

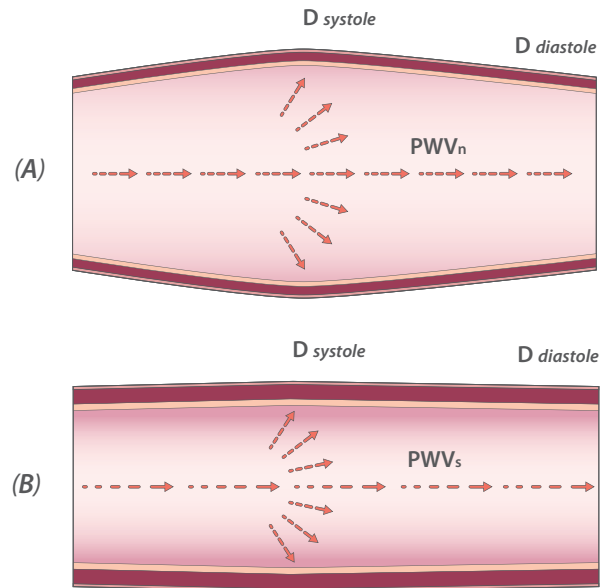
ZST+ Advanced Vascular Applications

R-VQS

Radiofrequency Vascular Stiffness Quantification

Increased arterial stiffness has long been known to be both a precursor to and a predictor of subsequent cardiovascular events, i.e., heart attack and stroke. Normal arteries are more compliant and have a greater diameter change across the cardiac cycle (A). Early changes in aging and diseased arteries are characterized by diminished compliance (B). Traditional methods of quantifying changes in arterial compliance are cumbersome, not readily available to general patient populations, and produce variable and inconsistent data results.

Mindray's proprietary R-VQS automatically identifies the intimal surface of the artery (C) under investigation and tracks changes in vessel diameter over several cardiac cycles. Vessel distensibility, an indicator of vascular stiffness, is calculated from the difference between systolic and diastolic linear measurements and is displayed on the screen. The data can also be saved to user customizable, on-board vascular report pages.



$$D_{systole} - D_{diastole} = \text{Distention } (\mu\text{m})$$

Formula

Distention (μm)

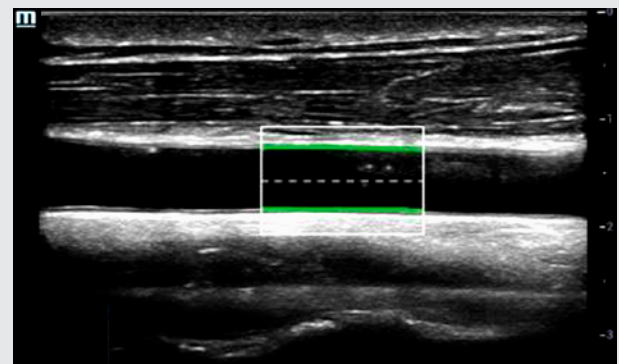
- + manual input BP
- + other variables



Stiffness Quantification

- pulse wave velocity
- stiffness index

(C)



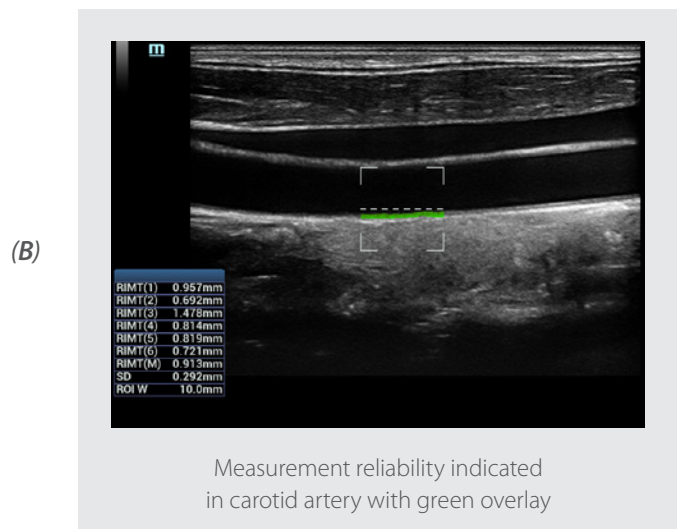
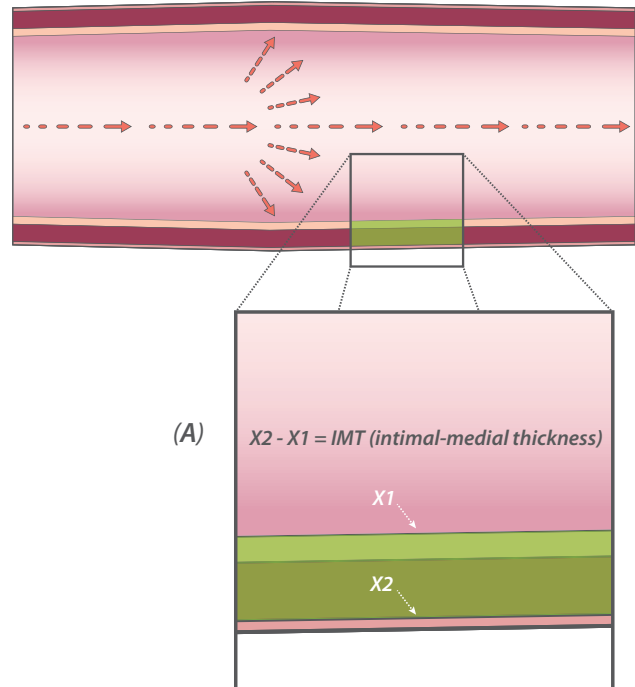
Automatic detection of both near and far field vessel walls.

