The Expanding Role of Advanced Imagine in Glioblastoma

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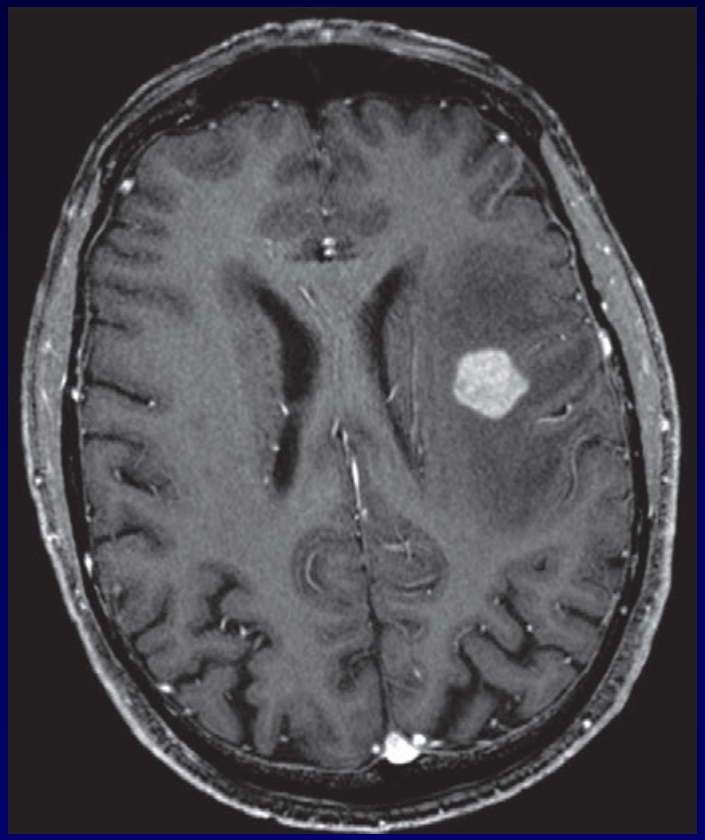
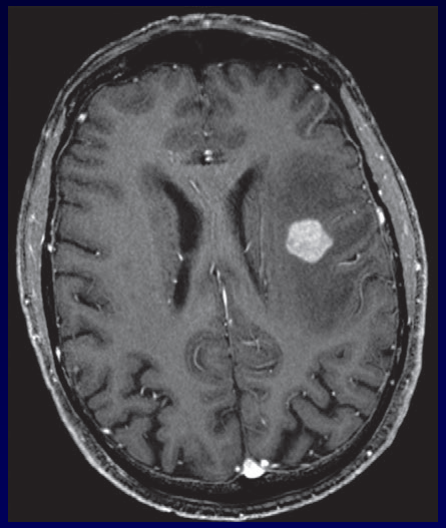
Advanced imaging techniques for…

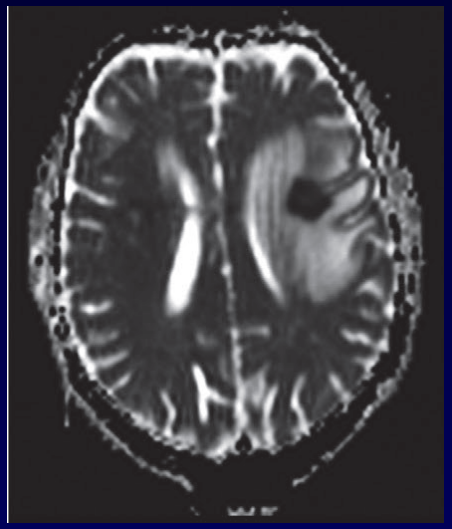
1. Differential diagnosis
2. Identification of pseudoprogression
3. Identification of pseudoregression / T2-progress

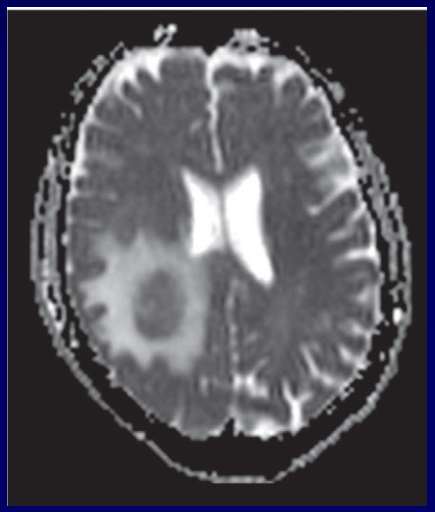
Advanced MRI for Differential Diagnosis: PCNSL vs GBM



