Diffusion abnormality index: a new imaging biomarker for early assessment of tumor response to therapy

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NIH grant Support:
RO1 NS064973

Nothing to disclose
Tumor Response to Therapy

- When a cancer patient is given a treatment, some tumor responds to therapy and some does not.

- Assessment of tumor response to therapy is conventionally done by measuring a change in tumor size/volume after treatment is completed.

- A change in tumor biology and physiology may occur much earlier than the volumetric change, which could be used for prediction of tumor response to a particular treatment ahead of time.
Diffusion Imaging

- Diffusion imaging is sensitive to water mobility in tissue structures (e.g., tumor).

- Water mobility is affected by cell density, cell membrane permeability, and water content in cancer tissue, which can be altered by radiation.

- Diffusion imaging, one of many promising physiological imaging techniques, has shown the potential for early prediction of tumor response to treatment.
As highlighted in the image at the left, the red regions indicate the areas with the highest diffusion.

Diffusion properties within a tumor are not uniform.

A tumor can consist of high cell density, necrotic, and edema regions.

Water mobility in the high cell density region is low, but high in the necrotic and edema regions.

Hence, measuring the mean diffusion change in the tumor limits its ability for assessment of response.
Study Aim and Design

We aimed to

— Develop a new diffusion abnormality index of a tumor, which considers the underlying physiologies of diffusion imaging in the tumor and captures its complex behavior in response to treatment
— Test if its early change could predict response of brain metastases to whole brain radiation therapy

Diffusion imaging was acquired

— Pre radiation therapy
— Two weeks after the start of treatment
— One month after the completion of RT
Responsive vs Progressive Tumors

- The image on the left indicates the responsive lesion. The image on the right is a progressive lesion.
- DAI decreases more in responsive lesions in compared with progressive ones.
- DAI has the potential to provide a spatial map highlighting the sub-volumes of the tumor that need more care or intensified treatment.

Cancer Imaging and Radiation Therapy Symposium
A Multidisciplinary Approach
Early Indicator of Response

- Changes in tumor diffusion occur earlier than changes in the tumor volume.

- The diffusion abnormality index performed better for prediction of response than other (tested) diffusion metrics.
Potential Role for Adaptive Treatment

- Early prediction of treatment response in the brain metastases could allow us to select non-responsive lesions for intensified treatment, including radiosurgery, resection, and chemotherapy.

- The new diffusion index will be further tested and investigated to improve its sensitivity and specificity for detecting early changes in the tumor.