Prostate LDR Brachytherapy using I-125 seed implant at Methodist Univ. Hospital

Presenter:
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MUH, Memphis, TN
Aim of this presentation

To provide an overview of the key aspects of Radioactive Seed Implant Brachytherapy for early stage prostate cancer
Contents

- Background
- Classification of Radiation therapy
- Prostate cancer facts, staging and grading
- Characteristics of prostate brachy sources
- Brachytherapy at MUH
- Prostate seed implant flowchart
- Equipment needed
- Seed ordering, handling and receiving
- Treatment planning approaches
- Needle preparation, patient positioning and seed insertion
- Post implant dosimetry
- Few case studies
- What can go wrong and its severity
- Preventive measures
- Open for discussion
Background

Treatment options?
Radiation Therapy

External Beam

Brachytherapy

External beam radiotherapy (external source of radiation)

Source

- X-ray tube
- Cobalt-60 teletherapy
- Linear accelerator (linac)

Brachytherapy (internal source of radiation)

Sealed sources

Co-60
Cs-137
Ir-192
I-125
Pd-103
Brachytherapy

Based on location

- Intracavitary: *source placed in the body cavity* (TnO)
- **Interstitial**: *source placed in the tissue* (prostate)
- Intraluminal: *source placed in the lumen* (egus, trachea)
- Intraoperative: *source placed in the tumor*
- Intravascular: *source placed in blood vessels*
- Surface plaque: *source placed on the surface* (skin ca)
Brachytherapy

HDR
MDR: 12 > DR > 2 Gy/hr
LDR: DR < 2 Gy/hr

LDR

HDR: DR > 12 Gy/hr

Permanent
Encapsulated sources left in place permanently in tissue
Few distinct advantages:

1. Accurate positioning
2. Minimal geometrical miss
3. Outpatient technique

Temporary
Advantages of Interstitial Brachytherapy

- High local dose to tumor in short period of time
- Better tumor control
- Rapid dose fall off
- Minimized dose to other organs
- Less radiation morbidity
- Functional preservation of organs
- Superior cosmetics
Most common for male, after skin ca, in US
Approximately 180K diagnosed every year
>10% of diagnosed die of prostate cancer
1/4-5 diagnosed and 1/30-35 die

With the help of available treatment today:
3-5 years survival 100%
10 years survival 90%
15 years survival 75%
Prostate Cancer Staging/Grading

- Prostate cancer is graded according to T N M grading system
- Early stage: T1 or T2
- If disease is local, brachytherapy is the best option
- But unfavorable prognostic factors is present even for T2c
- NCCN classifies early stage cancer in three risk groups based on clinical T-stage, GSS, PSA as follows:

  Low risk: Gl score < 6; PSA < 10; clinical stage T1-T2a
  Intermediate risk: Gl score = 7; 10 < PSA < 20; clinical stage T2b
  High risk: Gl score 8-10; PSA >20; clinical stage ≥ T2c
# Prostate Brachy sources

<table>
<thead>
<tr>
<th>Isotope</th>
<th>$T_{1/2}$</th>
<th>$E$ (KeV)</th>
<th>Rx (Gy)</th>
<th>BED (Gy)</th>
<th>Boost Rx (Gy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-125</td>
<td>60 d</td>
<td>28</td>
<td>145</td>
<td>111</td>
<td>110</td>
</tr>
<tr>
<td>Pd-103</td>
<td>17 d</td>
<td>21</td>
<td>125</td>
<td>115</td>
<td>90</td>
</tr>
<tr>
<td>Cs-131</td>
<td>10 d</td>
<td>29</td>
<td>115</td>
<td>112</td>
<td>90</td>
</tr>
</tbody>
</table>

## Notes:

- Cs- (2004); Pd- (1990) and I-125 (1965)
- DR is an important factor to prostate brachy Rx dose
- DR effect: Rx dose of Pd- and Cs- is 15% and 20% lower to I-125
- Cs-131 is better for uniform dose dist but higher bldr & rect dose
- Cs-131 may cause early complication due to high DR
Prostate Brachy Sources