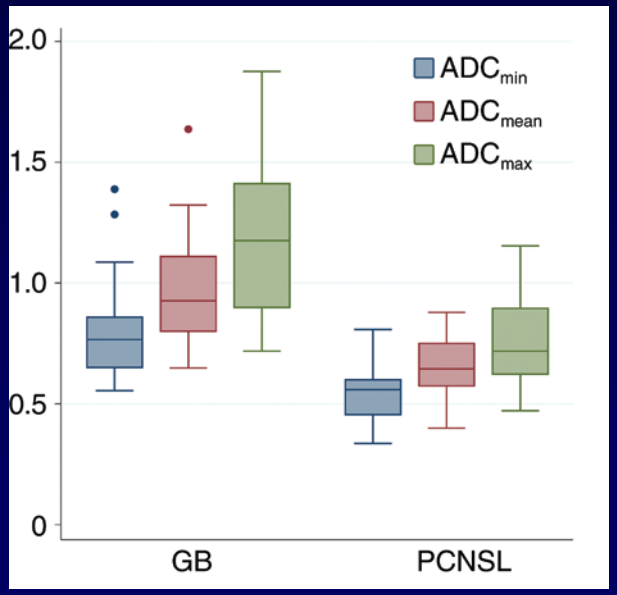
Diffusion Imaging: PCNSL vs GBM







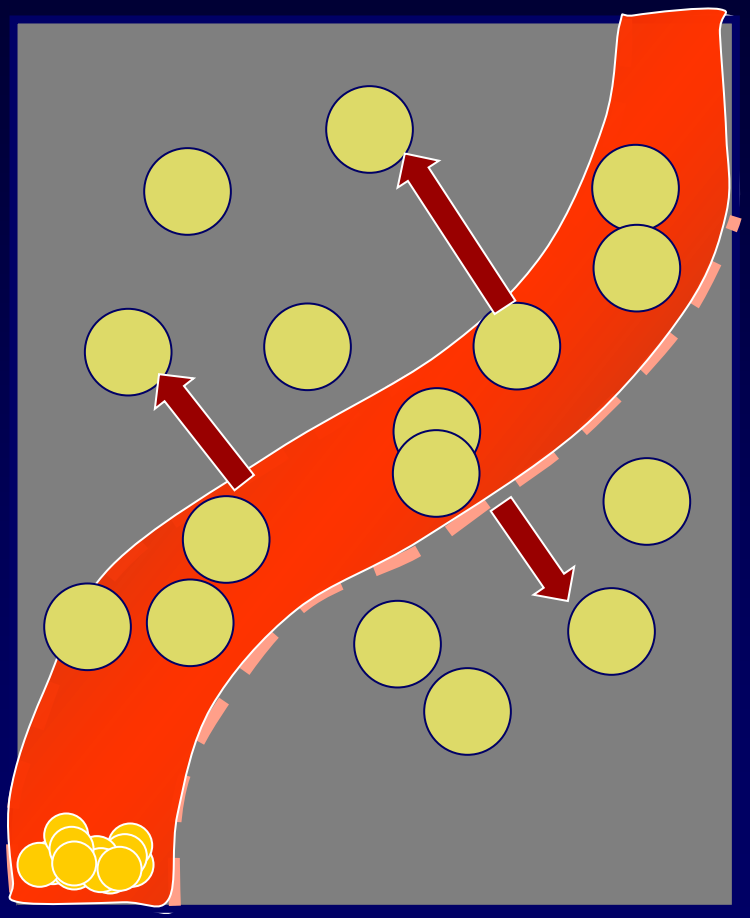
PCNSL: Low ADC
High Cellularity



GBM: High ADC
Lower Cellularity

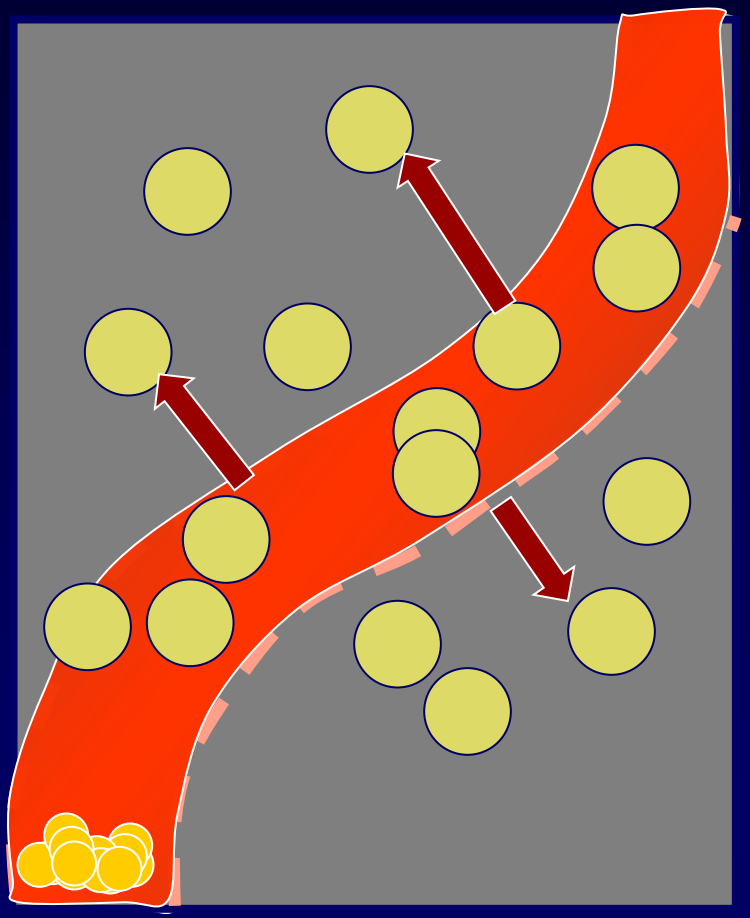
Kickingereder P, et al. *AJNR Am J Neuroradiol.* 2014;35(8):1503-1508.

DCE Perfusion



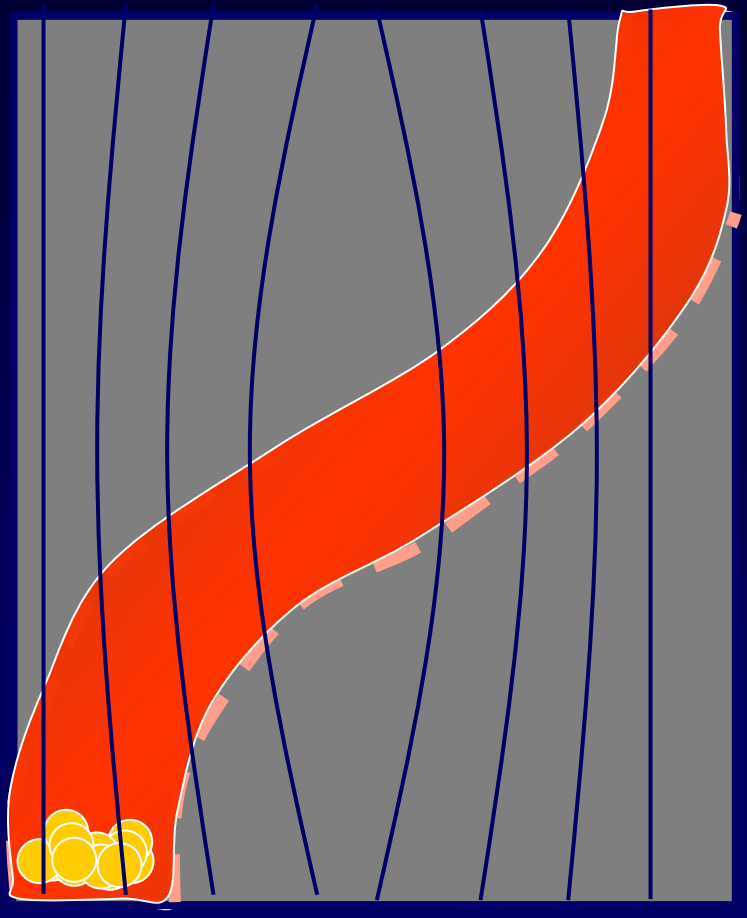
- T1 effect
- Assessment of the BBB (k_{trans})
- Scan time 4 - 10 min

DCE Perfusion



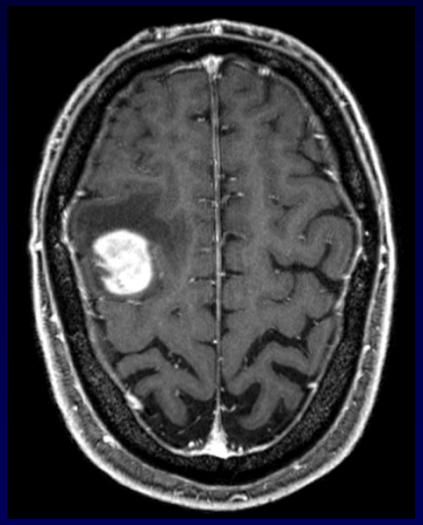
- T1 effect
- Assessment of the BBB (k_{trans})
- Scan time 4 - 10 min

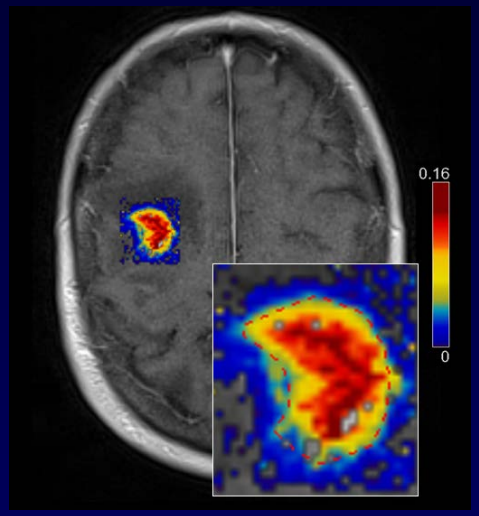
DSC Perfusion

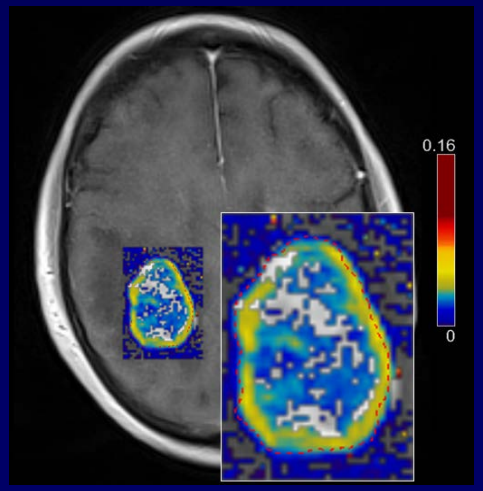


- T2* effect
- Assessment of CBV
- Scan time 1:30 min
- Correction techniques needed

