On-line Appendix

The MS algorithm is based on the Fick principle with the assumption of no venous outflow. CBF is calculated as (maximum slope of tissue TAC) / (maximum reference vessel enhancement). CBV is calculated as (maximum tissue enhancement) / (maximum reference vessel enhancement). TTP is the time from the beginning of contrast enhancement in the earliest artery to the point of maximum tissue enhancement. Implementation details can be found in Klotz and Konig.[1] MTT and TTD cannot be calculated with this technique.

The DC algorithm used can be derived from the Fick principle by assuming that there is no dissipation of the intracapillary flow component and that any extravascular flow remains extravascular during the measurement time. Then the voxel enhancement $C(t)$ can be described by

$$C(t) = CBF\left[\int_0^t C_A(t' - t_{in})dt' - (1 - E)\int_0^t C_A(t' - t_{out})dt'\right],$$

with $C_A(t)$ the AIF, E the extraction fraction, and t_{in} and t_{out} the time the voxel entered and left. The 4 parameters are determined by LMS fitting of the voxel enhancement curves. Solving this equation is equivalent to performing a deconvolution:

$$C(t) = [C_A(t) \otimes IRF],$$

with the following impulse residue function (IRF):

$$IRF(t) = \begin{cases} 0 & t < TTS \\ CBF & TTS < t < TTD \\ E \cdot CBF & t > TTD. \end{cases}$$

From this form follows MTT = TTD − TTS and CBV = MTT × CBF. The new parameter, TTD, describes the mean start of outflow out of the voxel. The delay parameter, TTS, is not explicitly analyzed.

This form can also be seen as a further approximation of the adiabatic solution of St Lawrence and Lee,[2] by assuming that there is no backflow from tissue into capillaries, which again is the major assumption of the Patlak model, which has been successfully used to model brain tumors and blood-brain barrier disruptions in stroke.[3,4] The benefit of this approximation is that it allows minimizing the examination time and thereby the radiation dose and the probability for patient motion.

References

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