Ultrasound for intrafraction motion monitoring

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**Impact of delivery technologies for pancreas cancer RT**

<table>
<thead>
<tr>
<th>No IGRT</th>
<th>IGRT No gating</th>
<th>IGRT gating</th>
<th>TART gating</th>
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<tbody>
<tr>
<td>Duodenum V50.4</td>
<td>72%</td>
<td>66%</td>
<td>42%</td>
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<tr>
<td>Duodenal toxicity GI Grade ≥2</td>
<td>23%</td>
<td>17%</td>
<td>11%</td>
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**Intrafractional motions**

- Contrast CT images with one-min delay.
- Initial change in 1.7min treatment state.

**Literature:**

(a) Clarity Autoscan system (Elekta)
(b) Stanford prostate imaging robot,
(c) University of Lubeck robot
(d) Johns Hopkins robot
(e) Stanford abdominal imaging robot
Probe/positioning device modifications

US: Pancreas and the Portal Vein

Portal vein as a surrogate for motion estimation of pancreas head
CT-US registration


CT-US registration

MRI acquisition

US-probe deformation
Difficult to track pancreas head.

Easy to see:

**PSVC:** Portal-Splenic Vein Confluence

**IVC:** Inferior Vena Cava

**A:** Aorta

**SMA:** Superior Mesenteric Artery
Monitoring Session

Monitoring Session (max motion SI/LR)

Limitations

• Deformation with US probe pressure
• Poor quality of US images for some patients
• Some limitations on the beam angles.
**US motion tracking of diaphragm**

**Idea:**
- Acquiring synchronized US and X-ray images
- X-ray images (4D/3D/2D) acquired before and periodically during RT delivery
- Continuing US acquisition during RT delivery

**Oral Talk:**
Real-time motion tracking using ultrasound and intrafractional kV cone beam projection images
Farshad Mostafaei, An Tai, William Haase, David T. Cooper, Martin Lachaine, and X. Allen Li

**System Setup**
Elekta research software was used to acquire B-mode US and cone beam projection image (CBPI) using Clarity® and XVI platforms

**Volunteer setup, larger diaphragm motion in SI direction.**

**Ultrasound b-mode image of the right diaphragm in three directions.**
**US probe through the ribs, not interfering with treatment beam.**
Monitoring diaphragm with Clarity

CT-sim room  treatment room

Synchronization of US and CBPI acquisition

Synchronized through a video capture card (VCE-PRO, IMPERX Inc.) triggered by XVI

Testing synchronization using a motorized motion platform with adjustable motion range
Acquiring images from US phantom positioned on motion platform with synchronized CBPI and US.

Acquiring synchronized CBPI and US.

The system is ready to test on patient in a IRB approved study for motion monitoring during lung SBRT.
Summary:

Portable, non-invasive, and inexpensive ultrasound imaging can be potentially used for intrafractional motion monitoring during RT for tumors in thorax and abdomen.