Clinical Ultrasound Transducer Degradation Effects on the Accuracy of Spectral Doppler Velocity Measurements

Pulsed and continuous-wave ultrasound Doppler velocity measurements are routinely used to determine the severity of a stenosis in the carotid, renal or peripheral arteries. The objective of this study is to determine and demonstrate the relationship between spectral Doppler velocity measurements and transducer degradation conditions encountered in a clinical environment. This research study utilizes two complex analytical ultrasound evaluation systems, the First Call aPerio Test System (Sonora Medical Systems, Longmont, CO) and the Optimizer 1425A LE Doppler Flow System (Gammex, Middleton, WI). A clinical Siemens Acuson S2000 (Siemens AG, Erlangen, Germany) ultrasound system designed for general imaging, vascular and cardiac diagnostic applications was employed to determine spectral Doppler velocity measurements.

The First Call aPerio Test System transducer analyzer is a device used to measure acoustic and electrical parameters of ultrasound transducers. The transducer is placed in a medium of water and the transducer’s electrical assembly is connected with the First Call device. The First Call device pulses each piezoelectric element of the transducer’s array and evaluates the following characteristics: peak-to-peak amplitude, center frequency, pulse width, bandwidth, and the pulse waveform. Additionally, the accumulated capacitance of every element is evaluated and element electrical integrity is tested identifying electrical failures. Typical findings include dead elements, lens delamination, wire cuts, and capacitance shorts. Ultrasound transducers are an important component of a complex imaging system, transducer degradation is frequently not observed with a tissue mimicking phantom or during a clinical exam.

The Gammex 1425A LE Doppler Flow system evaluates the Doppler and B-mode performance of a clinical ultrasound unit. This system includes line reflectors and anechoic cyst targets at 2, 4 and 6 millimeter (mm) depths to evaluate depth penetration and distance accuracy performance. Additionally, two 5 mm flow vessels are integrated into the system permitting Doppler testing. The first vessel is located parallel to the plane surface and mimics a carotid artery. The second vessel was designed with a descending 45 degree angle and tests for Doppler sensitivity. The flow controller allows for incremental velocities from 1 to 12.5 ml/s. Some of the quality indicators include maximum signal penetration, channel isolation, and flow rate visibility for various angles. The flow rate at various angles is crucially important to this research study. The accuracy of flow velocity readout is an essential part of this device as this research study compares the flow velocity with the functionality of selected clinical transducers.

The Siemens Acuson S2000 clinical ultrasound system, Gammex 1425A LE Doppler flow system and the First Call aPerio Test System transducer analyzer are shown left to right.