Tumor vs. Necrosis

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Various MDA CC Buildings
Neuro: Chief and 5.5 neuroradiologists
-(7 faculty on call for neuro), 1-3 residents, 1-2 fellows
-35 phycisist, one full time for neuro section
-CNI Lab (computational neuroimaging lab) for post processing:
  1 phycisist, 1 tech

~200 Neuro CT and MRI scans daily + procedures
- 9 Clinical GE 1.5T MR scanners
- 3 Clinical GE 3T MRI
- 17 multislice CT scanners (4-64 slice scanners)
28 y/o with Anaplastic Oligodendroglioma in 2003, s/p glial wafers and chemoradiation

- Examination: Brain MRI, 6-25-04
- Clinical History: AO
- IMPRESSION:
- **FULL RESULT:** Routine brain imaging was obtained. This is the first study at M.D. Anderson and outside imaging is not available.

There is an irregularly shaped, 3.0 or so cm, operative site in the right high posterior parietal lobe. There is internal heterogeneity, and on the FLAIR images as well as the other sequences, internal areas of linear-shape that correspond to the wafers that were placed surgically elsewhere. There is a rim of enhancement that is not clearly tumor. I do not see any clearly internal enhancing tumor, and the study is somewhat difficult to interpret in the absence of any prior imaging. This will serve as a baseline M.D. Anderson scan. I do not see surrounding infiltrative tumor or nonenhancing disease elsewhere.
Postradiation Necrosis May Mimic Tumor

- Late delayed radiation injury can be progressive and fatal
- May need surgery

- ........Diagnostic dilemma
Dg of Radiation Injury Is Challenging

- The pattern of abnormal enhancement closely mimics that of recurrent brain tumor
Proposed Mechanism of Radiation Induced Neurotoxicity

- Vascular Injury: thrombosis, infarction necrosis

- Glial and white matter damage:
  oligodendrocytes sensitive to radiation →
  destruction leads to demyelination

- Effect on the fibrinolytic enzyme system
- Immune mechanism (?autoimmune vaculitis)
Diagnostic Dilemmas....

- **Mild form of radiation injury: white matter enhancement**: nodular, linear, curvilinear

- **Suspect progression to radiation necrosis if**: increase in size, edema, mass effect

- **Cortical gyral enhancement may simulate infarction**
Suspect Chemoradiation Injury on MRI

- **Soap bubble or Swiss cheese interior** – lace-like appearance
- **Cave**: can be solid lesion

**Proximity to original lesion:**
- Edge of the treated tumor
- Several cm from tumor
  - Ipsilateral, but also contralateral
- Within the tumor site
Brain Has Limited Number of Ways to Respond to Various Insults

Both tumor recurrence and radiation injury can cause:

- Vasogenic edema
- Disruption of BBB
- Cavitations
Follow up of Treated Tumors

- CT, MRI with contrast
- MRS, DWI/ADC
- CT / MR perfusion studies
- PET, SPECT
Follow up of Treated Tumors

- **CT, MRI** anatomical information
- **IV Contrast**: breakdown of BBB
- **Hemodynamic perfusion MRI**: rCBV mapping
- **Diffusion MRI**: ADC: physical & chemical information
- **MRS**: Biochemical parameters
- **PET, SPECT** biological information
Radiation Injury Area

- Irradiated tumor cells
- Coagulation necrosis
- Reactive gliosis
- Active fibrosis
Necrosis & Tumor Recurrence
AJNR Aug 2001, Schlemmer et al.

Fig 1. A 67-year-old patient with astrocytoma grade II. MR examination 36 months after stereotactic radiotherapy showed two contrast-enhancing lesions on T1-weighted spin-echo images.

A and C, A lesion with ring-shaped enhancement zone is seen in the left frontal lobe (A) and a lesion with homogeneous enhancement is seen in the left temporal lobe (C) (boxes indicate MRS voxels).

