Cardiac function and infarct size assessment in the rat at 1.5T

J-L. Daire[1], K. Montet-Abou[1], J-N. Hyacinthe[1], I. Gunes Tatar[1], M. Ivancevic[1], M. Costa-Jorge M[2], M. Brunet[2], D. Morel[2], J-P. Vallee[1]
[1]Radiology, University Hospital of Geneva, Geneva, Switzerland, [2]Anesthesiological Investigations Unit, University Hospital of Geneva, Geneva, Switzerland

Introduction

The use of Magnetic Resonance Imaging (MRI) is increasing in cardiac investigation and there is a need to develop MR protocol dedicated to heart function study of small animal. The aim of this work is to demonstrate in a coronary artery occlusion model the feasibility of cardiac function imaging and infarct size assessment in rat on a 1.5T clinical MR system.

Methods

Seven adult Sprague-Dawley rats underwent a single episode of 30 minutes coronary artery occlusion followed by reperfusion. All images were acquired on a clinical scanner at 1.5T (Philips Medical System, Best, NL). The protocol contains: ECG-gated cine Turbo Field Echo (TFE) sequence (TR/TE 14.2/4.6 ms, FA 30°, 544x544 matrix sampled, 160 mm FOV, 2 mm thickness, 6 signal averages 30 phases per heart beat) in short and long axis views; delayed enhancement imaging T1 with inversion recovery sequences (TR/TE 13/8.9 ms, inversion time 220-300ms, FA 45°, 416x416 matrix sampled, 160 mm FOV, 2 mm thickness) after injection of a bolus (0.15mmol/kg) of gadolinium DOTA (Dotarem, Guerbet, France).
Each rat was scanned at day 0 (6h after occlusion), day 2 and day 9. Rats were deeply anesthetized and sacrificed at day 10. The heart was washed with NaCl and fixed with formaldehyde. The organ was then embedded for histological experiments.
Ejection fraction was assessed using the Simpson's modified method at days 0, 2 and 9 after occlusion. Regional contraction analysis was realized by a measurement of myocardium thickness changes between diastolic and systolic phases using 128 radial sectors per slice. Infarct size was assessed by means of manual tracing of the hyperintense myocardium signal on each section and time. Measurements were correlated with histological analysis.

Results

Due to the high image quality obtained, all exams were analyzed. We observed a significant increase of the ejection fraction between day 0 (41.39% ± 7.2) and day 2 (61.32% ± 3.7) and day 9 (60.62% ± 3.7) (normal rat 71,1% ± 6,9). Contraction study showed a contraction significantly higher at day 2 and day 9 regarding to day 0 in infarct area ($p<0.01$)(fig1 and 2). Infarct size measured on late enhanced MR images seems to decrease between day 0 and day 9 but no significant reduction was found. However, enhanced area at day 9 was well correlated to the infarct zone measured in histology analysis ($r=0.72$, $p<0.01$) (fig 3 and 4).

Conclusion

This work demonstrates the feasibility of infarct size prediction in rat at 1.5T and demonstrates a strong potential for cell and gene therapy monitoring.

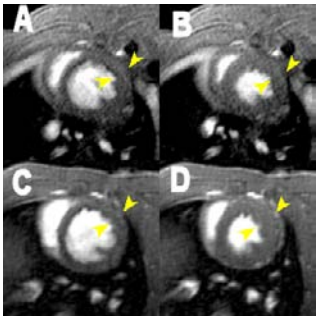

Fig 1: diastolic and systolic phases in cine imaging at the same level at J0 (A & B) and day 9 (C & D). We can note the great difference in contraction between day 0 and 9.

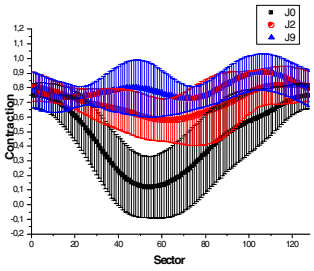

Fig 2 : evolution of local contraction: a clear deficit appears at day 0 which is partially recovered at days 2 and 9

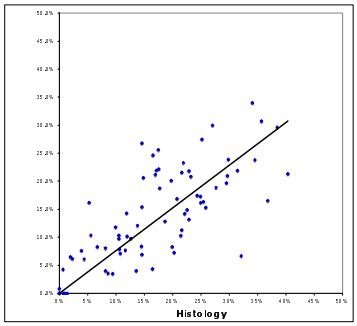

Fig. 3: correlation between MR infarct size and histological analysis ($p<0.01$)

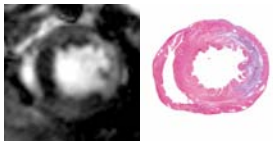
Fig4: example of late enhanced MR image and the corresponding histological slice

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