Initiative / Innovation

5T MRI: Bridging innovation and whole-body clinical need

Lan Zhang, M.D.
From The 1st Affiliated Hospital of Henan University of Chinese Medicine, Henan, People's Republic of China.
Address correspondence to L.Z.(E-mail: 13837187787@163.com)

Received 15 April 2025; accepted 19 May 2025
doi:10.46475/asean-jr.v25i2.950

Abstract

This article introduces the clinical debut of whole-body 5T magnetic resonance imaging (MRI), a novel ultra-high-field system designed to bridge the gap between conventional 3T and 7T MRI. Developed through international collaboration, the 5T platform overcomes major technical barriers in RF design, field homogeneity, and SAR control, to enable stable, high-resolution imaging across the whole body. Clinical evidence demonstrates its superiority in multiple applications, including intracranial vascular imaging, cardiac and coronary assessment, and abdominal imaging. By delivering both ultra-high resolution and whole-body capability, 5T MRI establishes a new paradigm for clinical imaging and paves the way for broader access to advanced diagnostic technologies.

Keywords: Abdominal, Cardiac, MRI, TOF MRA, Ultra-high-field MRI, 5.0T MRI.

It is a great honor to participate in RCRT-RST 2025. This year's theme, "The Art and Science of Radiology: Bridging Knowledge and Practice," reflects a shared commitment across our community — to translate technological progress into meaningful clinical outcomes.

In this context, I would like to introduce the clinical debut of ultra-high-field whole-body 5.0T MRI. It enables radiologists to see subtle findings that were previously difficult to detect — and in doing so, helps us "see the unseen" and improve diagnostic confidence.

Part I. The Evolution of MRI: From Low Field to Ultra-high Field

MRI has undergone remarkable progress over the past four decades — from low-field systems with limited capabilities to 1.5T and 3.0T scanners that became the mainstay of clinical imaging. Each leap in field strength has brought new possibilities in spatial resolution, image quality, and diagnostic accuracy.

In 2017, the U.S. FDA approved the first 7T MRI system for clinical use, but its clinical applications primarily limited to the head and extremities [1]. Meanwhile, clinical demands continue to evolve. Radiologists are increasingly in pursuit of both ultra-high resolution and whole-body imaging capabilities — spanning the brain, joints, heart, abdomen, breast, and spine.

Part II. The Birth of 5T MRI: Bridging Vision and Feasibility

Several years ago, Professor Jürgen Hennig, a pioneer and former president of ISMRM, said, "The Tesla has to come to the clinic, not the clinic to the Tesla." Prof. Hennig is widely regarded as a living legend in the field of MRI and the inventor of the Fast Spin Echo sequence, who proposed the idea of 5.0T MRI as a feasible clinical alternative to 7T. I knew him in 2008 and later joined his lab at the University of Freiburg in 2016. His vision of a clinically meaningful ultra-high-field MRI system profoundly inspired my own path in MRI development.

However, the development of a 5.0T MRI system was technically challenging. Operating at this field strength required major breakthroughs in the RF system design, B0 and B1 field management, coil optimization, and SAR control to ensure stable and high-quality imaging across the whole body.

After years of collaborative innovation between engineers, physicists, and clinical experts, the world's first whole-body 5.0T MRI scanner was successfully developed in China. It received both U.S. FDA clearance and CE certification in Europe, and its clinical use is rapidly expanding.

Part III. Clinical Impact of 5T MRI: See the Unseen

5.0T MRI is far more than just a technological advancement—it represents a new paradigm in whole-body clinical imaging. By bridging the gap between 3.0T and 7.0T, it delivers unparalleled image quality while maintaining workflow efficiency and patient accessibility.

In brain imaging, 5.0T MRI demonstrates significant advantages in visualizing distal arterial segments and small perforating branches. A recent prospective study comparing 3T, 5T, and 7T TOF-MRA found that 5T imaging provided notably better visualization of the lenticulostriate and pontine arteries than 3T, with vessel detail approaching that of 7T [2]. Quantitatively, the total length of small vessel branches detected at 5T was more than twice that of 3T, with no significant difference compared to 7T. These results confirm that 5T TOF-MRA offers both the resolution and stability needed for high-quality intracranial vascular imaging, making it a clinically viable tool for detecting small vessel diseases and assessing a complex cerebrovascular anatomy.

