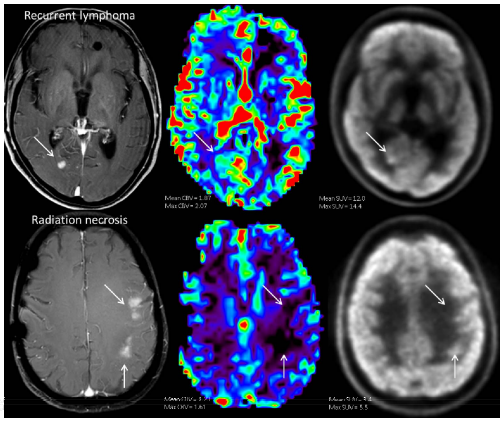
# COMBINED FUNCTIONAL AND METABOLIC ASSESSMENT OF BRAIN TUMORS USING HYBRID MR-PET IMAGING

Beatrice Sacconi[1], Roy Raad[2], Joon Lee[3], Howard Fine[4], John Golfinos[5], Girish Manokar Fatterpekar[6], Fernando Boada[7], Kent Friedman[3], James Babb[3], and Rajan Jain[3]
*[1]Radiological, Oncological and Anatomopathological Sciences, Sapienza University of Rome, Policlinico Umberto I, Rome, Rome, Italy, [2]Radiology, NYU School of medicine, New York, New York, United States, [3]Radiology, NYU School of Medicine, New York, New York, United States, [4]Neuro-oncology, NYU Langone Medical Center, New York, New York, United States, [5]Neurosurgery, NYU Langone Medical Center, New York, New York, United States, [6]Radiology, NYU Langone Medical Center, New York, New York, United States, [7]Neurosurgery, Psichiatry and Radiology, NYU Langone Medical Center, New York, New York, United States*

**Purpose:** To retrospectively analyze functional MR perfusion and FDG uptake data obtained from hybrid MR-PET imaging in patients with brain tumors. We assessed the diagnostic accuracy of concurrently acquired perfusion parametric maps and FDG uptake in diagnosing treatment naive low and high-grade gliomas and also differentiating tumor progression from treatment/radiation induced necrosis in brain tumor patients after chemo-radiation therapy.

**Materials and Methods:** Twenty patients (11 F, 9 M; average age 49.3 years, range 14-74) underwent hybrid MR-PET as part of the brain tumor imaging assessment between January 2014 and October 2014. Nine patients had MR-PET assessment for 16 treatment naïve neoplastic lesions, whereas 11 patients who have been treated in the past for various brain neoplasms were assessed for 18 distinct lesions. At the time of the exam, information about clinical status, surgery and other previous therapies were available for all the patients. PET/MR imaging was performed using an integrated MR-PET system (Biograph mMR; Siemens Healthcare), which acquires simultaneous PET and MR data with a 3.0-T magnet. Patients were injected with 10 mCi of 18F fluoro-deoxyglucose (FDG). A T1-weighted Dixon gradient-echo sequence was acquired first for attenuation correction and generation of an attenuation map. PET images were acquired in list mode for 60 minutes. MR imaging included routine pre and post contrast imaging sequences following injection of 0.1 mmol/kg of body weight dose of gadobutrol including DSC T2* sequence with contrast agent bolus injection (single-shot echo planar imaging sequence; TE 30 ms; flip angle, 45 degrees, image matrix, 64x64; field of view, 24 cm; slice thickness, 4 mm). Perfusion parametric maps were generated using leakage correction and commercially available software (OLEA Sphere Stroke diagnosis suite, Olea medical Solutions, Cambridge, MA). FDG uptake analysis was performed using MiM 6.4 fusion viewer, MiM Software, Cleveland, Ohio. All the ROIs were drawn on perfusion parametric maps and FDG maps fused with post contrast T1 weighted images. Free hand drawn ROIs included the solid enhancing component of the tumor, excluding necrosis or overlying vessels. ROIS were drawn using FLAIR images fused with above maps in non-enhancing lesions. For PWI analysis, mean and maximum CBV values within each slice were recorded and mean and maximum ratios were calculated in relation to normal appearing white matter values. For PET analysis, early FDG uptake values were recorded as mean and maximum values. Both readers were then blinded to the images and location of the lesions, and attempted to predict the histologic grade of treatment-naïve tumors and the likelihood of tumor recurrence versus radiation necrosis in the post-treatment group based solely on PWI and PET numerical data. The final diagnosis for each lesion was then cross-referenced to histopathology results when available (7 patients, 12 lesions) or clinical and imaging follow-up (8 patients, 17 lesions). Logistic regression for correlated data was used to assess and compare modalities (PWI, PET) in terms of accuracy for the detection of low grade tumors within treatment naïve patients and radiation necrosis for lesions within treated patients. Pearson correlations were used to characterize the association of max CBV with max FDG uptake. All statistical tests were conducted at the two-sided 5% significance level using SAS 9.3 software (SAS Institute, Cary, NC).




**Results:** Diagnostic accuracy using MR perfusion was 90% and 94.1% in the treatment naïve (p=0.056) and post-treatment groups (p=0.033) respectively, compared with 40% and 55.6% for FDG-PET. High-grade tumors showed higher rCBVmax (3.80 vs 2.54) as compared to low-grade tumors (p=0.042). In the post-treatment group, recurrent tumors had higher rCBVmax (3.99 versus 2.92) as compared to treatment/radiation induced necrosis (p=0.165). Mean SUVmax values were 7.71 for high-grade tumors and 5.13 for low-grade tumors (p=0.012), 8.51 for recurrent tumors and 5.16 for treatment/radiation induced necrosis (p=0.001) (Fig 1). However, there was poor correlation between rCBV and FDG-SUV in treatment naïve lesions (r = 0.22; p = 0.403), in post-treatment lesion groups (r = 0.02; p=0.942) as well as in the entire patient population (r = 0.13; p=0.482).

**Discussion:** Our study demonstrated that there is no significant correlation between metabolic (FDG-SUV) and functional (perfusion rCBV) parameters in brain tumor patients. Only a few studies have previously reported their experience on this topic, with quite discordant results, probably due to the different image analysis. We obtained data using hybrid concurrent MR-PET acquisition and used fused images for outlining lesions for both PWI and PET image analysis, however, obtaining results that are in discordance with the work of Fills et al (1), which is the most recent and the one with a large patient population. Low accuracy of PET observed in our study could be accounted for by the lack of a specific numerical SUV cut-off value used for characterizing lesions as high versus low-grade, or recurrent tumor versus radiation necrosis, and hence necessitating the need to subjectively assess lesions comparing them to background gray and white matter activity. Larger studies are therefore needed to further assess the value of this promising novel hybrid imaging modality.

**Conclusion:** Our work demonstrates feasibility of obtaining both functional/perfusion and metabolic assessment of brain tumors and usefulness of interpreting the results in conjunction. These two techniques likely provide complementary information about tumor biology and hence, helping provide an improved powerful imaging tool. PWI demonstrated better diagnostic accuracy in differentiating low from high-grade tumors in the treatment naïve group, similar to the performance in differentiating recurrent tumor from treatment/radiation induced necrosis in the post-treatment group.

**References:**

1. Filss CP et al. The Journal of Nuclear Medicine 2014; 55:540-545. 2. Dhermain FG, et al. Lancet Neurol 2010; 9: 906–20.
3. Zukotynski KA, et al. J Nucl Med. 2013; 54:1237-1243. 4. Ozsunar Y, et al. Acad Radiol 2010; 17:282–290.