Challenges and pitfalls in radiological response assessment of brain metastases

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Patient 1: Melanoma BM
Patient 2: Melanoma BM
Patient 1: True Progression
Patient 2: Radiation Necrosis
Radiation Necrosis

- After stereotactic radiosurgery (SRS) or radiation
- Can occur weeks to months after SRS

Kickingereder et al. Radiation Oncology 2013, 8 :52
Guidance in the case of uncertain attribution of radiographic findings according to proposed RANO (BM)

1. Repeat the scan at the next protocol scheduled evaluation
2. Histopathological evaluation
3. Advanced MR/PET Imaging techniques
Advanced MR Imaging

- ce-T1
- SWI
- DCE-Perfusion
- DSC-Perfusion
- Diffusion
- Advanced Postprocessing
- FMRI
- Ultra High Field: 7 Tesla
- CEST (pH Imaging?)
- X-Nuclei Imaging (O17)
Diffusion MRI

• Mostly used: Apparent Diffusion Coefficient (ADC)

• ADC is supposed to reflect tumor cellularity

• Low ADC is correlated with high vascularity - true progression
Calculation of ADC

Low Cellularity - High ADC

High Cellularity – Low ADC
Perfusion MRI

- Mostly used parameter: Cerebral Blood Volume (CBV)

- CBV reflects vascularity of the tumor

- High CBV is correlated with high vascularity and true progression
Principle of Dynamic Susceptibility Contrast Enhanced Perfusion

T2*-Effect

- Paramagnetic contrast agent causes inhomogeneties of magnetic field:
  - Long distance effect
Identification of Radiation Necrosis

Kang et al, Morphological and functional MRI, MRS, perfusion and diffusion changes after radiosurgery of brain metastasis, Eur J Radiol 2009
Problem: T1-Effect of Contrast Agents

T1-Effect:

• short distance effect
• antagonistic to T2*-effect
• Can be neglected if the BBB is intact
Disrupted BBB: False decreased Perfusion Values

- T1- and T2*-effect are antagonistic
- Pure T2*-effect that determines CBV cannot be measured
- Underestimation of CBV
Correction technique: Preload

Most common:
Preload of contrast agent
5 minutes prior to DSC-Perfusion
Correction technique: Preload

After drainage of contrast agent:

Interstitium is presaturated!
Correction technique: Preload

After 5 minutes: DSC-Perfusion

Reduced drainage of contrast agent in interstitium

Measurement of pure T2*-effect
Underestimation of CBV

Urgently needed: Standardization of MRI techniques within different centers and in clinical trials

Covarrubias et al; The Oncologist 2004;9:528-537 “Dynamic Magnetic Resonance Perfusion Imaging of Brain Tumors”
What is on the horizon?
Ultra-High-Field: 7 Tesla
Thank you for your attention!
7 Tesla
Thank you for your attention!