UKE Paper of the Month November 2020

Monitoring Intracranial Cerebral Hemorrhage Using Multicontrast Real-Time Magnetic Particle Imaging

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ABSTRACT:
Magnetic particle imaging (MPI) is an innovative radiation-free tomographic imaging method providing excellent temporal resolution, contrast, sensitivity, and safety. Mobile human MPI prototypes suitable for continuous bedside monitoring of whole-brain perfusion have been developed. However, for the clinical translation of MPI, a crucial gap in knowledge still remains: while MPI can visualize the reduction in blood flow and tissue perfusion in cerebral ischemia, it is unclear whether MPI works in intracranial hemorrhage. Our objective was to investigate the capability of MPI to detect intracranial hemorrhage in a murine model. Intracranial hemorrhage was induced through the injection of collagenase into the striatum of C57BL/6 mice. After the intravenous infusion of a long-circulating MPI-tailored tracer consisting of superparamagnetic iron oxides, we detected the intracranial hemorrhage in less than 3 min and could monitor hematoma expansion in real time. Multicontrast MPI can distinguish tracers based on their physical characteristics, core size, temperature, and viscosity. By employing in vivo multicontrast MPI, we were able to differentiate areas of liquid and coagulated blood within the hematoma, which could provide valuable information in surgical decision making. Multicontrast MPI also enabled simultaneous imaging of hemorrhage and cerebral perfusion, which is essential in the care of critically ill patients with increased intracranial pressure. We conclude that MPI can be used for real-time diagnosis of intracranial hemorrhage. This work is an essential step toward achieving the clinical translation of MPI for point-of-care monitoring of different stroke subtypes.

STATEMENT:
Magnetic Particle Imaging (MPI) is a novel tomographic imaging technology developed in Hamburg. As one of the world's leading research groups in this field, we have already constructed the first human MPI scanner for future use in clinical routine. On the way "from bench to bedside", we were now able to publish important preclinical results in this research work: We were able to show that MPI allows fast and quantitative detection of intracranial and subarachnoid hemorrhage. In addition, MPI has the unique ability to differentiate between different agglomeration states within the hemorrhage by spectral separation and draw conclusions about the stability and age of the hemorrhage. Our work shows that MPI provides comparable results to CT and MRI and thus lays the foundation for the first human trials, which are scheduled to follow next year. In addition to the excellent scientific results for the application area of MPI, this work demonstrates the broad competence of the institutions at Hamburg and especially at the University Medical Center Hamburg. This work was realized in close cooperation between the Department of Neurology (Peter Ludewig) and the Section of Biomedical Imaging (Patryk Szwargulski) of the UKE. The interdisciplinary perspective of medical doctors and engineers led to success.

BACKGROUND:
This work was performed in cooperation between the Department of Neurology (Peter Ludewig) and the Section of Biomedical Imaging (Patryk Szwargulski) of the UKE.

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