Sampling duration in DCE-MRI: In vivo comparison using data acquired within a clinical phase I study

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Introduction

For assessing treatment response to novel cancer therapeutics dynamic contrast enhanced magnetic resonance imaging (DCE-MRI) is a valuable tool. With appropriate data acquisition, quantitative functional parameter estimates can be obtained by fitting a physiological model to the data. Model free parameters like initial area under the Gd concentration curve (IAUC) are independent from the sampling duration as long as there are enough data points sampled. In contrast to this, parameters calculated using pharmacokinetic modelling may show a dependency on the number of sampled data points. This was previously investigated by computer simulations [4] but there is limited verification of these findings using real in vivo patient data.

Methods

10 examinations of 4 patients (2 patients with 3 and 2 patients with 2 examinations) were analysed. The patients are a subgroup of a larger cohort which took part in a clinical study. All patients had liver metastasis and received DCE-MRI examinations with an extended sampling duration of 8.5min and 170 time points of acquisition. The acquisition protocol consists of a 2D Inversion Recovery trueFISP (IR-trueFISP) sequence [1]. Further parameters were TR/TE=3000ms/1.28ms, 170 time point's Δt=3s, single slice of 10mm, matrix size of 128x128, FOV of 400mm and α=40°. To minimize through-plane movement during breathing data is acquired in a mainly coronal oriented view.

Data were analysed with a custom-built software package developed under Matlab. Data processing consists of several steps

1. A ROI spanning the metastasis is defined and then semi automatically tracked using a correlation analysis-based algorithm.
2. T1 quantification is performed by a Levenberg-Marquardt (LM) routine using the analytic expression as published [2].
3. Data-driven analysis is performed assessing pharmacokinetic modelling by using the multi-compartment model from Tofts assessing the transfer constant Ktrans, which equals the permeability surface product under permeability limited conditions [3].
4. Separate analysis's were carried out using all 170 time point (8.5 min), the first 110 (5.5 min) and the first 55 (2min 45s) time points respectively. Typical acquisition times used for DCE-MRI in clinical studies range from 5 to 8 minutes.
5. Since investigated lesions are mostly inhomogeneous, not only a region of interest (ROI) covering the whole target lesion but additional ROIs covering the core and the rim area of the target lesion were investigated as shown in Fig. 1.

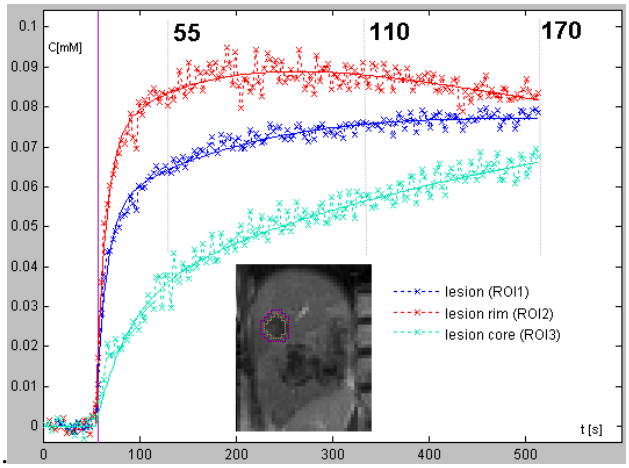

Fig 1.

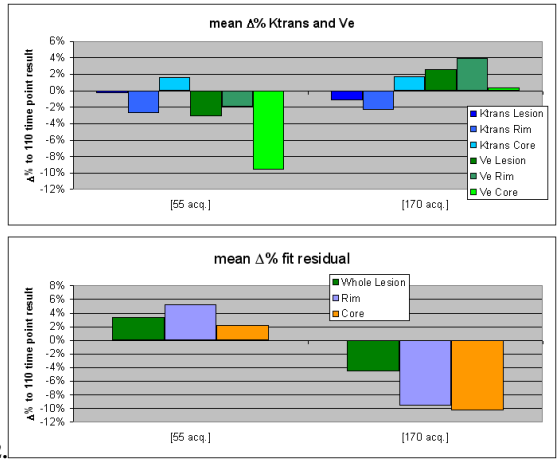

Fig 2.

Fig 1: Example of a Gd concentration time curves for three ROIs: Whole lesion, rim and core of the lesion. Analyses were compared for the whole time curve of 170, for the first 110 and the first 55 data points. **Fig 2:** The mean percentage difference of Ktrans, Ve and the fit residual relative to the 110 data point analysis.

Results

For all ROIs the mean over all data sets of the fit residual decreased with the number of time points used for analysis. Fig. 2 shows for the 55 time point subset an increase by 2 to 5% and for the 170 time point subset a decrease of 5 to 11% of the mean percentage difference of the fit residual relative to the 110 data point analysis.

Differences in resulting Ktrans and Ve are all less then 10% compared to the 110 data point analysis. While Ve values on average were smaller in the 55 data point analysis it was on average larger in the 170 data point analysis. Ktrans differences on average were smaller than Ve differences but didn't show a uniform tendency as a function of used data points.

There was no dependency of the percentage difference of Ktrans, Ve nor of the fit residual between the data sets on ROI size.

Discussion

The found differences by using data acquired with different sampling durations were less than 9%.

Ktrans showed smaller differences than Ve which is most possibly due to the fact, that Ktrans mainly describes the signal rise part of the curve, which was equal in all three compared data sets. Ve is more dependent on the later part of the time curve, which had different length in the always compared three data sets.

Although the findings did not reach statistical significance they were in agreement with the published simulation [4]. A larger number of data sets, which was limited in this study, would be required to support these observations.

References

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