

Quantification of capillary blood flow and endothelial permeability in inflammatory joint diseases: MR-perfusion results

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Purpose: The possibility to directly measure capillary blood flow would be of great advantage for therapy control studies in patients with inflammatory joint diseases. The Tofts model, which has been used to quantify perfusion so far, does not produce direct measurements of capillary blood flow [1]. Therefore, the purpose of this study was to test a standard two compartment model [2] for direct measurement of blood flow and endothelial permeability by using a dynamic sequence with high temporal resolution (2.5 sec, in literature 13 sec [3]) and to analyze it considering stability, explanatory power and plausibility compared to the Tofts model.

Material and Methods: Dynamic contrast enhanced MR images of the hands were acquired over 5 min at a 3.0 T magnet (Magnetom Trio, Siemens Medical Solutions, Germany) in 5 patients with rheumatoid arthritis (TWIST, 30 partitions, 1.5 x 0.5² mm², T_{acq} per dataset 2.5 sec). Arterial input functions were measured from the images. Six regions of interest (ROI) were set in muscle and inflammatory tissue. Enhancement curves were fitted to the standard two-compartment model [2] and the tofts model. Plasma volume (PV, ml/100ml), extraction flow (EF, ml/100 ml/min), interstitial volume (IV, ml/100ml) and interstitial transit time (sec) were calculated with both models, additionally plasma transit time and plasma flow with the standard model. The results were analyzed and compared regarding stability (reproducibility from 3 repetitive evaluation processes), explanatory power (comparison to clinical and laboratory activity) and plausibility (presence of realistic values).

Results and Discussion: Compared to the muscle values as reference, vascular parameters for inflammatory tissue were substantially higher (plasma volume 6-8fold, plasma flow 5-20fold), Fig. 1. Pixelwise analysis of different inflammatory ROIs resulted in intraindividually varying perfusion characteristics of up to 30% difference for e.g. the plasma flow, Fig. 2. Both models result in comparable values for the extraction flow whereas the Tofts model does not produce values for plasma flow and in some cases unphysiological resp. implausible (negative and very small) values for the plasma volume, Fig. 3.

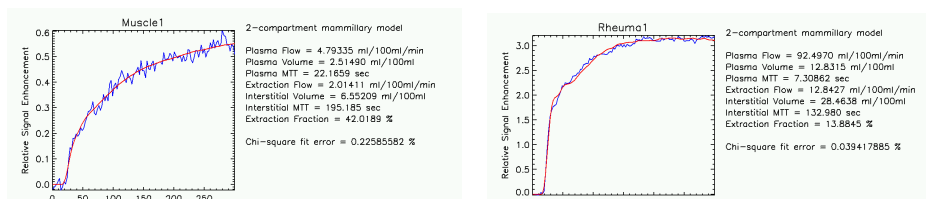


Figure 1. Graphs and perfusion values for two ROIs in muscle and inflammatory tissue in a patient with moderately rheumatoid arthritis as calculated by the standard two compartment model.

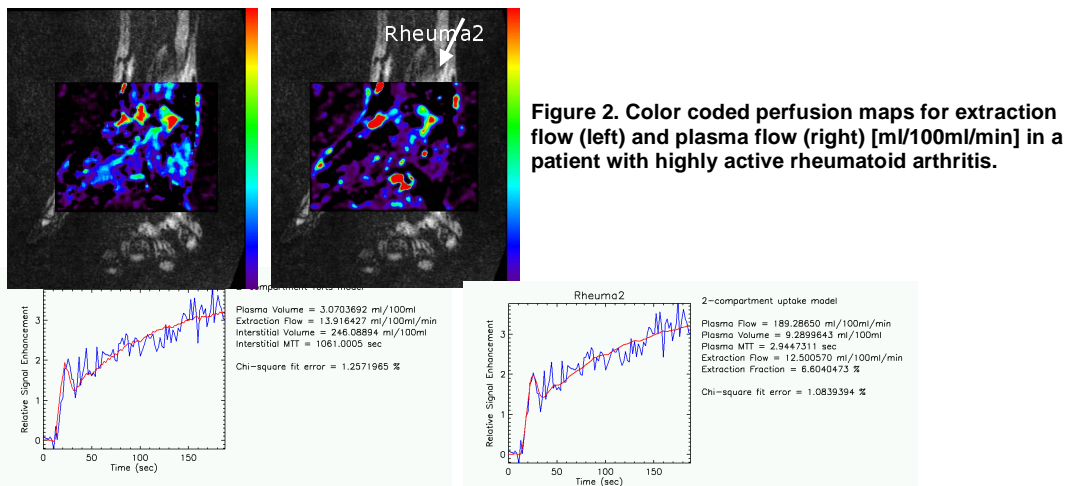


Figure 3. Graphs and perfusion values for one inflammatory ROI ["Rheuma 2"] in a patient with highly active rheumatoid arthritis as calculated by the standard two compartment model.

Conclusion: By using a two-compartment model and an MR sequence with high temporal resolution a separate quantification of blood flow and permeability in patients with inflammatory joint diseases seems possible with stable and plausible results. Compared to previous studies a direct measurement of capillary blood flow and a ROI-based mapping of perfusion parameters might improve sensitivity and specificity with regard to future therapy control studies.

References:

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