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower $\alpha/\beta$ means less repair, favors high dose rate</td>
<td>$Cs &gt; Pd &gt; l$</td>
</tr>
<tr>
<td>High tumor repopulation rate favors short $t_{1/2}$</td>
<td>$Cs &gt; Pd &gt; l$</td>
</tr>
<tr>
<td>Slower normal tissue repair rate favors long Tx</td>
<td>$l &gt; Pd &gt; Cs$</td>
</tr>
<tr>
<td>Greater tumor hypoxia favors greater dose</td>
<td>$l &gt; Pd &gt; Cs$</td>
</tr>
<tr>
<td>Greater normal tissue sparing favors lower energy</td>
<td>$Pd &gt; l &gt; Cs$</td>
</tr>
<tr>
<td>Greater biological effect favors lower energy</td>
<td>$Pd &gt; l &gt; Cs$</td>
</tr>
<tr>
<td>Edema affects BED less for long $t_{1/2}$ and higher $E$</td>
<td>$l &gt; Cs &gt; Pd$</td>
</tr>
</tbody>
</table>

Questions

Radiation oncologist told his physicist that he likes 15-10-10-15-15 mgRaEq

Which of the following procedures is he talking about?

• EBRT / Brachy
• LDR
• MDR
• HDR
• Temporary
• Permanent

• Intracavitary
• Interstitial
• Intraluminal
• Intraoperative
• Intravascular
• Surface plaque

Correct answer: Intracavitary LDR temporary Brachytherapy (T & O)
Brachy at MUH
Pre-West Cancer Center  Post-West Cancer Center

Brachytherapy cases at MUH/WCC

- GYN BRACHY
- APBI
- Prostate
- Eye Plaque
- Total brachy
MUH in-house Protocol & Treatment guidelines

Patient Selection criteria:
- Life expectancy > 5 yrs
- Clinical Stage: T1b-T2c
- Gleason scores: 2-10
- PSA ≤ 50 ng/ml
- No pelvic LN involved
- No distant metastasis

Contradictions:
- Extensive TURP defects
- Severe pubic arch interference
- Prostate dim. > grid (6x5 sqcm)
- Prior pelvic radiotherapy?
- Inflammatory bowel disease
- Gross SV involvement

Low risk: Gl score <6; PSA<10; clinical stage T1-T2a
Intermediate risk: Gl score 7; 10<PSA<20; clinical stage T2b-T2c
High risk: Gl score 8-10; PSA>20; clinical stage T3a

At MUH in almost all (> 500) cases: cT1c-T2a No Mo
Seed implant flowchart

1. Order & receive Seeds
2. Estimate seeds per PrePlan / Nomogram
3. Seed assay
4. Verify Positioning in the OR or intraOp plan
5. Prepare needles for implant per plan
6. Clinician inserts the needles and drops the seeds
7. Evaluate implant with fluoroscopy
8. Verify seed displacement using cystoscope
9. Tx complete

US vol study
US Volume Study, Seed strength & Seed order

- **Initial volume study** is performed at Urology office
- Based on the volume, total activity and source strength are determined from the in-house Nomogram
- Number of seeds are determined for seed order
- 10% extra seed are added per protocol for seed assay
- All seeds are ordered for sterile stranded seeds except 10% loose non-sterile seeds for seed assay
- These loose seeds are sterilized prior to implant
- **Implant volume study** is performed in the OR intraoperatively
Equipment taken to OR

- US machine
- C-arm
- Stabilizer
- Rad Survey meter
- Radioactive Seeds
- Needles & spacers
- Seed cutter and loader
- Template
- Tweezers and rulers
- Needle holder
- Radioactive door sign
- Written directives
- Rad safety items
Questions

What category does the Prostate seed implant fall under?

