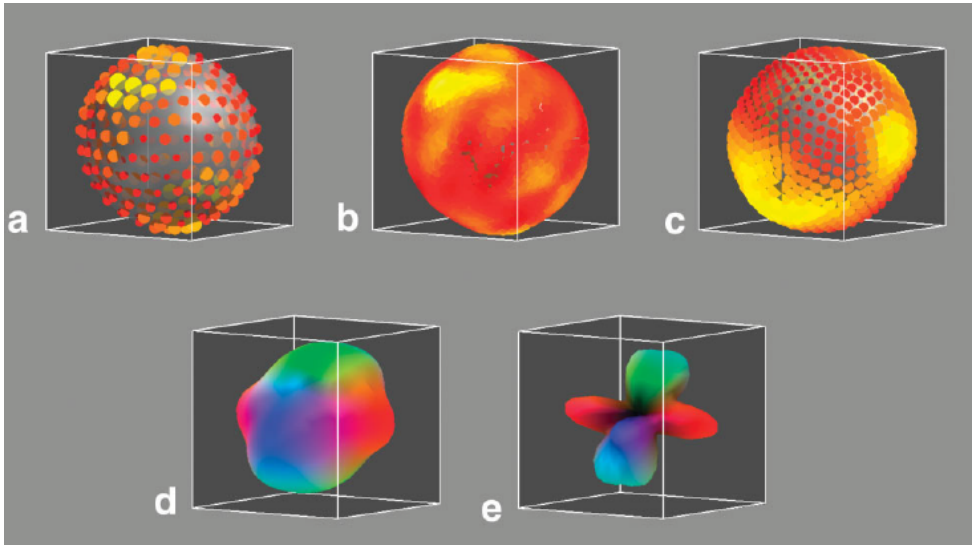
Advanced diffusion methods –
acquisition and analysis

Multiple compartment models and multiple fiber reconstruction algorithms

High b values, Diffusion spectrum imaging, QBall imaging….etc



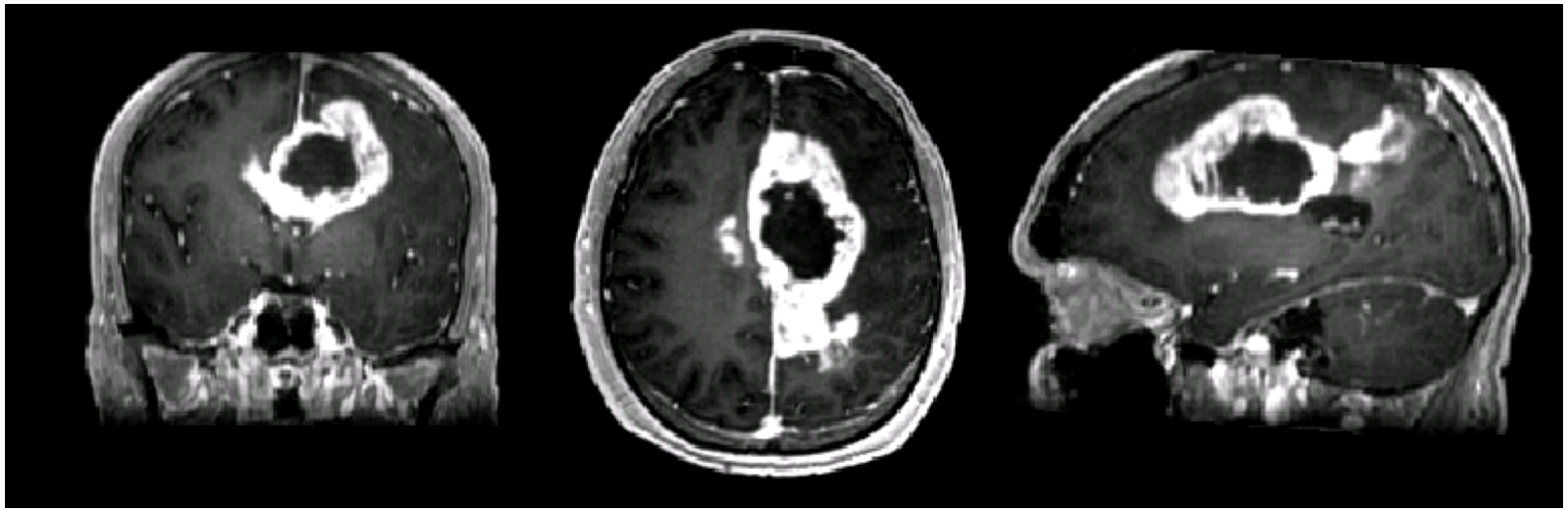
Tuch, NMR in Biomed, 2004

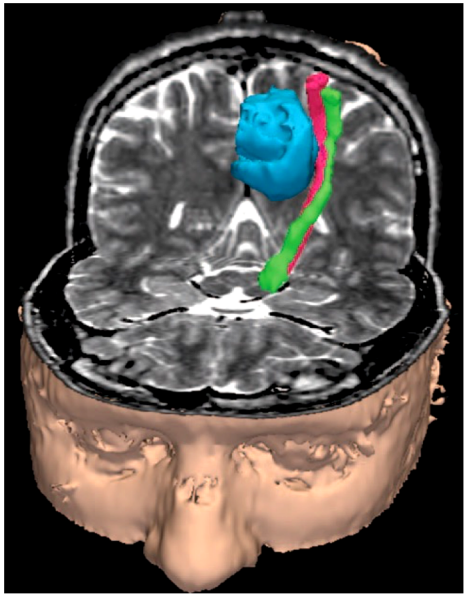
Clinical Applications:

Diffuse axonal injury
Neuro-degenerative disease
Demyelination disorders
Pre-surgical mapping - Neurosurgery
Brain development and developmental disorders
Diagnosis and assessment of severity of injury
Neuroplasticity

Applications in:
Glaucoma, Blindness, Multiple Sclerosis, Alzheimer's Disease, Stroke, Trauma, Tumor, Epilepsy, Language & reading, Movement disorders

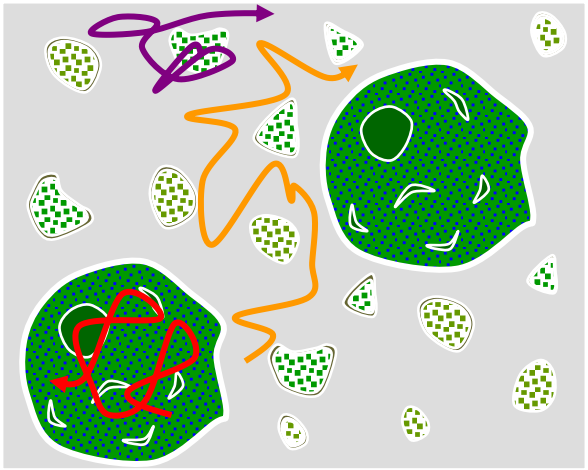
Pre-surgical mapping

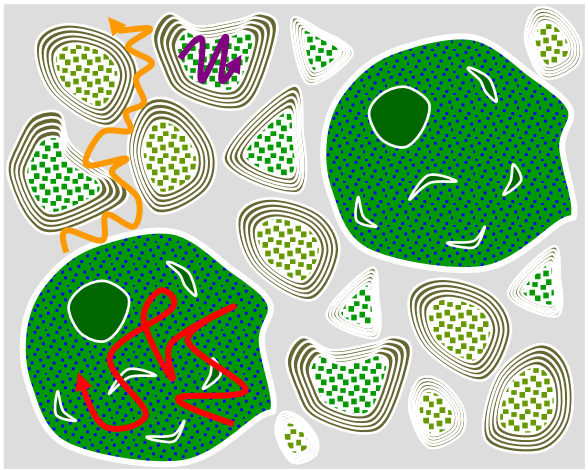


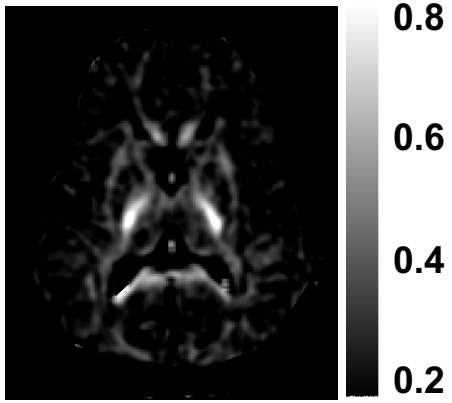


Mukherjee et al. AJNR 2009

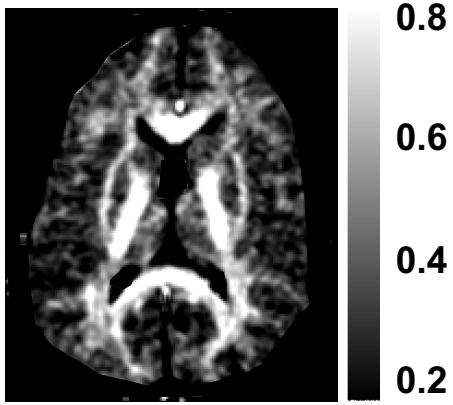
Clinical applications- Examples
Brain development





