Top Studies in Cancer Imaging and Radiation Therapy

Moderated by
Julia White, MD, Ohio State University
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Hepatic Function Model Based upon HIDA SPECT and Dose for Physiological Adaptive RT

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Radiotherapy of Liver Cancer

- Liver cancer is a most rapidly increasing cancer in the US.
- High dose radiotherapy seems effective for liver cancer but limited by radiation-induced liver injury.
- Early assessment of liver function in response to radiation dose would prevent from liver injury after irradiation.
HIDA SPECT for Liver Function

- HIDA, a radiolabeled trace, can be extracted and cleared by liver tissue.
- SPECT can record the liver process of HIDA spatially.
- If regional hepatic function is damaged by radiation dose, its ability to process the hepatic function specific tracer will be decreased and can be recorded by SPECT.
Regional Liver Function Response

➢ Our aims

• Predict regional liver function post RT by assessing regional liver function response to initial radiation dose using HIDA SPECT

• Develop predictive models for regional hepatic function post-RT by combining the regional liver function response and local radiation doses, thereby to prevent from liver injury
Study Design

- Patients with intrahepatic cancers and treated by conformal RT

- HIDA SPECT
  - Before treatment to assess pre-RT condition of patient liver function
  - After delivering 45%~60% planned radiation dose to evaluate patient liver response to treatment
  - 1 month after completion of treatment to assess regional liver damage from RT
Regional hepatic function decrease indicates local damage by radiation, as indicated by the areas marked in blue.

The extent of the hepatic function damage under the same dose characterizes individual and regional sensitivity to radiation.
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Prediction of Liver Function post RT

- **Prior Model:**
  Regional Liver Function post-RT
  Regional LF pre-RT + Local Planned Dose

- **Adaptive Model:**
  Regional Liver Function post-RT
  Regional LF during RT + Planned Undelivered Dose
Adaptive Treatment of Liver Cancer

- Combining local radiation doses with regional liver function assessment pre RT and re-assessment during RT could allow us to adapt radiation therapy of liver cancers based on individual response.

- The individualized and adaptive therapy could provide patients with highest radiation dose for better tumor control, while minimizing the risk for each patient.
CT Tumoral Heterogeneity as a Prognostic Marker in Primary Esophageal Cancer Following Neoadjuvant Chemotherapy

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Cancer Imaging and Radiation Therapy Symposium
A Multidisciplinary Approach
February 8-9, 2013 | The Hilton Walt Disney World Resort | Orlando
Background

• Esophageal cancer associated with poor outcome
• Preoperative chemotherapy +/- radiotherapy used to improve survival
• Need to improve treatment response assessment in this group
Texture analysis

- Specific software to look at CT/MRI/PET images in great detail which cannot be appreciated by human eye
- Relationship between pixels within an image
- May indicate biological variation within tumors
Aims

• Investigate the use of texture analysis as a prognostic marker in patients treated with preoperative chemotherapy for esophageal cancer
Image analysis

- Mean grey-level intensity (MGI)
- Kurtosis
- Skewness
- $\text{SD}_{\text{histogram}}$ ($\text{SD}_H$)
- Uniformity
- Entropy

Unfiltered & filtered: 1.0, 1.5, 2.0 & 2.5
Results

• 31 patients
• All had pre-treatment & post-treatment contrast-enhanced CT
• Entropy decreases & uniformity increases after chemotherapy
Results

Changes in skewness after chemotherapy, pre-treatment $SD_H$ & post-treatment MGI were associated with survival
Conclusions

• Exploratory study
• Warrants further investigation in prospective setting
Pretreatment $SUV_{\text{max}}$ as a Marker for Progression-Free Survival in Stage 1 NSCLC Treated with SBRT


* University of Pittsburgh Cancer Institute, Department of Radiation Oncology
+ University of Pittsburgh Medical Center, Department of Thoracic Surgery
Are these the same?

$\text{SUV}_{\text{max}} = 3.8$

$\text{SUV}_{\text{max}} = 6.4$
Apparently Not.

![Graph showing progression-free survival with SUVmax Cutoff](image)

- **SUVmax < 5**
- **SUVmax >= 5**

26%!  

*p = 0.024*
### Differences in outcomes

#### Table 3: Overall Outcomes

<table>
<thead>
<tr>
<th>Event</th>
<th>Overall (%)</th>
<th>SUV&lt;5 2-year freedom (%)</th>
<th>SUV≥5 2-year freedom (%)</th>
<th>K-M p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local Failure</strong></td>
<td>93.7%</td>
<td>97%</td>
<td>86%</td>
<td>.256</td>
</tr>
<tr>
<td><strong>Regional Failure</strong></td>
<td>90.5%</td>
<td>94%</td>
<td>82%</td>
<td>.131</td>
</tr>
<tr>
<td><strong>Distant Failure</strong></td>
<td>86.3%</td>
<td>91%</td>
<td>78%</td>
<td>.371</td>
</tr>
<tr>
<td><strong>Any Progression</strong></td>
<td>93.7%</td>
<td>88%</td>
<td>62%</td>
<td>.024</td>
</tr>
<tr>
<td><strong>Death</strong></td>
<td>64.2%</td>
<td>72%</td>
<td>49%</td>
<td>.024</td>
</tr>
</tbody>
</table>
Is there a magic number?

• We chose a cutoff of 5
  – Many other cutoffs were significant
• Increasing SUV implies increasing metabolism
  – Risk increases proportionally to SUV

• What about that 23% difference in overall survival?
Diffusion abnormality index: a new imaging biomarker for early assessment of tumor response to therapy

Presented by:

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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 subvolumes of the tumor that need more care or intensified treatment.

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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.
Q & A
Thank you for joining us today. This News Briefing will be available online at astro.org.

If you have any questions or would like to speak with any of these study authors, please contact Michelle Kirkwood at ASTRO, michellek@astro.org