SUPERIORITY OF A REAL TIME PLANNING TECHNIQUE OVER IMAGE GUIDED RADIATION THERAPY FOR THE TREATMENT OF PRIMARY PROSTATE CANCERS

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I have no conflicts of interest to disclose
HOW DID WE GET HERE?...

- IGRT

CT-ON-RAILS
(In room diagnostic CT scanner)

- Installed in **2000**
- First of its kind in the United States
- Initially used for prostate treatment
- Eventually extended for use in all other sites as well
HOW DID WE GET HERE?...

- IGRT

Lots of Questions!...

- Why – is it necessary?
- Level of improvement?
- Too labor intensive?
- Costs / Reimbursement?

CT-ON-RAILS
(In room diagnostic CT scanner)
HOW DID WE GET HERE?...

IGRT

• Why – is it necessary?
  • Our Chairman Dr James Wong believed that in some cases, weekly Port Films were insufficient

• Soft tissue can move independently of bony anatomy which goes unseen using portal imaging
HOW DID WE GET HERE?...

IGRT

- Level of Improvement?
  - Increased Accuracy
    - Daily assurance of target coverage led to smaller target margins
  - Opens possibility for increasing total dose / hypo fractionation

 SMALLER MARGINS = REDUCED COMPLICATIONS
HOW DID WE GET HERE?...

- IGRT

  - Too labor intensive?
    - At first... Well yes → Early 2000’s there was no IGRT computer software available

- Axis placed over isocenter (BBs)
- Physician measures from axis to edge of prostate on multiple slices in all directions
- Dosimetrist/Physicist hand plot numbers and compare to initial CT for shifts.
HOW DID WE GET HERE?...

**IGRT**

- Too labor intensive?
  - Not anymore – Eventually IGRT specific software became available
  - This streamlined the process using tools like auto-fusion which significantly reduced the daily additional time and effort

- Reimbursement?
  - Eventually – YES
  - An IGRT Procedure code was created
**How Did We Get Here?...**

- IGRT – it's come a long way...

<table>
<thead>
<tr>
<th>IGRT in 2000</th>
<th>IGRT in 2014</th>
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</thead>
<tbody>
<tr>
<td>Prostate cases only</td>
<td></td>
</tr>
<tr>
<td>5 consecutive treatments only</td>
<td></td>
</tr>
<tr>
<td>Hand-plotted calculations to determine shifts</td>
<td></td>
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<tr>
<td>Therapists, Physicists, Dosimetrists, and Physicians involved</td>
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<tr>
<td>30 – 40 additional minutes</td>
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<td>All areas can be IGRT.</td>
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<tr>
<td>IGRT standard of care and used daily throughout treatment</td>
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<tr>
<td>Auto fusion software immediately determines shift offsets</td>
<td></td>
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<tr>
<td>Only Therapists needed</td>
<td></td>
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<tr>
<td>5 – 10 additional minutes</td>
<td></td>
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</tbody>
</table>
HOW DID WE GET HERE?...

➢ IGRT – Today all types of modalities exist

- Portal Imaging
- Ultrasound
- Cone Bean CT
- Implant markers for Radiosurgery
HOW DID WE GET HERE?...

➢ IGRT

Best Image Quality
Same Grade Diagnostic CT as a CT-Simulator
Best Suited for Re-planning

CT-ON-RAILS
(In room diagnostic CT scanner)
HOW DID WE GET HERE?...

- IGRT – *has improved overall EBRT tremendously*

- BUT – What else are we seeing from IGRT?
  - Changes in target size and shape
    - Temporary vs. Permanent
  - Daily changes in critical organs
    - Rectum & Bladder filling and voiding
  - More setup issues than originally thought
    - Body rotations despite the use of immobilization devices
IGRT Limitations

- Only takes into account target position - tries to fit 2 CT scans (puzzle pieces) together

- What do you do if the 2 pieces simply won’t fit?
  - Adaptive Planning?
Adaptive Planning

The DAILY creation of an IMRT treatment plan that is customized to match the anatomy on each particular treatment day

Lots of Questions!...
• Why – is it necessary?
• Level of improvement?
• Too labor intensive?
• Costs / Reimbursement?

Look familiar?...

WHERE TO START?...
  Prostate Cancer!
Necessity – Anatomical Change

It's happening!
Necessity – Anatomical Change

Prostate patient’s anatomy on 9 consecutive days
Necessity – Anatomical Change

- What does all this mean?
- What is causing these IGRT shifts?
- What affect does it have on the initial treatment plan, if any?
- Does IGRT sufficiently correct for the problem?
Necessity – Anatomical Change

2 Reasons for IGRT corrections

1. Setup error
   Anterior tattoo skewed due to excess belly fat

2. Anatomical Change
   Prostate movement based on rectal filling

FOCUS ON ANATOMICAL CHANGE RELATED IGRT SHIFTS ONLY
Necessity – Dose Degradation

**Retrospective Look**

Initial Planned Doses for prostate treatment with IMRT

10 IGRT CT scans taken during the 1st 2 weeks

The initial treatment plan + resulting shift copied & recalculated onto the new daily CT data set

Some degree of breakdown does occur and we should be able to improve dose distributions
Improvement?
(Retrospective look)