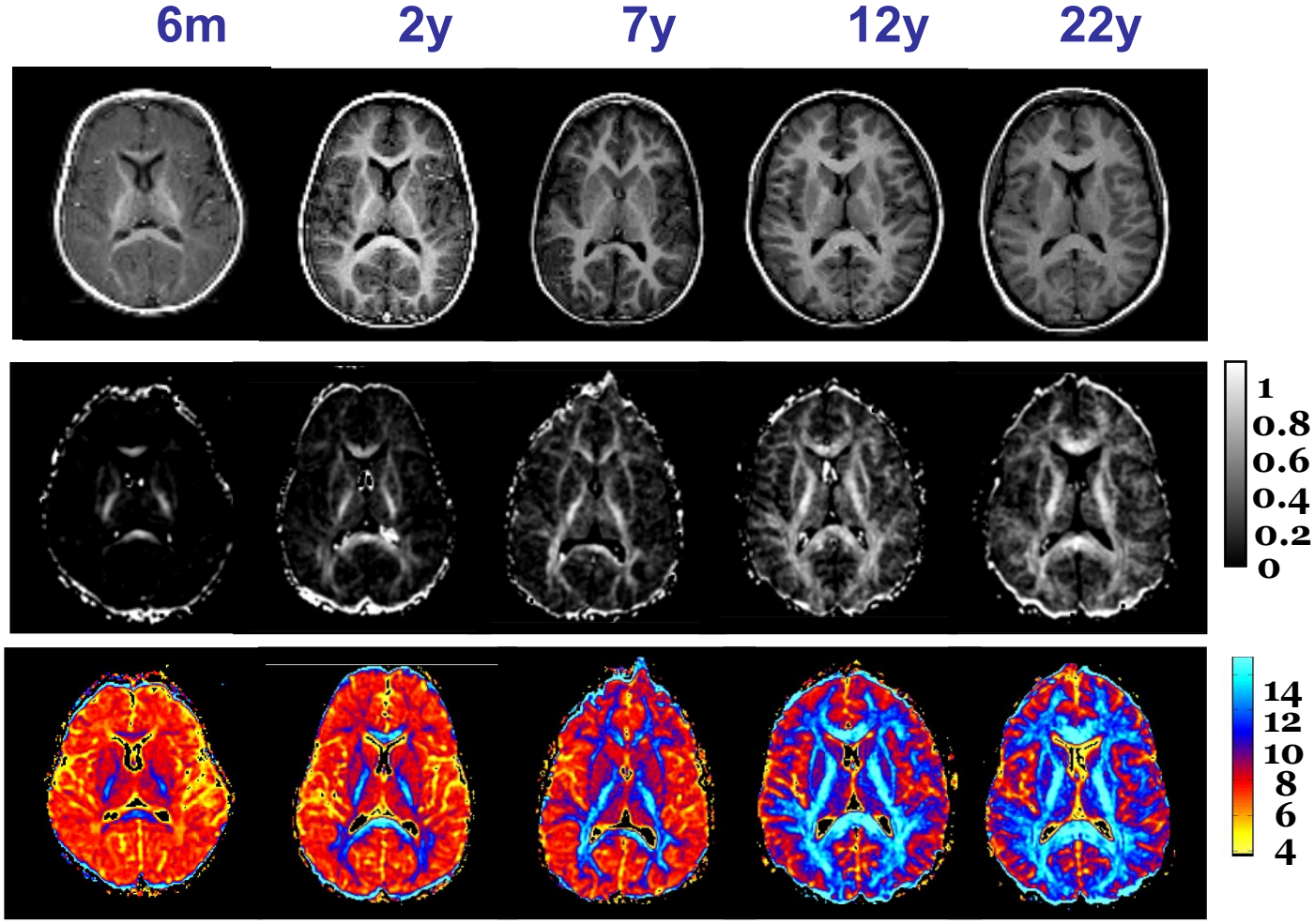


11months



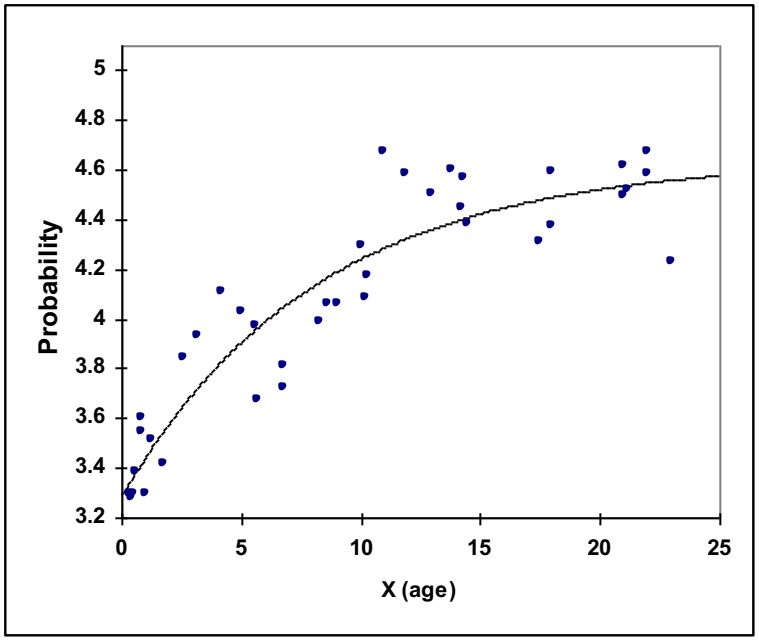
11years

Normal development – developmental disorders

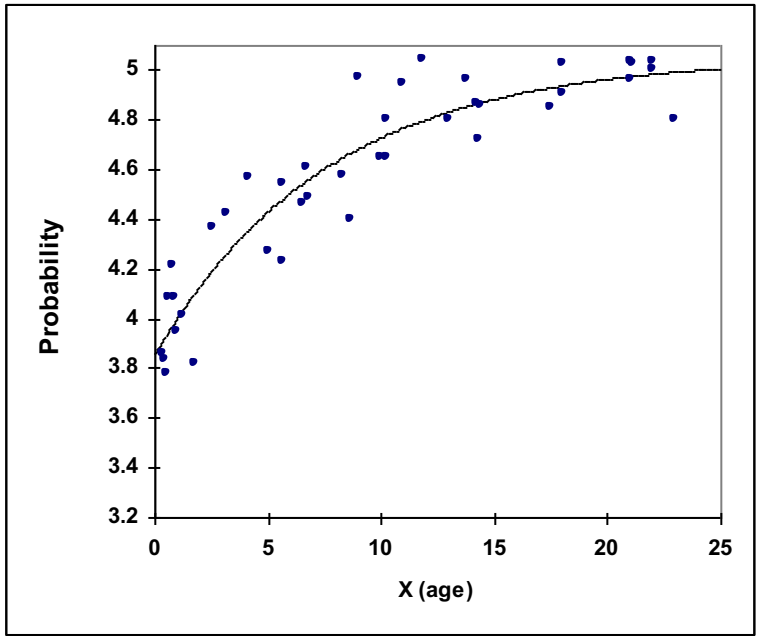


Ben Bashat et al., JMRI, 2005

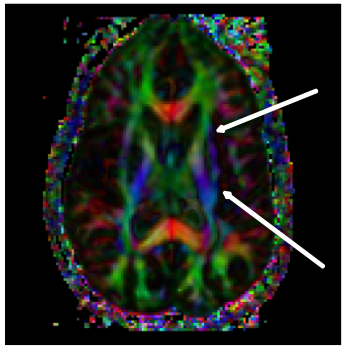
Early Diagnosis – Normal development



Anterior limb internal capsule - Left

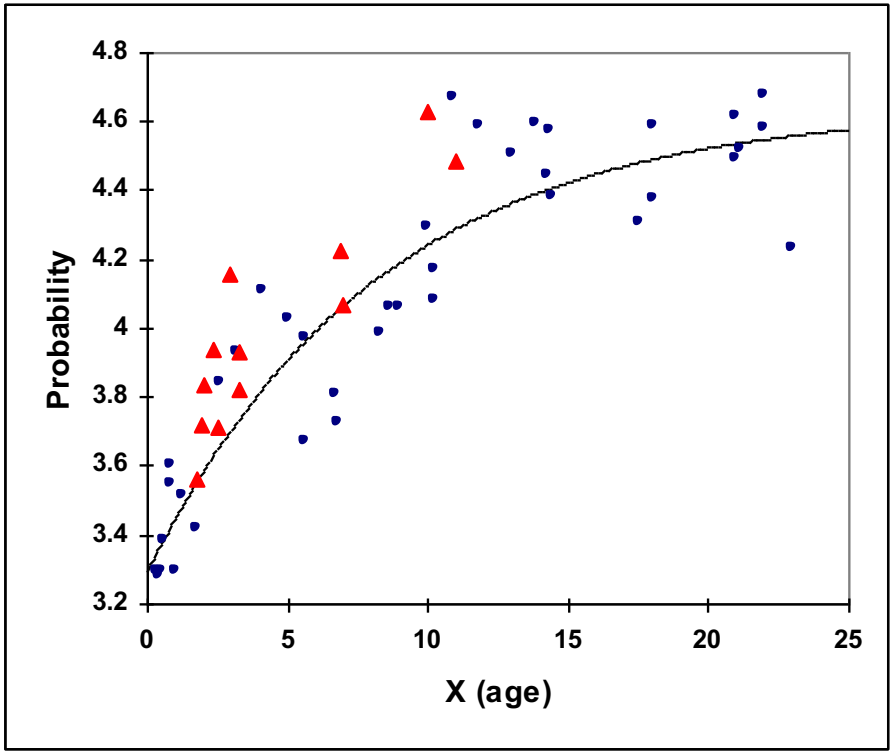


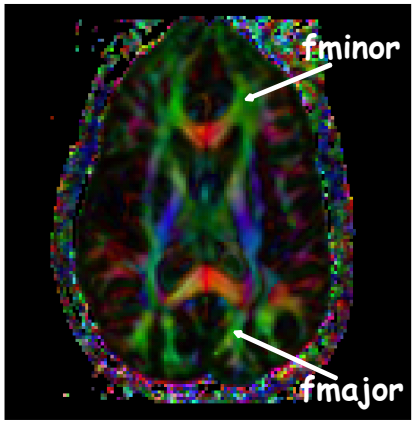
Posterior limb internal capsule - Left

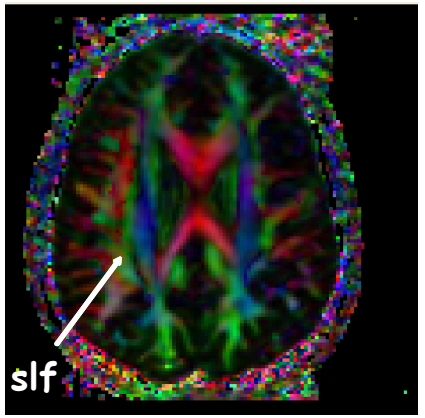


Early Diagnosis – Autism

Increased restriction in some areas in the brain correlating with increased brain volume during the first two years of life

