Application of Signal-Time Analysis for Perfusion Imaging with High Temporal Resolution

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Introduction:

Conventional perfusion imaging of abdominal organs is usually performed with the application of contrast agents by bolus injection. Tissue specific enhancement curves and patterns are observed. The time course of the signal changes can be sampled accurately enough even with relatively slow 3D imaging techniques. This might not be true immediately after contrast injection, when rapid signal changes are caused by the arrival and first pass of the tracer. An adequate temporal resolution is required for analyzing the signal changes in the vasculature. This gains importance if the signal-time information in the vasculature is used as input functions for analyzing the signal response of the tissue. Additionally it would be very helpful to separate apparent vessels from tissues and to characterize the arterial and venous components of the vascularization.

Methods:

Based on our experiences in signal-time analysis we developed the superposition of gamma-variate and multi-compartment solution using independent parameters. This signal equation is given by:

$$s(t) = \frac{S(t)}{\bar{S}(t < T_o)} - 1 = g(t) * (t < \tau) \quad ; \qquad \tau = p_1 + p_2 / p_3 + p_5$$

$$s(t) = \frac{S(t)}{\bar{S}(t < T_o)} - 1 = g(t) + c(t) * (t > \tau)$$

with $g(t) = p_0 (t - p_1)^{P_2} \exp[-p_3 (t - p_1)] + p_4$ and $c(t) = p_6 \{\exp[-p_7 (t - \tau)] - \exp[-p_8 (t - \tau)]\}$.

The parameters p_i are least-square fitted. The characteristic parameters of the first pass can be calculated and separated from the multi-compartment solution c(t). Those parameters are, for example: *appearance time* **T zero**, *time to peak* **T peak**, *signal slope* **S slope** and *temporal width* of the gamma-variate **T width** and its *integral* **Area**.

Experiments and Results:

The above described method was applied to an image series of a saturation prepared TrueFISP sequence for liver perfusion. The temporal resolution of the signal-time curve was 1 second. 4 slices have been scanned; each image within 250 ms. Retrospective planar image registration was used in case of subject motion.

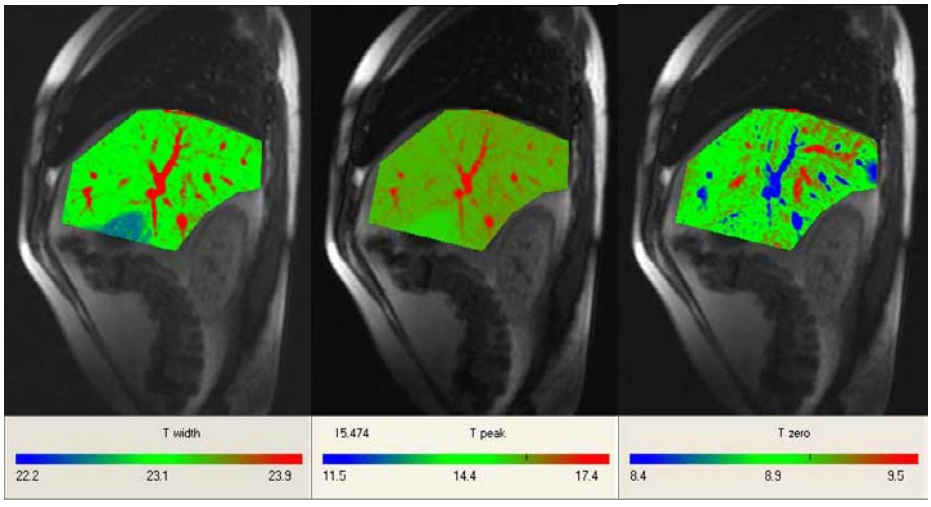

Figure 1: Characteristic first pass time parameters in the liver: T width, T peak and T zero.

Discussion:

The complete automatic calculation of the parameter maps revealed a clear separation of vascular from tissue components on a highly resolved time scale. It also enables a differentiation between different types of blood flow to the tissue. This is useful in tissues with multiple blood supplies, like the liver, and in tumor characterization. The method provides additional guidance for segmentation problems or for finding the correct location of RoIs, in order to better classify tissue components and to avoid partial volume effects.