



*White Paper*

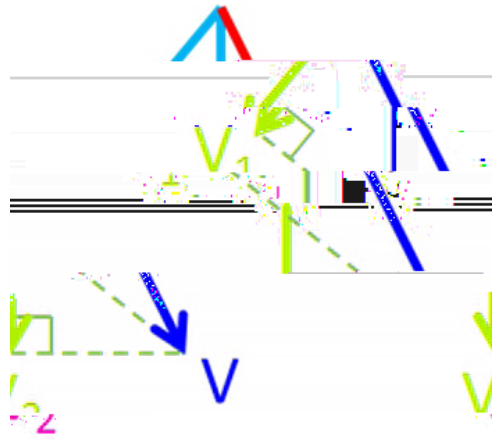
# V Flow

a novel visualization  
of blood flow

**mindray**



Fig. 1: Scan sequence of conventional CFMM



The vector flow results can be displayed slower than real-time with an ultra-high frame rate up to over 400 Hz, so complex flow patterns with an extremely high velocity can be captured [7,8]. Snapshots for flows such as laminar, turbulent, secondary, vortex and contra flows can be demonstrated intuitively in this unique imaging technology, an integral part of the ultrasound diagnostic V Flow system.

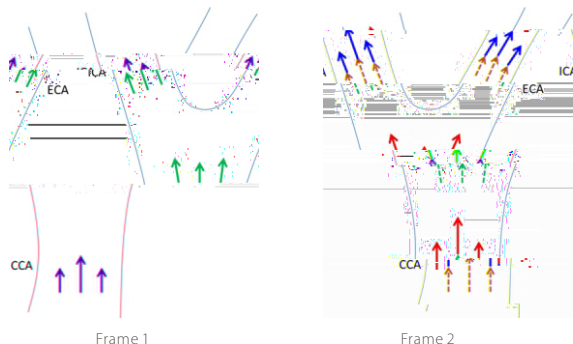


Fig. 4: Dynamic display of vector arrows. Left figure: Frame 1, green arrows indicate current flow velocity and direction and right figure: Frame 2, red arrows represent flow moves forward from the dotted green arrows which correspond to green arrows in Frame 1. CCA: common carotid artery; ICA: internal carotid artery; ECA: external carotid artery.

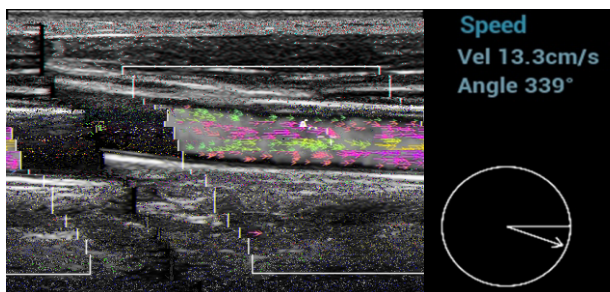


Fig. 5: The velocity and its direction are shown with their physical units at the right image parameter display area. The parameters are updating as a function of frames and places where the cursor is located.

where  $\tau$  is the WSS,  $\mu$  is the blood viscosity,  $v$  is the blood flow velocity calculated by V Flow. The WSS is calculated at a position  $r=R$ , normally on the wall of the vessel (intima).

## Characteristics of V Flow

- Millisecond level temporal resolution which can detect the tiny hemodynamic changes and provide more valuable information than conventional color Doppler
- Grayscale display intuitively shows the spatial distribution of blood flow, which shows better flow sensitivity than conventional power Doppler
- Arrow color/ length, and direction indicate blood flow velocity and direction respectively which helps doctors easily capture abnormal hemodynamics change
- Complex flow imaging illustrating laminar, vortex, secondary, and retrograde flows allows better understanding hemodynamics in different conditions
- Quantitative measurement of velocity and direction at an arbitrary location, and display for velocity curves at three different location in the same cardiac cycle and same moment, minimizes time-domain influence factors and improves measurement accuracy
- Three measurements of volume flow implemented based on vector flow imaging offers more precise volume flow value
- Wall Shear Stress (WSS) calculation at three locations based on vector flow imaging opens a new way in studying early plaque development

## Calculation of WSS based on V Flow

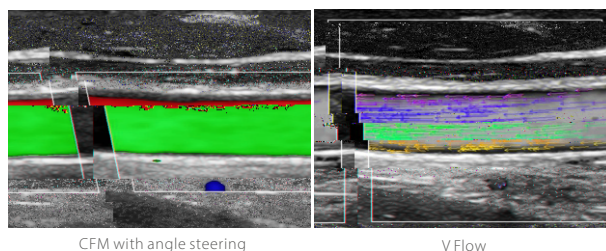
Wall Shear Stress (WSS) is an important parameter for clinical studies of arterial diseases. There are various clinical researches [12-14] using the WSS as an evaluating key factor presenting the relation between the WSS and different arterial diseases. Conventional method for calculating WSS is based on MRI. For V Flow's new generation, the WSS is calculated using ultrasound, which is more convenient and much easier to be obtained. The algorithm can be formulated by [15,16]

$$\tau = \mu \left. \frac{\partial v}{\partial r} \right|_{r=R}$$

## Comparison of V Flow and CFM

V Flow has been applied to different types of flow in the carotid artery to find any difference in comparison to the conventional CFM method.

**Case 1.** Laminar flow occurs in the flat carotid artery as shown in Fig. 6 - Angle steering for CFM





- [1] C. Kasai, K. Namekawa, A. Koyano and R. Omoto. *Real-time two-dimensional blood flow imaging using an autocorr*