Objective

- The main focus of this study is to find droplet vaporization threshold of nanodroplets as a function of acoustic parameters including excitation pressure, frequency, pulse repetition period and number of cycles.
- Acoustic response of in-house made microbubbles with vaporized liquid nanodroplets at varying excitation pressures are compared.

Background and Introduction

Despite a number of advantages ultrasound imaging offers, it suffers from low sensitivity. To overcome this limitation, microbubbles (MB) have been introduced, which are gas-filled particles with a size range of 1-7 micrometers. These droplets undergo a phase transition to the highly echogenic gaseous state and are convertible to micron-sized bubbles upon the input of sufficient acoustic activation energy. This is called acoustic droplet vaporization (ADV). A transition of a superheated liquid droplet into gas is an important process in ADV. Once nanodroplets are exposed to ultrasound energy, vaporization of the droplet core occurs.

Results

- At high excitation pressure, scattering signals from the vaporized nanodroplets were significant. This figure shows acoustic responses of vaporized droplets at 5 MPa with 2.25 MHz center frequency.
- Above ADV threshold, both microbubbles and vaporized droplets showed similar responses. Because of their size distributions, MB cannot be used for extravascular interrogations. Phase shift nanodroplets offer a number of advantages over ordinary microbubbles due to their enhanced stability and smaller size distribution.

Conclusions

- Above ADV threshold, both microbubbles and vaporized droplets showed similar responses.
- At ADV, fundamental and odd harmonics were found to be significantly higher than the background noise.
- ADV threshold varies significantly with PRP; while at PRP of 10 ms, the ADV threshold was found to be 3.6 MPa (pk-pk), for PRP of 1 ms, 100 μs and 500 μs, ADV was not observed even at 10 MPa.

Future Studies

- Further investigations are needed to characterize the stability of PFC droplets in vitro and in vivo.
- Since the ultimate goal of droplets is for in vivo applications where they will be exposed to different temperatures, pressures and blood viscosity, it demands a thorough investigation of acoustic droplet vaporization threshold dependence on these ambient parameters.

Effects of acoustic parameters on nanodroplet vaporization

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