GE Healthcare

Blood Flow Imaging (BFI)

Thaddeus Chodakauskas, RDCS
Trond Kleveland, M.Sc
Stienar Bjaerum, PhD

Background

Conventional color Doppler imaging has become a routine standard and accepted method for the non-invasive imaging of blood flow through the vessels, by displaying blood flow data on a B-Mode image. A new clinical tool, called Blood Flow Imaging (BFI), utilizes a unique signal-processing algorithm for visualizing blood flow data on the Vivid™ 7 Dimension system.

To understand the benefits of BFI, it is necessary to review the basic principles of color-flow Doppler imaging. To obtain a color Doppler image, multiple pulses are transmitted along each scan line of the image. For each sample volume in the image, there is a packet of data samples available for estimating parameters describing the blood flow (see Figure 1).

The first step in processing, is to remove the clutter noise originating from stationary and slowly moving tissue. Using this filtered packet, the mean blood velocity can be estimated by calculating the mean phase shift from sample to sample in the packet. In addition to the mean velocity, the amplitude of the echo from blood, as well as the variance of the velocities around the mean, can be calculated.

Large accelerations and turbulent flow patterns result in a broad distribution – and large variance – of velocities. To obtain robust estimates of the flow parameters, substantial temporal and spatial averaging is performed on the data. This averaging blurs potential clinically valuable flow details in both the temporal and spatial dimensions.

As a result of the physics of ultrasound imaging, a distribution of sound scatterers inside the body produces an image with spatially varying amplitude. The variation in amplitude is called a speckle pattern, and is a well-known phenomenon in regular B-mode images. The spatial averaging performed in conventional color Doppler imaging smoothes out the amplitude variation, and the speckle information is not clearly seen in the color image.

Following the wall filter, but prior to collapsing the acquired packets to a one color image, the resulting set of images display the flow with both high spatial and temporal resolution. Each image is a snapshot of the speckle pattern produced by the spatial distribution of the red blood cells at the instant the image was acquired.

With displacement of the blood cells from image to image, there will be a corresponding displacement of the speckle pattern from image to image. When a series of such images is displayed, the user perceives a movement in the speckle pattern, corresponding to the movement of the blood cells producing the speckle flow information.

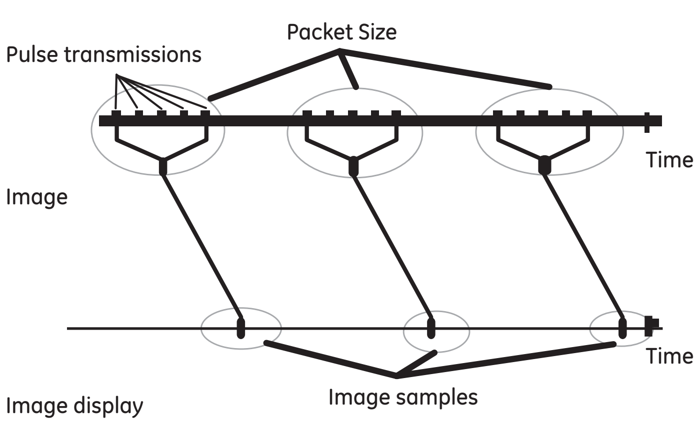


Figure 1. Conventional color flow imaging

The Vivid 7 Dimension system transmits multiple transmission pulses per packet size for each ultrasound beam. For each blood flow image, the ultrasound system also displays the B-Mode image.

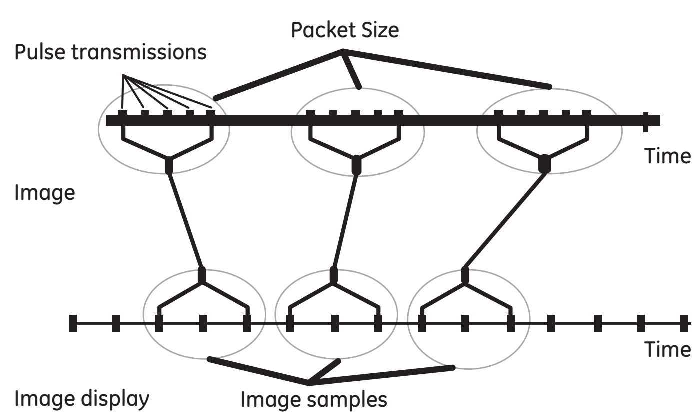


Figure 2. Multiple blood flow images

BFI samples multiple blood flow images for each packet size containing multiple transmit pulses.

Blood Flow Imaging (BFI)

The BFI technique attempts to maintain the available details in the echoes from the red blood cells. The concept in BFI is to combine these images with the conventional color Doppler images (see Figure 2).

In BFI, the speckle amplitude modulates the color intensity level. The resulting images include the conventional color information, as well as a flowing speckle pattern corresponding to the direction and magnitude of the velocity in the blood flow. The benefit is more hemodynamic information and increased visual differentiation between true blood flow and wall motion artifacts.