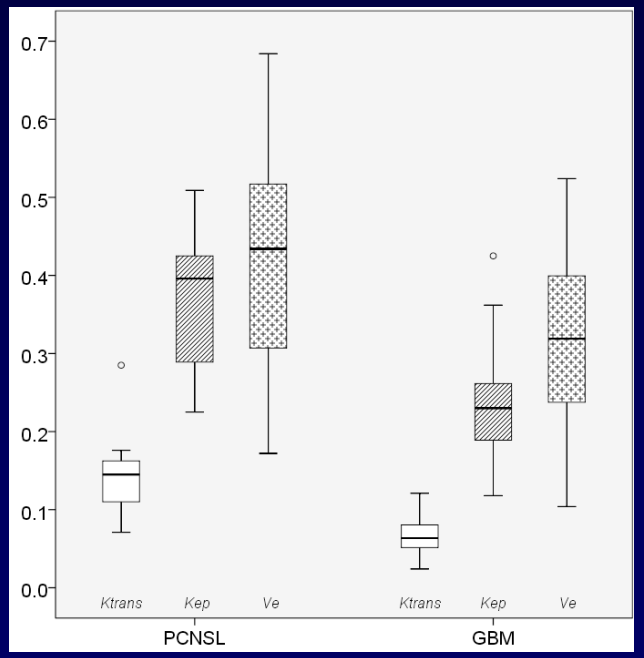
DCE-Perfusion: PCNSL vs GBM







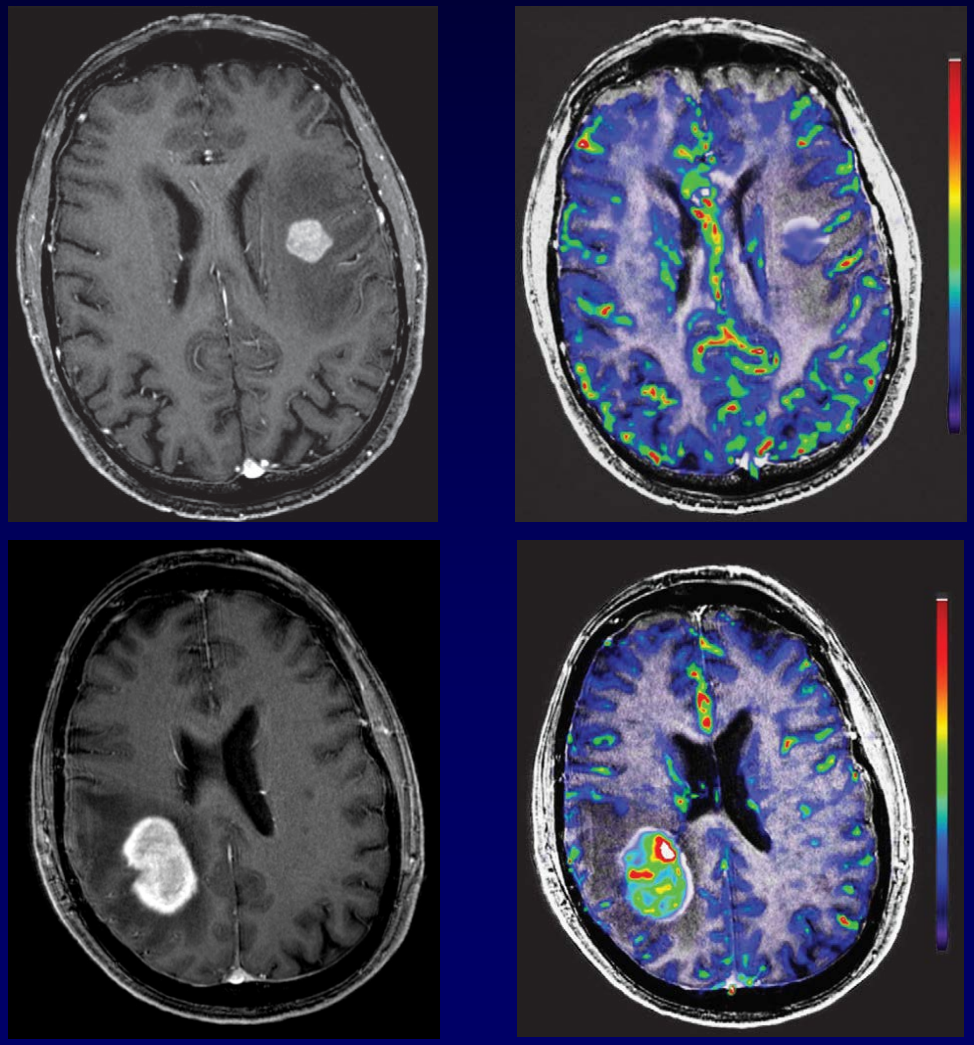
PCNSL: High k_{trans}
Severe Damage of BBB



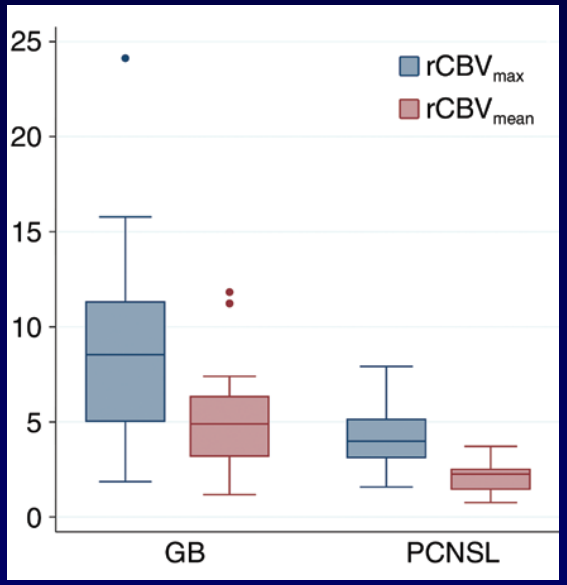
GBM: Lower k_{trans}
moderate damage of BBB

Kickingereder P, et al. *AJNR Am J Neuroradiol.* 2014;35(8):1503-1508.

DSC-Perfusion: PCNSL vs GBM



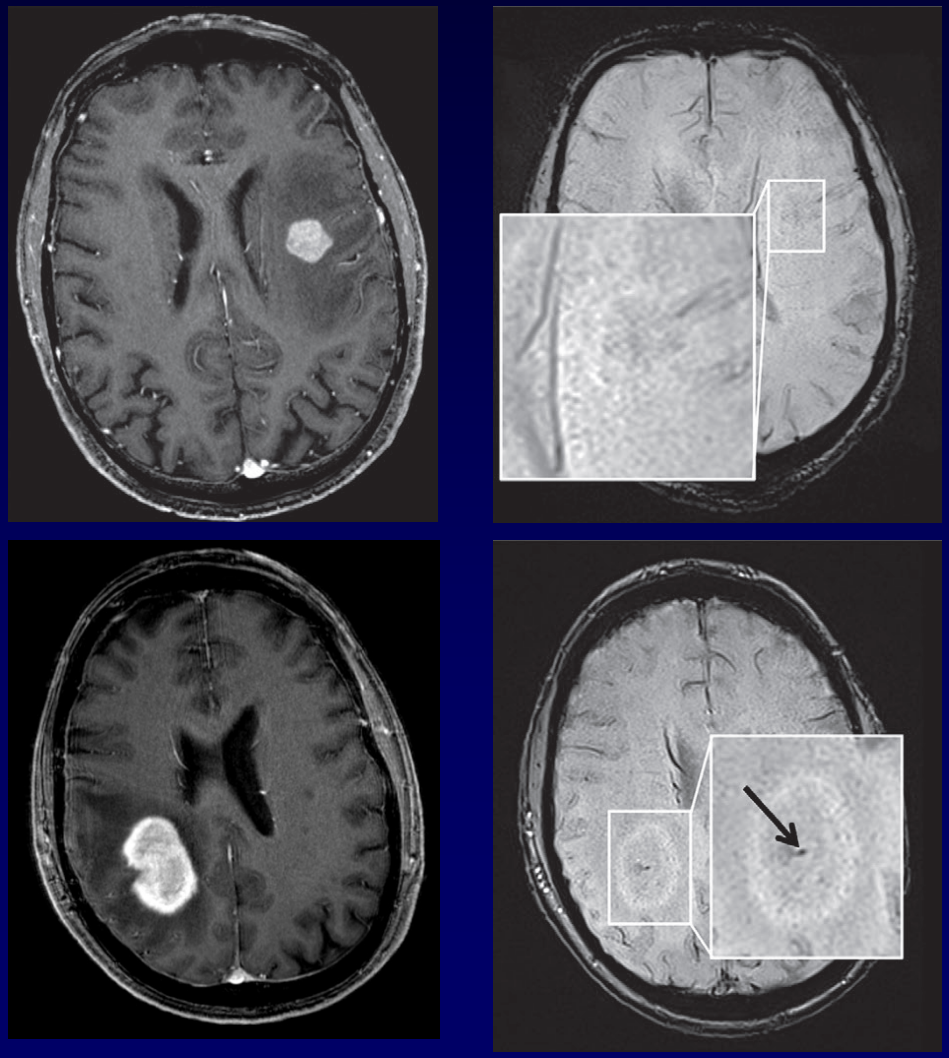
PCNSL: low CBV
low vascularity



GBM: high CBV
high vascularity

Kickingereder P, et al. *AJNR Am J Neuroradiol.* 2014;35(8):1503-1508.

DSC-Perfusion: PCNSL vs GBM



PCNSL

PCNSL: No microbleeds
GBM: microbleeds

GBM

Kickingereder P, et al. *AJNR Am J Neuroradiol.* 2014;35(8):1503-1508.

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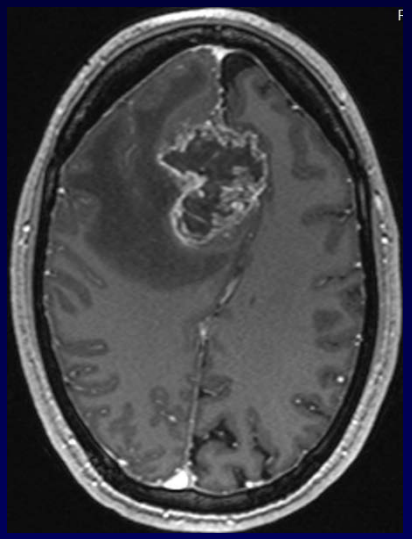
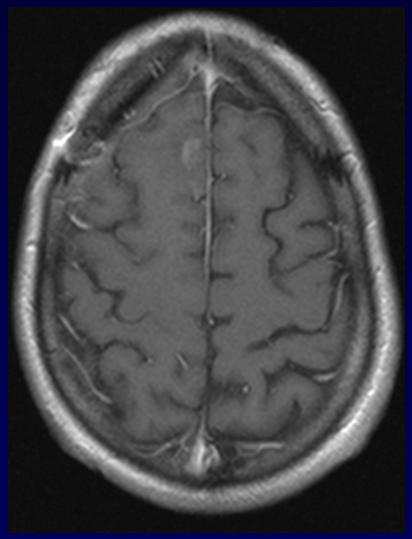
3. Identification of pseudoregression / T2-progress

