QIBA Ultrasound Shear Wave Speed (SWS): System Dependencies Subcommittee
Friday, October 18, 2013; 11 AM CT
Call Summary
Additional notes provided by Dr. Wear/ approved by Drs. Palmeri & Nightingale

In attendance

Mark Palmeri, MD, PhD (Co-Chair)
Keith Wear, PhD (Co-Chair)
Paul Carson, PhD
Thomas Deffieux, PhD *(guest speaker)*
Brian Garra, MD
Timothy J. Hall, PhD
Christopher Hazard, PhD
Ted Lynch, PhD
Kathy Nightingale, PhD
Nicholas Rognin, MSc, PhD
Daniel Sullivan, MD
Matthew Urban, PhD

RSNA

Julie Lisiecki
Madeleine McCoy

Moderator: Keith Wear, PhD

1. The call summary from 2013-09-20 was approved.

2. Dr. Thomas Deffieux gave a presentation based on the paper T Deffieux, JL Gennisson, B Larrat, M Fink and M Tanter, "The Variance of Quantitative Estimates in Shear Wave Imaging: Theory and Experiments" IEEE Trans UFFC, 59, Nov., 2012. The goal is to assess the bias and variance in shear wave imaging. The context is shear wave imaging from 1D plane shear waves based on time of flight*, e.g.,* Supersonic Shear Wave Imaging. The algorithm is not optimized for 1D single value shear modulus estimation. It is not necessarily the lowest bias or lowest variance algorithm for 2D imaging, but the algorithm has the advantage that it is simple enough to provide statistics using Cramer Rao analysis. A cross correlation method is used. The analysis assumes propagation in a linear homogeneous or weakly heterogeneous medium with 1D plane wave. Low viscosity (low dispersion) is assumed. Another assumption is low white noise on the beamformed IQ or directly on the tissue velocity field. They assume no additional IQ decorrelation due to shear waves inside the PSF or due to B mode artifacts. They assume no shear waveform decorrelation (*e.g.*, due to dispersion, viscosity, discretization or secondary shear waves or natural low frequency vibrations such as breathing). The method gives an explicit formula for elastic modulus variance from acquisition SNR, shear wave frequency and bandwidth. Experimental data suggests that the noise autocorrelation is consistent with Gaussian white noise. The authors obtain a formula for the tissue velocity variance in terms of imaging frame rate, ultrasound frequency, and SNR. Experimental data *in vivo* supports the formula prediction for tissue velocity variance. The authors show that the shear modulus estimate is biased. Variance increases with true shear modulus. Shear modulus bias decreases with SNR. Shear modulus standard deviation also decreases with SNR, as the authors have shown in tissues *in vitro*. Shear wave velocity is also biased. Stiffer media have higher variance. Bias and standard deviation decrease with SNR. Relative shear velocity bias is 3 times lower than relative shear modulus bias. Relative shear velocity standard deviation is 2 times lower than relative shear modulus standard deviation.

3. Depth Dependency in the Phase I study (Drs. Palmeri, Nightingale)

   Kathy Nightingale gave a presentation on SWS vs. depth and viscoelastic (VE) behavior in QIBA round 1 phantoms. There were 2 phantoms with shear velocities of approximately 0.95 m/s and 2.05 m/s. They used 2 linear arrays and 1 curvilinear array. They found consistent results for SWS (within 9%) for all 3 transducers. They found some depth dependence with the curvilinear array, and also with one of the linear arrays. Experiments using coupling fluid consisting of water/alcohol solutions suggest sound speed mismatch between coupling fluid and phantom contributes to a measurement of depth dependence. Therefore, the take home point for QIBA is that the coupling medium should be sound speed matched to the phantom. However, even with matched coupling medium, there is still some measured depth dependence. They have done Field II simulations coupled with FEM mechanical models to model the effect of out-of-plane sources of depth dependence on SWS estimates. Simulations of the mechanical dynamics (not ultrasonic tracking) show a similar trend of increasing SWS bias as the lateral focal point becomes increasingly shallow as compared to the lens focus, but not as extreme as experiment (SWS decreases with depth). They have been exploring displacement (TTP) vs. velocity (TTPS) arrival time estimation. When they use a displacement-based time of arrival estimator they get a slightly lower SWS estimate. When they use phase spectroscopy, they find similar phase velocity measurements whether derived from displacement data or velocity data. They fit Voigt models to phase SWS data to measure tan δ to compare with results reported from DMA measurements. They found good agreement for tan δ among all probes. Tan δ values vary from approximately 0.06 to 0.25 between 300 and 1150 Hz. Phase velocity measurements with consistent focusing geometry at single frequency (300 Hz) still show some variation. Discrepancy might be due to inconsistent position of lateral beams (due to, *e.g.,* incorrect assumed speed of sound in beam former).

Recommendations for QIBA phantom study:

1. Use 1540 m/s coupling fluid with phantoms
2. Depth dependence
    a. Separate comparisons for different depths
    b. Calibrate based upon predicted trend in simulation/phantom
3. Explore impact of beam position calibration on SWS measurements

November Call Schedule:

Date	*Time (CT)*	*Day*	*Committee/ Subcommittee*	*Moderator*
11/04/2013	1:00 pm CT	Monday	US SWS Technical Committee	Dr. Hall
11/15/2013	11:00 am CT	Friday	System Dependencies Subcommittee	Dr. Palmeri
11/18/2013	1:00 pm CT	Monday	Phantom System Testing & Measurement Subcommittee	Dr. Garra

RSNA 2013 Annual Meeting - QIBA Technical Committees Working Meeting:

Wednesday, December 4th| 2:30pm – 5:00pm| Chicago, McCormick Place| Room: **N136**
Please let us know whether you plan to attend by responding to the following poll**:** http://www.doodle.com/fwf76ceggb78r75b.
We appreciate your continued support and look forward to your participation - Thank You!

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