Planning CT
Initial Plan

Daily IGRT CT
Initial Plan Recalculated

Daily IGRT CT
Adapted Plan

[Images of dose-volume histograms for Prostate and Rectum]
**Labor Intensive**

- **Question** – How to best complete a highly complicated process with a high level of precision and accuracy in a short amount of time

- **Ideas**
  - **Site – Prostate:**
    - Minimal structures to contour (Prostate, Rectum, Bladder)
    - Consistent location (centrally located, same beam arrangements)
    - Minimal IMRT segmentation
  - **Schedule**
    - 1st 10 fractions only
    - Same machine, end of the day
    - Rotating schedule (on-call physician, physics...)
  - **Model after the IGRT Process**
    - Practice (lots of dry-runs)
    - Training (Therapists, Dosimetrist, Physicists, MDs)
    - Ideal patients (prepping them to remain still)
Labor Intensive – Methodology (Basic Idea)

- Import the Daily IGRT CT scan
- Draw a new set of structures
- Create a new optimized IMRT plan & evaluate
- Import the new plan into the R&V system
- Perform a second plan check, MU check, etc...
- Approve all fields & treat

All this while the patient is lying on the table...
Labor Intensive – Methodology (Basic Idea)

Contouring…

2 Issues

• Time
  • Brand New Structure Set
  • ~ 40% of the total time
• Consistency
  • Large variations MD – MD

Solution

• Importing original contours
• Planner Draws OARs
  • Faster Time
  • Better Consistency
Planning...

Safety Net
- IGRT & RTP simultaneously

2 Plans
- Adaptive Plan
  - A new optimized plan based on the daily CT anatomy
- IGRT Plan
  - The original plan imported and recalculated with IGRT results

Evaluate
- Treat with the plan that has better target coverage and superior OAR sparing

Adaptive Plan: Solid Line
IGRT Plan: Dashed Line
Labor Intensive – Methodology (Basic Idea)

R&V
- Attaching letters to the adaptive plan beams
- Constant communication to the therapists about which fields to treat

Plan Check
- MU Check
- Physicist 2nd Plan Check

QA?
- None
- % differences (beam weight, beam MU, total MU)

Practice, practice, practice...

Total Treatment Time: 
30 – 35 minutes
Improvement

Planning CT
Initial Plan

Daily IGRT CT
Initial Plan Recalculated
With IGRT Shift Corrections

Daily IGRT CT
Adapted Plan
RESULTS

- Overall results of successful Adaptive Plans
  - Target coverage & normal tissue sparing was always as good or better than the resulting IGRT plan

- Target Doses (Prostate)
  - Little to NO variation (<1%) to overall mean dose
    - IGRT
    - PTV margins eliminated prostate contour variations
RESULTS

- Mean Bladder Dose Reduction via Adaptive Planning
  - 31.7% 3 – 5% reduction
  - 22.3% 6 – 10% reduction
  - 10.8% > 10% reduction

- Majority of these results affected by 2 factors:
  1. Variations of bladder filling
  2. Contouring variations between physicians at the prostate-bladder interface
RESULTS

- Mean Rectal Dose Reduction via Adaptive Planning
  - 32.5% 3 – 5% reduction
  - 8.1% 6 – 10% reduction
  - 1% > 10% reduction

- Higher Doses
  - Reduced Mean Doses most significant in the V50%, V70%, and V90% ranges
RESULTS

- Variation patient to patient
  - Patient A: 1/10 Days with 5% rectal mean dose reduction
  - Patient B: 6/10 Days with over 5% rectal dose reduction
RESULTS

• Beneficial Insights:
  
  • The Rectum can have a profound effect on the prostate’s location, shape, and tilt
  • In these instances, an adaptive plan can more efficiently reduce the radiation dose to the rectum

• Unfortunately, contouring variations still exist to some degree
CONCLUSIONS

**Improve**

- Change in patient anatomy can occur at varying frequencies on a daily basis
- Dose Degradation exists
  - Initial documented planning parameters may not be as accurate as we think even with IMRT/IGRT
- IGRT Improved target accuracy ≠ Improved OAR sparing
- Improvement is possible
  - The adapted plan was consistently better or equivalent in achieving both target coverage normal tissue dose-sparing compared to initial plan with IGRT
CONCLUSIONS

Labor Intensive

- Build a Process / Automate / Patient Selection / Scheduling
  - Total Time – 30 to 35 minutes

- Well Trained On-call Team
  - Physician, Physicist, Dosimetrist, Therapists

Reimbursement?

Sorry...
CONCLUSIONS

- Adaptive Planning is still in its early stages
  - Still quite labor intensive
    - Better/faster software
    - Auto segmentation improvements
      - Difficult to completely eliminate contour variations – Consistency!
    - More definitive indicators for predictability
      - IGRT Shift Causes: Setup error / anatomical change
      - Magnitudes of organ size and shape change
      - Examination of overlapping structures
  - More applicable situations?
    - Other sites of disease
    - Hypo-fractionation
    - Other modalities – proton therapy
CONCLUSIONS

Ultimately...

- Daily IGRT has an enormous amount of information
- We should be taking a closer look at what’s there
THANK YOU

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