<u>**Diffusion Tensor Imaging of Healthy and Cryo-injured Pig Hearts**</u>

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Introduction: Myocardial infarction is one of the most common health problems worldwide. Improvement in the diagnostic evaluation of this pathology could potentially increase the survival rate. New magnetic resonance techniques such as diffusion tensor imaging (DTI) may provide additional information for more accurate prognosis. DTI has been used in the evaluation of cardiac fibers (1,2); however, fibers *tracking* is a novel procedure that provides an entirely new insight into anatomical structure. While it has been used successfully in neurological research, its potential in other areas has been insufficiently explored. Our study therefore examines its applicability to cardiac assessment.

Methods: Myocardial architecture was evaluated in healthy and in injured excised pig hearts in which cryo-ablation was used to produce targeted infarctions. Our objective was to investigate changes in direction-dependent water diffusivity. Five excised pig hearts (3 healthy sham-operated, 2 cryo-injured) were used in this *ex vivo* study. Pigs were euthanized at 5 months' age and 4 weeks' post cryo-injury. The hearts were extracted, placed in a plastic container with saline solution and ice, and scanned immediately post mortem. A whole-body 3T clinical MRI scanner (Siemens TIM TRIO) was used for data acquisition. Anatomical scans in the sagittal imaging plane were acquired with the MPRAGE sequence using the following parameters: FOV: 180mm, slice thickness: 1 mm, 50% interslice gap, TR: 1900 ms, TE: 2.2ms and 176 slices. DTI data were acquired using a single-shot spin echo (SE) EPI sequence with the following parameters: axial imaging plane; phase encoding direction: A-P; TE: 109 ms; TR: 8100 ms; number of slices: 51; interslice gap: 0 mm; voxel size: 1.3x1.3x1.9 mm; acquisition matrix: 128x128; b-values of 0 and 1000 s/mm2 in 20 directions (icosahedral scheme). Parallel acquisition using GRAPPA (generalized autocalibrating partially parallel acquisition) with an effective acceleration factor of 2.56 was used to limit the extent of susceptibility. Data were analyzed with Siemens DTI post-processing software. Fibers in the cryo-injured hearts were tracked using the infarcted area as a "seed" or starting point; an equivalent area was selected in healthy hearts. Data were analyzed with Siemens software (DTI Task Card).

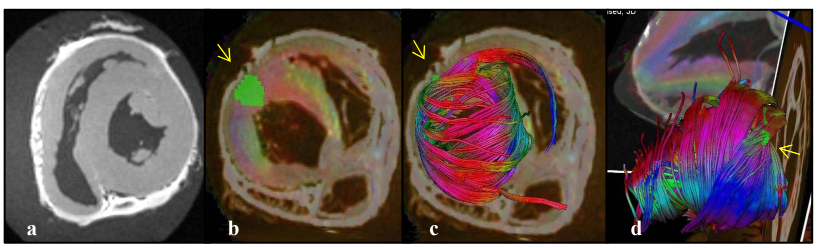

Figure 1: Healthy heart

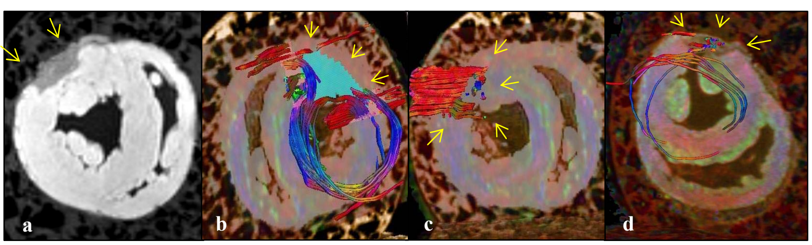

Figure 2: Infarcted heart

Results: Figures 1 and 2 show selected anatomical and diffusion tensor images of healthy and infarcted excised pig hearts. Figure 1a shows an anatomical view of the healthy myocardium in the short axis. Figure 1b shows the seedpoint (green region of interest (ROI)) used for tractography. The corresponding fibers travelling through this ROI are seen in Figure 1c -1d. Fibers are colour-coded according to orientation; blue = superior-inferior; red = left-right; green = anterior-posterior.

Figure 2a shows an anatomical image of an infarcted heart (arrows indicate the infarcted region). Figure 2b-d show the fiber tracts using the infarct and penumbral region as a seedpoint. There are no fibers in the infarcted region, however some fibers are traceable in the penumbral region (see arrows in Figure 2c-d). Accordingly there were changes in diffusion tensor parameters. FA values are lower in infarcted and penumbral regions (FA = .29 and .38, respectively) when compared to the same region in healthy hearts (FA = .55 and .53). In both areas the apparent diffusion coefficient is increased (ADC = .60 x $10^{-3}mm^2$ /sec, .58 x $10^{-3}mm^2$ /sec) relative to healthy hearts (ADC = .47 x $10^{-3}mm^2$ /sec, .52 x $10^{-3}mm^2$ /sec).

Discussion: Our study suggests that DTI has the potential to add valuable information to the assessment of injured myocardium. Using the lesion and penumbral region as seed points fibers were not detectable in the infarct region, FA was reduced and ADC values increased. The penumbral region contained traceable fibers although FA and ADC values were affected. This work suggests that the changes in fiber architecture, FA and ADC involve not only the infarct area but also the adjacent tissue. Tractography of these regions can provide a new perspective on the integrity of injured heart tissue and may have an important application in the evaluation of treatment alternatives.

References:

1. Ed X. Wu et al (2007). Magnetic Resonance in Medicine, 25: 1048-1507.
2. Ming-Ting Wu et al (2006). Circulation, DOI10.1161:1036-1045.