Several treatment modalities for neurodegenerative diseases or tumors of the central nervous system involve invasive delivery of large molecular weight drugs to the brain. Despite the ample record of experimental studies, accurate drug targeting for the human brain remains a challenge. A promising approach to drug delivery without chemical drug transformations includes invasive drug administration. 

Convection-enhanced delivery (CED) has received attention because larger distribution volumes can be achieved than by molecular diffusion alone. In CED, volumes of drug distribution depend on (i) infusion parameters like infusion pressure, flow rate and drug concentration; (ii) molecular properties such as effective diffusivity and hydraulic conductivity; (iii) catheter design and position.

We developed novel methods of computer-assisted brain analysis featuring the following innovations: (i) accurate reconstruction of the brain geometry and tissue anisotropy, and (ii) prediction of treatment volumes based on transport principles. The proposed rigorous mathematical framework predicts achievable volumes in target regions as a function of brain anatomy and infusion catheter position. The two-dimensional brain anatomy is reconstructed accurately using medical images; tissue anisotropy and heterogeneity are quantified with the help of diffusion tensor imaging (DTI).

Infusion experiments are also conducted in agarose gel brain phantoms for quantifying the distribution volume using image analysis of digital images or MRI. Optical methods are also being applied to investigate tissue deformation due to infusion.

References