Optimal ROI Size for Parameter Determination in IVIM Imaging

Mikael Montelius[1], Maria Ljungberg[1,2], Eva Forssell-Aronsson[1,2]
[1] Department of Radiation Physics, Institute of Clinical Sciences, Sahlgrenska Cancer Centre, Sahlgrenska Academy, University of Gothenburg, Sahlgrenska University Hospital, Gothenburg SE-413 45, Sweden
[2] Division of Medical Physics and Medical Engineering, Sahlgrenska University Hospital, Gothenburg SE-413 45, Sweden

Purpose & Introduction

Successful delivery of therapy agents to tumor cells depends on tumor tissue perfusion and diffusion. Assessment of these parameters prior to and during treatment would facilitate decision-making regarding e.g. treatment strategy. The intravoxel incoherent motion (IVIM) model (Le Bihan 1988) applied to multi b-value diffusion weighted MRI offers non-invasive quantification of tissue diffusion (D), perfusion-related pseudo diffusion (D*) and perfusion fraction (*f*). However, the quantification is highly affected by the size of the analyzed region of interest (ROI).

Our aim was to investigate the optimal ROI size for quantification of D, D* and f.

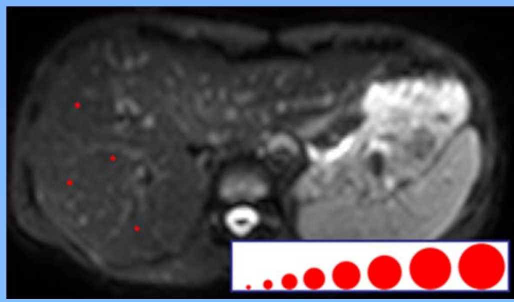

Figure 1. IVIM (b=0) image of liver with ROI positions and sizes shown. 2, 19, 53, 104, 173, 258, 360 and 480 mm^2.

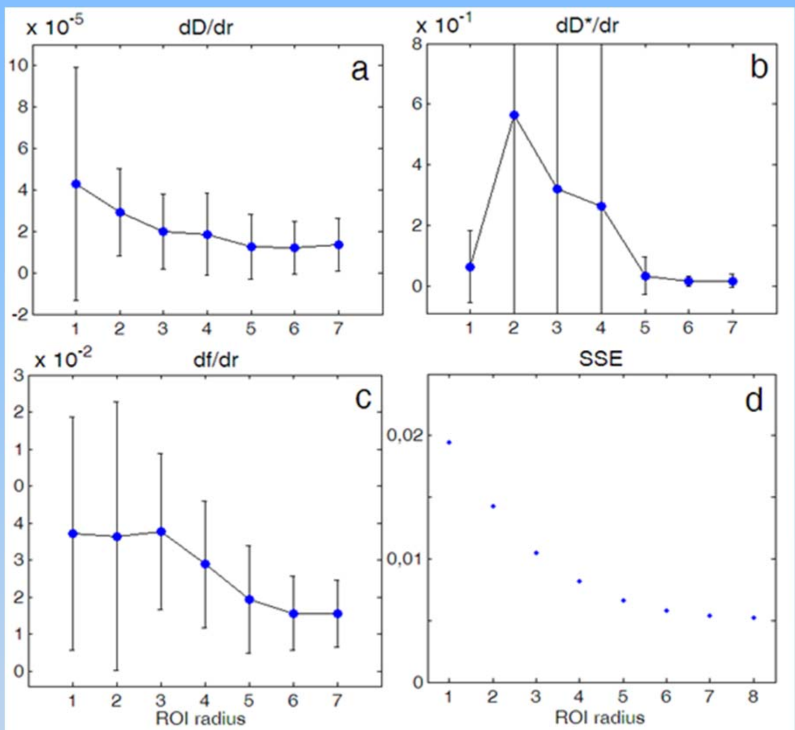

Figure 2. The parameter variation with increasing ROI radius is plotted vs. ROI radius in a), b) and c) for the pure molecular diffusion parameter (D) and the perfusion related diffusion parameters D* and perfusion fraction *f*, respectively (error bar = std). The corresponding average goodness of fit parameter SSE is shown in d).
Note the scales of the y-axes when comparing a), b) and c).

Subjects & Methods

Liver IVIM images of 4 healthy volunteers were acquired on a 3T MR equipped with a 16-channel torso XL phased-array surface coil using a navigator triggered SE-EPI: 12 b-values (0-800); fat suppression: SPIR; TR/TE/NSA: 2000 ms/53 ms/2; voxel size: 1.46*1.46*5 mm^3; SENSE factor: 2; total scan time (including triggering) ~ 12 min. Average signal intensity decay curves for ROIs in 4 different positions of the liver were fitted to the IVIM model function (Fig. 1). Eight concentric ROIs with increasing size [ROI areas: 2, 19, 53, 104, 173, 258, 360 and 480 mm^2] were analyzed for each position and D, D*, *f* and SSE (error sum of squares) were extracted. The magnitude of the variation of the extracted parameters with increasing ROI radius was calculated for each ROI position and subject, and the average variation with increasing ROI size was analyzed.

Results

The variation of D, D* and *f* with increasing ROI size approaches zero at a ROI size of approximately 5-6 pixels (radius) which corresponds to 170-260 mm^2 using the above described imaging parameters (Fig. 2). SSE shows a strongly improved model fit with increasing ROI size (improves from 0.02 for the smallest ROI to approximately 0.005 for the 5-6 pixels ROI radius).

Discussion & Conclusion

The variation of the extracted parameters does not reach zero (Fig. 2). This is probably due to the heterogeneity of the tissue. Nevertheless, the initial variation of the extracted parameters stabilize and we suggest using a ROI area close to the stabilization, i.e. a 5-6 pixels ROI radius or approximately 170-260 mm2, where the parameters are least affected by ROI size.

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References
Le Bihan et al. *Separation of Diffusion and Perfusion in Intravoxel Incoherent Motion MR Imaging* Radiology 1988

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UNIVERSITY OF GOTHENBURG