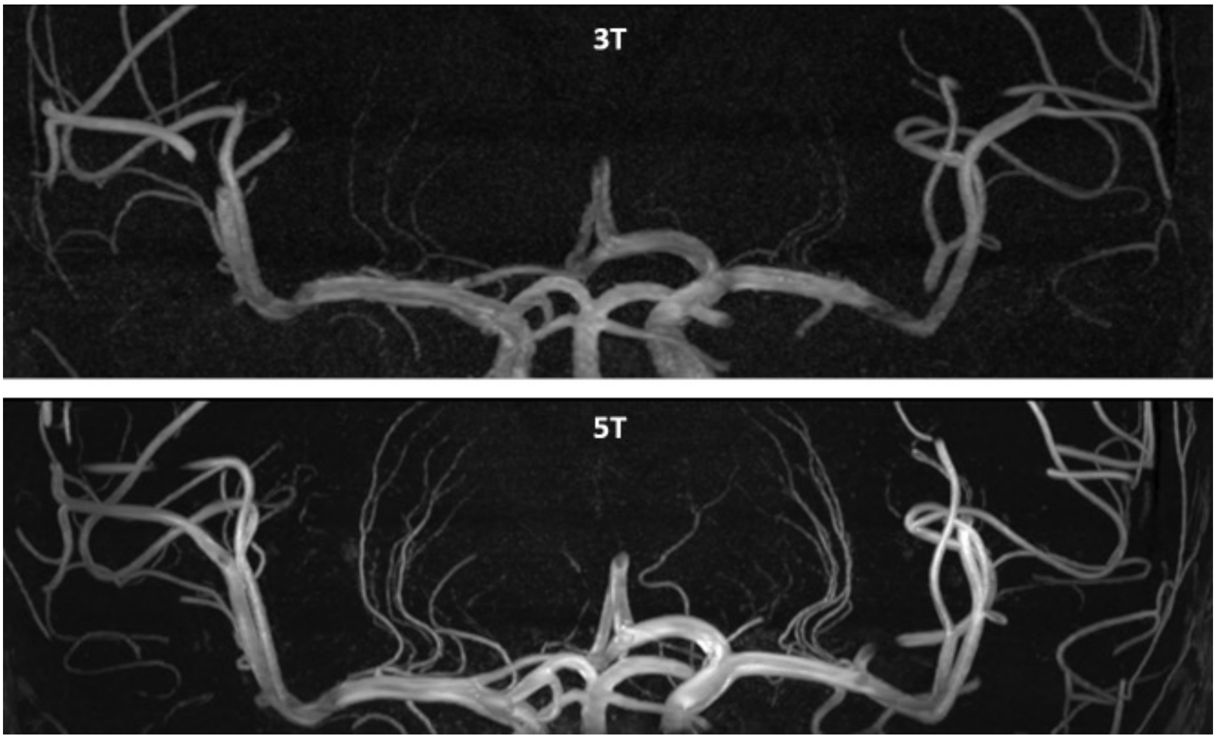

Figure 1. *Time-of-flight (TOF) intracranial MRA at 3.0T (top) and 5.0T (bottom), acquired with identical voxel size (0.40 × 0.40 × 0.40 mm³) and scan time; 5.0T TOF-MRA shows more continuous and well-defined visualization of the lenticulo-striate arteries and distal branches compared to 3.0T.*

In cardiovascular imaging, 5.0T MRI has demonstrated clear benefits in both coronary and myocardial applications. For non-contrast coronary MRA, recent prospective studies have shown that 5T achieves significantly higher SNR, CNR, and vessel edge sharpness compared to 3T, while maintaining shorter scan times [4]. In myocardial imaging, late gadolinium enhancement (LGE) scanned by 5T can provide superior SNR and CNR, especially in the myocardium and pericardial fat, without affecting quantitative fibrosis assessment [5]. These findings support the clinical feasibility of 5T MRI for comprehensive cardiac evaluation, enabling clearer visualization of coronary anatomy, plaque, and fibrosis, and offering a non-invasive, radiation-free alternative for patients contraindicated for CCTA.