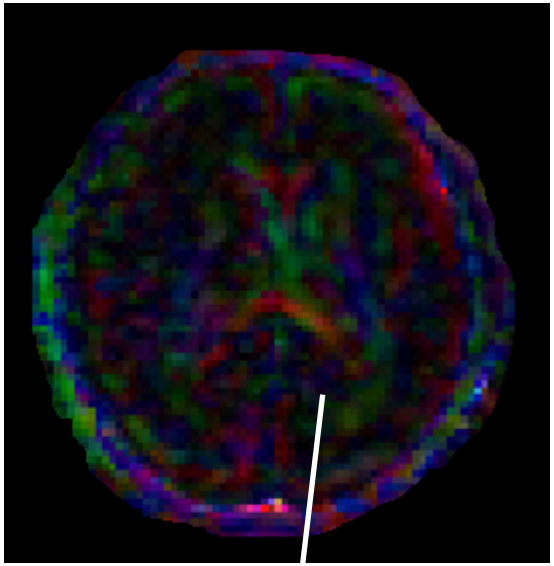


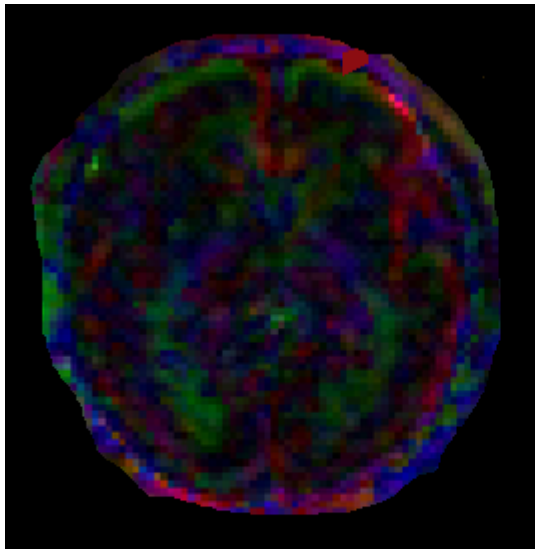




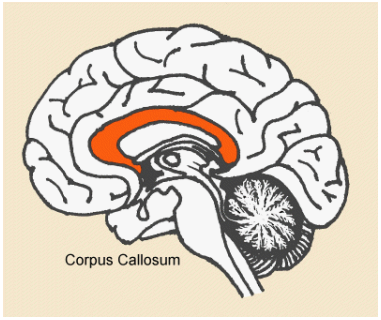
Ben Bashat et al., NeuroImage, 2007
Weinstein et al., HumanBrain Mapping, 2011

Fetal - MRI

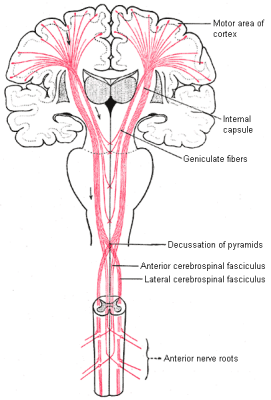


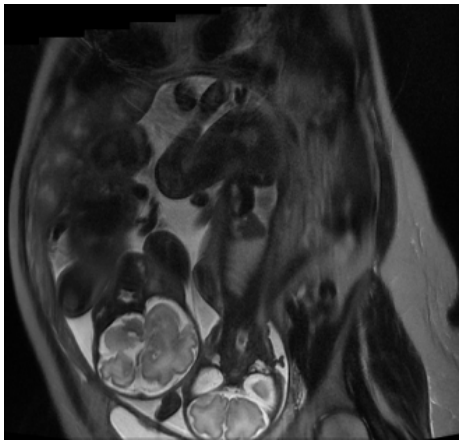


Corpus callosum

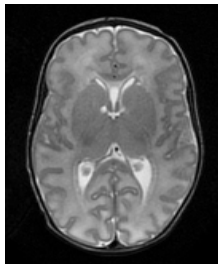


Corticospinal tract

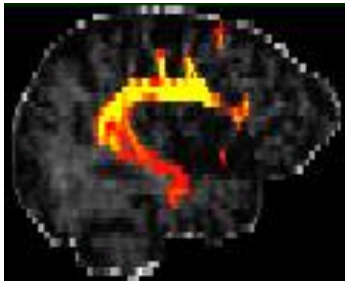


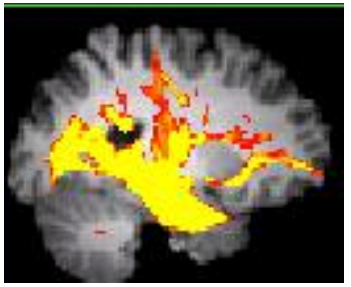


Preterm & term infants

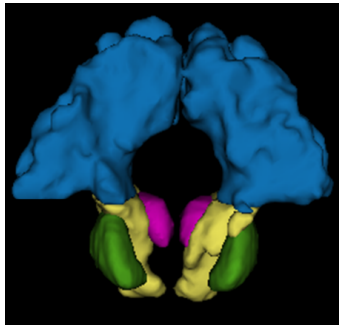


- To study integrity in premature infants in order to predict neurological outcome

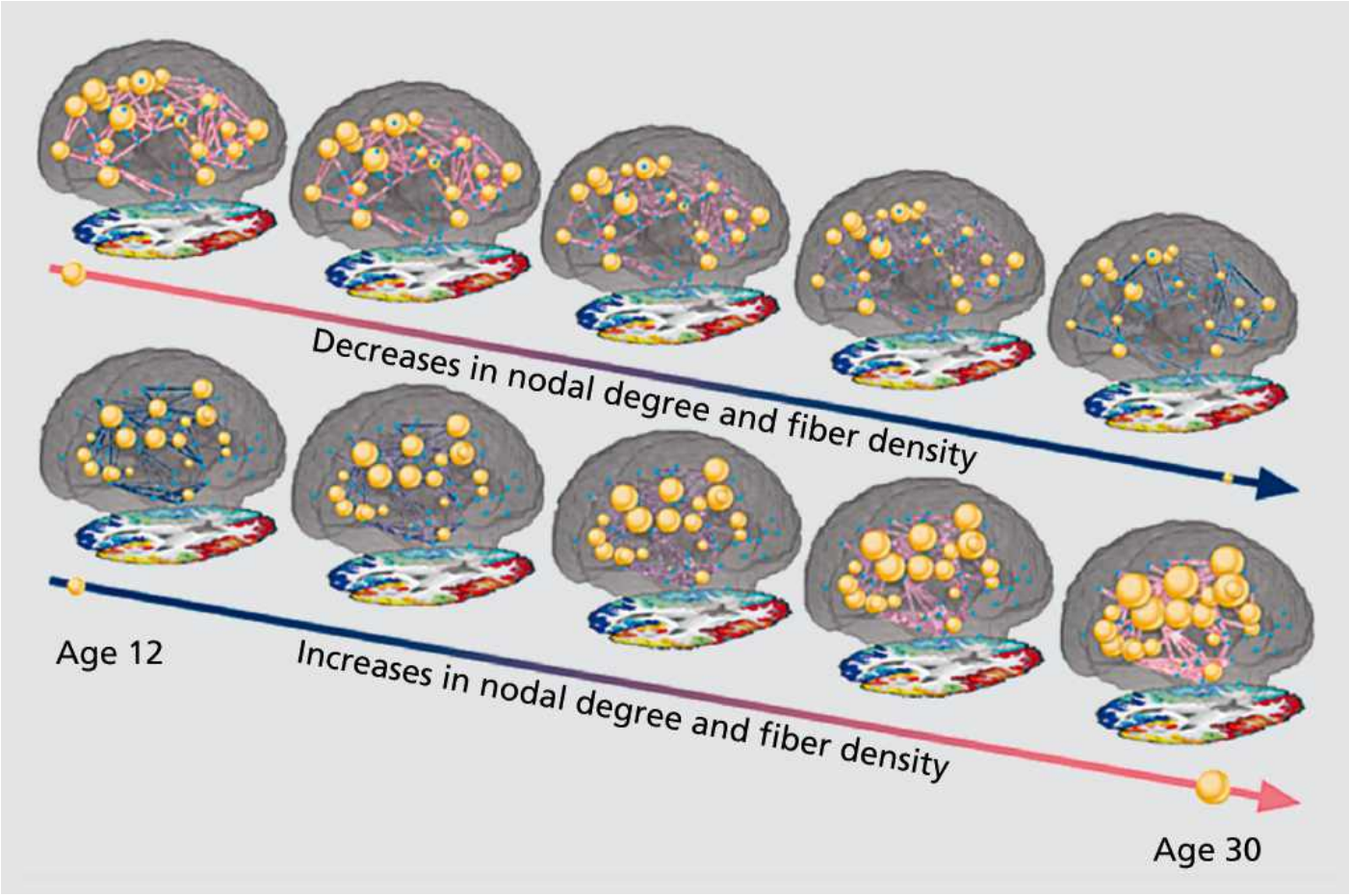


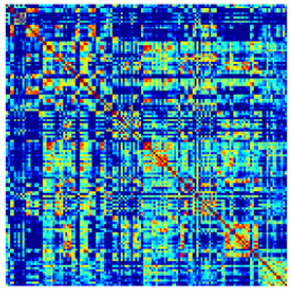


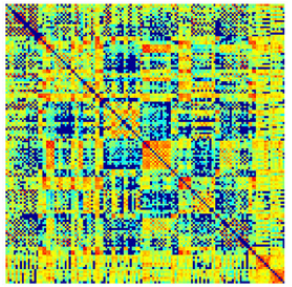
- To assess brain diffusivity in term infants with hypoxic ischemic encephalitis:



Structural connectivity – brain development



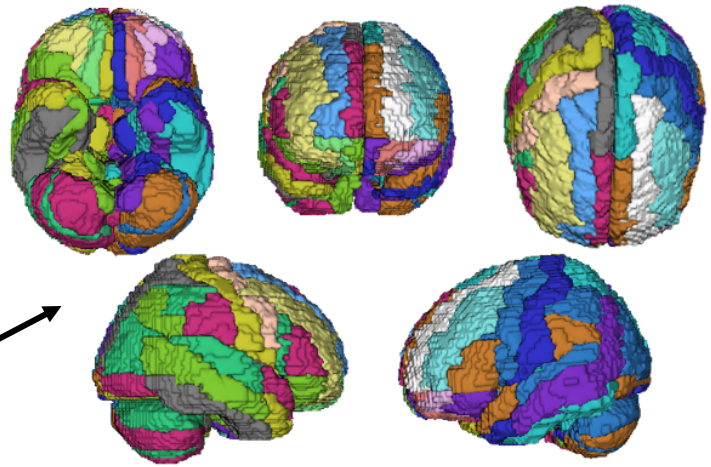




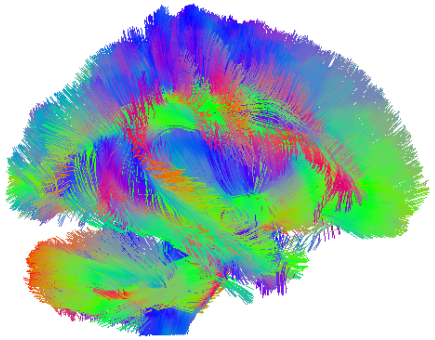
Emily L. Dennis, BA ; Paul M. Thompson, Dialogues Clin Neurosci. 2013.

