# High resolution cardiac imaging in small laboratory animals using a standard clinical 3.0T gradient set

**P. A. Wielopolski[1], S. T. van Tiel[1], G. Houston[2], H. Flick[3], G. P. Krestin[1], and M. R. Bernsen[1]**

[1]Radiology, ErasmusMC, Rotterdam, Netherlands, [2]General Electric Healthcare, Netherlands, [3]Flick Engineering B.V., Winterswijk, Netherlands

## Purpose

We consider and explore the potential of a standard clinical 3.0T scanner for high resolution cardiac imaging work in rodents.

## Methods

Cardiac imaging was performed on healthy/infarcted mice and rat hearts on a General Electric 3.0T scanner (Excite HD software level 12) using:

- the standard clinical imaging gradient set (40 mT/m, SR 150, 266 µs rise time to maximum)
- the clinical cardiac package
- the standard ECG gating interlace with regular cardiac electrodes

For high SNR, custom designed small diameter surface coils (1-3 cm ID; loops and loop-quadrature combinations) were used in conjunction with a 4/8 multi-channel signal reception interface. A birdcage coil with an internal diameter of 4.5 cm-length 5.0 cm was available.

In-plane resolution was varied between 80-150 µrn$^2$, with 0.7-3.0 mm sections. Temporal resolutions were set to a maximum of 30/60 ms per frame for cine/non-cine scans, respectively. For cine scans, flow compensation was selected. Table 1 illustrates the minimum TR/TE combination achievable for different slice thicknesses and slice orientations with the current gradient hardware for a 156 µrn$^2$ resolution typically acquired in rat functional cardiac imaging on higher magnetic field animal scanners.

Gd-DTPA (Magnevist. Schering, Germany) and an intravascular contrast agent (Gd-DTPA-Albumin, Brasch, UCSF, USA) were employed to improve blood/myocardium contrast for cine scans and/or to delineate myocardial infarctions. Animals were anesthetized by intraperitoneal injection.

**Table1**

Rat Cine Scan

| TR (ms) | TE (ms) | Slice (mm) | BW (kHz) | FOV (cm) | Nf | Ny | Resolution (µm$^2$) | Plane |
|---|---|---|---|---|---|---|---|---|
| 15.2 | 4.2 | 3 | 11.9 | 6 | 384 | 256 | 156 | axial |
| 16.8 | 5.1 | 2 | | | | | | |
| 21.7 | 6.2 | 1 | | | | | | |
| 22.2 | 6.6 | 0.9 | | | | | | |
| 15.9 | 5.4 | 3 | 15.63 | 6 | 384 | 256 | 156 | Oblique 45°-45°-45° |
| 16 | 5.4 | 2 | | | | | | |
| 17.6 | 6.9 | 1 | | | | | | |
| 18 | 7.3 | 0.9 | | | | | | |

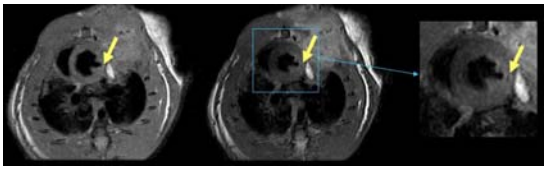

**Figure 1:** (a) PDw (b) T2w BBFSE illustrating a one-week old induced myocardial infarct in a rat. Arrows show a small infarct.

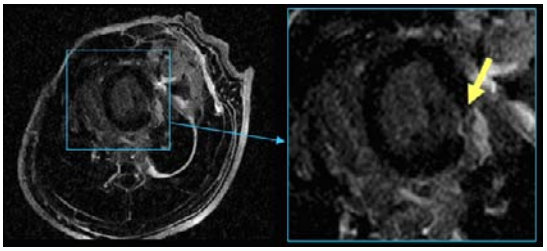

**Figure 2:** DCE scan in the rat of Figure 1.

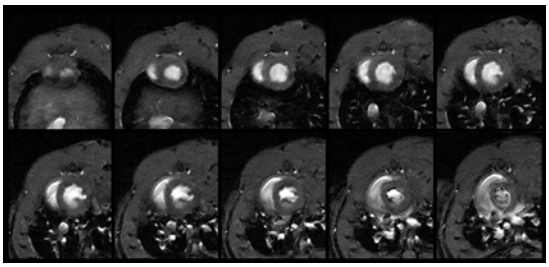

**Figure 3:** 10 (1.8 mm) stack short-axis cine in a rat collected in 18 min.

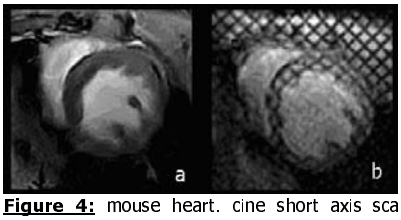


**Figure 4:** mouse heart. cine short axis scan (a) and grid tagging (b).

## Results

By placing standard cardiac electrodes on the paws of the animals all the relevant pulse sequences such as proton density (PDw) and T2-weighted (T2w) black blood fast spin echo (BBFSE), standard cine, cine 1D and 2D tagging and delayed contrast enhanced (DCE) scans were obtained (Figure 1, Figure 2; rat with small 1-week myocardial infarction). ECG gating hardware handled heart rates up to the maximum observed of 350 beats/minute with the injected anesthetics. Scanning times were short depending on the reception coil used and sequence selection and did not exceed 8 minutes per slice at the highest resolution attempted (0.9 mm, 80 µrn$^2$).

Functional cardiac scans were performed efficiently in both rats and mice. Figure 3 demonstrates a short axis cine stack in a rat heart completed in 18 min. For mice, hearts could he covered with ten to twelve 0.9 mm contiguous slices in the short axis (temporal resolution 25 ms, 100 µrn$^2$ in-plane resolution).

1D and 2D tagging could be performed with a minimum tag line thickness of 130 µm and tag line separations down to 400 µm. Figure 4 illustrates an example of cine and grid tagging in a mouse heart.

## Conclusion

- A standard clinical 3.0T system and the clinical cardiac package were well suited for high resolution work in rodent hearts using specialized signal reception hardware.
- Microimaging on unmodified clinical scanners with signal reception hardware adjusted to the size of the imaging target is realistic. Our initial experience proves adequate even for scanning mouse hearts. This warrants a greater effort and flexibility for translational research in molecular imaging at relevant clinical MRI field strengths.