Effects of temporal resolution on DCE-MRI parameter estimation: In-vivo repeatability analysis of lung tumors using retroactively adjustable KWIC reconstruction

Xia Zhao[1,2], Yiqun Xue[1,2], Mark Rosen[2], Hyunseon Kang[3], Ramesh Rengan[4], and Heekwon Song[1,2]

[1]*Laboratory for Structural NMR Imaging, University of Pennsylvania, Philadelphia, PA, United States,* [2]*Department of Radiology, Hospital of University of Pennsylvania, Philadelphia, PA, United States,* [3]*MD Anderson Cancer Center, University of Texas, Houston, TX, United States,* [4]*Department of Radiation Oncology, University of Washington School of Medicine, Seattle, WA, United States*

Introduction: Dynamic contrast enhanced (DCE) MRI is useful for evaluating tumor perfusion and observing changes following treatment. With improved MRI strategies for rapid data acquisition the dynamic frame rate has been substantially reduced over the years. Still, achieving sufficiently high spatial and temporal resolution over large volumes, such as lung/liver coverage, remains a challenge. Most imaging applications fall well short of the 1-2 sec frame rate previously suggested for accurate measurement [1]. In this work, we investigate the effects of temporal resolution on measured tumor perfusion parameters and its effects on repeatability on a test-retest dataset acquired in patients with lung tumors. We utilize interleaved radial acquisition (golden angle increment [2]) along with KWIC reconstruction [3] which enables different temporal resolutions to be chosen retrospectively during image reconstruction.

Methods: Twenty-seven lung tumor patients were each scanned twice on average two days apart on a 1.5T Siemens Sonata MRI scanner. 3D hybrid radial acquisition scheme [4] with golden angle view ordering [2] was used. Scan parameters were as follows: coronal FOV=300mm, slice thickness=8mm, 192 readout points, TR/TE=3.38/1.6ms, flip angle 25°; 32 slices with 80% partial Fourier encoding. Bolus injection of 0.07mmol/kg Gd (Multihance) was administered at 1 cc/sec, two minutes after scanning began, followed by a 20 cc saline flush. Dynamic image series were reconstructed using KWIC [3] with varying numbers of views at k-space center: 21, 34, 55, 89, 144, 233 views (numbers of the Fibonacci series to minimize angular gaps [2]) which correspond to effective temporal resolutions of 1.85, 2.99, 4.83, 7.82, 12.65 and 20.48 sec. All resolutions utilized 300 views in the outer-most k-space region.

The analysis included 22 patients with tumors > 2cm. Tumor ROIs were drawn by an experienced physician and the dynamic time points fitted pixel-by-pixel to the standard two-compartment Kety model [5] to extract K^{trans} and v_e. Baseline correction technique was implemented to enhance estimation accuracy [6]. Median K^{trans} and v_e over the entire tumor were used for statistical analyses.

Table 1 Reproducibility analysis for K^{trans}

Temp Res (sec)	Slope	R^2	C.V. (%)
1.85	0.873	0.812	11.15
2.99	0.877	0.812	11.32
4.83	0.884	0.812	11.46
7.82	0.913	0.830	11.46
12.65	0.988	0.849	11.15
20.48	0.898	0.711	14.23

Table 2 Reproducibility analysis for v_e

Temp Res (sec)	Slope	R^2	C.V. (%)
1.85	1.028	0.789	11.15
2.99	1.032	0.787	11.30
4.83	1.037	0.786	11.54
7.82	1.034	0.784	11.61
12.65	1.033	0.783	11.57
20.48	1.057	0.776	12.01

Results and Discussion: **Tables 1** and **2** summarize the linear regression and repeatability results of K^{trans} and v_e. Aside from the results at the lowest frame rate (20.48s), no clear difference in repeatability was observed among different temporal resolutions. **Figure 1 a, c** show average K^{trans} and v_e measured from two scans at the various temporal resolutions for each subject. On average, measured K^{trans} slightly decreases, while v_e increases with reduced temporal resolution (**Figure 1 b, d**). These findings are in agreement with findings in previous simulation [7] and in-vivo animal studies, where fully sampled Cartesian k-space was down-sampled during post-processing to achieve lower temporal resolution [8].

Conclusion: To the best of the authors' knowledge, the current study is the first to examine the effects of temporal resolution on MR perfusion parameters in an in-vivo test-retest repeatability experiment. Overall, repeatability is relatively constant up to about 13 sec frame rate (CV ~ 11%). In agreement with previous simulation studies, K^{trans} is increasingly underestimated with reduced temporal resolution [1]. However, in the case of lung tumors, the overall differences appear to be relatively small.

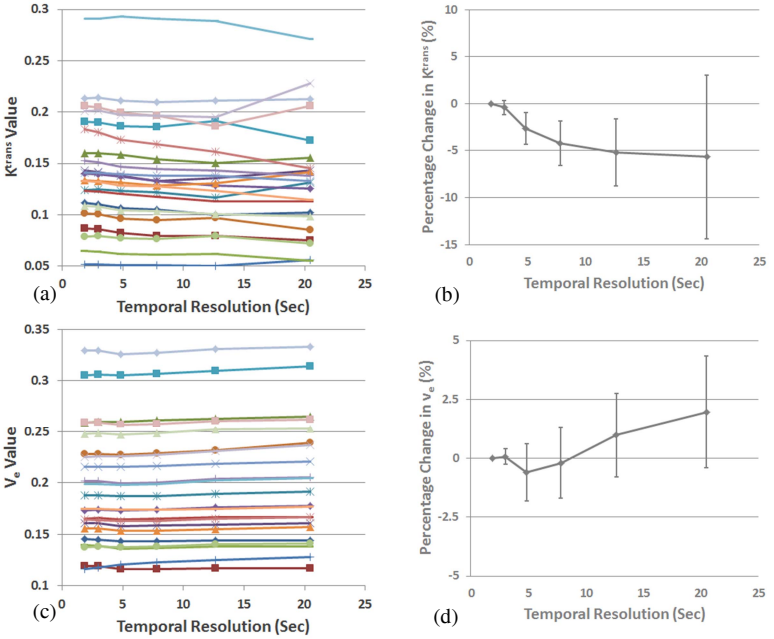

Figure 1 Average K^{trans} (a) and v_e (c) from two scans at different temporal resolutions. Each line represents a subject. Average difference (in %) of the mean K^{trans} (b) and v_e (d) values from those parameters at the highest temporal resolution (1.85 sec). The error bars represent standard deviations.

References: [1] E Henderson et al. MRI 16:1057-1073 (1998). [2] S Winkelmann et al. IEEE Trans on Med Imaging. Vol.26 NO.1, Jan 2007. [3] HK Song et al. MRM 52:815–824 (2004). [4] W Lin et al. MRM 60:1135-1146 (2008). [5] P Choyke et al. JMRI. 17:509-520 (2003). [6] Y Xue et al. ISMRM (2011) Abstract 1093. [7] M Heisen et al. MRM 63:811– 816 (2010). [8] H Aerts et al. Phys Med Biol 56: 5665–5678 (2011).

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