B and D, 1H MR spectra (double spin-echo sequence 1500/135/200 [TR/TE/excitations]) of both lesions show a peak attributed to free lipids, indicating necrosis. An intense tCho resonance is only seen in the lesion in the left temporal lobe. FDG-PET revealed high glucose uptake in this region, indicating tumor progression. Low tCho signal was found in the lesion in the left frontal lobe. Radionecrosis in this region was confirmed by...
38 Year Old Female
GBM since 2003, Left Occipital
GBM left occipital: First Crani 4/03, Rx 7/’03. Second Crani 11/’04
37 year old female
Anaplastic Oligoastrocytoma, status post chemoradiation, follow-up in 3/2005 with new periventricular enhancement
GBM: Tumor recurrence vs necrosis
Crani 10/03. Radiation completed 12/03

2/10/’05
GBM: Tumor recurrence vs necrosis?
Crani 10/03. Radiation completed 12/03

Jan ’05
MRS#1 Feb
MR Apr

4/7/’05
MRS#2

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Radiation Injury: Predilection of Periventricular White Matter Involvement

- Poor blood supply from long medullary arteries
- Lack of collateral supply
- Subependymal necrosis may mimic tumor spread
GBM
Sept 2004
36 year old male
Necrosis

GBM in a 36 year old male, 5 month follow-up post radiation and 3 cycles of temozolomide
Recurrent GBM, Triple Dose of Contrast, 3T Magnet

20 min later: Gd leaks into surgical cavity
Recurrent GBM, 3T
Recurrent GBM, 3T

rCBV: Positive Enhancement

Maximum Slope of Increase

Integral

Postsurgical
Change In Tumor Grade

12/'04. Radiation Injury

4/'05 Tumor & Rad. injury
Summary
Suspect Radiation Injury If:

1. If the tumor was nonenhancing before surgery and enhancing foci subsequently develop: more likely radiation injury than progression to a higher grade
2. If an enhancing focus develops at a distance from the primary lesion
3. Enhancing periventricular lesion develops
4. New lesions exhibits soap bubble, Swiss cheese or lace like pattern
MRS Protocols

**Tumor vs Necrosis**
- TE = ~144 msec
- For: Lipid, Cho/Cr

**Gliomatosis, Low grade astrocytoma**
- TE = 35 msec
- TE = 144 msec
- For: m-Ins & Gly
MRS

MRS before administration of contrast despite of problems in voxel location, but verify the location in postcontrast image:

- Decrease of Cho signal intensity after Gd

Ref:
Sijens PE et al: 1H chemical shift imaging reveals loss of brain tumor choline signal after admin. of Gd-contrast.

Magn Reson Med (1997) 37;222-225
MD Anderson CC, Alkek Building
Anaplastic Oligo (gr III) (3/22/05)

MRS 3/21/05

Gd+
16 year old female, NF-1
asymptomatic
Gliomatosis Cerebri

TE = 20 & 135 msec

Fig. 2. Single voxel spectroscopy. Localized STEAM (TE 20) spectra were acquired from the normal appearing right peritriatal region (A1) and from the hyperintense left peritriatal region (B1). PRESS (TE 135) spectra were acquired from the same locations (A2 and B2, respectively). The right and left STEAM spectra are displayed by using the same vertical scale factor, as are the right and left PRESS spectra.
Diffuse Astrocytoma
High m-Ins/Gly

TE=30msec
Summary

- Hyperintense lesion with minimal or no enhancement on post Gd T1WI and
- lack of Cho/Cr elevation does not exclude primary glial neoplasm
m-Ins & Gly
3.5-3.6 ppm

**m-Ins**
- Long echo: Weak/absent peak
- Short echo: Strong peak

**Gly**
- Long echo: Weak peak
- Short Echo: Strong peak

TE=20msec

TE=135msec
If m-Ins or m-Ins/Cr elevated, include low grade astrocytoma or gliomatosis in the differential diagnosis
Low Grade Astrocytoma

m-Ins: Glial marker

- Change in phospholipid composition or abundance of cell membranes
Anaplastic oligo (grIII), Crani 12/’03
28 year old female
Oligodendroglioma, Status post surgery and radiation with new enhancing lesions.
Martin et al. AJNR 2001

Posterior lesion most necrotic