Whole-Heart Myocardial BOLD MRI with Adenosine Stress Using Fast Free-Breathing 3D T2 Mapping: A Validation Study in Canines

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Introduction Myocardial BOLD MRI is an emerging non-contrast approach in the assessment of ischemic heart disease. Most commonly used myocardial BOLD MR method rely on weighted imaging (T2-weighted, T2*-weighted or bSSFP). In spite the benefits these techniques have provided to the advancement of myocardial BOLD imaging, several limitations continue to persist. Standard T2 mapping approaches are limited to 2D imaging, require suspension of breathing and cannot provide full ventricular coverage over the time period over which adenosine is typically delivered. Recently, we developed a fast, free breathing 3D T2 mapping technique that utilizes 100% imaging efficiency, which allows for full coverage of the whole left ventricle within 5 minutes. In this study, we demonstrate the practical utility of the approach using a canine model subjected adenosine stress.

Methods Animal preparation Mongrel dogs (n=4) were studied according to the protocols approved by the Institutional Animal Care and Use Committee. Prior to imaging, animals were fasted, sedated, anesthetized, intubated and transferred to a 3T Siemens Verio MRI system (Siemens Medical Solutions, Germany) and were mechanically ventilated via a pneumatic anesthesia ventilator. IV lines were placed for adenosine infusion. Image acquisition After localization scans, whole-heart shimming, and scouting to determine the appropriate center frequency, fast 3D free breathing T2 mapping sequence was applied during rest and adenosine stress (0.14/min/kg) with the following scan parameters: TR/TE =3.4/1.7 ms, flip angle = 15°, imaging resolution = 2 x 2 x 6 mm^3 with 14 partitions, adiabatic T2 prep pulses with T2prep duration of 0, 24 and 55 ms every other heart beat. Total acquisition time for whole LV coverage was 5 mins**.** For validation purpose, commercially available 2D T2 mapping sequence, requiring breath-holding, was also prescribed.

Results Figure 1 shows representative T2 maps of basal, mid and apical slices acquired during rest and adenosine stress using the proposed 3D and standard 2D sequences. Figure 2 shows the mean T2 values obtained at rest and under adenosine stress with both acquisition schemes. Multiple measurement ANOVA was used to test the difference in T2 values between rest and stress. We observed the following changes in T2 values relative to baseline: 12% (3D) and 10% (2D) and were statistically different from baseline ($p<0.05$). No differences in T2 values were observed between 2D and 3D acquisition either at baseline or adenosine stress ($p=0.53$ (baseline) and 1 (stress)).

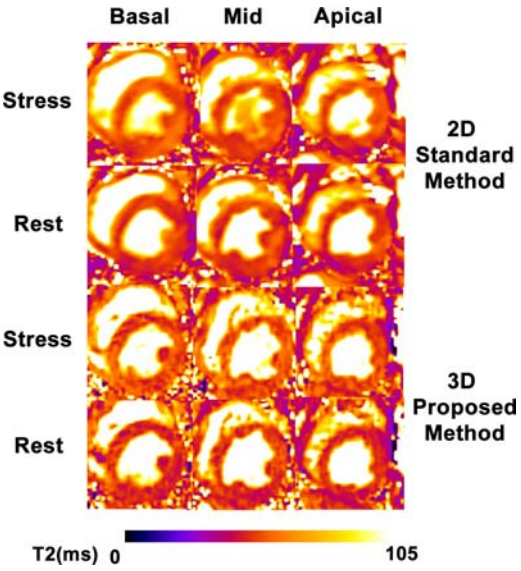

Figure 1 Representative short axis (basal, mid and apical) images under rest and adenosine stress from standard 2D and proposed 3D sequence are shown. T2 increase during stress is visually evident in both 2D and 3D cases.

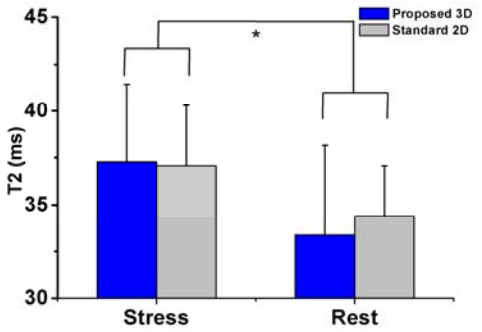

Figure 2 Mean T2 values measured from both standard 2D and free-breathing 3D sequence under rest and stress condition are shown. No difference was observed between the standard and proposed sequences. *denote p< 0.05.

Conclusion Proposed fast 3D free breathing T2 mapping technique has the capability to map the BOLD response throughout the left ventricle during adenosine administration in canines. Patient studies are required for clinical validation.