Evaluation of a CT Guided Robotic Positioning System to Minimize Needle Manipulation During Placements to Small in Vivo Targets

Presentation by: Govindarajan Srimathveeravalli.

Contributing authors: Haruyuki Takaki, Manojkumar Laskhmanan, Francois Cornelis, Majid Maybody, George Getrajdman, Constantinos Sofocleous, Jeremy Durack, Joseph Erinjeri, and Stephen B Solomon
Acknowledgement and Disclosures.

The study was supported by a sponsored research agreement between Perfint Healthcare Inc. and Memorial Sloan Kettering Cancer Center. Dr Srimathveeravalli was the MSKCC PI of this agreement.

The presentation includes additional results from data collected following original abstract submission.
Background.

**Available Technologies**
- Electromagnetic navigation
- Laser guidance
- Optical guidance
- Robotic systems

**Potential Benefits**
- Radiation dose reduction.
- Improved accuracy.
- Reduced dexterity requirement.
- Novice physicians.

**Evaluation**
- **Phantom models**
  - Unrealistic tissue interaction.
- **Ex-vivo tissue**
  - Simplistic scenarios.
- **Large animal study**
  - Very few pre-clinical studies.
- **Patients**
  - Lack of control (manual insertion).
  - Heterogeneous targets.
  - Self assessed outcomes.

**Unanswered Question:** How do assistance systems compare with performance of an experienced physician?
Hypothesis.

When an experienced IR physician performs needle placement manually and with assistance from CT-guided robotic positioning system (RPS) for the same target ....

1. When compared to manual needle placement, placement using RPS will require fewer needle manipulations and check scans to reach the target.

2. The use of RPS will result in placement accuracy that is non-inferior to accuracy achieved during manual placement.
Experimental Methods.

• Participant Demographics
  – 7 experienced physicians from MSKCC IR service.
  – 6 years of independent median experience with needle placement procedures.

• In-vivo Targets
  – 7 healthy female swine (40-50kgs).
  – 4 targets, distributed over all lobes of the liver (50-120mm depth).
  – 5mm long, 18G dia seeds.

• Materials and Protocol
  – Placement of 18G, 150mm or 100mm coaxial needle.
  – Manual placement preceded RPS assisted placement.

7 physicians X 4 targets = 28 data points/cohort. 56 total samples.
Experimental Methods.

• Manual Placement
  – Standard clinical procedures (sequential CT or CT fluoroscopy).
  – Self judged time vs. accuracy optimization.

• RPS Assisted Placement
  – Paralytic induced breath hold.
  – Needle insertion in one go.
    • Did not include stop and check or needle holder available with the system.
  – One repeat if result was poor.
Metrics.

• **Number of needle manipulations.**
  – Total number of times the physician adjusts the needle till the tip reaches satisfactory end point.

• **Number of check scans.**
  – Total number of check scans, excluding planning scan and confirmation scan, used to complete needle placement.

• **Placement accuracy.**
  – Shortest distance between needle tip and closest location on the seed when measured on confirmatory scan CT images.

• **Procedure time.**
  – Time taken to complete placement, starting with planning scan and ending with final confirmatory scan.
Work Flow.

A: Planning image, magenta line shows planned needle trajectory from skin entry (dashed arrow) to target seed (arrow).

B: Post needle placement CT image.

C: Image overlay comparing planned trajectory (dashed line) and actual needle position.
System in Action.
Results: Number of Needle Manipulations.

<table>
<thead>
<tr>
<th></th>
<th>Manual</th>
<th>RPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.06</td>
<td>0.39</td>
</tr>
<tr>
<td>S.D</td>
<td>3.48</td>
<td>0.57</td>
</tr>
<tr>
<td>t-Test</td>
<td>p = 0.0000076</td>
<td></td>
</tr>
</tbody>
</table>

Hypothesis 1: Means are significantly different. RPS has lower mean.
Results: Number of Checkscans.

Hypothesis 1: Means are significantly different. RPS has lower mean.
Results: Accuracy.

Hypothesis 2: There is no difference in means of the two study arms.
Results: Procedure Time.

<table>
<thead>
<tr>
<th></th>
<th>Manual</th>
<th>RPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>6.19</td>
<td>9.64</td>
</tr>
<tr>
<td>S.D</td>
<td>2.89</td>
<td>3.98</td>
</tr>
<tr>
<td>t-Test</td>
<td>p = 0.000231</td>
<td></td>
</tr>
</tbody>
</table>

Means are significantly different. Manual has lower mean.
## Results: Radiation Dose

<table>
<thead>
<tr>
<th></th>
<th>Manual</th>
<th>RPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1075.77</td>
<td>636.4</td>
</tr>
<tr>
<td>S.D</td>
<td>717.74</td>
<td>373.32</td>
</tr>
<tr>
<td>t-Test</td>
<td></td>
<td>$p = 0.03$</td>
</tr>
</tbody>
</table>

Means are significantly different. RPS has lower mean.
Discussion.

• Experienced physician or Novice robot operator?
  – The learning curve.
  – Cognition (experience) vs. dexterity (robot).
  – Multi-plane approach.
  – Procedure time for multiple RPS placement.

• Effect of standardized work flow.
  – Reduction of inter-operator variance.

• Limitations.
  – Breath holds may work differently in patients.
  – Irregular or poorly defined targets in patients.
  – Blind insertion in one go.
  – Bending or other effects.
Questions and Comments.