Ultrasound Guided Radiotherapy for Pancreatic Cancer

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Disclosure

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  – USGRT: NCI CA161613, Elekta
  – EUSGRT: JHU Rad Onc Discovery Grant, Augmenix
Learning Objectives

• The audience will learn the major components including ultrasound imaging, coordinate calibration, probe positioning and image tracking for ultrasound monitoring in radiotherapy for pancreatic cancer

• The audience will learn how to incorporate the real-time ultrasound monitoring with existing pancreatic cancer treatment clinical workflow
Pancreas Cancer

- 4th leading cause of cancer-related death in US
- Typically late presentation of disease
  - Only 15-20% of patients are considered resectable
- 5-year overall survival after pancreaticoduodenectomy (whipple surgery)
  - 25-30% for node-negative disease
  - 10% for node-positive disease
- More recent data suggest outcomes may be improving over time
Breath hold monitoring during pancreas SBRT
USGRT components

*Elekta Clarity user manual
CT/US Sim

*L. Su et al, Feasibility study of ultrasound imaging for stereotactic body radiation therapy with active breathing coordinator in pancreatic cancer, JACMP 2017
Ultrasound contouring
Probe impact on planning

*L. Su et al, Feasibility study of ultrasound imaging for stereotactic body radiation therapy with active breathing coordinator in pancreatic cancer, JACMP 2017, Issue 4*
**Probe impact on planning**

<table>
<thead>
<tr>
<th>Duo V15</th>
<th>Sto V15</th>
<th>Bowel V15</th>
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<td>5.96 cc</td>
<td>8.52 cc</td>
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<td>1.45 cc</td>
<td>1.44 cc</td>
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<th>PTV V33</th>
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Treatment setup
CBCT initial setup
Ultrasound monitoring

*L. Su et al, Feasibility study of ultrasound imaging for stereotactic body radiation therapy with active breathing coordinator in pancreatic cancer, JACMP 2017, Issue 4
Robotic arm for gated proton therapy

*Collaboration with Dr. Haibo Lin, University of Pennsylvania Proton Center*
Visual servoing automatically place probe

*H.T. Sen et al, Cooperative control with ultrasound guidance for radiation therapy, Frontier Oncology 2016
Visual servoing automatically place probe

Ultrasound probe controlled by robotic arm

Real time ultrasound image being registered to reference image

*H.T. Sen et al, Cooperative control with ultrasound guidance for radiation therapy, Frontier Oncology 2016
Tracking relies on imaging speed

Ground truth (optical tracking)
0.3 Hz, 45° sweeping angle
1 Hz, 15° sweeping angle
11 Hz, 3° sweeping angle

*Collaboration with Drs. Tuathan O'Shea and Emma Harris PhD, Institute of Cancer Research, Royal Marsden
Fast tracking (15ms/frame)

Frame Indexing vs. Template Matching

- **Training Stage**
- **Frame Indexing**
- **Template Matching**

- Coarse tracking
- Refinement

*P. Huang et al, Respiration-Induced Landmark Motion Tracking in Ultrasound Guided Radiotherapy, AAPM 2017, Abstract SU-F-708-4*
Biodegradable hydrogel with endoscopic ultrasound guidance

*Z. Feng et al, A Dose Predication Model for Duodenum Sparing in Pancreatic Cancer with Biodegradable Hydrogel Spacer, AAPM2017, Abstract SU-K-FS1-1
Biodegradable hydrogel with endoscopic ultrasound guidance

Biodegradable hydrogel with endoscopic ultrasound guidance

Pre-Injection Plan with PTV priority
- Duo V15 = 7.07 cc
- Duo V20 = 3.86 cc (!)
- Duo V33 = 0.15 cc
- PTV V33 = 95.01%

Pre-Injection Plan with Duo priority
- Duo V15 = 3.33 cc
- Duo V20 = 1.27 cc
- Duo V33 = 0.01 cc
- PTV V33 = 80.36% (!)

Post-Injection Plan
- Duo V15 = 2.02 cc
- Duo V20 = 0.36 cc
- Duo V33 = 0.0 cc
- PTV V33 = 97.87%

* A. Rao et al, Novel Use of a Hydrogel Spacer to Separate the Head of the Pancreas and Duodenum for Radiotherapy for Pancreatic Cancer, ASTRO 2017
Conclusions

• Ultrasound guidance can be used for motion monitoring in radiotherapy for pancreatic cancer

• Clinical workflow has to be adapted to incorporate the changes

• Endoscopic ultrasound can guide the injection of hydrogel to potentially reduce the duodenum dose
Acknowledgement

USGRT team

• Radiation Oncology
  – John Wong, Lin Su, Yin Zhang, Sook Kien Ng, Junghoon Lee, Ken Wang, Ted Hooker, Joseph Herman, Harry Quon, Phuoc Tran, Danny Song
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  – Iulian Iordachita, H. Tutkun Sen, Peter Kazanzides, Muyinatu A. Lediju Bell, Emad Doctor
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  – Jinyuan Zhou, Chen Yang
• The Institution of Cancer Research Radiation Oncology
  – Tuathan O’shea, Emma Harris
• University of Pennsylvania Radiation Oncology
  – Haibo Lin
• Shandong Normal University
  – Dengwang Li, Pu Huang, Ziwei Feng
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- Radiation Oncology
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- Gastroenterology
  - Eun Shin, Seonghun Kim

- Surgery
  - Jin He, Richard Burkhart

- Pathology
  - Kevin Waters

- Radiology
  - Michael Schar, Lauri Pipitone, Juls Meyers, Hugh Wall, Jorge Guzman, Eleni Liapi, Stephanie Coquia, Bob De Jong

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  - Caroline Garrett, Sarah Beck, Anna Goodroe

- Industrial Partners
  - Augmenix (hydrogel): Kolbein Kolste, Patrick Campbell
  - Pentax (EUS): Robin Rynn

- Shandong Normal University
  - Dengwang Li, Pu Huang, Ziwei Feng
Questions