In vitro evaluation and correction of the bias due to the position and orientation of a passive cavitation detector.

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Background, Motivation and Objective

Cavitation is a crucial mechanism in several ultrasound-based brain therapies, including the transient disruption of the blood-brain barrier, currently under clinical investigation. Passive cavitation detection (PCD) can be used to evaluate microbubbles (MB) activity in situ. In a clinical setting, the characteristic acoustic emissions from the cavitating MB can be detected with a simple hand-held single-element sensor through the patient bone. However, the recorded signal is affected by several parameters, including the position of the sensor relative to the region of MB activity and transmission through the skull, which can greatly impact the variability of the PCD measurement. To our knowledge, an evaluation of the uncertainty of PCD related to acquisition conditions in the context of cavitation-based brain therapy is lacking. The goal of this study was to quantify the bias due to position and orientation *in vitro* and to develop a correction method.

Statement of Contribution/Methods

The experiment was done in a degassed water tank. MB circulated in a polyimide tube and were activated with a 1.1 MHz, 25,000 cycle ultrasound pulse every second. Two in-house broadband sensors were used (PVDF, 10-mm diameter). One served as a reference (RPCD) and was placed at 10.5 mm from the tube. The other was movable (MPCD) with a robotic arm, and used to reproduce the variability of positioning and orientation expected for acquisitions performed during BBB disruption in human brain. The directivity patterns of the sensors were obtained by scanning their acoustic fields and using the reciprocity principle. Three acoustic pressures were chosen empirically and used to obtain different levels of MB activity: 0.36, 0.42 and 0.49 MPa. Nine positions of MPCD were tested. Subharmonic (SH) magnitudes were extracted and averaged from 50 waveforms for each configuration. The variability of the SH magnitudes due to the position of MPCD was evaluated, without correction and with a correction using the directivity pattern of the sensor.

Results/Discussion

The coefficients of variation (Cv) of the SH magnitudes for RPCD were 5.5, 4.7 and 4.7 % for 0.36, 0.42 and 0.49 MPa respectively. For MPCD, Cv were 32.1, 33.6 and 37.7 % without correction and 9.6, 12.2 and 8.7 % with correction. These results show that a correction based on the knowledge of the position and orientation of the sensor relative to the MB activity zone reduces the uncertainty of PCD measurements. Future studies will examine the influence of the skull on PCD measurements.

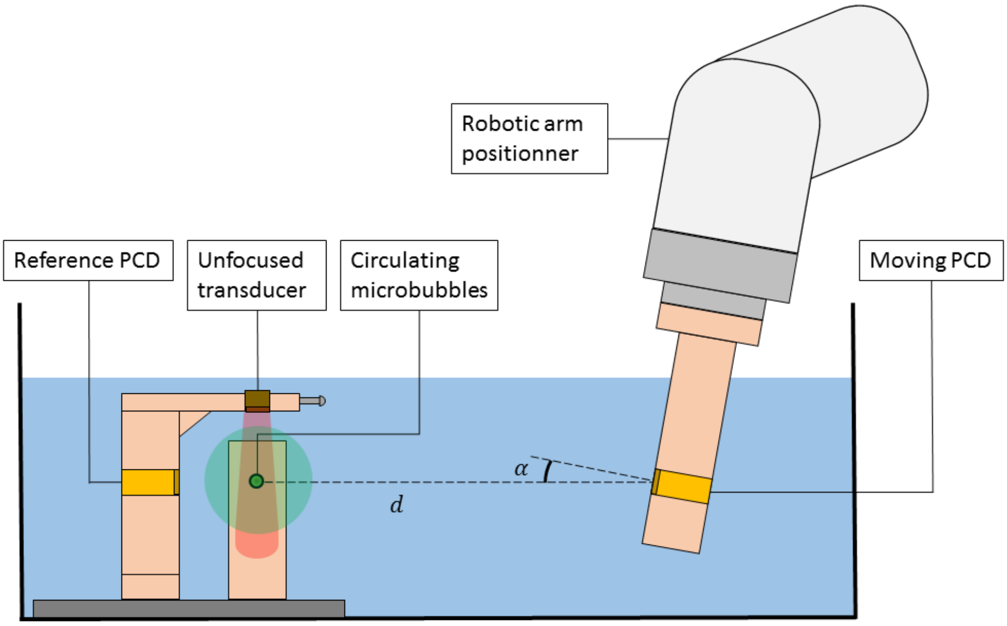

Figure 1 : Diagram of the experimental setup. The combinations of 3 pressures for the transducer, 3 values of d and 3 values of α were tested, for a total of 27 configurations.