Ultrasound microcalcification detection using harmonic power Doppler imaging: a preliminary study with tissue-mimicking and chicken breast phantoms

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Background, Motivation and Objective

The formation of mircocalcifications (MCs) due to the accumulation of calcium causes a disorder of organs or cardiovascular function. Recent studies have shown that the color Doppler twinkling artifact, which arises from random scattering or bubble oscillations on the rough surfaces, has the potential to detect calcium substances (e.g., microcalcification in breast or kidney stone). Nonlinear harmonic signals can be also observed in the calcium substances similar to microbubbles. In this study, we conducted a preliminary study of microcalcification detection using harmonic power Doppler imaging (HPDI) in a fabricated tissue-mimicking phantom and a chicken breast including calcium substances.

Statement of Contribution/Methods

For the tissue-mimicking phantom, three types of wires (i.e., the wire covered by calcium substances (CO, calcium oxalate), the grinded wire of rough surface and the wire of clean surface) were fabricated (diameter of 260μm) and surrounded by agar-based media as shown in Fig. 1 (a). In addition, five fabricated MCs of a few hundred micron size (<250μm) were placed in the chicken breast as shown in Fig. 1 (d). For HPDI, a focused beam with a narrow band pulse was transmitted (1 kHz Doppler PRF), and power estimation using autocorrelation was conducted using received harmonic signals. The experimental data were captured by using an ultrasound research platform (Vantage, Verasonics Inc., Kirkland, WA, USA) with a L11-5v linear array transducer.

Results/Discussion

Fig. 1(a) represents the result of HPDI in the tissue-mimicking phantom. As shown in Fig. 1(a), at certain power thresholding level, harmonic Doppler signals appeared on both the MC wire and the rough wire while no signal was produced on the clean surface wire. Fig. 1(b) illustrates the measured signal-to-clutter-ratio (SCR) with changing the acoustic pressure for the three wires. As shown in Fig. 1(b), the SCR of both MC and the rough wire increased as the acoustic power increased. Fig. 1(c) shows the averaged SCR values for Fig. 1(b) according to the transmit frequencies (i.e., 5.0 and 6.0 MHz). Fig. 1(e) represents the B-mode/harmonic power Doppler imaging results in the chicken breast phantom, and the five MCs (labeled as 1 to 5) were fully detected using the HPDI. These results demonstrated that the proposed HPDI can be used for detecting microcalcification in real time.

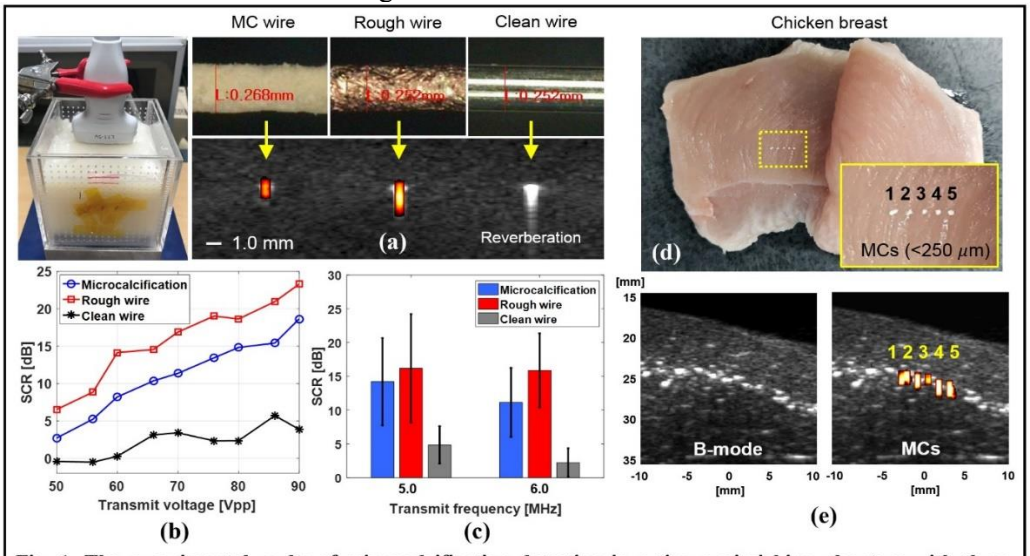

Fig. 1. The experimental reults of microcalcification detection in a tissue-mimicking phantom with three wires (MC, rough surface and clean surface) and a chicken breast including five MCs (<250μm). (a) HPDI result of tissue-mimicking phantom. (b) The measured SCR vlaues for the three wires. (c) The averaged SCR values of (b) according to the transmit frequency (i.e., 5.0 and 6.0 MHz). (d) Picture of chicken breast phantom including five MCs. (e) B-mode/HPDI images of the chicken breast phantom.