- EBRT / Brachy
- LDR
- MDR
- HDR
- Temporary
- Permanent
- Intracavitary
- Interstitial
- Intraluminal
- Intraoperative
- Intravascular
- Surface plaque

Correct answer: Interstitial LDR Permanent Brachytherapy
Treatment Planning
Prostate Anatomy
Planning Approach

- **PrePlanning:** Planning done before going to OR
- **IntraOperative:** Planning in the OR during implant
- **Interactive:** Plan revised based on US/Fluoroscopy images taken periodically in the OR
- **Dynamic approach:** Dose distribution updated continuously according to seed position feedback from image guidance
IntraOperative Planning

Advantages

- Accurate volume
- Less uncertainty in planning & positioning

Disadvantages

- Longer OR time
- Limited time for team member’s feedback
- Waste of seeds
IntraOperative Planning

- Nomogram approaches: 75% to periphery
- Uniform loading: low strength sources used
- Modified Uniform Loading: manual basis
- Peripheral Loading: high strength sources used
- Modified Peripheral Loading: manual basis

At MUH/WCC:

Autoplan followed by manually modified uniform / peripheral loading
IntraOp Planning Algorithm at MUH

TRUS scan of prostate → Contouring → Treatment plan developed

- Record planned dosimetry data
  - Yes: Dosimetry Acceptable
  - No: Implant seeds per plan (or add/remove extra seeds)
  - No: Review of seed coverage (using US and fluoroscopy) and dosimetry
    - Yes: Implant Dosimetry Acceptable?
      - Yes: Record implanted dosimetry data
      - No: Treatment complete
    - No: Implant seeds per plan (or add/remove extra seeds)
Patient Positioning / Stabilizing

- Lithotomy position

- Rectal Suctioning
- US probe placement
- Prostate deformation
Intraoperative US Volume Study

- Anesthesiologist put the patient on sleep
- Urologist / oncologist setup the pt for TRUS vol study
- A physicist is present to confirm that pt setup is good for vol study so that a satisfactory plan can be developed
- The volume study consists of consecutive axial images taken at 5 mm intervals from base-5mm to apex+5mm to accommodate PTV margin.
- Template hole patterns are superimposed in each images
- Once images are taken, oncologist draw the volumes
Prostate Brachy: Imaging issues
(US, Fluoroscopy, CT, MR)
US Image acquisition and Contouring
US image and Template registration
Contours & Margins

How much margin is necessary?

Mayo and Cleveland clinic: 5mm surgical margin controls 99% prostate cancer

At MUH/WCC:
2 mm surrounding the prostate except 1 mm posteriorly
PTV / PRV contouring
Planning

Autoplan followed by manually modified uniform / peripheral loading
Needle Insertion / retraction

Ruler, needle, needle plunger
### Plans at MUH / WCC

<table>
<thead>
<tr>
<th>Needle Number</th>
<th>Retraction (cm)</th>
<th>Hole Location</th>
<th>Number Seeds</th>
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<tbody>
<tr>
<td>1</td>
<td>0.50</td>
<td>c4.5</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>0.50</td>
<td>d4.5</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1.00</td>
<td>C4.0</td>
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<tr>
<td>4</td>
<td>1.00</td>
<td>D4.0</td>
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<tr>
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<td>1.00</td>
<td>E4.0</td>
<td>3</td>
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<tr>
<td>6</td>
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<td>b3.5</td>
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<tr>
<td>7</td>
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<td>e3.5</td>
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<td>8</td>
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<td>B3.0</td>
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<tr>
<td>9</td>
<td>0.00</td>
<td>C3.0</td>
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<tr>
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<td>0.00</td>
<td>E3.0</td>
<td>3</td>
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<td>11</td>
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<td>F3.0</td>
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<td>b2.5</td>
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<td>14</td>
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<td>e2.5</td>
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<td>f2.5</td>
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<td>16</td>
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<td>17</td>
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<td>C2.0</td>
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<tr>
<td>18</td>
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<td>19</td>
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<td>F2.0</td>
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<td>b1.5</td>
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<td>22</td>
<td>0.50</td>
<td>c1.5</td>
<td>4</td>
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<td>23</td>
<td>0.50</td>
<td>d1.5</td>
<td>4</td>
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<td>24</td>
<td>0.50</td>
<td>e1.5</td>
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<tr>
<td>25</td>
<td>1.50</td>
<td>f1.5</td>
<td>2</td>
</tr>
</tbody>
</table>

