is obscured or ambiguous. In particular, clear delineation of the commencement and cessation of flow improves the measurement accuracy of time intervals (Fig. 5.16).