RIMT

Radiofrequency Intimal-medial Thickness

Intimal-medial thickness (IMT) has long been known to be an important data point in assessing a patient's risk for future cardiovascular events. **(A)** Conventional IMT measurements are obtained from the B-mode image displayed on the screen. This introduces image quality and operator variations in single or serial IMT measurements.

Mindray's RIMT uses raw radiofrequency data stored in channel domain memory to obtain the combined diameters of the intimal and medial arterial layers. Sophisticated software auto-tracks the vessel wall under interrogation and provides a color-coded indicator of data acquisition quality; red, yellow, and green – with green indicating the optimal, acceptable data quality. **(B)** As the measurement is not obtained from the B-mode image, its accuracy is not dependent on image quality or operator experience. Values obtained with RIMT have a variance of approximately $5\mu\text{m}$; measurements obtained with conventional IMT methods have a variance of $60 - 90\mu\text{m}$.

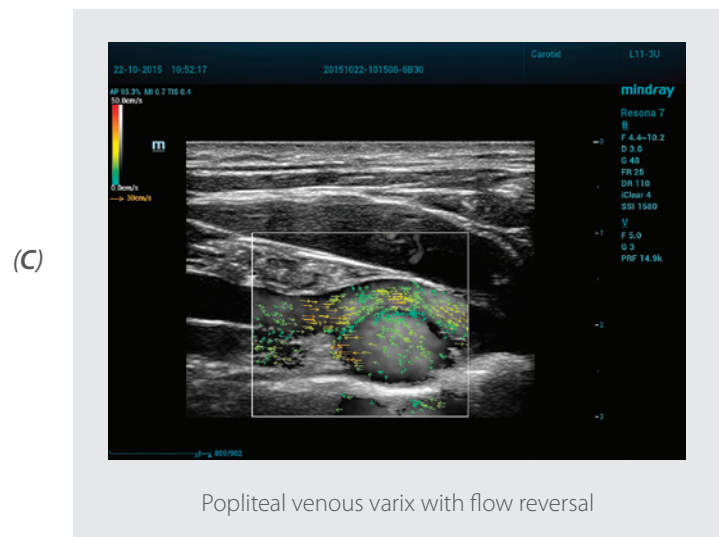
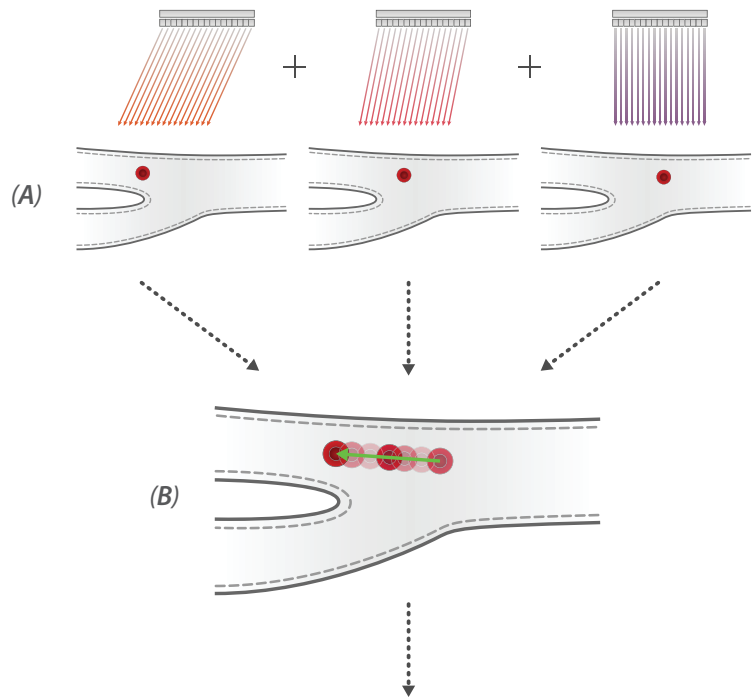


V-Flow

Vector Flow

Traditional color Doppler imaging displays hemodynamic states using frequency, phase and amplitude changes obtained from the returning acoustic data set. While color Doppler imaging (CDI) has evolved into an extremely sensitive and valuable ultrasound modality, it has well-established limitations. Chief among them is the inability to quantify flow velocity. CDI displays relative velocities within the color box and has become a critical adjunct in directing the placement of the spectral Doppler range gate which yields a waveform from which quantified velocity information can be obtained.

