Low-field magnetic resonance imaging

- Initial insights into post-contrast enhancement in ultra-low-field MRI: Case Report
- Ultra-Low-Field Portable Brain Magnetic Resonance Imaging in Patients With Cardiac Devices: Current Evidence and Future Directions
- 0.23-Tesla MRI to differentiate between ischaemic and haemorrhagic strokes within 24 hours of onset: a combined experimental-clinical study
- Ultra-Low-Field Portable MRI and Extracorporeal Membrane Oxygenation: Preclinical Safety Testing
- Clinical Use of Bedside Portable Ultra-Low-Field Brain Magnetic Resonance Imaging in Patients on Extracorporeal Membrane Oxygenation: Results From the Multicenter SAFE MRI ECMO Study
- Utilizing a portable magnetic resonance imaging (MRI) in the setting of an acute ischemic stroke in a patient with a cardiac implantable electronic device
- MRI-based ventilation and perfusion imaging to predict radiation-induced pneumonitis in lung tumor patients at a 0.35T MR-Linac
- Mobile 0.23 T MRI Detects Cerebral Infarction in Patients With Minor Ischemic Stroke or TIA

Low-field magnetic resonance imaging (MRI) refers to the use of MRI scanners with lower magnetic field strengths compared to the high-field MRI scanners commonly used in clinical practice. High-field MRI scanners typically have field strengths of 1.5 Tesla (T) or 3.0 T, while low-field MRI scanners have field strengths of less than 1.0 T.

Key points

Magnetic Field Strength: Low-field MRI scanners typically operate at field strengths ranging from 0.2 T to 0.5 T. These lower field strengths are achieved using permanent magnets or resistive magnets, as opposed to the superconducting magnets used in high-field MRI scanners.

Image Quality: The image quality in low-field MRI is generally lower compared to high-field MRI. This is because higher field strengths provide better signal-to-noise ratios, which result in clearer and more detailed images.

Clinical Applications: Low-field MRI is often used in situations where high-field MRI may not be practical or necessary. It is commonly used for imaging extremities (such as arms, legs, and joints), where the lower field strength can still provide diagnostic-quality images. It can also be used for imaging pediatric patients and in situations where cost constraints limit the use of high-field MRI.

Open Design: Some low-field MRI scanners have open designs, which can be more comfortable for patients who experience claustrophobia or have difficulty fitting into the narrow bore of high-field MRI machines.

Challenges: Low-field MRI has limitations, including lower image resolution, longer scan times, and reduced sensitivity to certain types of pathology. Additionally, it may not be suitable for all types of imaging, particularly for complex neurological or cardiac studies where high-field MRI is preferred.

Research and Development: Low-field MRI is also used in research and development settings, as it can be more accessible and cost-effective for certain experiments or studies that do not require the advanced capabilities of high-field MRI.

In summary, low-field MRI serves as a valuable tool in medical imaging, particularly for specific clinical scenarios and patient populations. While it may not provide the same level of image quality as high-field MRI, it offers an alternative when high-field imaging is not feasible or necessary.

While MRI is not yet ready for clinical use in the mobile stroke units (MSU) setting, the initial experience suggests the potential technological feasibility of this approach following future technical and MRI sequence development. Additional studies, incorporating patients, would be required to determine clinical feasibility [1)].

Data suggest intracerebral Hemorrhage can be characterized using low-field magnetic resonance imaging (MRI). Mazurek et al. primary objective was to investigate the sensitivity and specificity of ICH on a 0.064T portable MRI (pMRI) scanner using a methodology that provided clinical information to inform rater interpretations. As a secondary aim, we investigated whether the incorporation of a deep learning (DL) reconstruction algorithm affected ICH detection.

The Portable Magnetic Resonance Imaging device was deployed at Yale New Haven Hospital to examine patients presenting with stroke symptoms from October 26, 2020, to February 21, 2022. Three raters independently evaluated pMRI examinations. Raters were provided the images alongside the patient's clinical information to simulate the real-world context of use. Ground truth was the closest conventional computed tomography or 1.5/3T MRI. Sensitivity and specificity results were grouped by DL and non-DL software to investigate the effects of software advances.

A total of 189 exams (38 ICH, 89 acute ischemic stroke, 8 subarachnoid hemorrhage, 3 primary intraventricular hemorrhage, 51 no intracranial abnormality) were evaluated. Exams were correctly classified as positive or negative for ICH in 185 of 189 cases (97.9% overall accuracy). ICH was correctly detected in 35 of 38 cases (92.1% sensitivity). Ischemic stroke and no intracranial abnormality cases were correctly identified as blood-negative in 139 of 140 cases (99.3% specificity). Non-DL scans had a sensitivity and specificity for ICH of 77.8% and 97.1%, respectively. DL scans had a sensitivity and specificity for ICH of 96.6% and 99.3%, respectively.

These results demonstrate improvements in ICH detection accuracy on pMRI that may be attributed to the integration of clinical information in rater review and the incorporation of a DL-based algorithm. The use of pMRI holds promise in providing diagnostic neuroimaging for patients with ICH [2)].

Altaf et al. presented the first brain tumor case scanned using an Ultra-low-field pMRI at Aga Khan University Hospital in Karachi, Pakistan.

The imaging results suggest that the pMRI device can aid in neuroradiological diagnosis in resource-constrained settings. Further, research is needed to assess its compatibility for imaging other neurological disorders and compare its results with conventional MRI results [3)].

Portable, low-field imaging could be useful for identifying moderate to severe White matter hyperintensity (WMH) [4].

Workshops

In March 2022, the first ISMRM Workshop on Low-Field MRI was held virtually. The goals of this workshop were to discuss recent low-field MRI technology including hardware and software developments, novel methodology, new contrast mechanisms, as well as the clinical translation and dissemination of these systems. The virtual Workshop was attended by 368 registrants from 24 countries and included 34 invited talks, 100 abstract presentations, 2 panel discussions, and 2 live scanner demonstrations. Here, we report on the scientific content of the Workshop and identify the key themes that emerged. The subject matter of the Workshop reflected the ongoing developments of low-field MRI as an accessible imaging modality that may expand the usage of MRI through cost reduction, portability, and ease of installation. Many talks in this Workshop addressed the use of computational power, efficient acquisitions, and contemporary hardware to overcome the SNR limitations associated with low field strength. Participants discussed the selection of appropriate clinical applications that leverage the unique capabilities of low-field MRI within traditional radiology practices, other point-of-care settings, and the broader community. The notion of "image quality" versus "information content" was also discussed, as images from low-field portable systems that are purpose-built for clinical decision-making may not replicate the current standard of clinical imaging. Speakers also described technical challenges and infrastructure challenges related to portability and widespread dissemination and speculated about future directions for the field to improve the technology and establish clinical value [5]

1)

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2)

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3)

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4)

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5)

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