Pseudoprogression

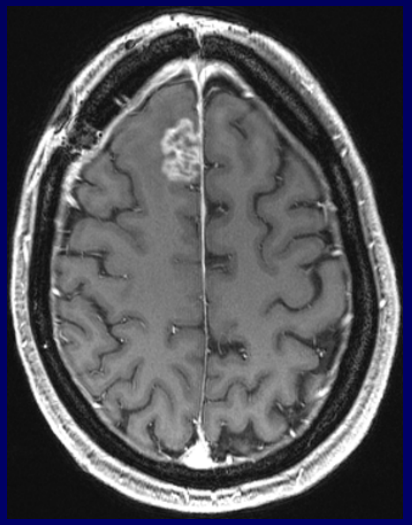
Pre-OP

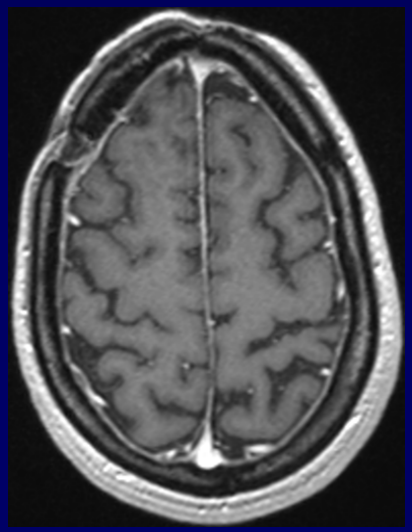




Post-OP

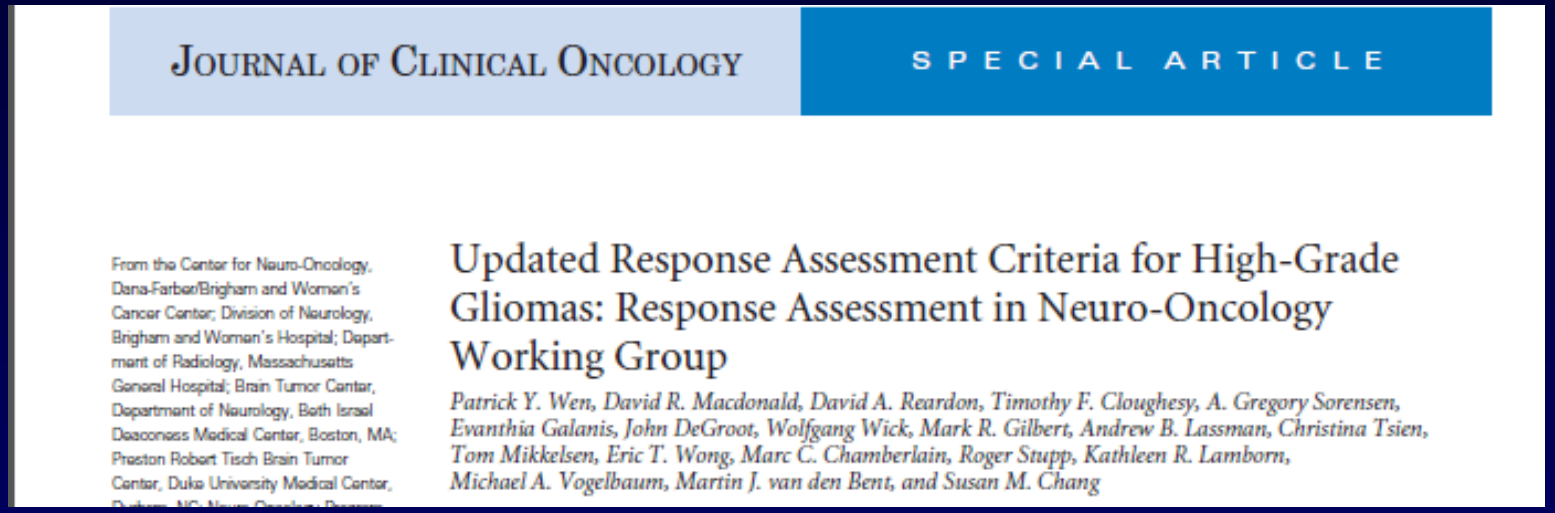
3 months post-OP (standard RCT)





6 months post-OP

RANO-Criteria



JOURNAL OF CLINICAL ONCOLOGY

SPECIAL ARTICLE

From the Center for Neuro-Oncology, Dana-Farber/Brigham and Women's Cancer Center; Division of Neurology, Brigham and Women's Hospital; Department of Radiology, Massachusetts General Hospital; Brain Tumor Center, Department of Neurology, Beth Israel Deaconess Medical Center, Boston, MA; Preston Robert Tisch Brain Tumor Center, Duke University Medical Center,

Updated Response Assessment Criteria for High-Grade Gliomas: Response Assessment in Neuro-Oncology Working Group

Patrick Y. Wen, David R. Macdonald, David A. Reardon, Timothy F. Cloughesy, A. Gregory Sorensen, Evanthia Galanis, John DeGroot, Wolfgang Wick, Mark R. Gilbert, Andrew B. Lassman, Christina Tsien, Tom Mikkelsen, Eric T. Wong, Marc C. Chamberlain, Roger Stupp, Kathleen R. Lamborn, Michael A. Vogelbaum, Martin J. van den Bent, and Susan M. Chang

"within the first 12 weeks of completion of radiotherapy, progression can only be determined, if the majority of the new enhancement is outside of the radiation field"

Danger: Delay of the necessary change of therapy in the most aggressive tumors, that recurr early

Differentiation with Diffusion and DSC Perfusion

Hypothesis Diffusion	Hypothesis DSC Perfusion
• **True Progression:** Increased Cellularity – Decreased ADC	• **True Progression:** Increased vascularity – Increased CBV
• **Pseudoprogression:** Decreased Cellularity – increased ADC	• **Pseudoprogression:** decreased vascularity – decreased CBV

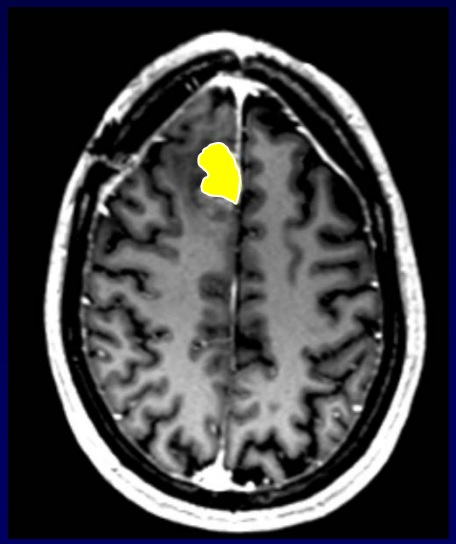
Challenge: Postprocessing

Parametric Response Maps:

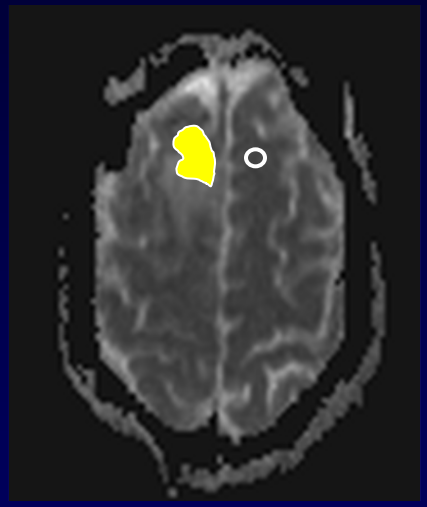
- Region of Interest Analysis does not reflect the heterogeneity of GBM
- Parametric Response Maps*: Voxelwise analysis of changes in ADC/CBV values

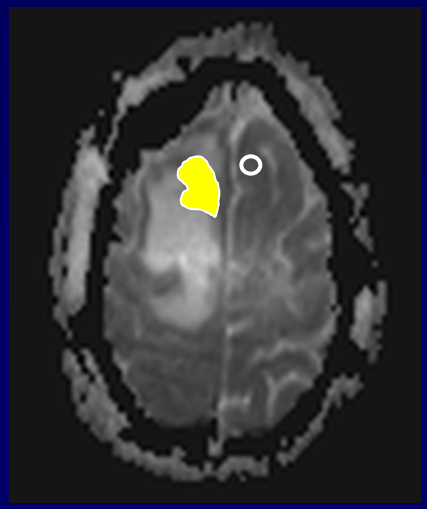
*Galban CJ, et al. *Nat Med*. 2009;15(5): 572–576.

