Differentiation of Recurrent Intra-Axial Metastatic Tumor from Delayed Radiation Effects of Gama Knife Radiosurgery Using Dynamic Susceptibility Weighted Contrast Enhanced Perfusion MR Imaging

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Abstract:

Background and Purpose: Differentiation of tumor recurrence from the effects of gamma knife radiosurgery in newly appearing contrast enhancing lesions arising from sites previously treated for intra-axial metastatic neoplasms is often difficult. The purpose of our study was to determine whether relative cerebral blood volume (rCBV), relative peak height (rPH), and percentage of signal intensity recovery (PSR) derived from dynamic susceptibility weighted contrast enhanced (DSC) perfusion MR imaging can differentiate recurrent tumor from the delayed effects of gamma knife radiosurgery.

Materials and Methods: Thirty four cases of histologically proven recurrent tumor (n=23) and radiation effect (n=11) were retrospectively studied using anatomical and DSC perfusion MR imaging on the basis of the following criteria: previous treatment with gamma knife radiosurgery following surgical resection of metastatic intra-axial tumor; subsequent new development of enhancement within radiation field and anatomical MRI findings consistent with tumor recurrence. Regions of interest were drawn around the entire contrast-enhancing region. Resulting T2* signal intensity-time curves were interrogated to produce three hemodynamic variables (rCBV, rPH, and PSR) for each case. A univariate analysis utilizing two sample Welch T test was used to compare mean values between the two groups. $P < 0.05$ was considered statistically significant.

Results:

TABLE 1: Relative cerebral blood volume, relative peak height, and percentage of signal intensity recovery in contrast enhancing region.

Final Diagnosis	Maximum rCBV	Mean rCBV	Maximum rPH	Mean rPH	Minimum PSR	Mean PSR
Recurrent Tumor	3.46 (2.19)	2.38 (0.95)	1.65 (1.32)	1.58 (0.55)	51.98 (12.76)	60.64 (9.95)
Radiation Effect	2.04 (1.29)	1.54 (0.92)	1.1 (1.03)	1.03 (0.49)	79.25 (6.98)	83.33 (3.59)
Welch *P* value (95%CI)	<0.01 (-2.95,-0.49)	0.024 (-1.56,-0.12)	<0.01 (-0.94,-0.14)	<0.01 (-0.94,-0.16)	<0.01 (20.35,34.19)	<0.01 (17.75,27.63)

Note: All data presented in mean values with (standard deviation). CI 95%= 95% confidence interval of t statistic value.

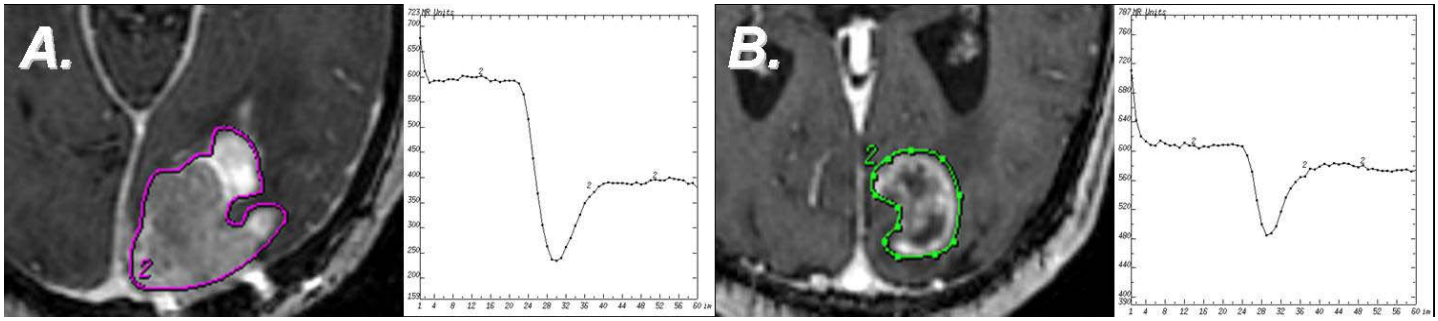

Figure 1: Transverse contrast-enhanced SPGR T1-weighted images (left) and T2* derived signal intensity time curves (right) show a statistically significant difference in rCBV, rPH, and PSR in histologically proven (A) lung cancer recurrence and (B) radiation effect due to gamma knife radiosurgery. (A). 73 year old man status post tumor resection and radiosurgery demonstrates markedly elevated mean rCBV (4.52) & relative peak height (1.82) associated with less than 36% signal intensity recovery. (B). 67 year old man with histologically proven enhancement due to effects of radiation status post gamma knife radiosurgery. Single region of interest surrounding entire contrast enhancing demonstrates slightly decreased mean rCBV (0.97) & relative peak height (0.93) associated with 84% signal intensity recovery.

The mean volume of enhancing regions in subjects with recurrent tumor was not statistically different from the radiation effect group (3271.29 mm³ versus 2343.00 mm³; P=0.29). Mean initial radiation dosage was found to be similar between the two groups (17.45Gy versus 17.95Gy; p>0.05). As summarized in Table 1, the mean and minimum percentage of signal intensity recovery values were significantly lower (P <0.01) in cases of recurrent tumor. The mean and maximum rCBV and rPH values were significantly higher (P <0.024) in the recurrent tumor group compared to the radiation effect group. A PSR cutoff value of 76.3% served as a reliable marker for differentiating between the two groups (sensitivity 95.65% and specificity of 100%).

Conclusion: Although the relatively small sample size of this retrospective study cautions against over interpretation, our results suggest that quantitative analysis of signal intensity time curves obtained from DSC perfusion MR imaging provides addition insight into tumor vascular properties that in a clinical setting may increase the specificity of differentiating tumor recurrence from the delayed effects of stereotactic radiosurgery (Figure 1).