SUMMARY

The basic concept of a tracer-kinetic experiment dates back to the 1920's [1]: an indicator is injected rapidly in the blood stream and its concentration in the tissue of interest (mmol/ml tissue) is measured as a function of time. The precise shape and form of these curves depends on the manner in which the agent is injected, and on the properties of the tissue under consideration. If the injection-profile is known from a separate measurement, tissue-characteristic parameters can be extracted from the time-curves.

MRI contrast agents cause an increase in transverse and longitudinal tissue relaxation rates (R2*=1/T2* and R1=1/T1) which is (roughly) proportional to concentration. If the relaxivity is known (i.e. the change in relaxation rate per unit of concentration), concentration-time curves can be derived from dynamic measurements of R2* or R1, and the principles of tracer-kinetics can be applied. The technique is known as Dynamic Susceptibility Contrast MRI (DSC-MRI) when R2* is measured [2], and Dynamic Contrast-Enhanced MRI (DCE-MRI) when R1 is measured [3].

T2*-relaxivities are typically an order of magnitude higher than T1-relaxivities [4]. This is highly relevant in brain tissue, where tissue concentrations in the first pass are low due to the small blood volumes. DSC-MRI therefore offers superior sensitivity to the intravascular component of the indicator. On the other hand, T2*-relaxivities are strongly dependent on the compartmentalization of the indicator. If the blood-brain barrier is broken, the indicator leaks into a different compartment and the T2*-relaxivity drops. The relation between DSC-MRI signal change and indicator concentration is then ambiguous.

The conventional view [5] is that DSC-MRI is most suitable for the measurement of perfusion parameters CBF (cerebral blood flow) and CBV (cerebral blood volume); and that DCE-MRI is most suitable for the measurement of permeability parameters PS (permeability-surface area product) or Ktrans (volume transfer constant) and v_e (interstitial volume). This paradigm is increasingly challenged in recent years: methods have been proposed to correct for leakage effects in DSC-MRI [6], and to compensate the reduced sensitivity to the intravascular phase in DCE-MRI [7]. Today, DSC-MRI and DCE-MRI both allow measurement of perfusion and permeability, but with different levels of accuracy and precision.

In this session, we will review (i) the basic principles of tracer-kinetic experiments and data analysis, with a focus on the brain; (ii) the basic acquisition strategies of DSC-MRI and DCE-MRI in the brain, as well as the most common approaches to data analysis; (iii) more recent developments towards a combined measurement of perfusion and permeability with DSC-MRI or DCE-MRI.
SYLLABUS

- Tracer-kinetics
  - Basic principles
  - Data acquisition
  - Data analysis
- DSC-MRI
  - Basic principles
  - Data acquisition
  - Data analysis
- DCE-MRI
  - Basic principles
  - Data acquisition
  - Data analysis
- Issues and current trends
  - Tracer-kinetics
  - DSC-MRI
  - DCE-MRI

REFERENCES