Workflow: 1. Step



new enhancement at
3 months





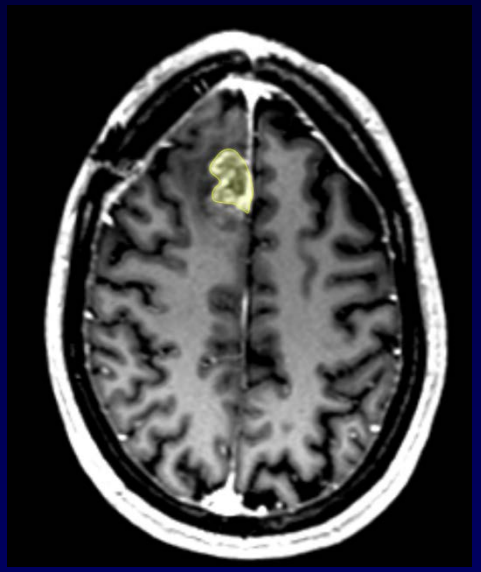
3 months ADC

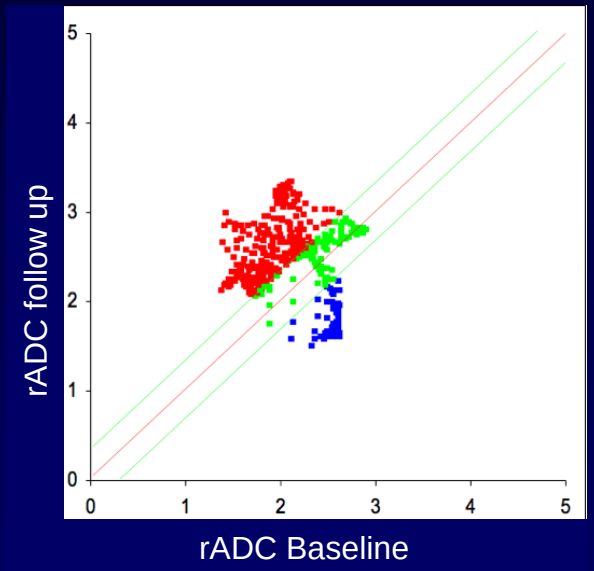
1. ROI delineated on ce-T1 follow up

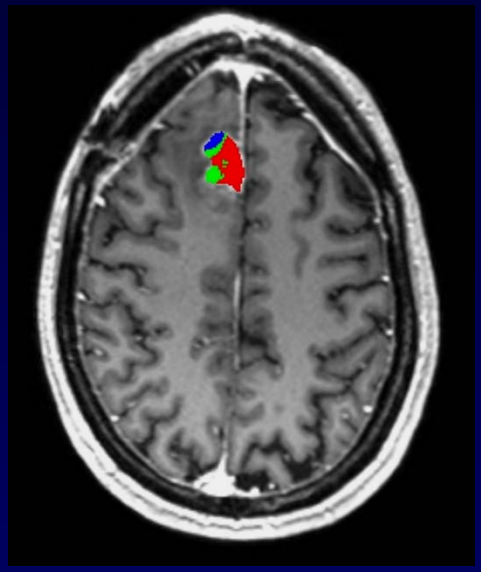
2. coregistration and transfer of ROI to ADC baseline and ADC f/u

3. calculation of rADC values by division of ROI with contralateral reference-ROI

Workflow: 2. Step







Voxelwise Subtraction of rADC values at baseline and follow up, presentation with scatter plott

Visualization on follow up ce-T1

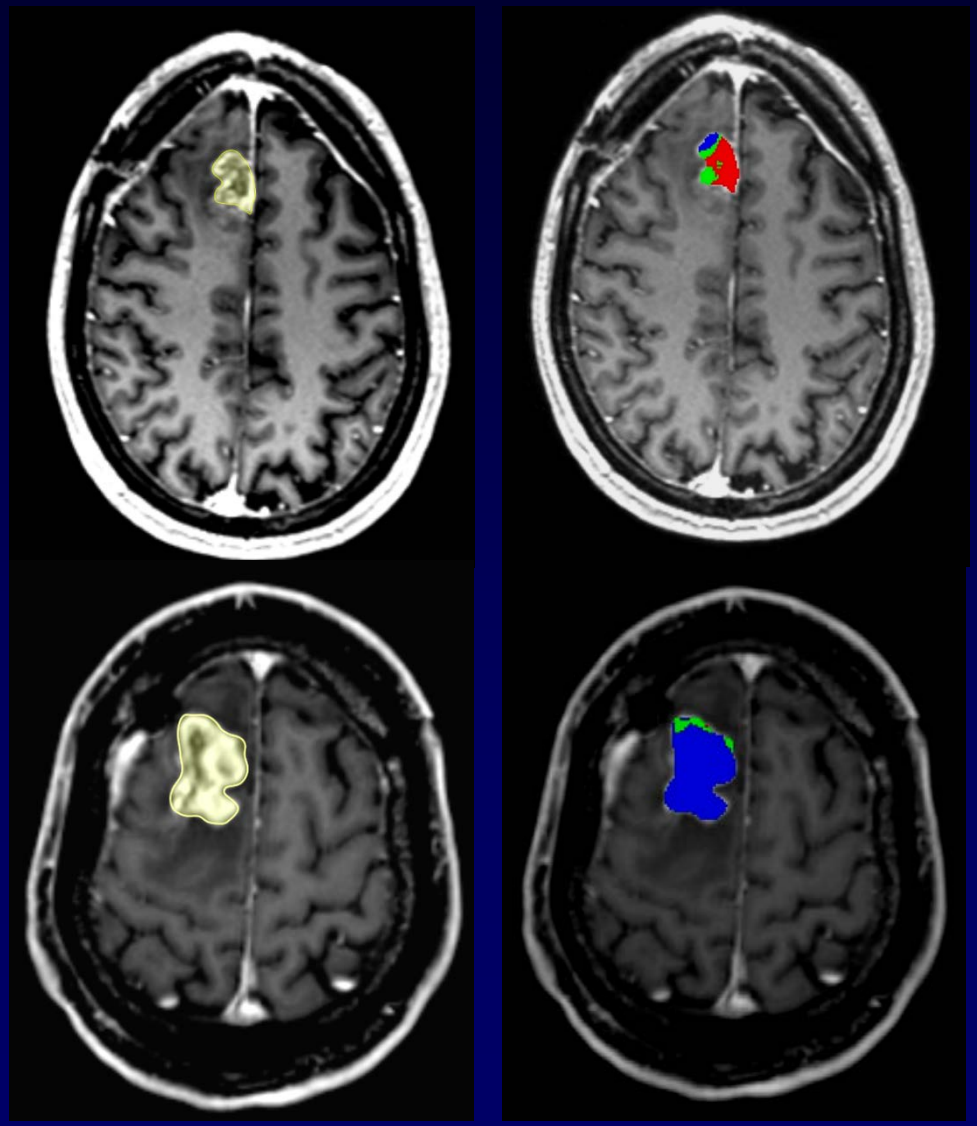
Quantification of voxels
1) rADC (baseline) – rADC (follow up) > 0.25
2) rADC (baseline) – rADC (follow up) < -0.25

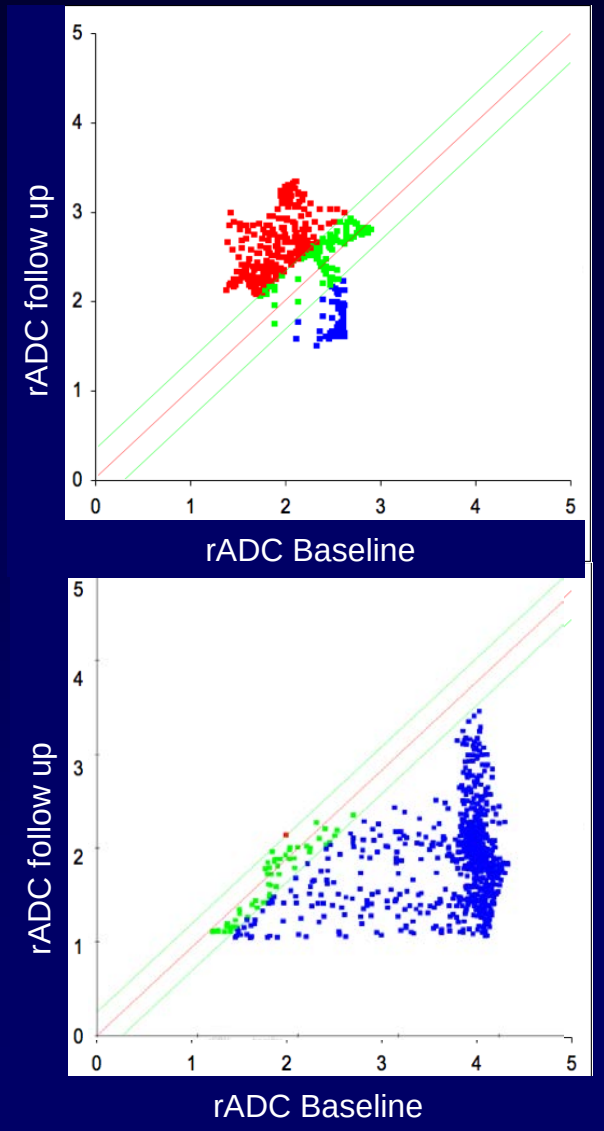
(Decrease of rADC)

(Increase of rADC)

Example: Pseudo-progression

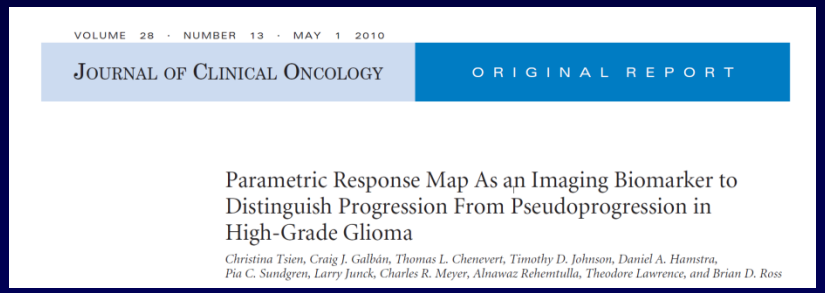
Example: True Progression





Radbruch A, et al. Presented at the 99th Scientific Assembly and Annual Meeting of the Radiological Society of North America. Chicago, Illinois, United States. December 1-6, 2013. Abstract SSM15-02.