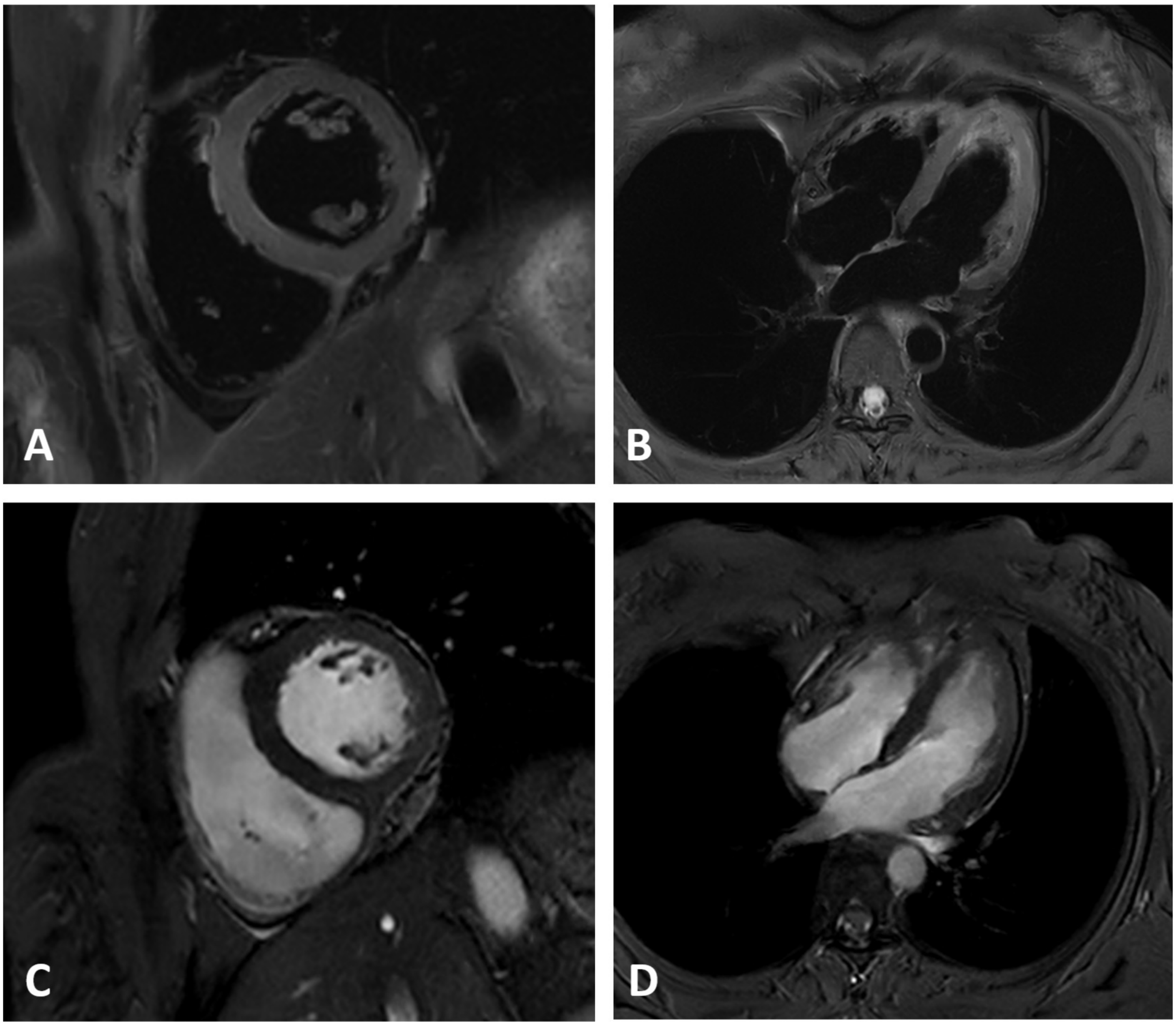

Figure 2. *High-resolution, non-contrast cardiac imaging sequences acquired at 5.0T: dark-blood images (A, B), cine images (C, D). Dark-blood images were acquired with a voxel size of 0.94 × 0.94 × 6 mm³ (A: short axis) and 0.83 × 0.83 × 6 mm³ (B: four-chamber), clearly delineating myocardial morphology at 5.0T. Cine images were acquired with a voxel size of 0.98 × 0.98 × 6 mm³ for both the short-axis (C) and four-chamber views (D).*

In abdominal imaging, recent studies have shown that 5.0T MRI offers clear advantages over 3.0T, particularly in terms of signal quality and small structure visualization. In pancreatic imaging, 5T DWI with reduced field-of-view provided a significantly higher signal-to-noise ratio and improved lesion conspicuity, without compromising ADC stability [5]. Similarly, in renal imaging, 5T MRI achieved better corticomedullary differentiation and clearer depiction of renal arteries and veins, with higher SNR and contrast ratios [6]. These results suggest that 5.0T MRI can enhance both structural and functional abdominal imaging, supporting its clinical potential beyond neuro and MSK applications.

