Response Assessment of Cerebral Metastases After High-Dose Stereotactic Radiation: Using Combined Diffusion and Perfusion MR Imaging

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Purpose:

In the evaluation of cerebral metastases treated with radiation, accurate assessment of treatment response versus pseudoprogression or radiation necrosis can be challenging on conventional imaging. The purpose of this study was to assess whether multiparametric MR perfusion and diffusion biomarkers can predict response to radiation treatment in cerebral metastases.

Materials and Methods:

Inclusion criteria for this retrospective study were: cerebral metastases that were treated with radiation, availability of multiparametric MRI including MR diffusion and dynamic susceptibility contrast (DSC) before the start of radiation and at least on two subsequent follow-up imaging studies. Image analysis was performed using FDA approved software (Olea Medical). Volumetric analysis of lesion volume was performed based on the signal intensity subsuming the entire region of enhancement on T1 postcontrast images. Dynamic susceptibility contrast studies were processed using Bayesian probabilistic method (1) to generate CBV maps. Using coregistered images, voxel-based ADC and rCBV values were obtained in the enhancing lesions. Disease progression was defined as an increase in lesion volume >40% over baseline pretreatment volume (2). Sequential follow-up rCBV and ADC values were scored to assess the fit with expected patterns of favorable response (rCBV: Steady decrease or increase followed by decrease; ADC: Increase or stable) or nonfavorable response (rCBV: Steady increase or decrease followed by increase; ADC: Decrease) (3). Pretreatment and follow-up values were assessed for significant differences using t-test and scores were assessed for diagnostic correlation using Fisher's exact test.

Results:

Fifteen cerebral metastases were included with a total of 60 MRI scans evaluated in this longitudinal study. The

mean follow up was 7.8 months after initial scan (range: 2.4 to 13.9). Twelve lesions (80%) remained stable or regressed after radiation as determined by lesion volume. The mean ± SD of imaging biomarkers in pretreatment scans versus sequential follow-up studies were: 1070 ± 325 versus 1227 ± 316 (10^-6 mm^2/s) for ADC (p=0.34); and 3.9 ± 5.1 versus 2.4 ± 2.0 for rCBV (p=0.37). Longitudinal follow-up MRI analysis demonstrated a progressive increase in ADC and a progressive decline in rCBV values compared to pretreatment scans (Figures 1 and 2). Using sequential ADC and rCBV scored values, expected response patterns matched volume-based response assessment in eleven (92%, p=0.37) and ten (83%, p=0.52) responding lesions, respectively. In subanalysis of the group with favorable biomarker response, five lesions (50%) showed an interesting trend of early rCBV increase followed by a gradual decline. It is plausible that the initial increase in perfusion can further accentuate the effect of radiation in this group.

Conclusions:

Multiparametric MR diffusion and perfusion can be used in the characterization of postradiation changes in patients with cerebral metastases. Longitudinal analysis of combined rCBV and ADC can be used to predict postradiation treatment response independent of morphological changes on conventional imaging.

Awards:

Trainee Award

Categories:

ADULT BRAIN, Neoplasms

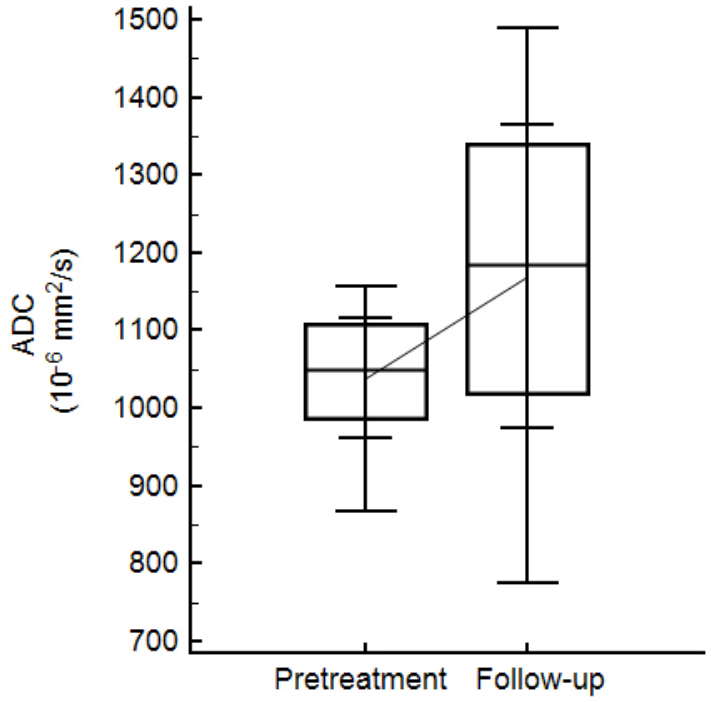

Figure 1. ADC values of lesions which responded to treatment. Follow-up values demonstrated an elevated ADC, which may signify an expected decrease in lesion cellularity.

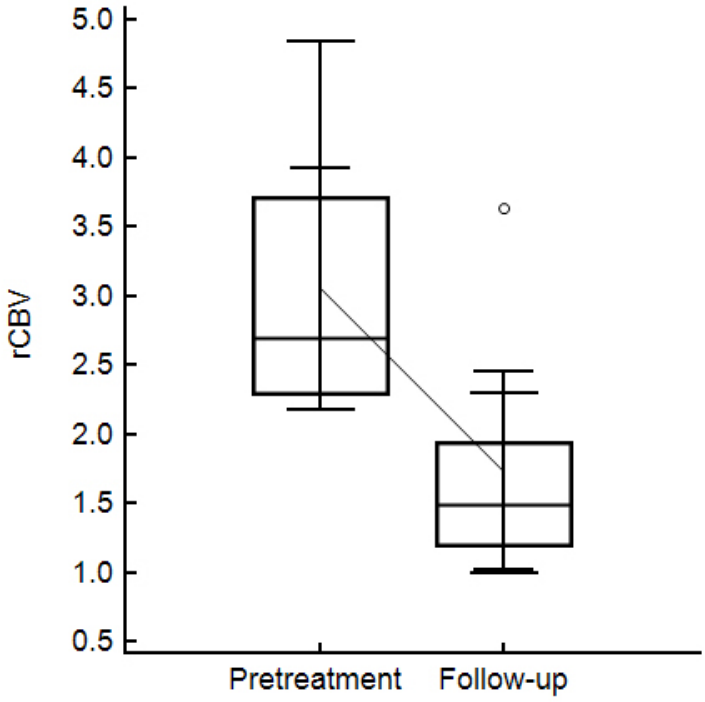

Figure 2. rCBV values of lesions which responded to treatment. Follow-up values demonstrated a decrease in rCBV, which may signify an expected decrease in lesion vascularity.

(https://ww4.aievolution.com/asn1501/files/content/abstracts/abs_2126/abstractfigureFINALVERSION.jpg)

Reference One:

Nael, K. et al. Bayesian Estimation of Cerebral Perfusion Using Reduced-Contrast-Dose Dynamic Susceptibility Contrast Perfusion at 3T. AJNR Am J Neuroradiol 2014 Dec 4. [Epub ahead of print]

Reference Two:

Tran, L.N. et al. Comparison of treatment response classifications between unidimensional, bidimensional, and volumetric measurements of metastatic lung lesions on chest computed tomography. Academic Radiology 2004:11:1355–60.

Reference Three:

Provenzale, J.M. et al. Diffusion-weighted and perfusion MR imaging for brain tumor characterization and assessment of treatment response. Radiology 2006:239:632–49.