Parametric Response Maps for DSC-Perfusion

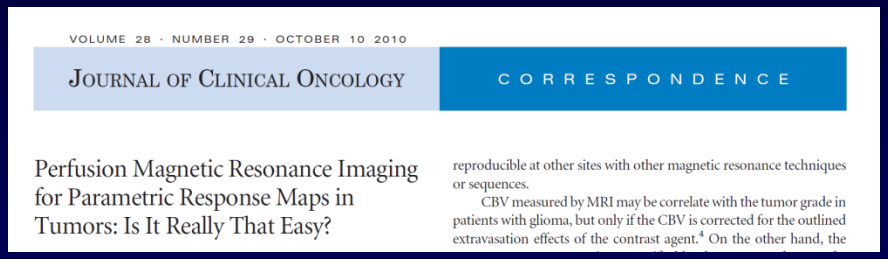


VOLUME 28 · NUMBER 13 · MAY 1 2010

JOURNAL OF CLINICAL ONCOLOGY | ORIGINAL REPORT

Parametric Response Map As an Imaging Biomarker to Distinguish Progression From Pseudoprogression in High-Grade Glioma

Christina Tsien, Craig J. Galbán, Thomas L. Chenevert, Timothy D. Johnson, Daniel A. Hamstra, Pia C. Sundgren, Larry Junck, Charles R. Meyer, Alnawaz Rehemtulla, Theodore Lawrence, and Brian D. Ross



VOLUME 28 · NUMBER 29 · OCTOBER 10 2010

JOURNAL OF CLINICAL ONCOLOGY | CORRESPONDENCE

Perfusion Magnetic Resonance Imaging for Parametric Response Maps in Tumors: Is It Really That Easy?

reproducible at other sites with other magnetic resonance techniques or sequences.

CBV measured by MRI may be correlate with the tumor grade in patients with glioma, but only if the CBV is corrected for the outlined extravasation effects of the contrast agent.[4] On the other hand, the

Findings:

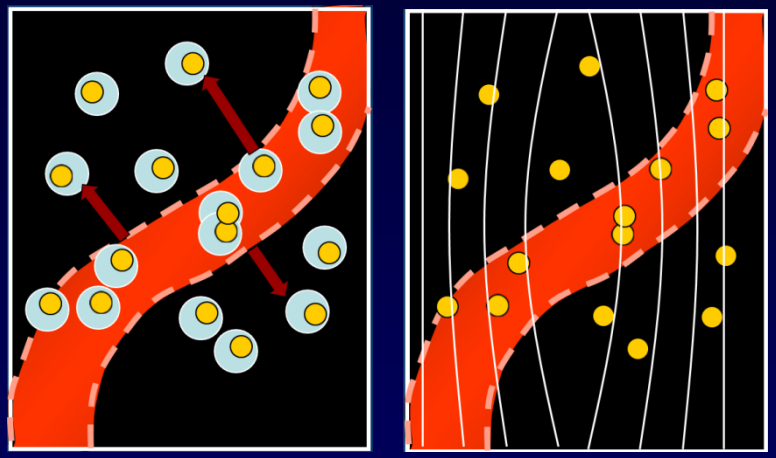
- Decreased CBV – True Progression;
- Increased CBV - Pseudoprogression

?

Comment by Heiland et al:

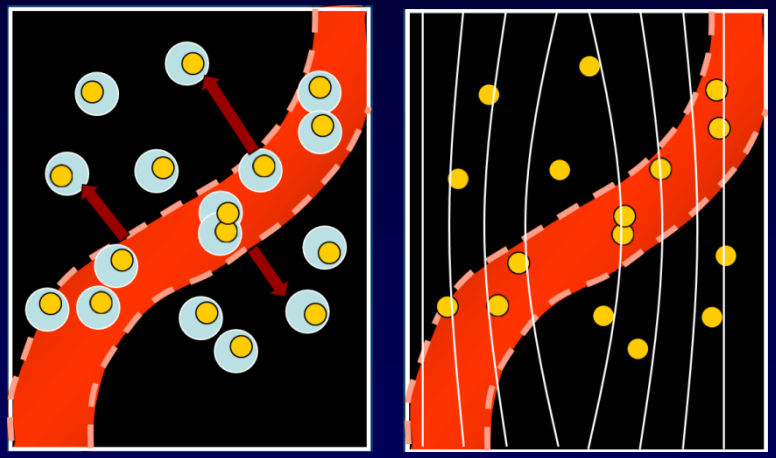
- Correction techniques are needed for DSC Perfusion in case of a disrupted BBB
- Otherwise: Underestimation of CBV

Underestimation of CBV



- T1 and T2* effects are antagonistic
- If DCE is perfomed prior to DSC Perfusion – Interstitium is saturated
- Otherwise preload of contrast agent is needed prior to DSC Perfusion

Underestimation of CBV



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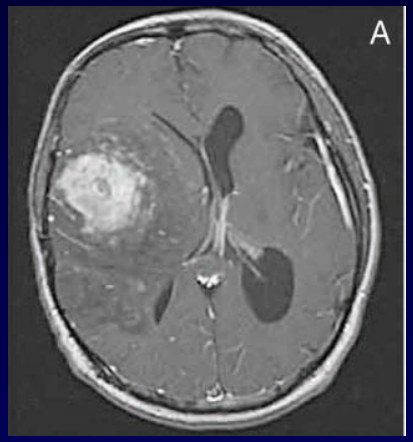
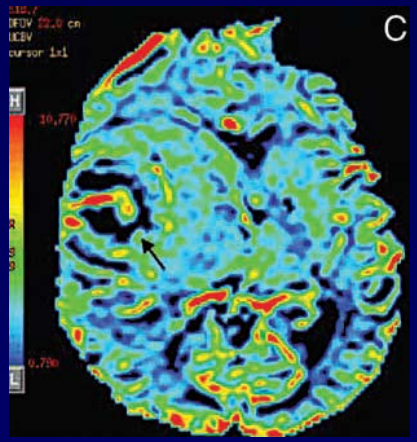
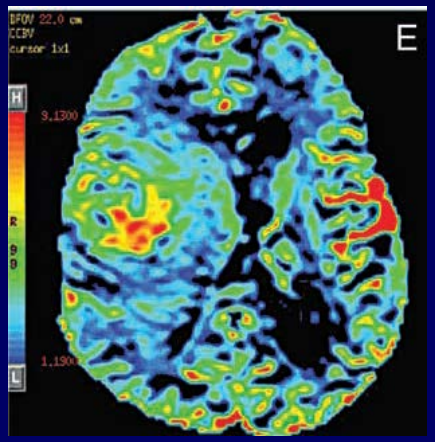




Without correction techniques



With correction technique

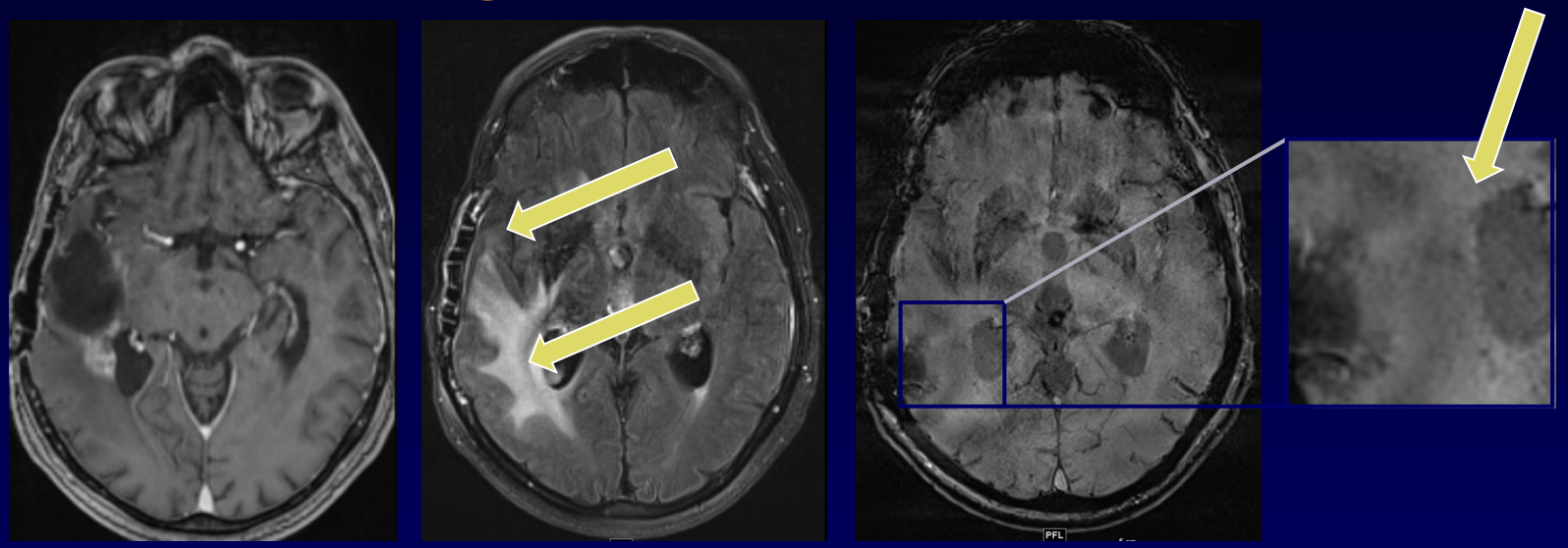
Covarrubias, Rosen, Lev; The Oncologist 2004;9:528-537
"Dynamic Magnetic Resonance Perfusion Imaging of Brain Tumors"

