Determination of Size Distribution of Cavitation Bubbles in Tissue Using Passive Cavitation Detection Method

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Background, Motivation and Objective

With the development of various cavitation-enhanced therapeutic applications, the ultrasound therapies have been put toward into solid tissue. Therefore, to have knowledge of the cavitation bubble size distribution in tissue is of significant importance to the increase of therapy efficiency. In a previous work, a pulsed scheme was utilized to determine the size of cavitation bubbles[1]. The study firstly measured the averaged sonoluminescence (SL) intensity of the sonicated pulses as an indicator for the cavitation intensity at a certain pulse off time between pulses. Then by varying the pulse off time and keeping the pulse on time constant, the SL intensity as a function of the pulse off time can be obtained, yielding a time intensity curve(TIC).Combining the decrease of the SL intensity in the TIC and the bubble dissolution kinetics in liquid, the size distribution of cavitation bubbles was determined. In our study, broadband noise (BN) was used instead of SL for cavitation activity quantification, which extended the previous work into the non- transparent media.

Statement of Contribution/Methods

The experiment was performed using a focused ultrasound (FUS) transducer (1.6MHz) aligned with a single-element transducer (5MHz) listening the emission from the cavitation bubbles inside the porcine kidney. The tissue was sonicated in a pulsed way at an acoustic power of 14W and constant pulse duration of 12μs, while the pulse off time between pulses was varied among 100μs, 200μs, 250μs, 400μs, 500μ, 625μs, 1ms, 2ms and 5ms. The passive cavitation detection (PCD) was synchronized with the FUS transmission and digitized at a sample rate of 20MHz.The combination of the decrease of the averaged intensity of BN in the TIC and the total bubble dissolution time in the soft material[2], can be used to map the active bubble size distribution.

Results/Discussion

Figure 1(a) depicts the backscattered signals from the porcine kidney when the pulse off time was 500μs. Figure 1(b) shows the corresponding frequency spectrum. Figure 1(c) illustrates the averaged intensity as a function of the pulse off time. And Figure 1(d) was the estimated active bubble size distribution. The mean bubble radius of the active bubbles involving in the pulse train was 0.63 μm. To our knowledge, this is the first study using PCD method to estimate the active bubble size distribution in tissue.

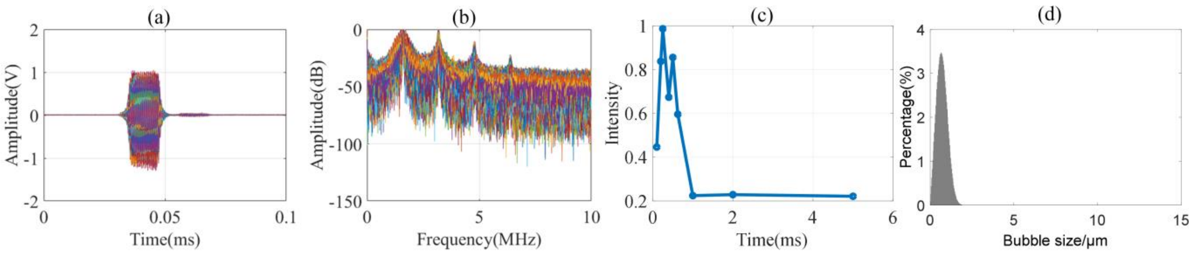

Fig. 1. (a) All PCD signals for each pulse acquired in one trial when pulse off time was 500 μ s. (b) The corresponding frequency spectrum of the signals in (a). (c) The averaged intensity as a function of the pulse off time. (d) The estimated active bubble size distribution in the porcine kidney when the pulse on time was 12 μ s and pulse off time was 500 μ s at an acoustic power of 14W.

1. A. Brotchie, et al. Physical Review Letters, 2009, **102**, 084302
2. J.M. Solano-Altamirano, et al. Soft Matter, 2015, **11**, 202-210