Optimisation of Colour Flow Doppler Images

As for 2D, M-mode and spectral Doppler, there are a number of controls that can be adjusted to optimise colour flow Doppler images. As previously mentioned, while many controls on all ultrasound machines are similar in their function, additional controls may be available for optimising colour flow Doppler images. Therefore, the sonographer should be familiar with the available controls for the machine that they operate. Details regarding these controls and how controls can be adjusted to optimise colour flow Doppler images can usually be found in the User Manual or can be obtained from the Application Specialist. Some of the more commonly used controls are discussed below and are summarised in Table 7.1.

Colour Box Size

The colour box can be adjusted in terms of its position, width and length. Importantly, the colour box size and position affects the frame rate and the colour velocity scale.
In particular, increasing the width of the colour box effectively increases the processing time due to an increase in the number of scan lines and sample volumes; as a consequence this lowers the frame rate. As high frame rates are desirable for the examination of the dynamic heart, it is important to ensure that the colour box is kept as narrow as possible.
The position and length of the colour box affects the colour velocity scale. Recall that the maximum mean velocity scale is limited by the Nyquist limit which is determined by PRF. In CFI, the PRF is essentially determined by the length and depth of the colour box such that longer colour boxes and colour boxes placed deeper into the image will lower the PRF and therefore lower the colour Nyquist limit. In most situations, it is desirable to have the colour scale set as high as possible. Hence, the colour box length and its depth into the image should be kept as short and as shallow as possible.

Table 7.1 Common Colour Doppler Optimisation Controls

Colour Doppler Control	Desired Adjustment/Usage
Colour box size	As narrow and as short as possible while ensuring the region of interest (including surrounding structures) are adequately interrogated
Velocity scale	Set as high as possible while allowing adequate filling of colour box Decrease to enhance detection of low velocity flow or when there is under-filling of the colour box
Colour gain	Increased to the point of random coloured pixels (speckling) and then decreased to just below speckling
Wall filter	Increased to eliminate low velocity signals and 'noise' May be decreased when investigating low velocity flow
Colour baseline	Remains at the default position in the centre of colour bar May be moved to increase the colour Nyquist limit in one direction (see text for examples)
Colour maps	Select colour map (including variance maps) based on sonographer's and/or institution's preference
2D/Colour image comparison	Useful when trying to determine aetiology of regurgitation or other abnormal flow (see text for examples)

> **i** While the colour box size should be as narrow and short as possible to maintain a high frame and colour Nyquist limit, it is also important to ensure that the colour box size is optimised to adequately interrogate the structures of interest as well as a small region surrounding these structures. Likewise, when abnormal flow is detected, the colour box size should be adjusted to encompass the entirety of the abnormal jet.

Velocity Scale

The colour velocity scale or colour Nyquist limit can be decreased or increased. However, as stated above the maximum mean velocity (or colour Nyquist limit) that can be displayed is determined by the length and depth of the colour box. In most situations, the colour velocity scale should be set as high as possible so the colour box length and its depth into the image should be kept as short and as shallow as possible.
Occasionally, it may be necessary to lower the velocity scale to enhance the sensitivity for detecting low velocity flow (Fig. 7.7). This is particularly relevant when there is under-filling of the colour box and/or when investigating low velocity flow such as that seen within the pulmonary veins, within pseudoaneurysms and when interrogating the interatrial septum from the subcostal view (Fig. 7.8). Under-filling of the colour box commonly occurs when interrogating the ascending aorta from a high parasternal long axis view. From this view the colour box position is relatively shallow resulting in a high colour Nyquist limit and under-filling of the colour box.

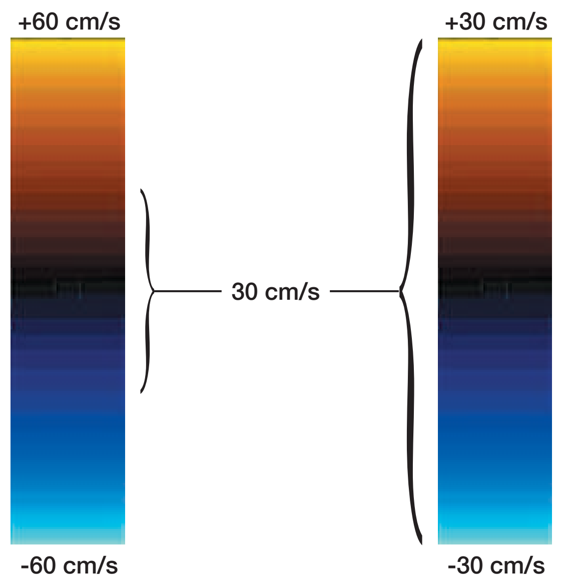


Figure 7.7 This figure illustrates the effect of decreasing the colour velocity scale to enhance the detection of low velocity flow. The colour bar on the left shows the colour velocity scale set to 60 cm/s. It can be appreciated that the range of colours assigned for the detection of low velocity flow (30 cm/s) is relatively small. By decreasing the colour velocity scale to 30 cm/s as shown in the colour bar on the right, the full range of colours is now 'devoted' to the detection of lower velocity flow.

Colour Gain

The colour gain control adjusts the degree of amplification of received Doppler signals. The colour gain should be increased to a level at which background "speckling" occurs and then decreased just down from this level. Optimisation of the colour gain should be performed for each and every view.

Wall Filters

Wall filters enable the elimination of Doppler shifts from the display. Wall filters can be increased to exclude low velocity signals which may arise from valve or walls and may contaminate the CFI. Wall filters may also be decreased when investigating regions of low velocity flow.