- **Red dot** = Special loading

**Special needles**
Plans at MUH / WCC
### Table 1. Post-implant dosimetry targets for avoiding urethral complications.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prostatic Urethra</td>
<td>&lt;360 (post–TG-43) Gy to significant lengths (10 mm) of the urethra</td>
</tr>
<tr>
<td>Prostate Gland</td>
<td>Urination Frequency, $D_{90} &lt; 180$ Gy (200 Gy)</td>
</tr>
<tr>
<td>Prostate Gland</td>
<td>Dysuria, Dosimetry not predictive of dysuria</td>
</tr>
<tr>
<td>Membranous Urethra</td>
<td>Stricture, Dose to the membranous urethra &lt; reference dose, no seeds &gt; 5 mm inferior to apical slice</td>
</tr>
<tr>
<td>Prostate Gland</td>
<td>Stricture, $V_{150} &lt; 60%$</td>
</tr>
<tr>
<td>Prostate Gland</td>
<td>No correlation between dose and complications, length of urethra is important</td>
</tr>
<tr>
<td>Prostate Gland</td>
<td>High-dose regions weakly correlate with IPSS score increases but only at 1 month</td>
</tr>
</tbody>
</table>

### Table 2. Post-implant dosimetry targets for avoiding rectal complications.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectum</td>
<td>Dose to &gt;1 cm length of anterior mucosal wall &lt; reference dose</td>
</tr>
<tr>
<td>Rectum</td>
<td>Dose to &gt;5 mm length of anterior mucosal wall &lt; 1.2 × reference dose</td>
</tr>
<tr>
<td>Rectum</td>
<td>Maximum dose to anterior mucosal wall &lt; 120% of reference dose</td>
</tr>
<tr>
<td>Rectum</td>
<td>Annular DVH of rectum &lt; 1.3 cm³ to 160 Gy or &lt; 2.0 cm³ to 145 Gy (1-125)</td>
</tr>
<tr>
<td>Rectum</td>
<td>Surface area of outer rectal wall &lt; 5 cm² to reference dose</td>
</tr>
<tr>
<td>Prostate</td>
<td>High dose regions, no correlation to rectal complications</td>
</tr>
<tr>
<td>Rectum</td>
<td>Surface area of outer rectal wall 30% &lt; 100 Gy, 20% &lt; 150 Gy, 10% &lt; 300 Gy (1-125)</td>
</tr>
</tbody>
</table>

### Table 3. Post-implant dosimetry targets for avoiding erectile dysfunction.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurovascular Bundles</td>
<td>Possible correlation between NVB dose and early impotence</td>
</tr>
<tr>
<td>Neurovascular Bundles</td>
<td>No correlation between NVB dose and erectile dysfunction</td>
</tr>
<tr>
<td>Prostate Gland</td>
<td>$D_{90} &lt; 160$ Gy (I-125), $D_{90} &lt; 100$ Gy (Pd-103)</td>
</tr>
<tr>
<td>Penile Bulb Dose</td>
<td>$PBD_{50} &lt; 50$ Gy; $PBD_{50} &lt; 40%$ mPD, $PBD_{25} &lt; 60%$ mPD</td>
</tr>
<tr>
<td>Prostate Gland</td>
<td>Avoid external beam radiotherapy, reduces 6 year actuarial potency preservation from 50–60% to 25–30%</td>
</tr>
<tr>
<td>Penile Bulb</td>
<td>Radiation dose to the penile bulb does not correlate to erectile dysfunction</td>
</tr>
<tr>
<td>Penile Bulb</td>
<td>$PBD_{90} &lt; 10%$ mPD</td>
</tr>
<tr>
<td>Neurovascular Bundles</td>
<td>No correlation between dose and retention of potency</td>
</tr>
<tr>
<td>Penile Bulb</td>
<td>No correlation between dose to the penile bulb and retention of potency</td>
</tr>
</tbody>
</table>
Plan Evaluation guidelines at MUH

Prostate / PTV:

High dose volume: \( V_{200} < 20\% \) of PTV vol
Homogeneity: \( V_{150} < 50\% \) of PTV vol
PTV coverage: \( V_{100} \approx 100\% \) (> 95% of PTV vol)
\( D_{90} < 120\% \) of Rx Dose
\( D_{50} < 150\% \) of Rx Dose
\( D_{10} < 200\% \) of Rx Dose

