Ultrasound and MRI for monitoring pancreas motion during radiation therapy delivery

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Pancreatic Cancer

Percent of Cases & 5-Year Relative Survival by Stage of Diagnosis: Pancreatic Cancer

Resectable | Borderline | Unresectable

MRI for Pancreas

- Drinking 120 cc 15 minutes prior to MR to help delineate duodenal wall
- Respiratory-triggered imaging corresponding to phase of gating window used during treatment

Multimodality imaging for target definition

Dose painting

- Boost GTV or poor-response regions to highest dose possible while maintaining OAR dose-volume constraints.
- 5 mm PTV margin

Need to address: Inter- and intra-fractional motions !!!
Inter-fraction changes

**Pancreatic cancer: Inter-fractional Variations**

Soft-tissue based registration with gated CT

PTV 10 mm margin

Dosimetric Impact of RT technologies on pancreas RT

<table>
<thead>
<tr>
<th>DVH &amp; Tissue</th>
<th>ART gating</th>
<th>IGRT gating</th>
<th>IGRT No gating</th>
<th>No IGRT no gating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duodenum V50-4</td>
<td>19%</td>
<td>42%</td>
<td>66%</td>
<td>72%</td>
</tr>
<tr>
<td>L-Kidney V15</td>
<td>8%</td>
<td>15%</td>
<td>22%</td>
<td>19%</td>
</tr>
<tr>
<td>R-Kidney V15</td>
<td>14%</td>
<td>23%</td>
<td>32%</td>
<td>35%</td>
</tr>
<tr>
<td>Large Bowel V45</td>
<td>0.4%</td>
<td>3%</td>
<td>8%</td>
<td>11%</td>
</tr>
<tr>
<td>Stomach V45</td>
<td>1%</td>
<td>4%</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>Liver V30</td>
<td>2%</td>
<td>6%</td>
<td>13%</td>
<td>17%</td>
</tr>
<tr>
<td>Small Bowel V45</td>
<td>1%</td>
<td>4%</td>
<td>10%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Average of 5 patients
Intra-fraction motions
Managed with respiration gated delivery

We are investigating:

MRI and US for monitoring intra-fractional motions

Clarity Hand-Held Autoscan Probe (m4DC7-3/60) 3-5MHz
US-based IGRT

- Anatomy specific workflows and contouring algorithms
- Quick daily alignment of the IGRT structure

Automatic 3D Patient Specific Segmentation

- Prostate
- Breast
- Uterus
- Bladder

US acquisition

Pancreas and the Portal Vein
MRI acquisition

- A 3-Tesla MRI scanner, with a 4-Channel Body Matrix Coil.
- Imaging sequence: Axial T2-weighted HASTE (spin-echo)
- Imaging parameters:
  - Field of view (FOV): 360x276 mm; slice thickness: 5mm; Voxel Size: 1.18x1.18x5; time repetition (TR)/time echo (TE): 2000/96 ms;
- US-probe deformation
MRI-US registration

MRI-US registration

MRI-US registration
US registered with CT


Registration of US and CT images for a patient with a tumor in pancreas head. The contours are created using the US which are translated into the CT. Red: Portal-Splenic Vein Confluence (PSVC). Blue: Dilated Pancreatic Duct. Green: Stent.

US for pancreas motion monitoring

Difficult to track pancreas head.

Easy to see:

- **PSVC**: Portal-Splenic Vein Confluence
- **IVC**: Interior Vena Cava
- **A**: Aorta
- **SMA**: Superior Mesenteric Artery

E. Omari (MCW)
Motion difference between surrogates and pancreas

Axial Acquisition

Sagittal acquisition
Motion monitoring prior to/during delivery

Monitoring Session (max motion SI)
Monitoring Session (max motion SI/LR)

Motion Management with MR-Linac

High resolution (0.7mm x 0.7mm x 1mm), 3D acquisition with exquisite image quality in all planes

High frame-rate, multi-planar acquisition for motion monitoring

*Confidential and privileged information. Not for distribution.*
Summary:

- Portable, non-invasive, and inexpensive ultrasound imaging may be used as an alternative imaging modality for motion monitoring during RT delivery for pancreatic cancer.
- Surrogate structures or anatomic landmarks surrounding the pancreas that are moving along with the pancreas may be used for the motion tracking.
- The MRI and/or CT acquired with ultrasound at the same patient treatment position may be used to help identify or to verify the locations and shapes of the pancreas and surrogates on the ultrasound images.