Tissue characterization of Myocardial Infarction using T1rhoe: Influence of contrast dose and time of imaging following contrast administration

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Introduction

It has been shown that $T_{1\rho}$ weighted cine turbo field echo ($T_{1\rho}$-TFE) MR sequences following contrast administration can improve the contrast between acute myocardial injury and normal myocardium [1,2]. The so-called delayed enhancement (DE) imaging also allows for exquisite visualization of irreversible myocardial injury when imaged after an appropriate time following contrast administration [3]. DE relies on the increased volume of distribution for extra-vascular Gd-chelate, and the difference in the contrast agent kinetics (wash in and wash-out rates) between the normal myocardium and irreversibly injured myocardium [2,4], and can be sensitive to the initial dose of contrast agent administered, and on the time between the contrast administration and imaging [5]. Although the underlying mechanism of generating contrast between irreversible injury and normal myocardium is different in $T_{1\rho}$-TFE than in DE, it is yet to be determined if such factors also are important in $T_{1\rho}$-TFE. The purpose of this study was to determine the effect of the following two variables in $T_{1\rho}$-TFE imaging: (a) contrast dose concentration, and (b) time of imaging after contrast administration.

Materials and Methods:

Patient Population: A total of 18 patients (12 male, age: 54 +/- 11), following acute myocardial infarction (confirmed by cardiac enzymes and ECG) were imaged 7.5+/-3.3 days after the onset of symptoms. All patients gave written informed consent. The patients were assigned randomly into three groups, A, B, and C, receiving contrast doses of 0.1mmol/kg, 0.2mmol/kg, and 0.3mmol/kg respectively.

MRI Data Acquisition: All imaging was done on a commercial 1.5T imager (Philips NT Intera), using a 5-element surface coil for signal reception and with vector-cardiographic gating. Four sets of images were acquired for each patient. $T_{1\rho}$-TFE images were acquired 11+/- 5min (Time 10) and 47+/-5min (Time 50) after contrast administration. Between the $T_{1\rho}$-TFE acquisitions, two sets of DE images were acquired at 19+/- 4 min (Time 20), and 40+/-3 min (Time40) after injection. Acquisition parameters for each sequence are described below:

$T_{1\rho}$-TFE: TR/TE/flip: 5.0-5.2 msec/2.1-2.3 msec/25°; field-of-view: 320-350 mm; slice thickness: 8-10 mm; temporal resolution: 46-72 msec; $T_{1\rho}$-composite RF pulse parameters: 90_y-135_x-360_x-135_x-90_{-y}, with element durations: 0.84, 1.26, 8.12, 1.26, and 0.84 msec.

DE: An inversion recovery prepared turbo-field echo sequence (IR-TFE) with an inversion delay (TI) iteratively chosen to null the signal from normal myocardium was used to collect data in diastole with the following parameters: TR/TE/flip=7 msec/3 msec/15°; FOV 340-400 mm; Acquisition matrix: 256 x 256; slice thickness: 8-10 mm; 16 views were collected each heartbeat; two signal averages were collected; total acquisition time: 16 heartbeats/slice.

Data Analysis: Regions of interest (ROI) drawn on irreversible injury and normal remote myocardium were used to determine the %enhancement (defined as ratio of signal difference between injury and normal myocardium to normal myocardium) on a post processing workstation (EasyVision, Philips Medical Systems).

Statistics: All data are expressed as mean+/-sd. A p-value of 0.05 was considered to be statistically significant.

Results: The % enhancement in DE imaging varies with contrast dose. However, there is very little difference in enhancement when imaged at 20 min or 40 minutes after contrast administration (Figure 1, left). However, this requires that the TI time be optimized for each time point of imaging as well as for contrast dose (Figure 2). In case of $T_{1\rho}$-TFE, while the % enhancement did not vary with dose (p=NS), there was a slight trend towards increased enhancement over time (between Time 10, and Time 40) at all dose ranges (Figure 2 A and B) although it did not rise to the level of statistical significance.

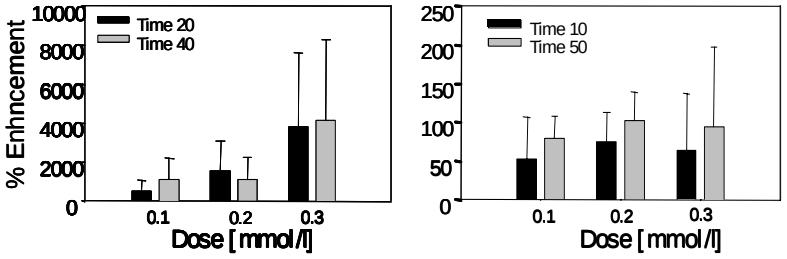

Figure 1: Note the increased %enhancement as a function of dose in DE (left), unlike the $T_{1\rho}$-TFE (right).

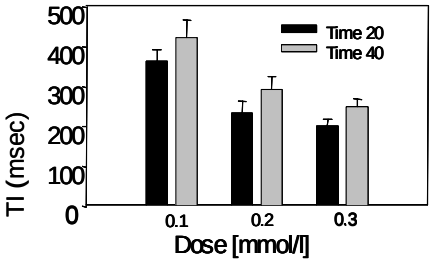

Figure 2: The TI time varies both as a function of dose as well as the time of imaging (increasing with prolonged delay in imaging time)

Conclusion: In an in-vivo prospective study of 18 patients our results show that enhancement of irreversibly injured myocardium depends on contrast dose for delayed enhancement imaging, but not for T1rho-weighted TFE cine imaging. When inversion delay is adjusted properly, DE imaging can provide sufficient contrast between injury and normal myocardium over time. The $T_{1\square}$-TFE imaging requires no such adjustment although the available contrast is lesser than DE.

References:1. Dixon et al. Magn Reson Med 36:90-94; 1996. 2. Muthupillai, et al. Radiology 232:606-610; 2004. 3. Kim and Chen. Circulation 94:3318-3326; 1996. 4. Pereira, R. et al. Magn Reson Med 36:684-693; 1996. 5. Oshinski, et al. Circulation;104:2838–2842; 2001.