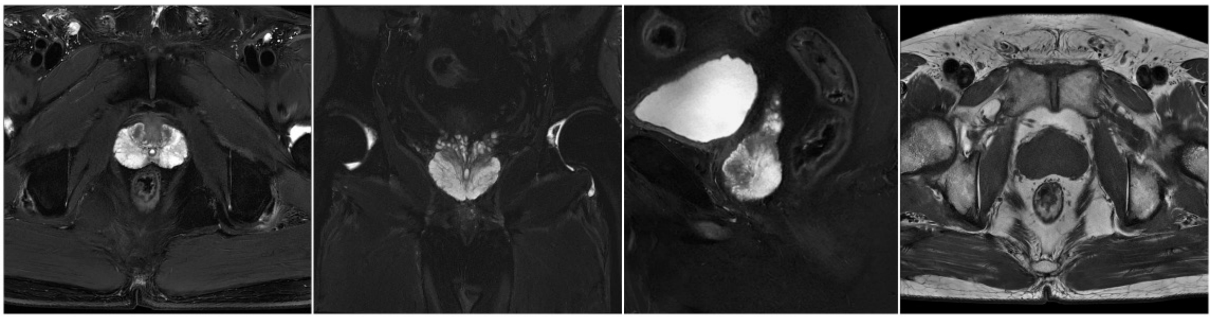

Figure 3. *High-resolution prostate imaging with 5.0T MRI, T2-weighted fat-suppressed FSE images in axial, coronal, and sagittal planes, and axial T1-weighted FSE (0.5 × 0.5 × 3 mm³); the fine internal structure and zonal anatomy of the prostate gland are clearly visualized.*

Part IV. Establishing the Future of Ultra-high-field MRI

As a member of the Chinese Society of Magnetic Resonance Imaging in Medicine (CSMRM), I am pleased to share that the 5.0T MRI system has now been installed in over 35 hospitals across China. Leading institutions such as Fudan University Zhongshan Hospital, Peking Union Medical College Hospital, and the Shenzhen Institutes of Advanced Technology are actively exploring new clinical applications and technical innovations based on this platform.

With ongoing research, growing clinical evidence, and wider adoption, 5.0T MRI is poised to reshape diagnostic standards and support earlier, more precise detection across a wide range of whole-body applications.

We are deeply honored to play a part in this transformative journey and to help extend its clinical advantages to a larger number of patients in need. This milestone also reflects a wider trend: as the world's most populous continent, Asia is now playing an increasingly dynamic and proactive role in supporting the global progress in radiological innovation.

The future of ultra-high-field MRI is no longer a distant goal. It is already here.

References

1. U.S. Food and Drug Administration [Internet]. Silver Spring (MD): The Administration; October 12, 2017 [cited 2025 Apr 28].. FDA clears first 7T magnetic resonance imaging device. Available from: https://www.fda.gov/news-events/press-announcements/fda-clears-first-7t-magnetic-resonance-imaging-device

2. Shi Z, Zhao X, Zhu, S, Miao, X, Zhang Y, Han S, et al. Time-of-flight intracranial MRA at 3 T versus 5 T versus 7 T: Visualization of distal small cerebral arteries. Radiology 2023;306:207–17. doi: 10.1148/radiol.220114.

3. Lu H, Miao X, Wang D, Zheng X, Zhang S, Wang R, et al. Feasibility and clinical application of 5-T noncontrast dixon whole-heart coronary MR angiography: A prospective study. Radiology 2024;313: e240389. doi: 10.1148/radiol.240389.

4. Guo Y, Lin L, Zhao S, Sun G, Chen Y, Xue K, et al. Myocardial fibrosis assessment at 3-T versus 5-T myocardial late gadolinium enhancement MRI: Early results. Radiology 2024;313:e233424. doi: 10.1148/radiol.233424.

5. Zheng L, Yang C, Liang L, Rao S, Dai Y, Zeng M. T2-weighted MRI and reduced-FOV diffusion-weighted imaging of the human pancreas at 5 T: A comparison study with 3 T. Med Phys 2023;50:344–53. doi: 10.1002/mp.15970.

6. Zheng L, Yang C, Sheng R, Dai Y, Zeng M. Renal imaging at 5 T versus 3 T: a comparison study. Insights Imaging 2022;13:155. doi: 10.1186/s13244-022-01290-9.