# Accelerated mouse cardiac imaging using threefold undersampling and kt-BLAST reconstruction

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## Introduction

Parallel imaging is now widely used to reduce scan times in clinical MRI. Meanwhile, undersampling of kt-space to exploit spatiotemporal correlations in periodic data by techniques such as UNFOLD[1] and kt-BLAST[2] has achieved accelerations of typically two to four times in human cardiac MRI.[3] In imaging studies of experimental animals, shorter scan times would improve animal welfare by reducing their exposure to anaesthesia. Although parallel imaging has been reported in mice[4], there are no corresponding reports of the translation of kt undersampling techniques. In this work we compared standard cardiac cine imaging with threefold undersampled kt-BLAST acquisition in healthy mice and one animal with myocardial infarct (MI).

## Materials and Methods

All experiments conformed to national and institutional regulations for animal care. Healthy adult male C57BL/6 mice ($n$=6) and one mouse with MI were anaesthetised and scanned at 7T using a Varian MRI system with a 39 mm quadrature coil. Prospective cardiac synchronisation and respiratory gating were used. Short-axis cardiac images were acquired with a standard gradient echo 'cine' sequence (TR/TE=7/3 ms), consisting of 12 time frames, 8 slices of 1 mm thickness, FOV 30 mm and a 192×192 matrix with 3 signal averages. The sequence was repeated with threefold undersampling of kt-space (every 3rd row of k-space, with the index of the first row being incremented between time frames), and then "training" data (consisting of the central 16 rows of k-space) was acquired. Training and accelerated data were used to reconstruct image sets using the standard kt-BLAST algorithm.[2] Cardiological indices of interest (left ventricular end diastolic volume EDV, end systolic volume ESV, ejection fraction EF, end diastolic mass EDM and end systolic mass ESM) were measured (ImageJ) from all image sets by one experienced analyst who was blinded to the identity of each set. Images were also given a subjective quality score, ranging from 1 ("poor") to 5 ("good"). After unblinding, the cardiological indices measured from the accelerated scanning were expressed as ratios with respect to those obtained from the standard cine scan for that animal.

## Results

Satisfactory images were acquired from all animals (Fig. 1). Image quality was similar between the standard (4.1±1.2) and accelerated (3.7±1.5) scans. The effect of kt-BLAST acceleration on cardiological parameters is shown in Fig. 2. It can be seen that acceleration led to overestimation of ESV (mean±std dev of 1.05±0.15) and underestimation of EDV (0.95±0.09) and hence of EF (0.96±0.11). EDM was overestimated by 9% (1.09±0.09) and ESM by 2% (1.02±0.08).

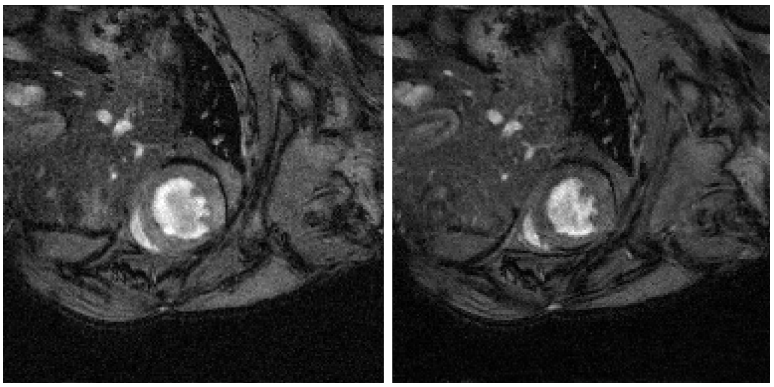

Figure 1. Representative images at end diastole acquired using (left) standard cine scan and (right) threefold accelerated kt-BLAST scan in a healthy mouse.

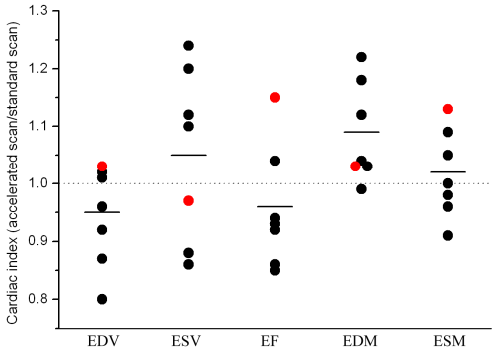


Figure 2. Cardiological indices relative to those acquired with the standard cine scan. Data from the MI mouse are shown in red.

## Discussion and conclusion

The group biases in the cardiological parameters (less than 10% in this study) should be considered in the context of intra and inter-observer variability of 3-10% for analysis of mouse cardiac images.[5] The overall acceleration factor as implemented was actually 2.4 times when taking into account the acquisition of "training" data. It is possible that fewer rows would have sufficed. The MI mouse had twice the EDV (170 vs 80μL) and less than half the EF (26 vs 63%) of the other 6 mice, and it is notable that three of its parameters appeared at the extreme of the ranges (Fig. 2). Further studies will be required to establish whether acceleration of cardiac scanning in infarcted mice is as robust as in healthy mice. Here, we have demonstrated that accelerated cardiac imaging of mice is feasible with acceptable accuracy for an undersampling factor of three times. This should enable increased throughput and improve animal welfare.

## References

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