

*ISMRM 2012 Sunrise Educational Course
Cutting-Edge Cardiovascular MR: From Small Animal Models to State-of-the-Art
Options for CMR in Small Animal Imaging*

Use of a Clinical Scanner: What's Possible

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Rationale of cardiac imaging in rodent using a clinical MR scanner

Despite the robust development of dedicated MR scanners for small animal, there is a strong interest in the MR research community to use clinical MR scanners for small animal imaging. There is a much larger base of available clinical MR systems in comparison to the dedicated small animal MR scanners. Often, the clinical MR systems may be available at low cost during the night and weekends. Successful experimental research on MRI using clinical systems is a very convincing step for translational research as the imaging power of dedicated small animal MR system is not available for clinical examination. The large diameter bore of the clinical MR system allows access for direct manipulation of the rodent during the imaging session to image, for example, the effect of an acute coronary occlusion. Finally, the use of clinical MR scanner may be particularly cost efficient, as a research team of MR programmers familiar with sequence development on the clinical MR system can also work on sequence development for small animal cardiac imaging.

The limitation of such an approach is that it is usually limited to reduced access during daytime as well as a lower hardware performance and a non permanent monitoring setup that could be time consuming to install and remove after each experiment.

Methods for cardiac imaging in rodent using a clinical MR scanner

In comparison to a dedicated small animal MR system, imaging with a clinical MR scanner is associated with the following difficulties: the limited signal noise ratio (SNR) and the gradient strength.

- 1) SNR: Clinical MR scanners have typically a lower magnetic field (3T or 1.5T) than dedicated small animal MR scanner operating between 4.7T to 11T. As a consequence, the SNR is reduced in the clinical setup. Sufficient SNR can be obtained by averaging and lowering the bandwidth at a price of a longer acquisition time. The SNR can also be boosted with the use of dedicated small animal coils that are commercially available. At 1.5T, a short axis CSPAMM slice acquisition suitable for automated processing can be obtained in less than 2 minutes in the rat ¹.
- 2) Gradient strength: Due to the larger diameter bore of clinical MR system, the resulting gradients are lower by comparison to dedicated small animal MR systems. The spatial resolution may be somewhat reduced in consequence but still sufficient for most of the applications. A resolution of 300 μm can be obtained in cine in rat at 1.5T ² and in mice at 3T ³. For PSIR sequences to

study uptake of contrast media in the heart, resolution of 156 μm has already been reported in standard clinical 3T MR scanners³. The reduced gradients also limit the use of short RF excitation pulses when a slice selection is needed. Therefore, the minimal repetition time of the cine sequence may be increased and can be an issue for the temporal resolution. An interleaved cine with a temporal regularization can achieve a temporal resolution as short as 6.8 ms with an in-plane resolution of 257 μm ⁴.

Application of cardiac imaging using a clinical MRI scanner

Cardiac mass and ventricular volume of mouse and rat heart can reliably be obtained using clinical 1.5T and 3T MR systems^{2,5}. Cardiac function, including dobutamine stress effect, can be measured using both cine- and tag- imaging with such systems^{2,6}. Recently, a clinical 3T MR system was used to show that treatment with anti-CCL5 mAb significantly reduced both infarct size and post-infarction heart failure in a mouse model of chronic cardiac ischemia⁷.

Myocardial infarct using both gadolinium and manganese enhanced imaging can be performed in mice at 3T on clinical MR scanners^{3,8}. 'Area at risk' can also be measured in rat at 1.5T using this type of methodology⁹.

Macrophage uptake of ultra-small iron oxide particles has been demonstrated in experimental acute cardiac transplant rejection in rat using a 1.5T MR system¹⁰. With in-vivo loading performed before coronary occlusion, macrophage migration toward the infarct area can be followed in rat using a 1.5T MR system¹¹. Stem cells loaded with iron oxide can also be monitored in the rat heart using a clinical MR scanner¹².

Conclusion

With more and more convincing results reported in the literature, cardiac imaging in rodents using a clinical MR scanner is becoming a viable option for researchers without access to a dedicated small animal MR scanners.

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