Urethra: \( D_{90\%} < 100\% \) of Rx Dose
\( D_{1\%} < 150\% \) of Rx Dose

Rectum: \( V_{100} < 1.3 \) cc
\( D_{90} < 5-10\% \) of Rx Dose

Bladder: \( V_{100} < 2 \) cc
\( D_{90} < 5-10\% \) of Rx Dose

Minimize:

Number of seeds
Number of needles
Number of special needles
Case of 2002
2002 PostOp Plan (1st prostate brachy at MUH)

Prostate:
- $V_{200} < 20\%$
- $V_{150} < 50\%$
- $V_{100} \approx 100\%$
- $D_{90} < 120\%$
- $D_{50} < 150\%$
- $D_{10} < 200\%$

Urethra:
- $D_{90\%} < 100\%$
- $D_{1\%} < 150\%$

Rectum:
- $V_{100} < 1.3 \text{ cc}$
- $D_{90} < 5-10\%$

Bladder:
- $V_{100} < 2 \text{ cc}$
- $D_{90} < 5-10\%$
Case of 2007
Plans at MUH / WCC (2007)

Prostate:
- \( V_{200} < 20\% \)
- \( V_{150} < 50\% \)
- \( V_{100} \approx 100\% \)
- \( D_{90} < 120\% \)
- \( D_{50} < 150\% \)
- \( D_{10} < 200\% \)

Urethra:
- \( D_{90\%} < 100\% \)
- \( D_{1\%} < 150\% \)

Rectum:
- \( V_{100} < 1.3 \text{ cc} \)
- \( D_{90} < 5-10\% \)

Bladder:
- \( V_{100} < 2 \text{ cc} \)
- \( D_{90} < 5-10\% \)
### Plans at MUH / WCC (2007)

**Prostate:**
- \( V_{200} < 20\% \)
- \( V_{150} < 50\% \)
- \( V_{100} \approx 100\% \)
- \( D_{90} < 120\% \)
- \( D_{50} < 150\% \)
- \( D_{10} < 200\% \)

**Urethra:**
- \( D_{90\%} < 100\% \)
- \( D_{1\%} < 150\% \)

**Rectum:**
- \( V_{100} < 1.3 \text{ cc} \)
- \( D_{90} < 5-10\% \)

**Bladder:**
- \( V_{100} < 2 \text{ cc} \)
- \( D_{90} < 5-10\% \)

### Dose Information

<table>
<thead>
<tr>
<th>Study Type:</th>
<th>Post-Op</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prostate:</strong></td>
<td></td>
</tr>
<tr>
<td>Total Volume:</td>
<td>37.07 cm(^3)</td>
</tr>
<tr>
<td>( V_{200%} ):</td>
<td>4.77 cm(^3) [12.87%]</td>
</tr>
<tr>
<td>( V_{150%} ):</td>
<td>15.92 cm(^3) [42.93%]</td>
</tr>
<tr>
<td>( V_{100%} ):</td>
<td>33.41 cm(^3) [90.10%]</td>
</tr>
<tr>
<td>( D_{90%} ):</td>
<td>145.22 Gy [100.15%]</td>
</tr>
<tr>
<td>( D_{50%} ):</td>
<td>207.42 Gy [143.05%]</td>
</tr>
<tr>
<td>( D_{10%} ):</td>
<td>308.87 Gy [213.01%]</td>
</tr>
<tr>
<td><strong>Urethra:</strong></td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Rectum:</strong></td>
<td></td>
</tr>
<tr>
<td>Total Volume:</td>
<td>45.92 cm(^3)</td>
</tr>
<tr>
<td>( V_{100%} ):</td>
<td>0.28 cm(^3) [0.61%]</td>
</tr>
<tr>
<td>( D_{100%} ):</td>
<td>2.26 Gy [1.56%]</td>
</tr>
<tr>
<td>( D_{30%} ):</td>
<td>40.28 Gy [27.78%]</td>
</tr>
<tr>
<td>( D_{10%} ):</td>
<td>78.59 Gy [54.20%]</td>
</tr>
<tr>
<td>( D_{1%} ):</td>
<td>136.64 Gy [94.23%]</td>
</tr>
<tr>
<td><strong>PTV:</strong></td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Bladder:</strong></td>
<td>N/A</td>
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</table>
Plans at MUH / WCC