Structural connectivity – Parkinson Disease (PD)

Connectivity analysis based on
AAL=Automated Anatomical Labeling

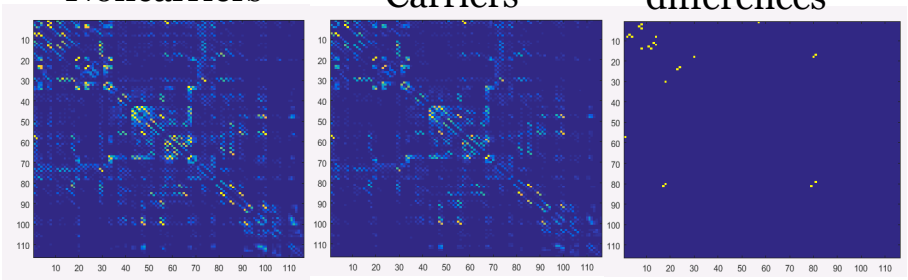


Whole brain deterministic
fiber tracking



Connectivity matrixes

Noncarriers | Carriers | Significant differences*

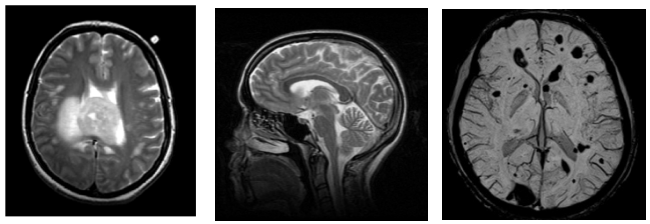


Artzi…Ben Bashat, work in progress

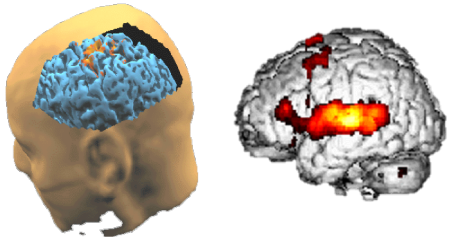
* p=0.0001 – corrected for multiple comparisons

MRI

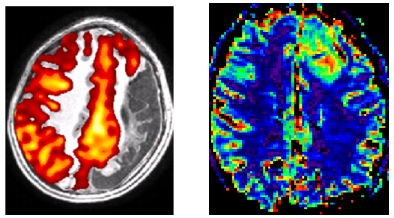
Structural information
Conventional methods

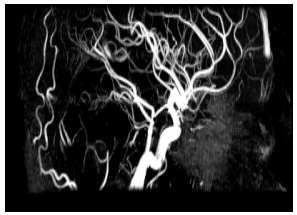


Functional MRI
1990 – BOLD Functional Imaging (fMRI)

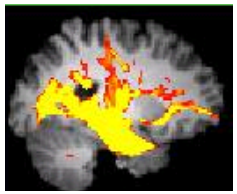


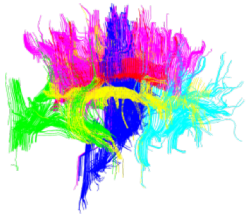
Vascular imaging
DSC / DCE / ALS
MRA / MRV



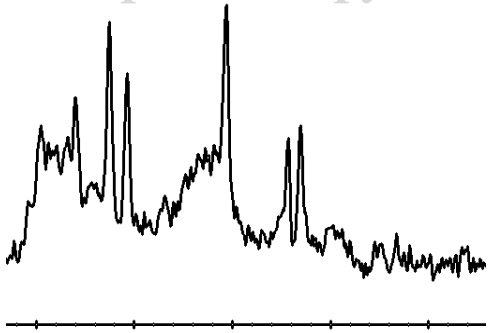


Structural and connectivity information
1994- Diffusion Tensor Imaging (DTI)

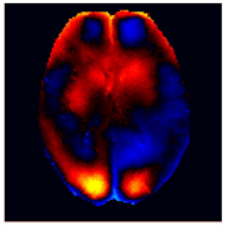


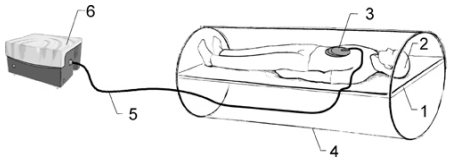


Metabolic information
Spectroscopy



Structural information
MR Electrography



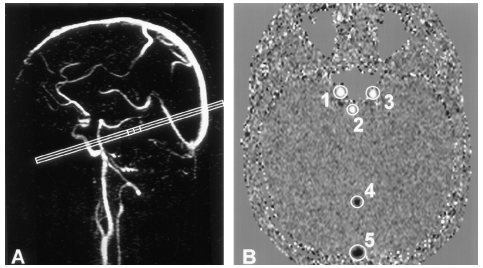


MR Vascular Imaging

Large blood vessels

Time of flight

Phase contrast (PC)



MR Vascular Imaging

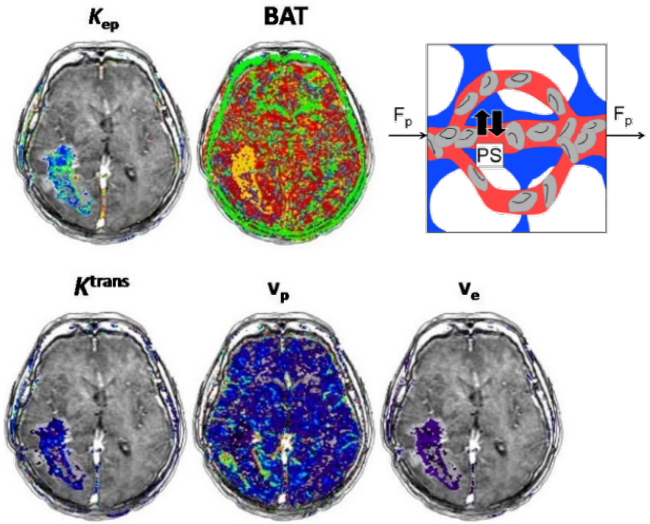
Large blood vessels

Time of flight

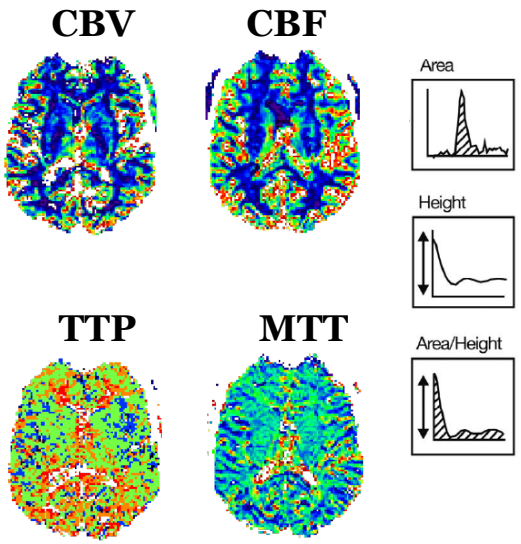
Phase contrast (PC)

Tissue perfusion

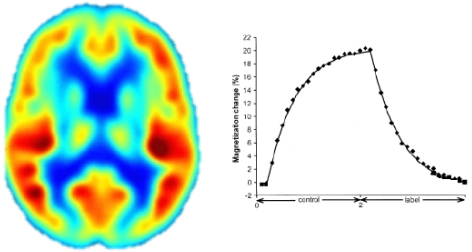
Dynamic Contrast Enhancement (DCE)



Dynamic Susceptibility Contrast (DSC)



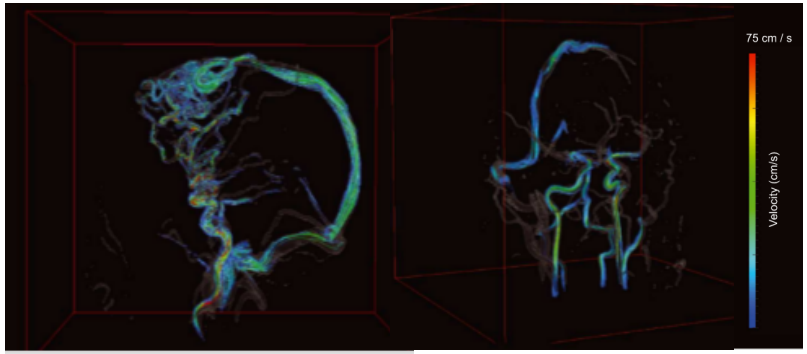
Arterial Spin Labeling (ASL)

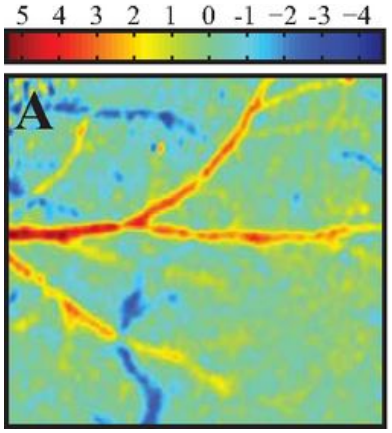


MR Vascular Parameters

Cerebral blood volume (CBV)
Plasma volume (Vp)