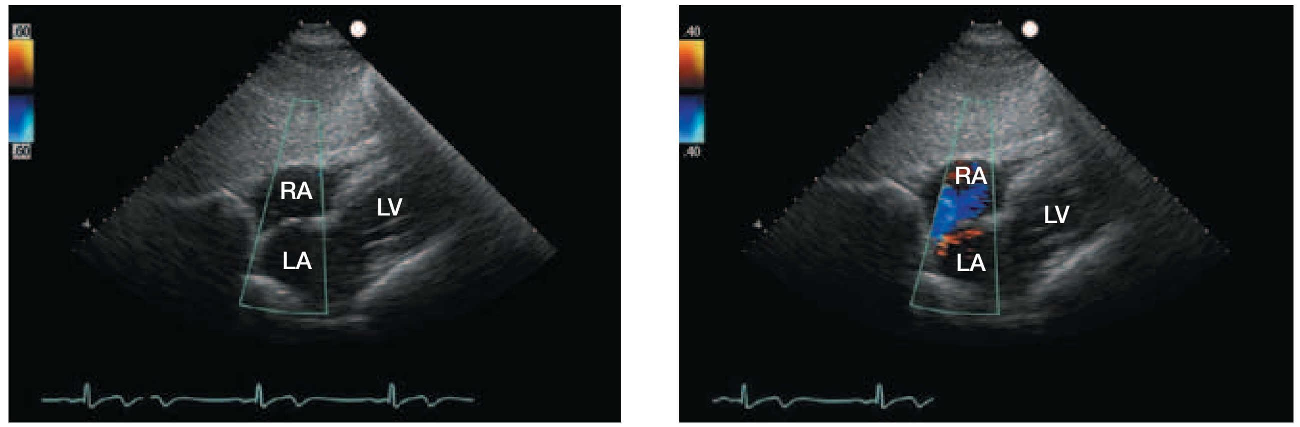
Colour Baseline

By default the colour baseline is set in the middle of the colour bar. However, the colour baseline may be moved to increase the colour velocity scale (Nyquist limit) in one direction in an attempt to overcome colour aliasing (see section on Artefacts). Colour baseline shift is also useful for measuring the flow convergence radius and for estimation of the effective regurgitant orifice area via the proximal isovelocity surface area (PISA) method (Fig. 7.9).

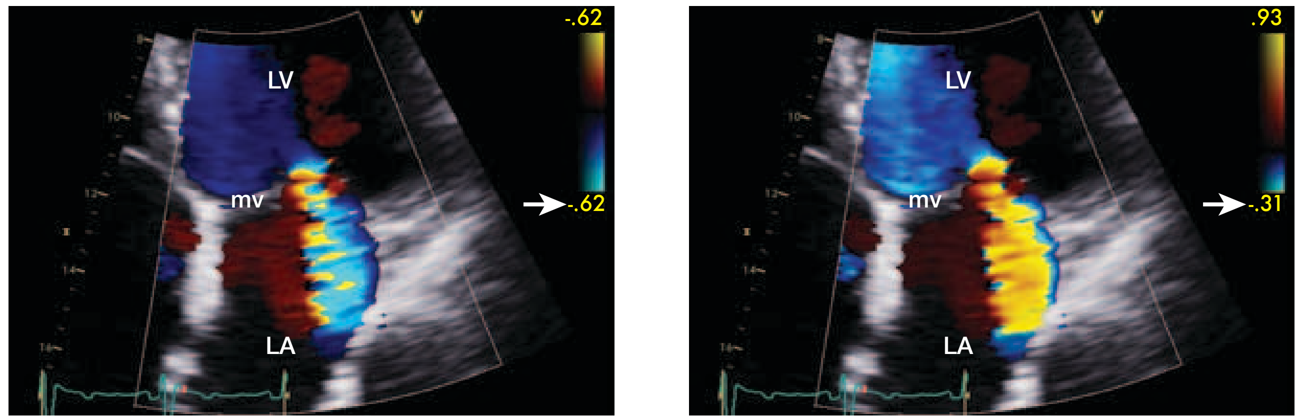
Colour Maps

Colour maps are always displayed on colour Doppler image in the form of the colour bar. This allows the interpretation of the direction of flow and the mean velocity of flow. Most ultrasound systems provide numerous colour maps which can be selected or changed according to the sonographer's and/or institution's preference. As a post-processing function, colour maps can be changed on the frozen image.

> **i** Colour gain and colour velocity scale are optimised in conjunction with one another. The colour gain should be adjusted to just below speckling; however, if the colour box remains under-filled despite adequate colour gain then the colour velocity scale should be decreased until there is adequate filling of the colour box.



▶**Figure 7.8** These two images, acquired from the subcostal 4-chamber view in the same patient, demonstrate optimisation of the colour velocity scale for low velocity flow. Observe that with the colour Nyquist limit set at 0.60 m/s, the colour box is devoid of colour (*left*). However, when the colour Nyquist limit is decreased to 0.40 m/s, colour is displayed within the colour box (*right*).
LA = left atrium; LV = left ventricle; RA = right atrium.



▶**Figure 7.9** These two images are acquired from a zoomed apical 4-chamber view of the mitral valve (mv) in the same patient. Mitral regurgitation (MR) into the left atrium (LA) is evident. In the image on the left, the colour baseline is set to the centre of the colour bar and the colour Nyquist limit is 0.62 m/s. In the image on the right, the colour baseline has been shifted downwards in the direction of the MR jet so now the colour Nyquist limit at the bottom of the colour bar is at 0.31 m/s (*arrow*); observe that this baseline shift has enhanced the flow convergence radius on the left ventricular (LV) side of the mitral valve.