Effects of Excitation Duration in Transthoracic Cardiac M-Mode ARFI Imaging

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Background, Motivation and Objective

Transthoracic echocardiography is widely used to assess anatomical and physiological features. Acoustic radiation force (ARF)-based methods such as ARFI and SWEI have not yet been clinically established for cardiac applications. We have previously examined feasibility, safety, and robustness of transthoracic ARFI on a clinical scanner but achieved limited magnitude of tissue displacement and depth of penetration. This work addresses these challenges using a new commercial US system and probe and examines the effects of the excitation pulse duration.

Statement of Contribution/Methods

In an ongoing clinical study enrolling patients with confirmed cardiac amyloidosis and age-matched healthy volunteer controls, ARFI and SWEI sequences were implemented on the Siemens Sequoia scanner and 5V1 phased array cardiac probe, both introduced in 2018. These allow generation of ARF "push" pulses with up to three times greater energy than achieved in our previous studies. Three different "push" strengths were prepared to study effects on derived cardiac elasticity metrics consistency and to quantify the loss of signal quality under low push strengths. The sequences employ a 20-Hz "push" PRF and are below FDA acoustic exposure and probe heating limits.

Results/Discussion

In the PLAX view of the IVS of thirteen subjects (12 volunteers, 1 patient), the yield rate was 61% for ARFI. In half the subjects, three or more acquisitions displayed clear systolic-to-diastolic cyclic variation in induced displacement. The others exhibited poor repeatability across the acquisitions. The following figure from a healthy control exhibits low clutter and good repeatability using the longest pulse length. In general, increasing the pulse length induced larger displacements in both systole and diastole. However, in high-clutter environments, the ARF impulse was observed to displace the near-field clutter, and ringdown reverberation obscured and corrupted displacements measured in the septum. Simply pushing harder does not appear to overcome the effects of a high-clutter imaging environment, and care must be taken to minimize clutter as a prerequisite. We will continue to enroll patients and volunteers and compare metrics between the groups.