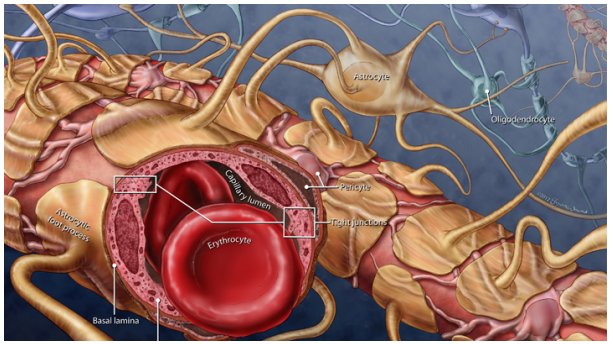
Cerebral blood flow (CBF)





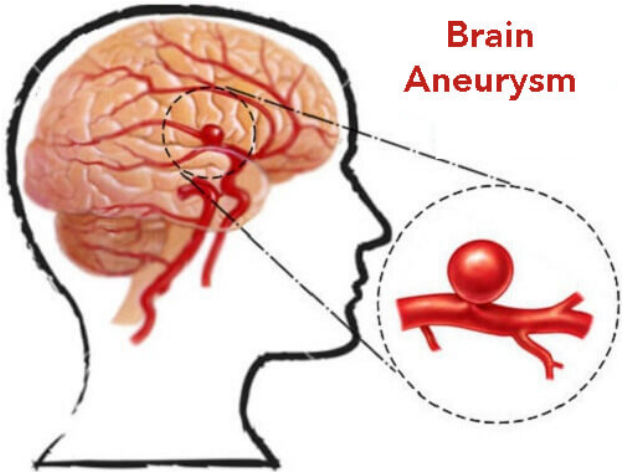
Mean transient time (MTT)
Bolus arrival time (BAT)

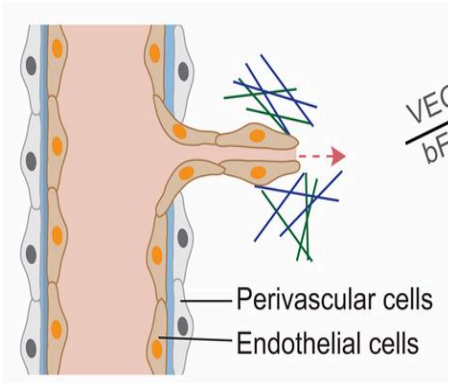
Blood brain barrier (BBB) integrity



K^{trans}=volume transfer constant
Kep=interstitium-to-plasma rate constant

Clinical applications

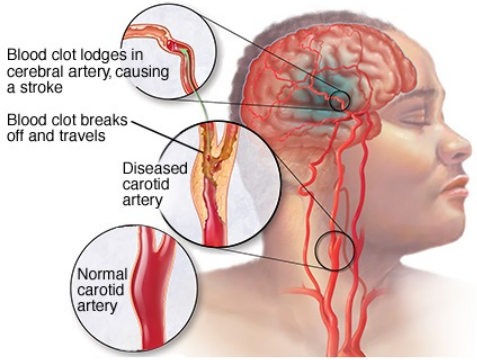


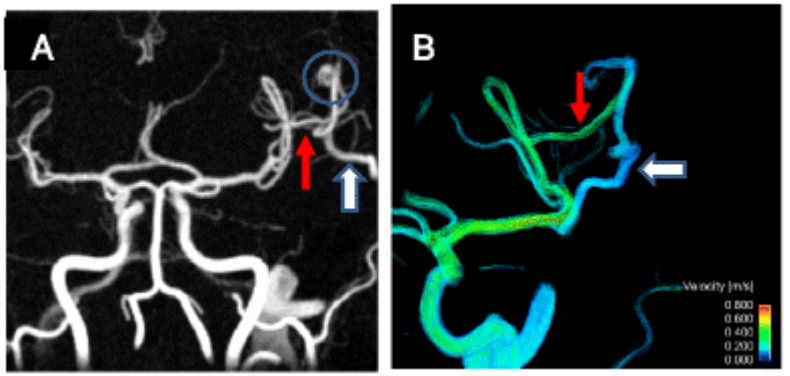


Angiogenesis

Abnormal flow

Stenosis and occlusion





Patrick Turski, Neurovascular Imaging 2016

Clinical applications

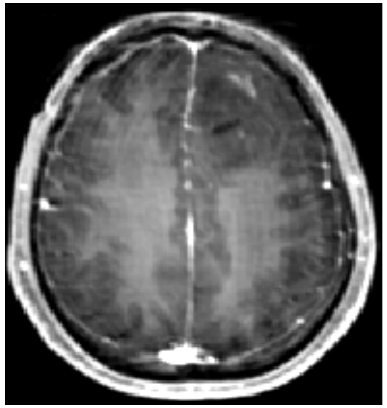
Stroke
Vascular disorders
Carotid stenosis
Aneurism
Vascular occlusion – stenosis
Brain tumors
Pre-surgical mapping - Neurosurgery
Bleeding
Hypoxic ischemic injury
Moya-moya
Epilepsy