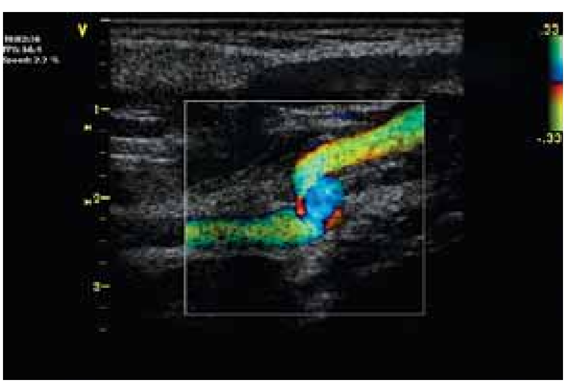
BFI enhances the conventional color-flow mode. Similarly, the BFI Angio mode enhances the conventional Angio mode. With BFI Angio, the speckle signal modulates the color intensity in the Angio display. The result is an Anglo display with flow directional information.

The B-Flow mode builds upon the BFI Angio mode. In B-Flow mode, there is no tissue/flow arbitration, i.e., no hard decision whether tissue or flow information should be displayed in a given pixel. Instead, the tissue and flow signals are added.

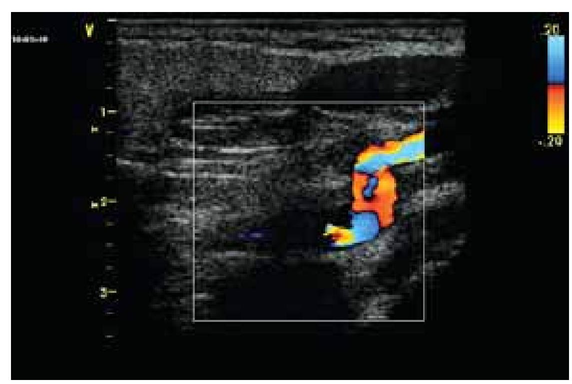
The resulting image displays a transparent flow with the underlying tissue visible through the flow signal. The main benefit of this display technique is reduced bleeding of blood flow information into the tissue, resulting in better visualization of the interface between blood flow and vessel wall.

Benefits of BFI

- Better visualization of blood flow dynamics.
  BFI provides a qualitative tool to assess and appreciate the hemodynamics of turbulent flow seen in certain carotid plaque morphology.
- The ability to visualize small collateral blood vessels.
  BFI demonstrates minimal bleeding of color information compared to color Doppler imaging.
- Better definition of vessel wall to blood tissue interface.
  BFI provides a unique clutter filtering technique in removing blood flow from wall motion artifacts.



BFI image visualizing a tortuous ICA vessel.



Color Doppler image visualizing a tortuous ICA vessel.

Case study

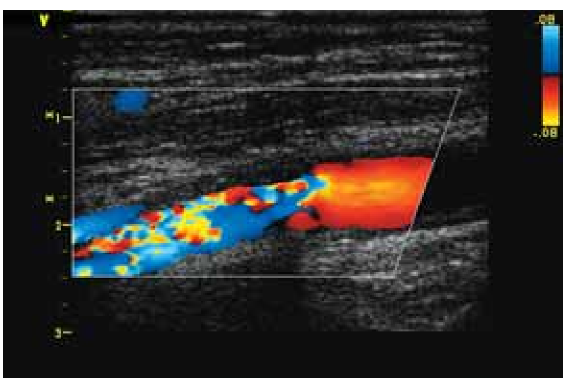
A patient with a diagnosis of 60 percent occlusion was confirmed by angiography and vascular ultrasound imaging using BFI. A bilateral duplex carotid ultrasound exam was performed as a pre-operative workup for coronary artery bypass graft. BFI is more sensitive and provides better delineation of the plaque formation in the proximal left internal carotid artery, as illustrated in the images below.

The carotid ultrasound examination revealed potentially hemodynamic significance of carotid stenosis in the proximal left internal carotid artery. It also revealed mild stenosis (50-70 percent range) on the right side. Further correlation with arteriography should be considered.

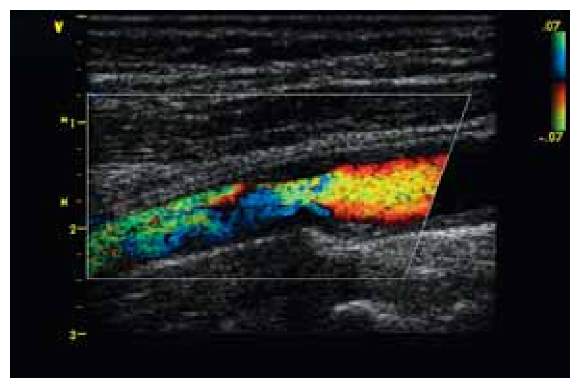
Cerebral arteriogram was performed on this patient the following day. Right common carotid injection with digital subtraction arteriography of the head demonstrates an angiographically normal petrous, cavernous and supraclinioid segments of the internal carotid artery. The ACA and MCA territories are angiographically normal with capillary or venous phase abnormality.

Left common carotid injection with digital subtraction arteriography over the neck demonstrates an angiographically normal common carotid, the carotid bulb, and origin of the internal carotid artery is approximately 60 percent stenosed. The external carotid artery is angiographically normal.

With the introduction of Vivid 7 Dimension, BFI technology is yet another example of continuing and ongoing breakthroughs to manage better patient care outcomes.



Color Doppler Imaging



Blood Flow Imaging (BFI)

GE Healthcare
9900 Innovation Drive
Wauwatosa, WI 53226
U.S.A.

www.gehealthcare.com

imagination at work

ULTC-0142-05.06-EN-US