Objectives:

Evaluation of potential gains of Passive Acoustic Mapping resolution using a higher-center frequency transducer via higher order ultraharmonic frequencies, with and without skull.

Methods:

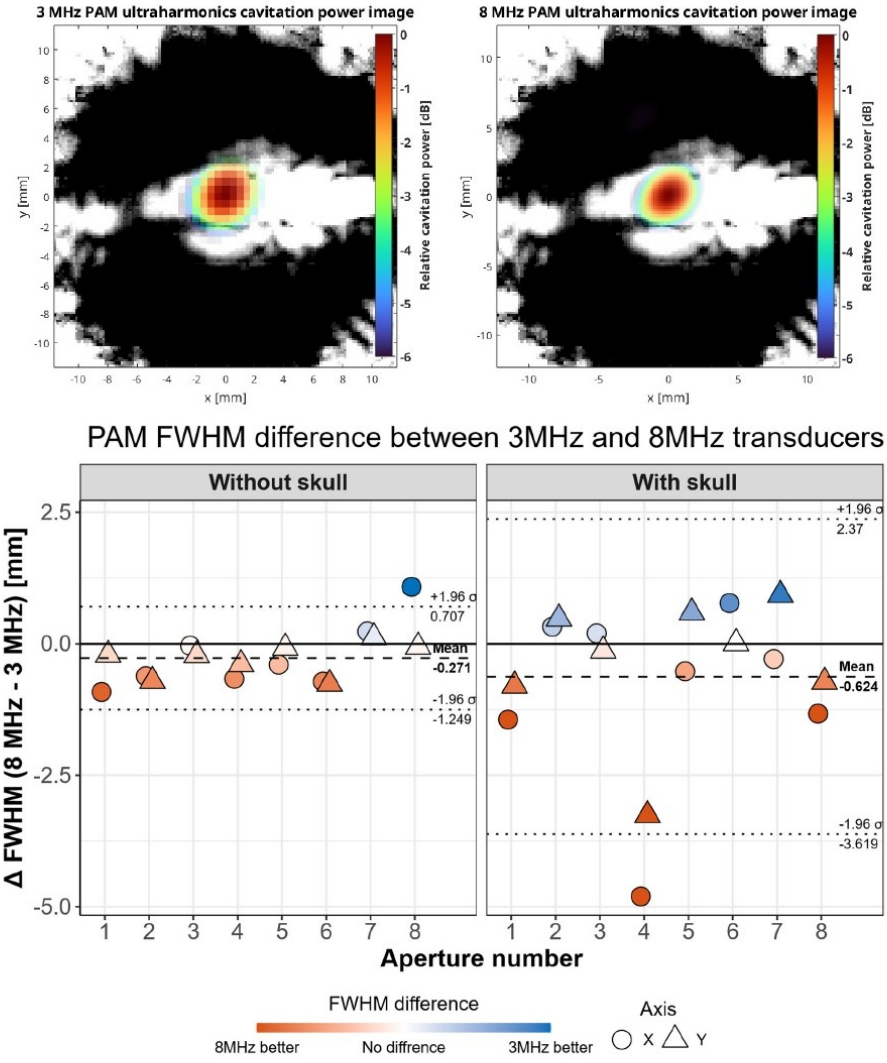
SonoVue microbubbles flowed through a silicone tube and were sonicated for 10ms with a 1.08MHz HIFU transducer. Cavitation emissions, including ultraharmonic and wideband signals were passively recorded using a Verasonics system consequently with the 3D Vermon transducers (3 and 8MHz) using 8 random apertures. The experiment was repeated with a rat skull between the tube and transducer. PAM in the frequency domain was applied and full width at half maximum were calculated for selected ultraharmonic bands.

Results:

PAM images were reconstructed using ultra-harmonic frequencies for each sample to minimize FWHM while ensuring the localized activity remained within the flow tube. Lower ultraharmonics yielded poorer spatial resolution and at higher ultraharmonics, skull-induced aberrations became visibly pronounced, leading to poorer Passive Acoustic Mapping performance. Median FWHM value is consistently lower for the 8 MHz array in both free-field and transcranial enivroments. Pairwise comparison for identical apertures reveal a mean FWHM reduction of 0.271mm (free-field) and 0.624mm (transcranial) in favor of 8 MHz. 8MHz array outperforms the 3MHz array in nearly all free-field cases, the transcranial trend splits 50/50.

Conclusions:

Even though higher-order harmonics and ultraharmonics are often avoided in PAM due to their sensitivity to skull-induced aberrations and increased side lobe levels, an appropriate selection of reconstruction frequency bands enable their effective use. Choosing a transducer with a suitable center frequency may improve signal-to-noise ratio and resolution while preserving reliable cavitation.


3 MHz PAM ultraharmonics cavitation power image
8 MHz PAM ultraharmonics cavitation power image
y [mm]
x [mm]
Relative cavitation power [dB]
PAM FWHM difference between 3MHz and 8MHz transducers
Without skull
With skull
Δ FWHM (8 MHz - 3 MHz) [mm]
+1.96 σ
0.707
Mean
-0.271
-1.96 σ
-1.249
+1.96 σ
2.37
Mean
-0.624
-1.96 σ
-3.619
Aperture number
FWHM difference
8MHz better
No diffrence
3MHz better
Axis
X
Y