Long Term Clinical Experience Using Ultrasound Alignment

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Overview
- Discuss various technique, and patient related, image quality issues.
- Present a technique to improve alignment quality and consistency.
- Is the prostate displaced during transabdominal ultrasound? (Heisenberg Uncertainty Principle)

Ultrasound Alignment Experience at Fox Chase
- FCCC and Cleveland Clinic first BAT™ sites in 1998.
- Since then 50-60 patients per day.
- Over 100,000 procedures to date.
- Very few patients non-imageable.
- Extreme shifts (>2cm) verified by CT.

Commercial Ultrasound Positioning Systems
- ZMED -SonArray
- CMS - I-Beam
The key to a good alignment starts with decent imaging. Imaging through a mostly full bladder improves prostate visualization. US image quality is not always desirable:
- Large patients – greater distance / decreased resolution
- Empty bladder – degrades prostate visualization
- Poor image – US procedure is skipped
  - Use skin marks

Operators must have proper training! Most common problem is therapists try to image too close to symphysis. Symphysis shields US energy and degrades image quality. Instruct therapists to move superior & angle probe to image through the bladder. At FCCC, each alignment reviewed by physician during OTV. Therapists receive feedback on alignment quality for each procedure.
Some other issues that can improve or degrade image quality.

- Increased probe pressure usually helps.
- Imaging through surgical scars degrades.
- Sometimes moving lateral to midline will improve quality.
- Making sure proper US parameters are used.

The Problem

- Noticed therapists were having some trouble aligning Sup/Inf
- CTV is commonly outlined with proximal SVs.
- SVs are typically easily imaged with US.
- Also, Nomos designed BAT so users capture an axial image before the sagittal
**Procedural Changes**

- Start with acquisition in sagittal plane.
  - Superior image of prostate/rectum interface.
  - Allows correction of largest shifts first
  - Better feel for patient anatomy
- Separated SVs into two structures – Proximal and Distal.

**Proximal and Distal SVs**

- Start the axial scan at base & scan through proximal SVs.
  - If SV/prostate transition makes sense it’s a good bet the SI & AP alignment is accurate.
- The only shift remaining should only be a small L/R shift.
Results

- Alignment printouts were reviewed before and after the technique was implemented
  - 10 patients each
  - 303 scans before, 310 after.
- Noted for physician comment of substandard alignment
  - Reviewed by same physician

Results

- Before
  - 15.1% comment rate
- After
  - 3.5% comment rate
  - \( p = 0.006 \)

Needless to say, this is our standard procedure now.

Objective

- Determine if transabdominal ultrasound displaces the prostate.
- Duplicate the probe position during image acquisition.
- Image the prostate during the simulated ultrasound.
- If there is a displacement, the position of the prostate during imaging is not the actual treatment position.
**Method**

- Utilize the department’s 0.23T Philips MRI.
- Patients placed in an alpha cradle cast and aligned to treatment position.
- Pelvic coil placed around patient.
- Scanned once for treatment and again with probe.
  - T2 FSE 3D Tr-3000mS Te-140mS 256x256

**Philips 0.23T Open MRI**

**Method**

- Simulate the ultrasound procedure during imaging.
  - Plastic mold of ultrasound probe from wax cast
  - Attached to bottom of pelvic coil
    - Angled at 30°
  - Adjust patient penetration using wood shims

**Plastic model of ultrasound probe**

**Wood shims used to adjust depth of probe penetration**
Method

- Depth of probe determined by clinical experience.
- Amount of pressure varies by patient
- Active portion of probe must view prostate
- Prostates contoured on each MRI data set by same physician.
- Fuse MRI images for each patient.
- Determine the center of volume shifts from each patient’s scan set.

Results

- 16 patients imaged

<table>
<thead>
<tr>
<th>Prostate Shifts (mm)</th>
<th>A/P</th>
<th>Lat</th>
<th>S/I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. Shift</td>
<td>-1.5</td>
<td>0.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Std. Error</td>
<td>0.5</td>
<td>0.3</td>
<td>0.4</td>
</tr>
</tbody>
</table>

- Average percent difference of prostate volumes = 5.7%
Suprapubic ultrasound shows minimal effect on prostate position.

- Probe placed superior to prostate and angled cephalo caudad.
- Tissue directly posterior to probe may show 3-5 mm posterior displacement depending on patient.
In Conclusion

- Discussed some ideas on how to improve image quality from an operator's point of view.
- Presented a simple procedural change which improved alignment quality.
- Examined some of the potential systematic errors involved with transabdominal ultrasound.