Non-invasive monitoring of changes in rabbit hearts with aging using MR microscopy

Min-Sig Hwang1*, Katja E Odening2, Bum-Rak Choi2, Gideon Koren2, Stephen J Blackband1, John R Forder1

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Background
Loss of myocytes followed by compensatory hypertrophy of the remaining cells and interstitial fibrosis are common hallmarks observed in aging hearts [1,2]. The cardiac conduction system is also subject to alterations with aging, resulting in reduced thresholds to diseases [3]. Biopsy is an accurate and informative means to delineate the age-related changes. However, it is destructive and requires intensive labor, often with severe complications for 3D reconstruction. The aim of this study was to investigate non-invasively morphological changes in aging heart using MR microscopy.

Materials and method
Isolated heart preparation
Hearts (n = 5) of New Zealand White male rabbits (2-5 kg) were isolated and fixed in situ according to the approved animal protocol. Young hearts (n = 2) were 6 month ~ 1 year old. Old hearts were 3 ~ 4 years old.

MRI
MR experiments were performed on a 17.6 T / 89 mm vertical wide-bore magnet (Bruker Instruments, Billerica, MA). Three dimensional MR microscopy data were collected using a fast gradient pulse sequence, achieving a voxel resolution of 35 x 35 x 82 μm³. High angular resolution diffusion microscopy (HARDM) using 21 directions was performed with a standard PGSE sequence, achieving an in-plane resolution of 60 μm² with a slice thickness of 600 μm. The b-value was 1000 s/mm².

Data analysis
Volume rendering of the 3D MR data sets was performed using ImageJ (ver. 1.31, http://rsbweb.nih.gov/ij/). The tensor processing of HARDM data sets was conducted using fanDTasla™ (@2008, http://www.cise.ufl.edu/~abarmpo/) and MATLAB (Mathsoft, Cambridge, MA).

Results
Aging in the rabbit heart results in significantly increased interseptal thickness (Fig.1). Volume rendered transverse images of the apical half suggest that the free-running Purkinje fiber network in the LV cavity may significantly alter with aging (Fig. 1). Dense reticular net observed in young ventricles becomes sparse with aging and the free running Purkinje fibers become thinner. From HARDM, aging in rabbit heart appears to be associated with increased radial diffusivity, which may arise from cellular hypertrophy (data not shown). A tensor component map of a young heart (Dyz) shows a well defined stripe pattern extending transmurally in the interseptum and left ventricular freewall (Fig. 2, left). In contrast, this highly directional structure was decreased in aged hearts (Fig.2, right). A volume rendered image of interseptum shows that

Figure 1 Volume rendered transverse images and manual separation (magnified) of the free-running Purkinje fiber network in the LV of a young rabbit heart (left) and an old rabbit heart (right). Lines and arrows in the green and red boxes indicate where sectioning occurred and viewer was located. Intersoretal thickness is approximately 3.93 mm (young) and 4.82 mm (old). I: ventricular interseptum, P: papillary muscle, FW: free wall.
the stripe pattern has a longitudinal direction and appears to exist in the basal half of the LV.

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Author details
1McKnight Brain Institute, University of Florida, Gainesville, FL, USA.
2Cardiovascular Research Center, The Rhode Island Hospital, Alpert Medical School of Brown University, Providence, RI, USA.

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References
1. Olivetti G, et al. Circ Res 1991, 68:1560-1568.
2. Brooks A, et al. Heart 2003, 89:1255-1256.
3. Pugh K, Wei J. Drugs and Aging 2001, 18:263-276.

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