Advanced imaging techniques for…

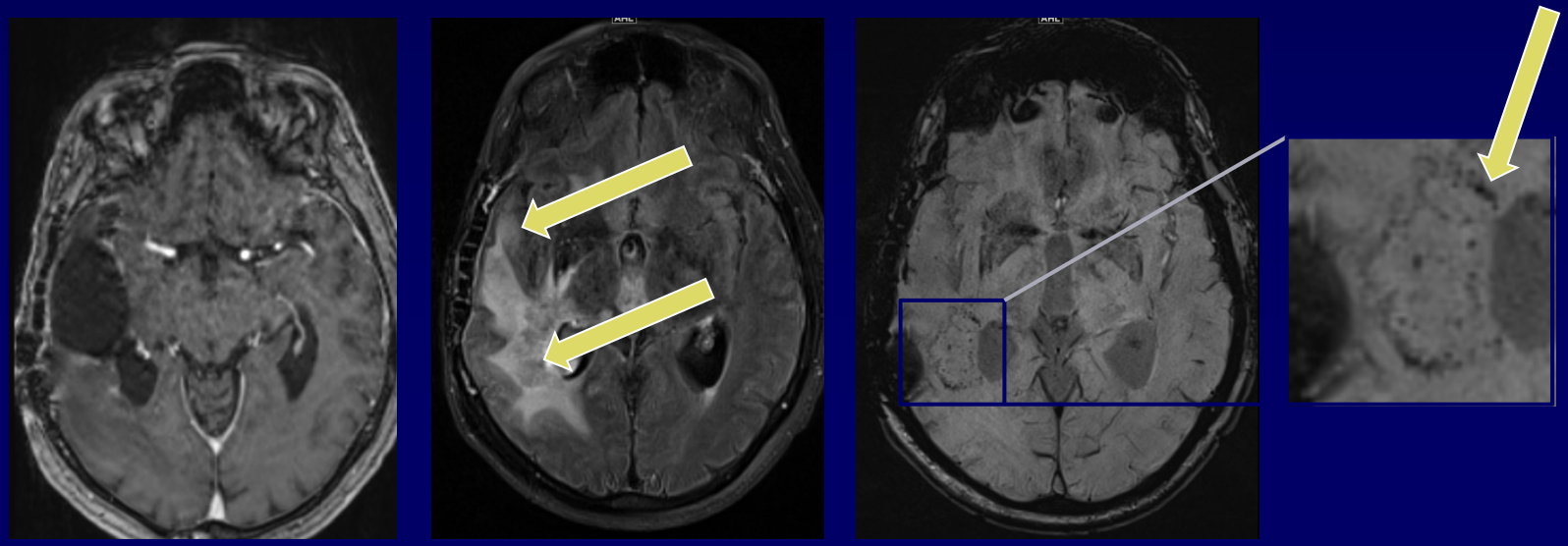
1. Differential diagnosis
2. Identification of pseudoprogression
3. Identification of pseudoregression / T2-progress

Pseudoregression and SWI

Baseline: Start of Bevacizumab



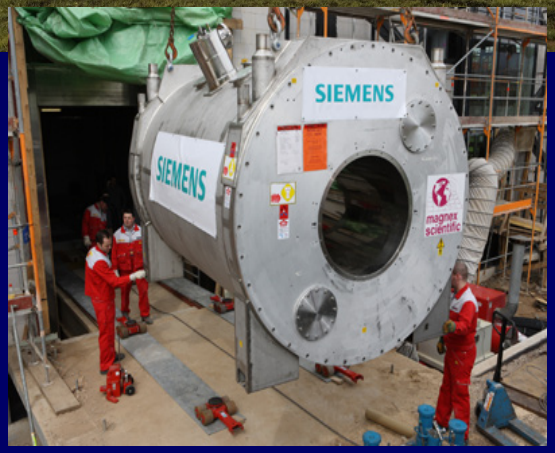
Follow up 3 months later:

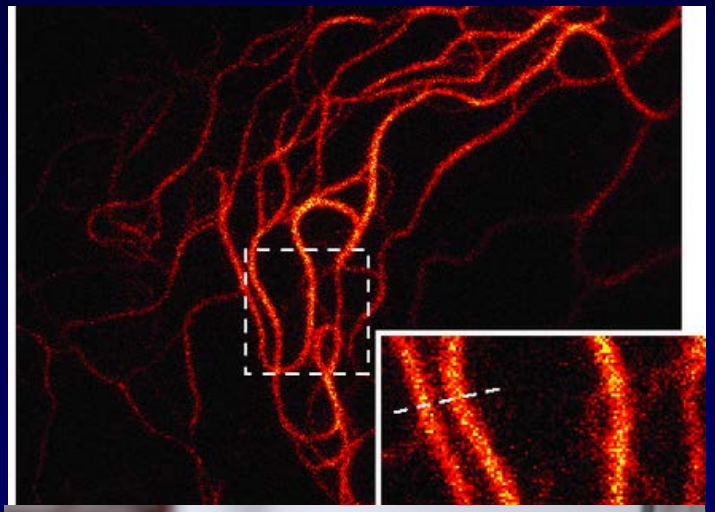


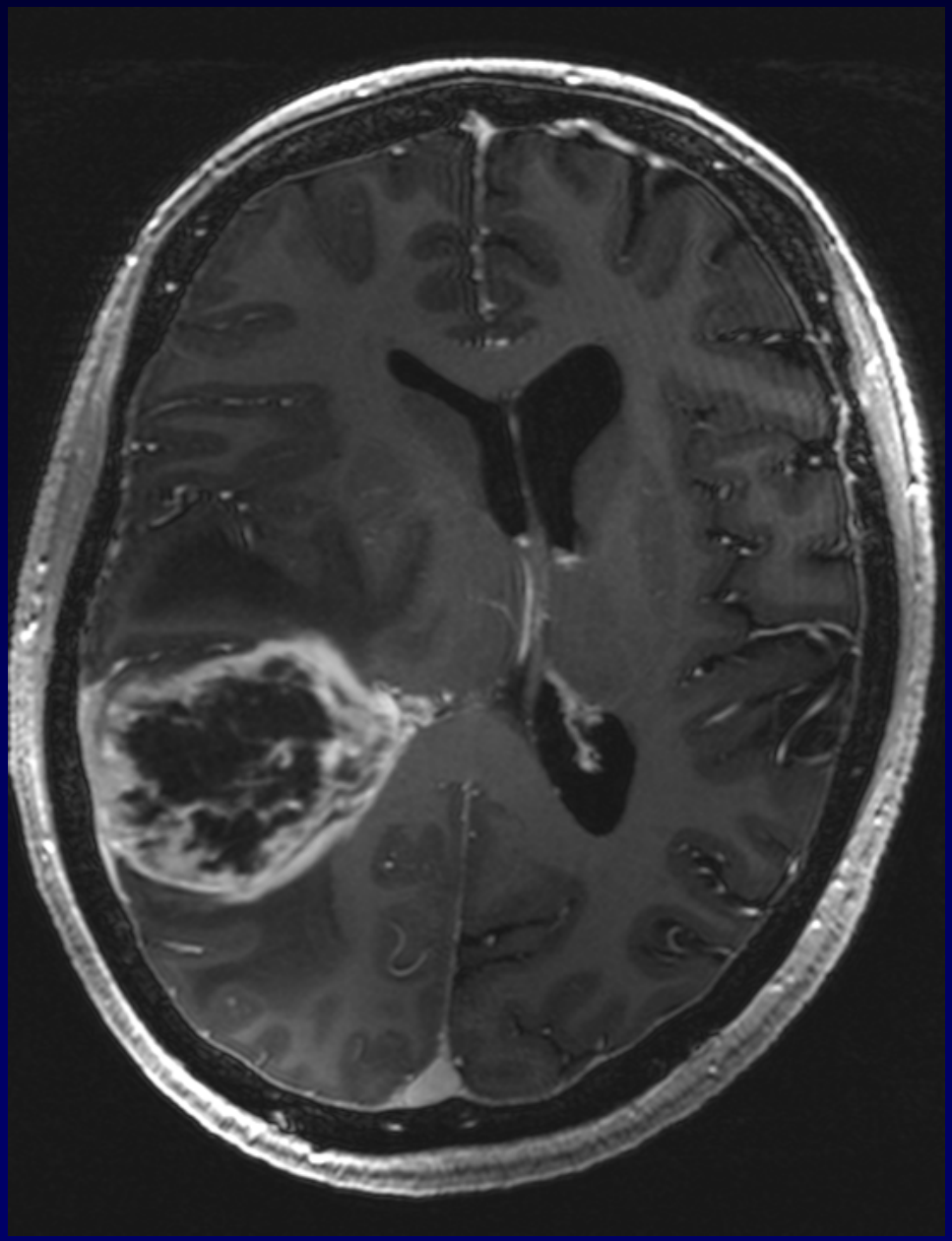
Radbruch A, et al. Presented at the American Society of Neuroradiology 50th Anniversary Meeting. New York, New York, United States. April 21-26, 2012. Abstract: eP-86.