Neuro Vascular coupling

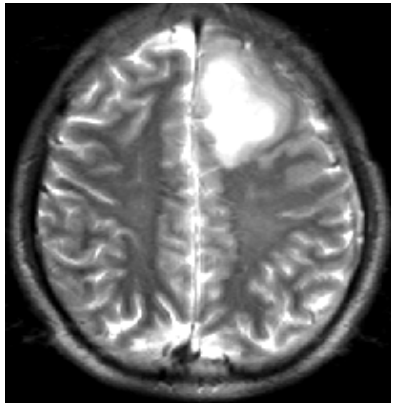
Brain tumors

Non enhancing lesion

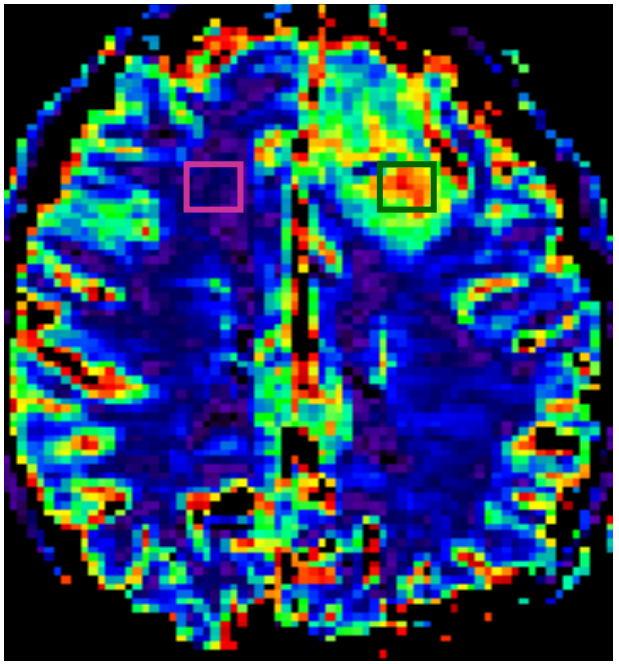
T1 +Gd



T2W



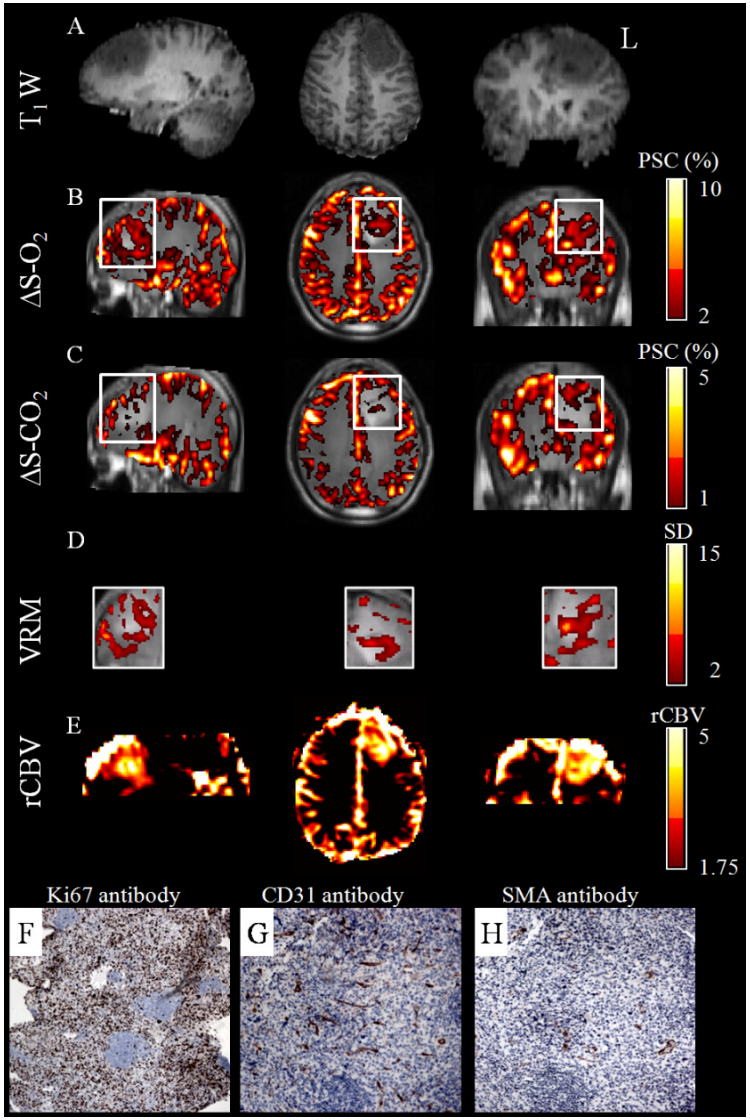
CBV map



rCBV=5.17

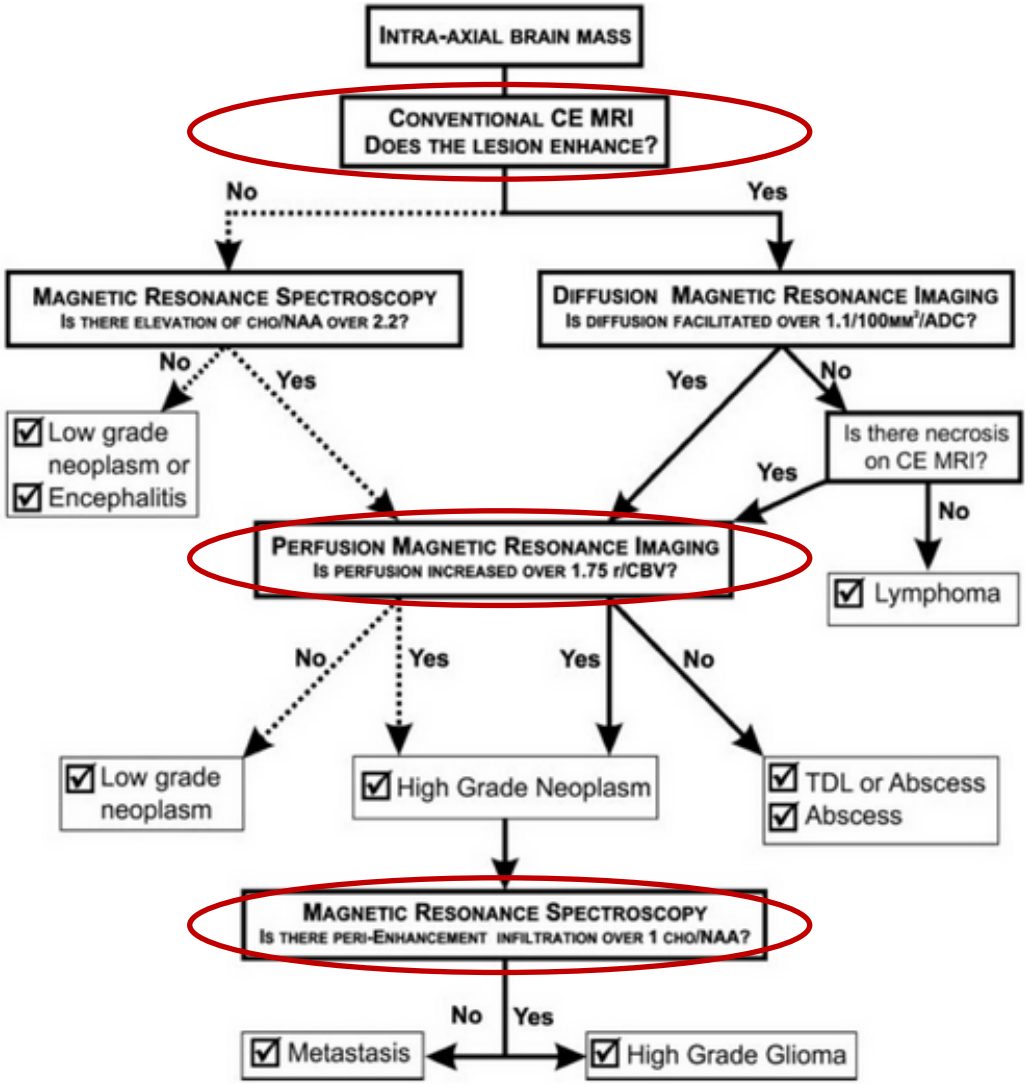
rCBV> 1.75 high grade tumor

Angiogenesis in high grade brain tumors



Ben Bashat et al., PloS One, 2012

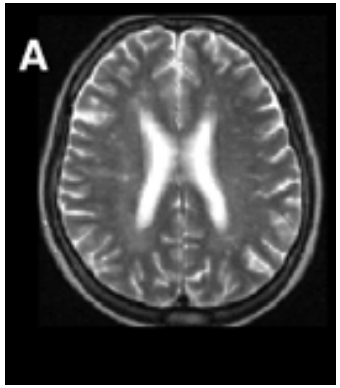
Routinely used in clinical practice

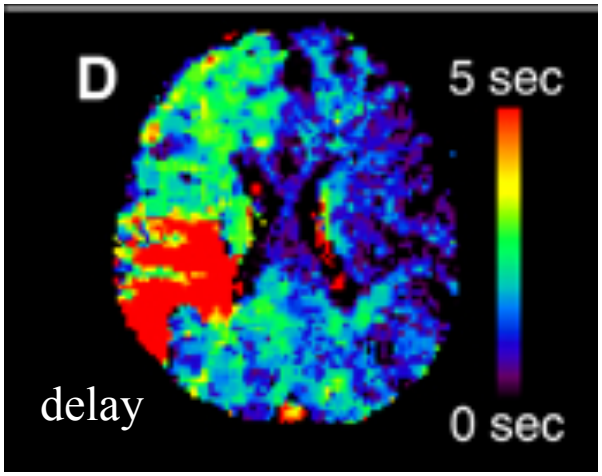


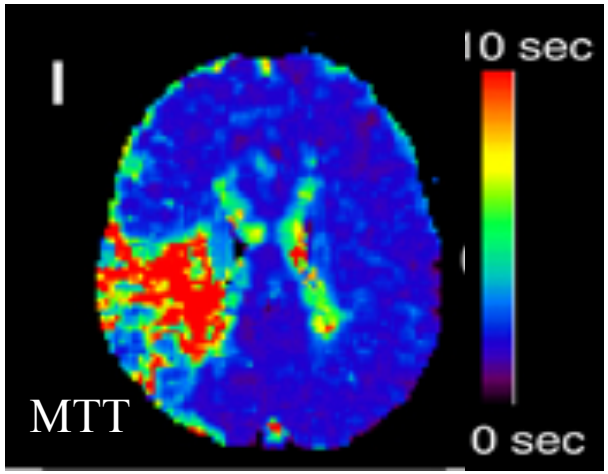
Neuroimaging Alena Horská et al. 2010

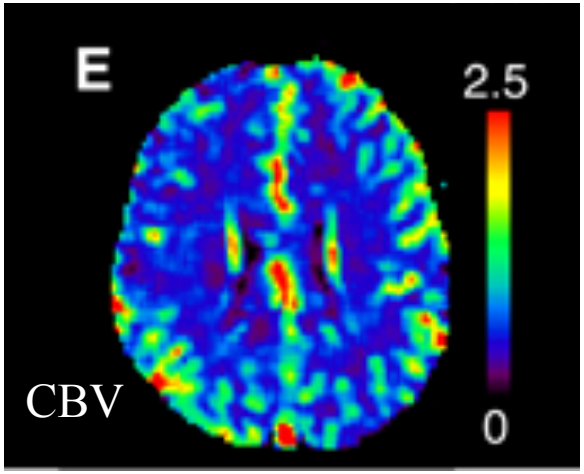
Stroke

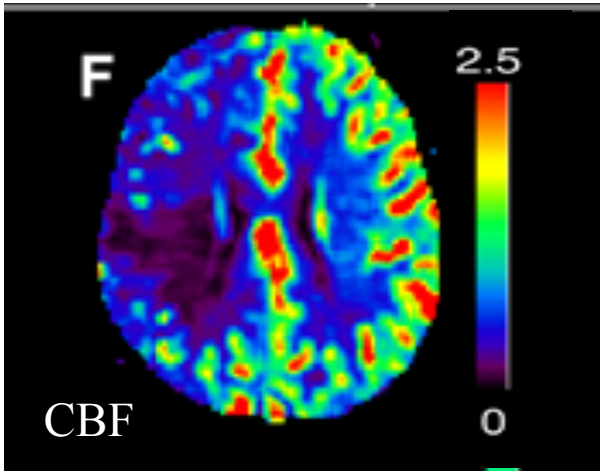
65 y.o. woman with acute ischemic stroke





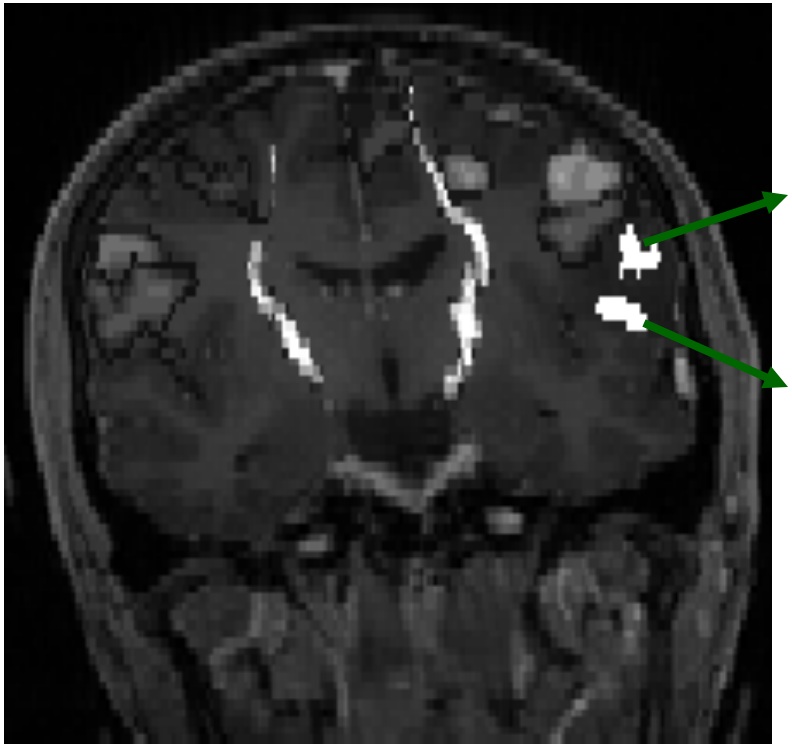






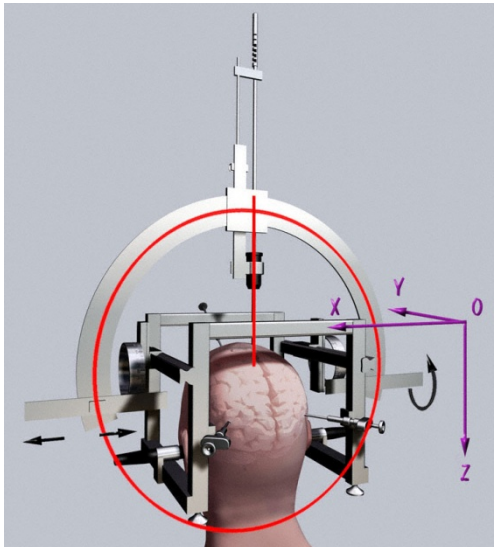
Pre-surgical mapping – stereotactic guided

