Diagnostic accuracy of PET, SPECT, and ASL in differentiating tumor recurrence from necrosis in cerebral metastasis post-stereotactic radiosurgery

Grace Y Lai PhD; David Alsop; David Hackney; Peter C. Warnke MD, FRCS; Ekkehard Matthias Kasper MD PhD; Bob Carter; Clark C. Chen MD PhD

University of California San Diego, La Jolla, CA; Beth Israel Deaconess Medical Center, Boston, MA; University of

Introduction

Radiographic assessment of cerebral metastasis after stereotactic radiosurgery (SRS) remains a major challenge in neuro-oncology (1). Because SRS can induce reactive changes leading to the break-down of the blood-brain-barrier, it is often difficult to distinguish tumor progression (TP) from radiation necrosis (RN) using conventional contrast-enhanced MRI (CE-MRI) (2-3). We hypothesize that physiologic imaging that rely on measures of cellular proliferation and metabolism would contribute to the discrimination of TP and RN. Physiologic imaging modalities studied as are follows: FDG-PET – adiolabeled glucose as tracer for metabolic activity; Thallium SPECT – 201Thallium chloride taken in by NaK ATP pumps as measure of cellular proliferation; Arterial spin labeling (ASL) – arterial blood water as endogenous tracer for cerebral perfusion.

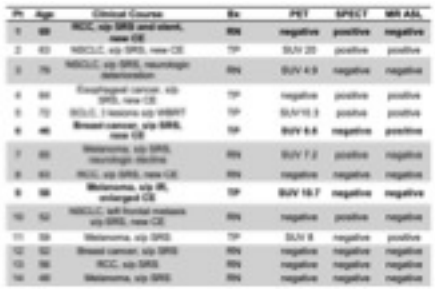
Methods

We retrospectively reviewed patients treated with SRS for tumor metastases to the brain from 2007-2010. Of 267 patients, we identified 14 who suffered clinical or radiographic progression following SRS and were imaged with ASL, FDG-PET, and Thallium-SPECT prior to stereotactic biopsy. To determine biopsy trajectories, CE-MRI, PET, SPECT, and ASL were fused and trajectories were selected to afford sampling of all positive regions. In all cases, the region of biopsy was positive in at least one of the imaging modalities.

Results

Diagnostic accuracy, specificity, sensitivity, positive predictive value, and negative predictive value were calculated for each imaging modality using pathologic diagnosis.

Subjects

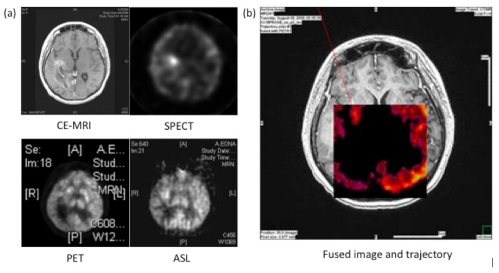


	CE-MRI	PET	SPECT	MR ASL
Accuracy	46.2%	78.6%	57.1%	92.9%
Sensitivity	-	83.3%	50.0%	83.3%
Specificity	-	75.0%	62.5%	100.0%
PPV	-	71.4%	50.0%	100.0%
NPV	-	85.7%	62.5%	88.9%

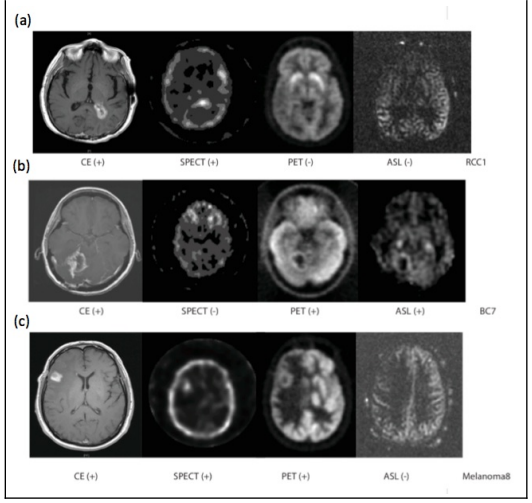
Combination of modalities

(A)	Positive = one modality positive			
	PET or ASL +	PET or SPECT +	SPECT or ASL +	Any one +
Accuracy	85.7%	71.4%	71.4%	71.4%
Sensitivity	100.0%	100.0%	66.7%	100.0%
Specificity	75.0%	50.0%	62.5%	50.0%
PPV	75.0%	60.0%	57.1%	60.0%
NPV	100.0%	100.0%	71.4%	100.0%
(B)	Positive = all modalities positive			
	PET and ASL +	PET and SPECT +	SPECT and ASL +	All +
Accuracy	85.7%	78.6%	78.6%	71.4%
Sensitivity	66.7%	50.0%	66.7%	100.0%
Specificity	100.0%	100.0%	100.0%	100.0%
PPV	100.0%	100.0%	100.0%	100.0%
NPV	80.0%	72.7%	72.7%	66.7%

Individual and fused images



Illustrative Cases



(a) case 1 with metastatic renal cell carcinoma to periventricular white matter of the posterior left lateral horn. CE-MRI shows new enhancement in region treated. SPECT was positive while PET and ASL were negative for tumor recurrence. Biopsy of target region indicated radiation necrosis

(b) case 2 with metastatic breast cancer to right cerebellum. CE-MRI shows new enhancement in region treated. PET (SUV 6.6) and ASL were positive for tumor recurrence. Biopsy of target region indicated tumor recurrence

(c) case 3 with metastatic melanoma to right inferior frontal cortex. Only PET was positive for tumor recurrence (SUV 10.7). Biopsy of target region indicated tumor recurrence.

Summary

6/14 (42%) patients had tumor progression on histology and 8/14 (58%) had radiation necrosis.

ASL was most accurate (TP+TN/Total)

ASL and FDG-PET were equally sensitive in detecting tumor progression (83%) and

ASL was most specific (100% vs 75% for PET and 63% for SPECT.

Combination of modalities did not augment the sensitivity, specificity, PPV, or NPV over ASL alone.

Conclusions

In our series, ASL positivity closely associated with pathological diagnosis of tumor progression after SRS. ASL provides a more accurate and less invasive surveillance modality for brain tumors treated with SRS. This will significantly impact clinical decision making (surgery or chemo for TP vs. steroids and anti-coagulants for RN). Because of the limited sample size of the current study, validation of our findings in a large series is warranted.

References

1. Chernov M, et al. Minim Invasive Neurosurg 48: 228-234, 2005

2. Stockham AL, et al. J Neurooncol 109: 149-158, 2012

3. Dooms GC, et al. Radiology 158: 149-155, 1986