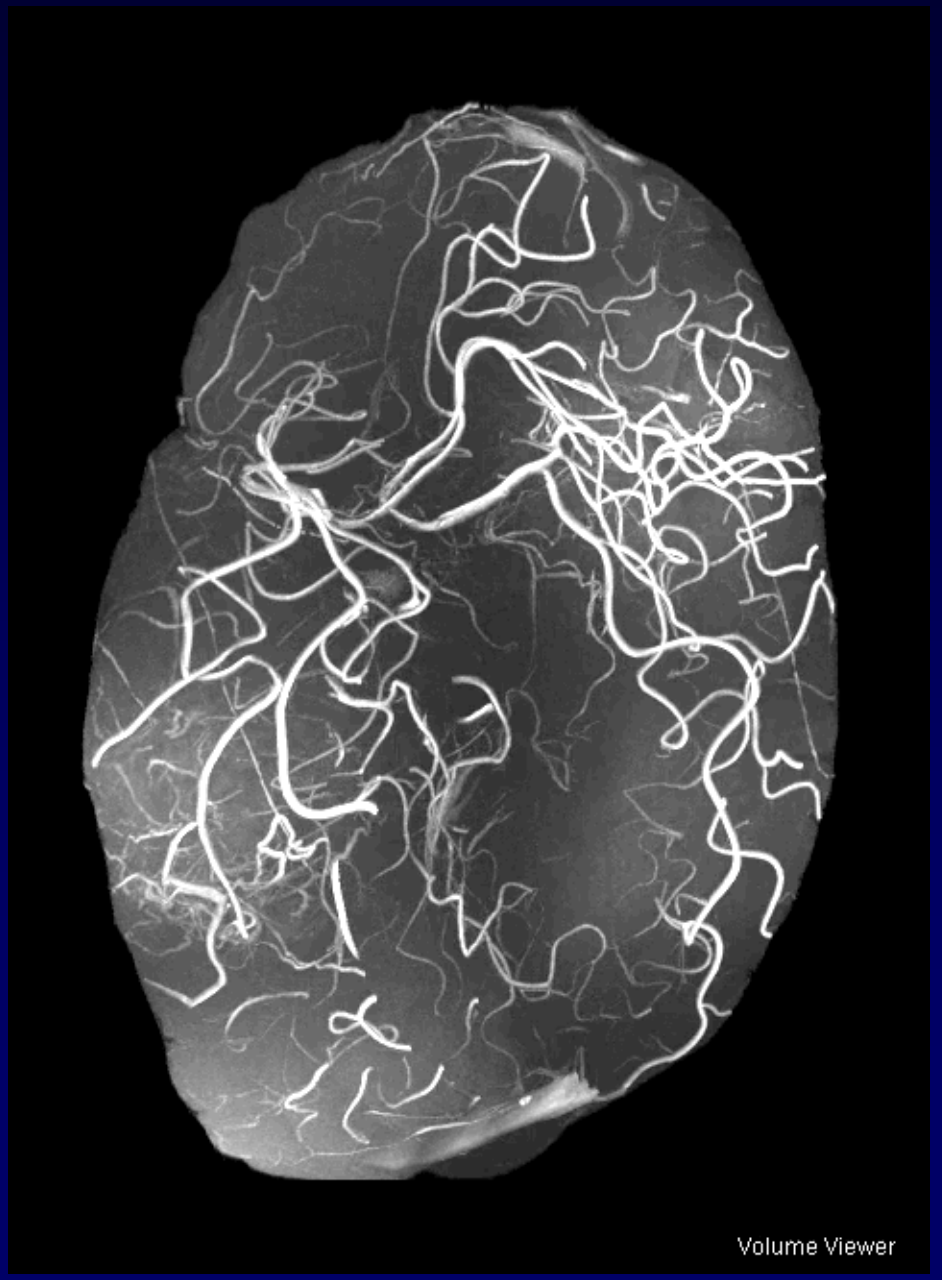

What is on the horizon?

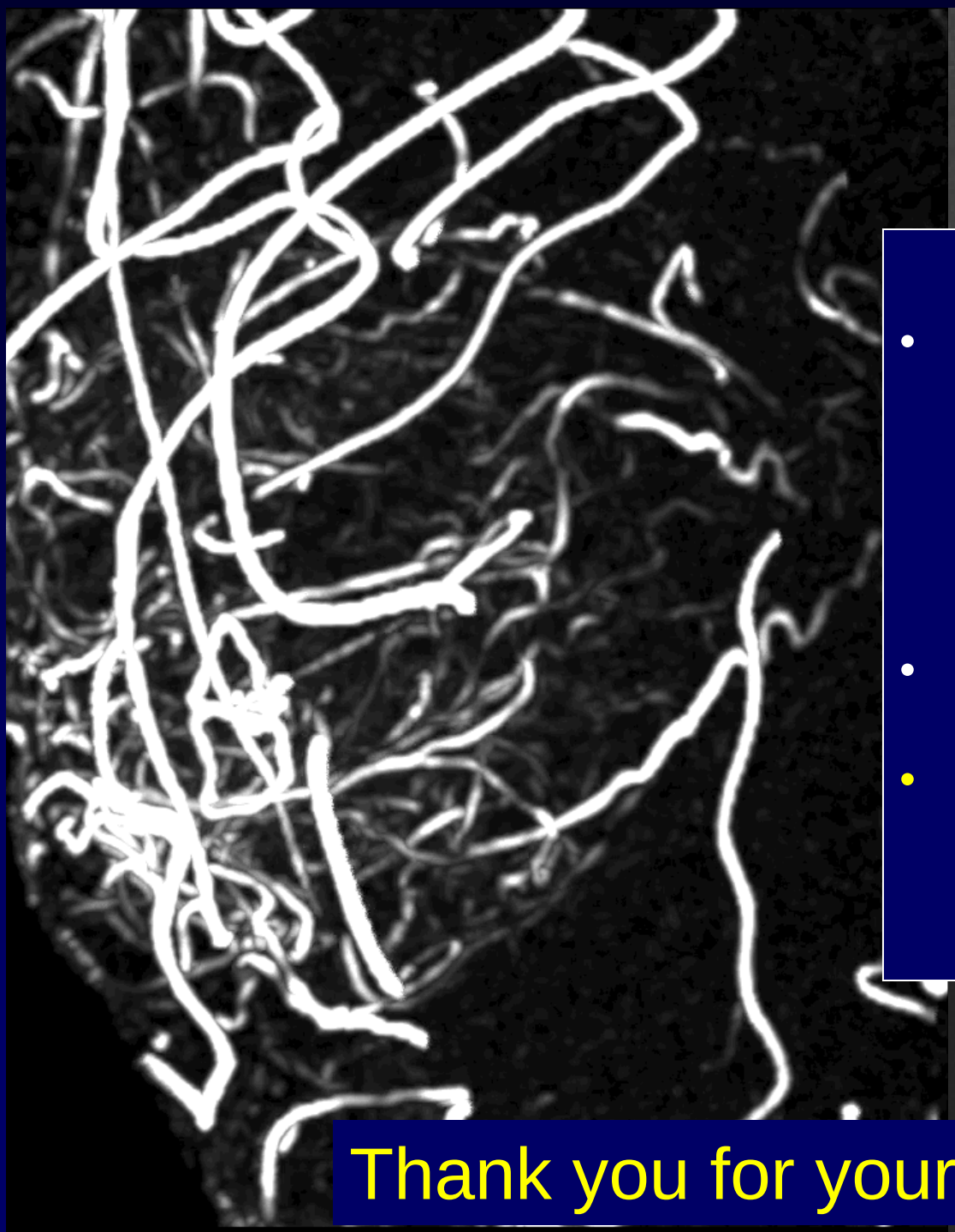
Increased spatial Resolution: 7 Tesla








Volume Viewer



Conclusion

- Advanced imaging techniques
  - improve differential diagnosis of GBM
  - improve identification of pseudoprogression/ pseudoregression
- Multiparametric approach is essential
- Standardization of Imaging parameters and multicenter studies are urgently needed

Thank you for your attention!