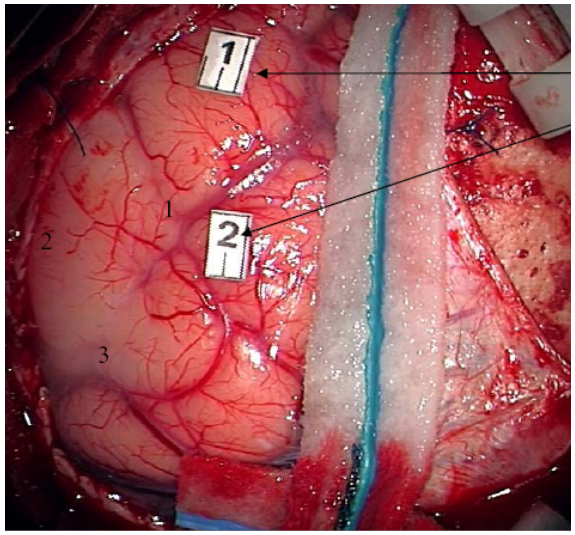
Stereotactic biopsy:
Correlations between MR and histopathology findings



Hyper perfused

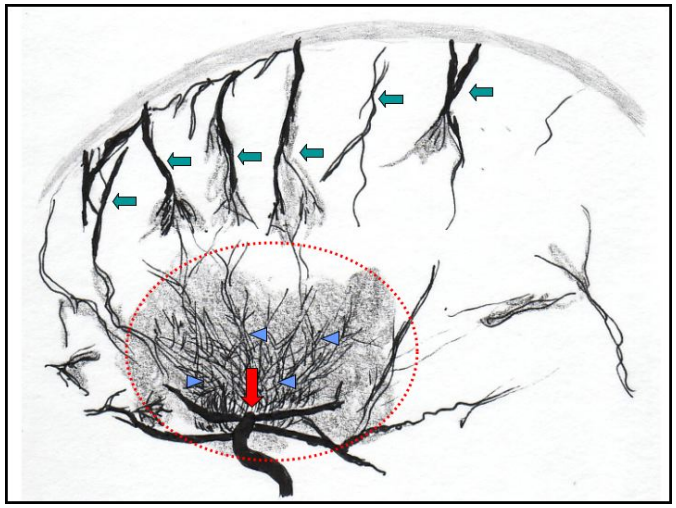
Hypo perfused





Moya Moya syndrome

Puff of smoke - もやもや (moyamoya) in Japanese



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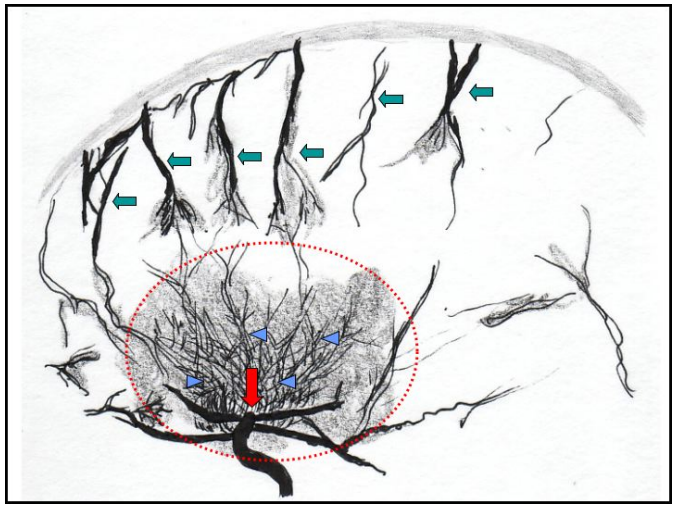
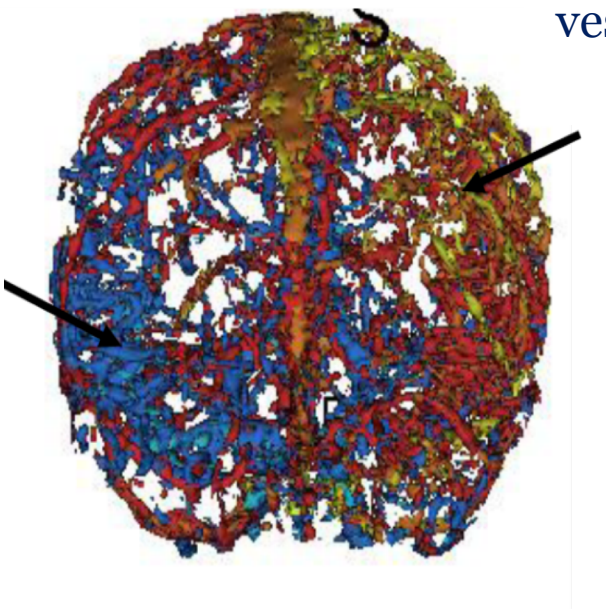


Moya Moya – quantitative imaging

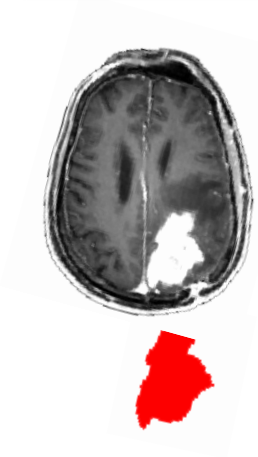
Pathological blood vessels

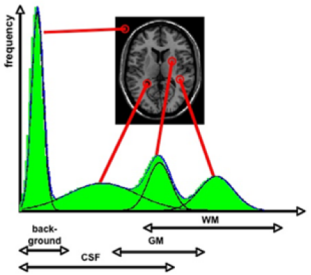
Normal blood vessels



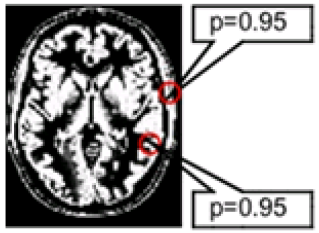
Quantitative imaging: segmentation methods