V-Flow overcomes this limitation by using multi-directional plane waves (A) that can be analyzed to determine flow direction and velocity of red blood cells (B). Angle-compounding technology is then applied to produce a map of vector arrows (C). (Unlike CDI, V-Flow is angle independent.) As this method requires very high backend frame rate, it requires a core technology that can acquire and process returning acoustic data much faster than traditional beamforming methods. ZST+ provides this capability. The resulting display demonstrates both velocity and directionality at each arrow as well as a global view of complex hemodynamic states such as vortical, secondary, and retrograde flow. Another feature of V-Flow is on-board software that can calculate wall shear stress (WSS) at operator selected locations within an artery.



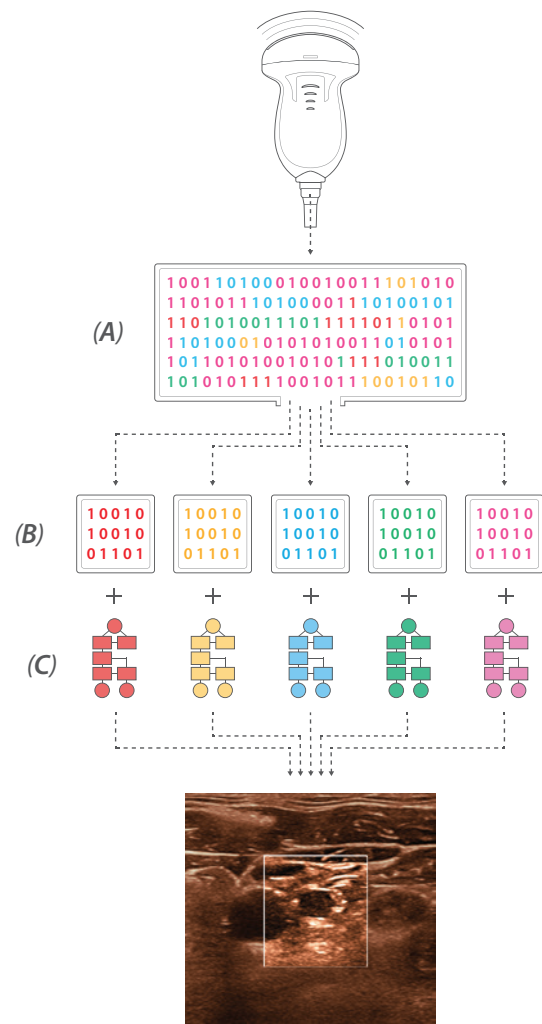
HD Scope

High Definition Scope

HD Scope is an advanced image processing technology made possible by unique and proprietary ZONE Sonography® Technology Plus (ZST+) and the integration of advanced channel data analysis and digital signal processing algorithms. Utilizing these exclusive and proprietary capabilities, HD Scope breaks through the constraints of traditional B-mode ultrasound imaging by permitting delineation of subtle or small soft tissue lesions based on the distinct acoustic characteristics of differing tissue types.

Traditional B-mode ultrasound imaging of anatomical structures relies on a limited number of echo parameters contained within the returning acoustic data set. Typically frequency, phase, and amplitude are used to create both 2-dimensional and Doppler image displays. Managing, applying, and integrating additional image creation resources within a defined region of interest (ROI) enables HD Scope to provide localized enhancement of tissue differences in that region.

On the back-end, HD Scope analyzes the characteristics of the returning acoustic data set (A) within the ROI and segments them in computer memory based on various tissue characteristics (B). Unique filtering and processing algorithms are applied to each segment of signals (C) to achieve optimal spatial and contrast resolution.



Cervical lymph node adjacent to carotid artery

Two side-by-side B-mode ultrasound images of a carotid bifurcation. The left image is labeled "without HD Scope" and shows a blurry, amorphous echogenic plaque. The right image is labeled "with HD Scope" and shows the same area with enhanced contrast, revealing internal structures like lucent cores and a possible surface ulceration.

Case Study: Plaque Morphology

Amorphous echogenic plaque in carotid bifurcation (left). Enhanced tissue differentiation reveals complex nature of plaque and the presence of lucent cores and a possible surface ulceration (right).

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