

H. Liu¹, P-H. Hsu¹, Z. Tsai¹, K. Ng², C-R. Shen¹, and J. Wang¹

¹ChangGung University, KueiShan, TaoYuan county, Taiwan, ²ChangGung Memorial Hospital, Taiwan

Introduction and Background

Focused ultrasound has been used to selectively disrupt the Blood-Brain-Barrier (BBB) in a reversible manner¹. Gadolinium enhanced T1-weighted MRI has been used to monitor the sonication process. In this study, we investigated the potential of super paramagnetic iron oxide particle (SPIO)² to monitor the disruption and separate it from the potentially induced brain hemorrhage by use of susceptibility weighted imaging (SWI).

Material and Methods

A 1.5-MHz spherically curved focused ultrasound transducer was used (Diameter = 60 mm, Curvature radius = 80 mm), which delivered a burst tone energy (burst length = 10 ms, PRF = 1s, Sonication time = 30s). Sprague-Dawley rats were subjected to sonications unilaterally under various HIFU power. Craniotomy was performed and microbubble (SonoVue[®], Bracco, Italy) was IV administered before the ultrasound sonication. All MRI images were acquired on a 3-T scanner (Trio with Tim, Siemens, Erlangen, Germany) using a surface coil. Two SWIs (TR/TE/flip angle = 28 ms/20 ms/15°, voxel size = 0.3×0.3×0.7 mm³) were acquired before and at least 10 minutes after the IV administration of SPIO.

Volume rendering of signal changes between both SWIs were reconstructed.

Result

Figure 1 demonstrated a sonication power of 2.45 MPa. Before the administration of SPIO, a region of hemorrhage can be noticed as indicated by red arrow in the left. An extensive region of BBB disruption, which is significantly larger than the detected hemorrhage, was shown in the right figure, after IV injection of SPIO. The mismatched areas in between indicated a safe range of HIFU power, which successfully induced the BBB disruption without hemorrhage. The measured volume is 2.268 mm³ (hemorrhage) and 11.025 mm³ (BB disruption).

Conclusion

SPIO-enhanced SWI provides a T2 based approach to in vivo monitoring of the focused ultrasound induced BBB disruption. The mismatched areas implied an area without brain tissue damage.

References[1]K. Hynynen et al., Radiology, pp. 640-6, 2001. [2]D. L. Thorek et al., Ann Biomed Eng, pp. 23-38, 2006. [3]D. Haddar et al., J Radiol, pp. 1901-8, 2004.

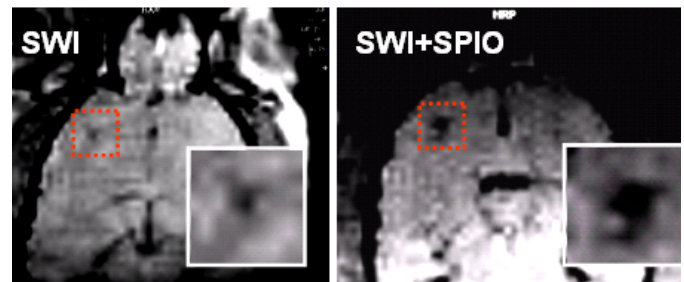


Fig. 1. Comparison of MR-SWI and MR-SWI before and after the administration of SPIO

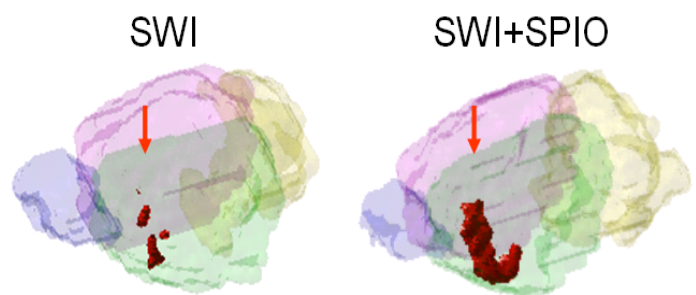


Fig. 2. 3D volume rendering of signal enhancement (red) detected from SWI before and after the SPIO administration. Arrows indicated the sonication direction.