Thresholding

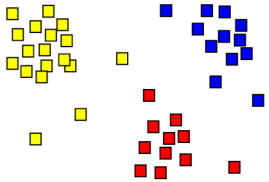




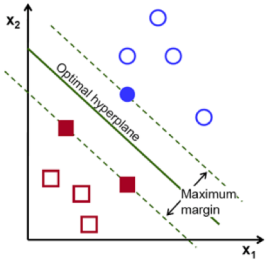
Probabilistic based



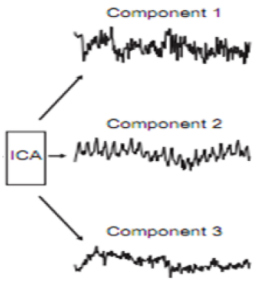
K-means

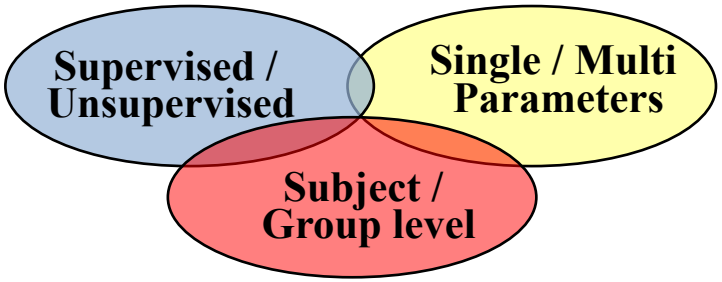


SVM

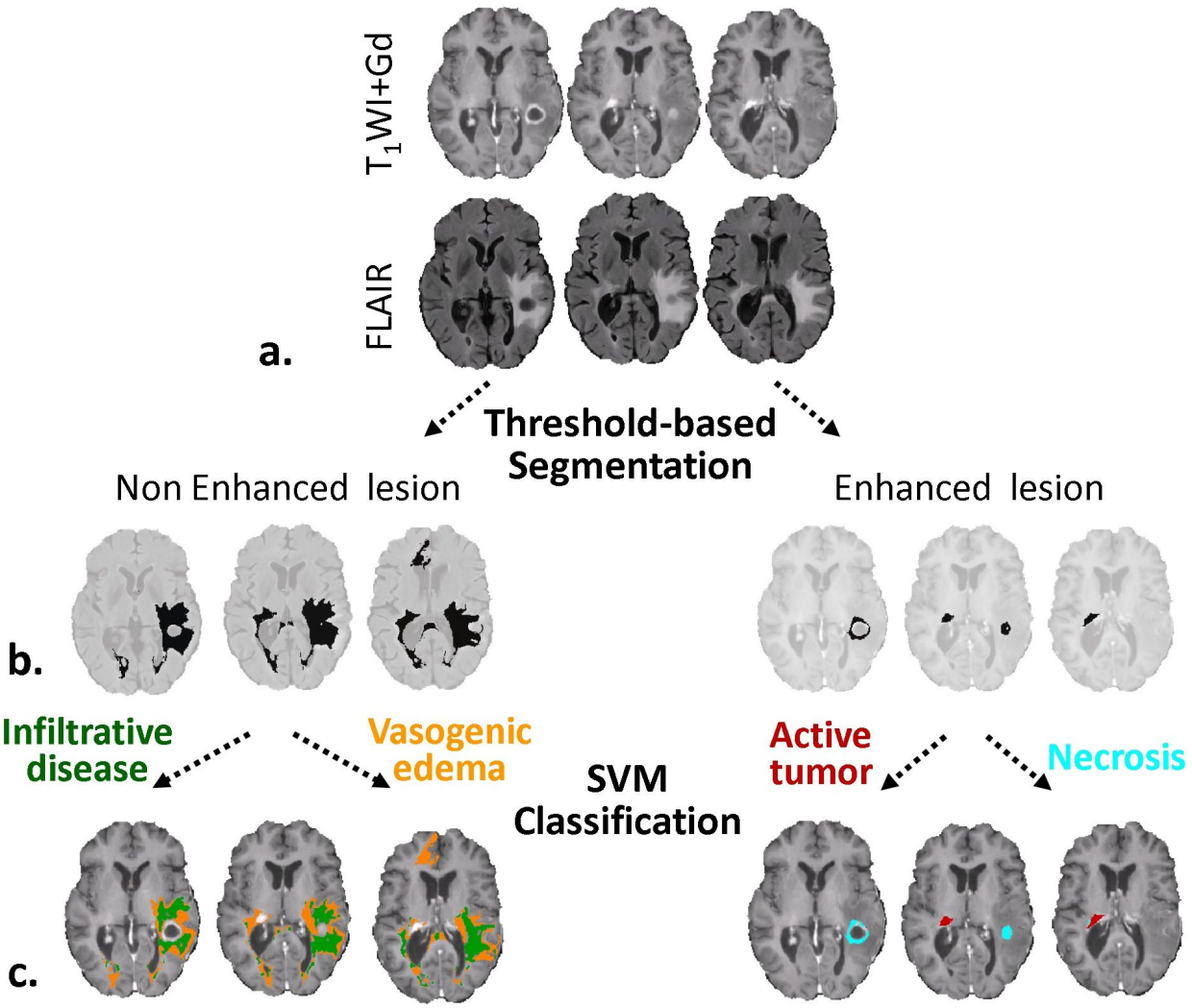


ICA

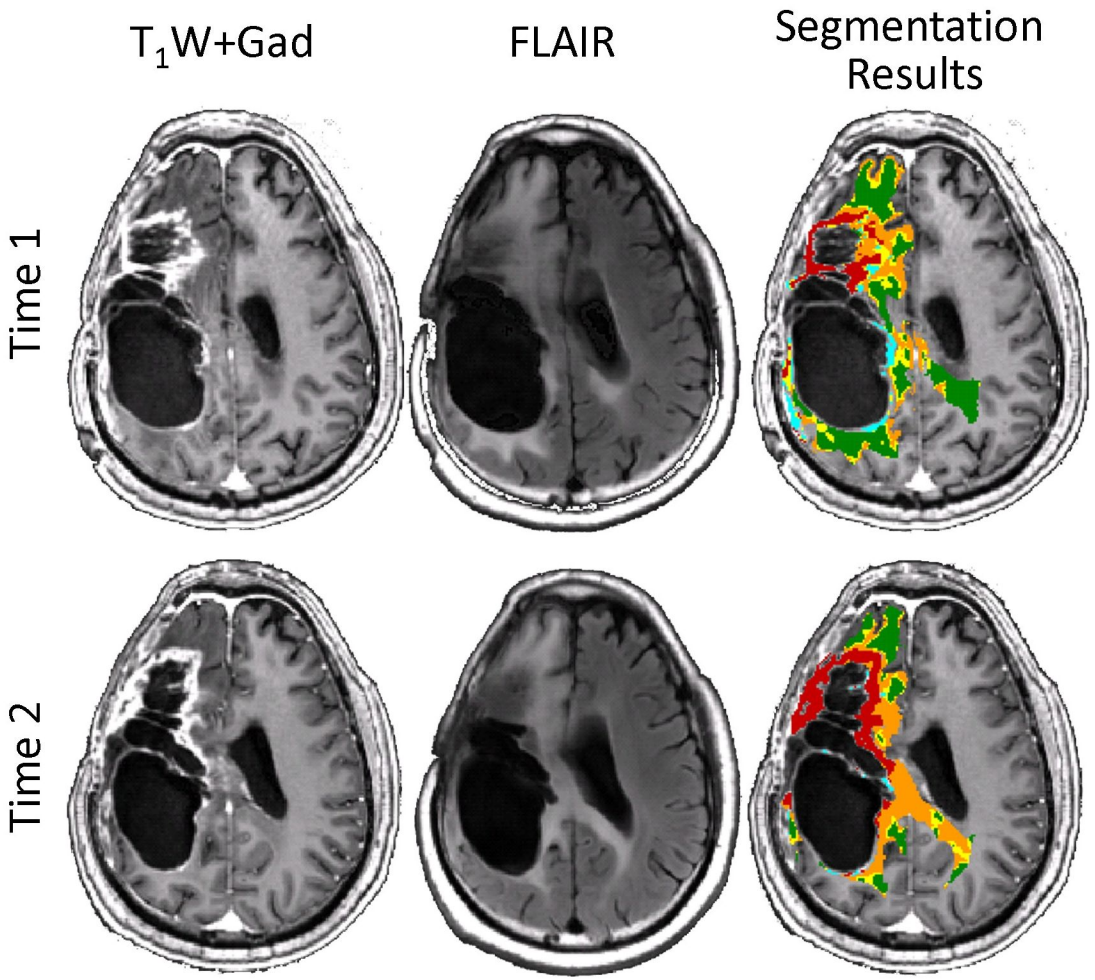


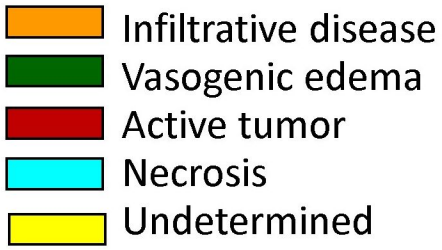


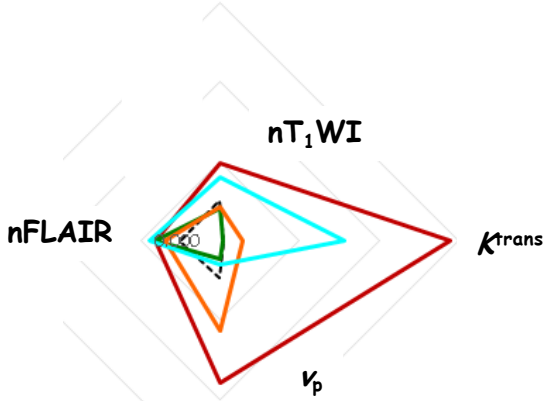
Segmentation and classification



Segmentation and classification





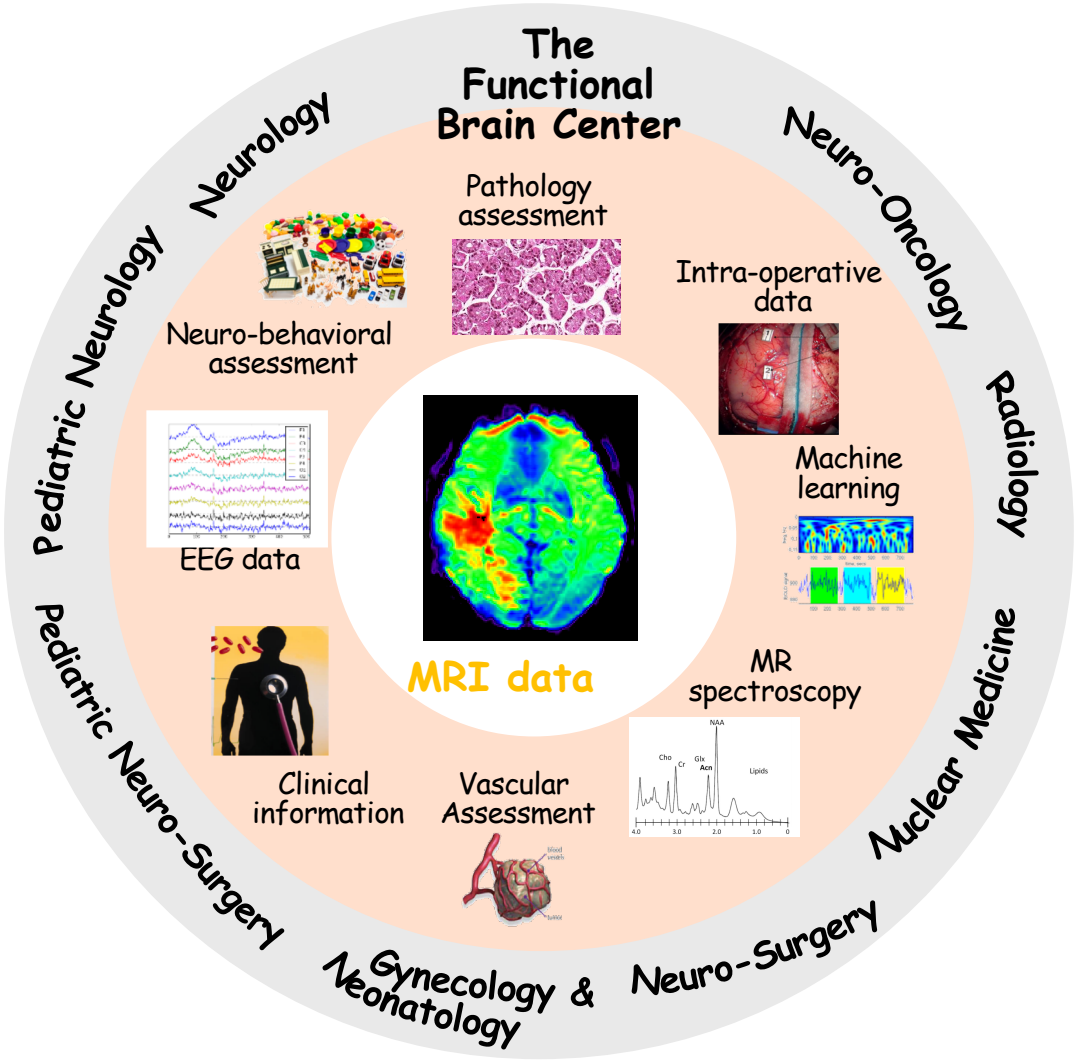


Differentiation between treatment related changes and progressive disease

Artzi M & Ben Bashat ISMRM, 2015

Summary

MRI always within the context of clinical and imaging parameters



Tel-Aviv Sourasky Medical Center

המרכז לתפקודי המוח תל אביב
Tel Aviv Center for Brain Functions

Human Brain Project

Sagol School of NEUROSCIENCE Tel Aviv University

TEL AVIV UNIVERSITY

Summary

>> Various parameters - microstructural properties of the tissue

>> MRI –Multi parametric (acquisition and analysis)

>> A gap between what can be done and what is actually used in clinical setting

Summary

>> A specific and tailored protocol

>> A need for Computer Aided Diagnostic (CAD) tools

>> Interdisciplinary - collaboration between physicians, physicists, computer science

>> A shift toward quantitative MRI