Case of 2012
## Plans at MUH / WCC (2012)

<table>
<thead>
<tr>
<th>Needle Number</th>
<th>Retraction (cm)</th>
<th>Hole Location</th>
<th>Number Seeds</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>0.50</td>
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<tr>
<td>2</td>
<td>0.50</td>
<td>a4.5</td>
<td>2</td>
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<tr>
<td>3</td>
<td>1.00</td>
<td>C4.0</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1.00</td>
<td>C4.0</td>
<td>3</td>
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<tr>
<td>5</td>
<td>1.00</td>
<td>E4.0</td>
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<td>8</td>
<td>1.00</td>
<td>B3.0</td>
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<td>E2.0</td>
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<td>11</td>
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<td>C2.0</td>
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<tr>
<td>17</td>
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<td>E2.0</td>
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### Plan Summary

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<tr>
<th>Number of Noodles</th>
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<tr>
<td>8</td>
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<tr>
<td>17</td>
<td>3</td>
</tr>
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<td>4</td>
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- Total Activity (U): 36.85
- Total Activity (mCi): 29.02
- Total Needles: 29
- Extra Seeds: 83
- Total Seeds to Order: 25
Plans at MUH / WCC (2012)
## Plans at MUH / WCC (2012)

### Prostate:
- $V_{200} < 20\%$
- $V_{150} < 50\%$
- $V_{100} \approx 100\%$
- $D_{90} < 120\%$
- $D_{50} < 150\%$
- $D_{10} < 200\%$

### Urethra:
- $D_{90\%} < 100\%$
- $D_{1\%} < 150\%$

### Rectum:
- $V_{100} < 1.3 \text{ cc}$
- $D_{90} < 5-10\%$

### Bladder:
- $V_{100} < 2 \text{ cc}$
- $D_{90} < 5-10\%$

### Dose Information

#### Pre-Op

**Prostate:**
- Total Volume: 41.00 cc
- $V_{200}$: 8.64 cc [21.07%]
- $V_{150}$: 24.89 cc [61.71%]
- $V_{100}$: 40.53 cc [98.87%]
- $D_{90}$: 175.01 Gy [120.70%]
- $D_{50}$: 233.68 Gy [161.16%]
- $D_{10}$: 344.94 Gy [237.89%]

**Urethra:**
- Total Volume: 1.04 cc
- $D_{90}$: 131.67 Gy [90.81%]
- $D_{30}$: 176.96 Gy [122.04%]
- $D_{10}$: 180.69 Gy [124.61%]
- $D_{1}$: 186.68 Gy [128.74%]

**Rectum:**
- Total Volume: 19.42 cc
- $V_{100}$: 0.07 cc [0.38%]
- $D_{100}$: 22.37 Gy [18.42%]
- $D_{30}$: 71.54 Gy [49.34%]
- $D_{10}$: 98.31 Gy [67.08%]
- $D_{1}$: 134.66 Gy [92.86%]

**PTV:**
- Total Volume: 49.78 cc
- $V_{200}$: 9.63 cc [19.35%]
- $V_{150}$: 27.34 cc [54.93%]
- $V_{100}$: 48.61 cc [98.05%]
- $D_{90}$: 167.87 Gy [115.77%]
- $D_{50}$: 225.03 Gy [155.19%]
- $D_{10}$: 345.07 Gy [237.98%]

#### Post-Op

**Prostate:**
- Total Volume: 42.98 cc
- $V_{200}$: 9.60 cc [22.33%]
- $V_{150}$: 19.90 cc [46.30%]
- $V_{100}$: 37.39 cc [87.00%]
- $D_{90}$: 138.24 Gy [95.34%]
- $D_{50}$: 209.13 Gy [144.23%]
- $D_{10}$: 351.49 Gy [242.41%]

**Urethra:**
- $D_{90\%} < 100\%$
- $D_{1\%} < 150\%$

**Rectum:**
- Total Volume: 63.25 cc
- $V_{100}$: 1.46 cc [2.35%]
- $D_{100}$: 2.96 Gy [2.04%]
- $D_{30}$: 37.97 Gy [26.19%]
- $D_{10}$: 88.64 Gy [61.13%]
- $D_{1}$: 164.45 Gy [113.41%]

**Bladder:**
- Total Volume: 40.58 cc
- $V_{100}$: 0.25 cc [0.61%]
- $D_{90}$: 11.98 Gy [8.26%]
Plans at MUH / WCC

Case of 2017
Plans at MUH / WCC (2017)

PrePlan
Plans at MUH / WCC (2017)

<table>
<thead>
<tr>
<th>Study Type:</th>
<th>Pre-Op</th>
</tr>
</thead>
</table>

### Dose Information

**Prostate:**
- Total Volume: 55.59 cc
- V200%: 8.97 cc [16.13%]
- V150%: 30.61 cc [55.07%]
- V100%: 54.61 cc [98.23%]
- D90%: 173.43 Gy [119.61%]
- D50%: 224.75 Gy [155.00%]
- D10%: 336.21 Gy [231.87%]

**Urethra:**
- Total Volume: 1.44 cc
- D90%: 133.17 Gy [91.84%]
- D50%: 181.81 Gy [125.38%]
- D10%: 193.74 Gy [133.61%]
- D1%: 201.09 Gy [138.68%]

**Rectum:**
- Total Volume: 26.45 cc
- V100%: 0.46 cc [1.76%]
- D100%: 18.96 Gy [13.07%]
- D50%: 72.65 Gy [50.10%]
- D10%: 104.60 Gy [72.14%]
- D1%: 153.73 Gy [106.02%]

**PTV:**
- Total Volume: 65.07 cc
- V200%: 9.78 cc [14.83%]
- V150%: 33.14 cc [50.24%]
- V100%: 63.85 cc [96.78%]
- D00%: 166.61 Gy [114.00%]
- D50%: 217.76 Gy [150.18%]
- D10%: 327.34 Gy [225.75%]

**Bladder:** N/A
Plans at MUH / WCC (2017)

PostPlan

Study Type: Post-Op

Dose Information

Prostate:
- Total Volume: 60.80 cc
- V200%: 12.56 cc [20.64%]
- V150%: 29.75 cc [48.94%]
- V100%: 52.87 cc [86.96%]
- D90%: 135.96 Gy [93.77%]
- D50%: 215.94 Gy [148.92%]
- D10%: 341.50 Gy [235.52%]

Urethra: N/A

Rectum:
- Total Volume: 79.39 cc
- V100%: 1.02 cc [1.28%]
- D100%: 2.41 Gy [1.66%]
- D30%: 34.40 Gy [23.73%]
- D10%: 77.59 Gy [53.51%]
- D1%: 153.02 Gy [105.53%]

PTV: N/A

Bladder:
- Total Volume: 361.33 cc
- V100%: 0.02 cc [0.01%]
- D90%: 2.77 Gy [1.91%]
## Implant Statistics

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</table>
What can go wrong? How severe can it be?

98 seeds implanted, 0 in the prostate (Brachytherapist attributed this to seed migration and did not report this as a medical event!)

prostate
penile bulb
rectum

2 seeds in penile shaft

NRC reported Medical Events

- Partial Dose intended but full dose given
  - 160 Gy instead of 107 Gy (49% higher; human error)

- Delivered different from ordered activity
  - Air Kerma ordered but not prescribed in Air Kerma
    (30% lower, human error)

- Wrong site (uncalibrated US)
  - All 53 seeds implanted outside prostate volume (in penile bulb)
  - 29% seeds implanted outside prostate volume (in bladder)

Medical event / misadministration?

- Wrong patient
- Wrong site
- Wrong mode of delivery
- Wrong radionuclide
- Dosage differs > 20% of the Rx dose
Safety measures at MUH

- Clear policy procedure
- Seed ordering & assay
- 2nd checked by another physicist
- Imaging system QA
- Source strength labeling
- Follow the protocol
- Complete Written directive
- Special physics consult review
- Periodic calculation accuracy check
- Review literature
Summary

✓ Brachytherapy is the ultimate conformal therapy
✓ Extracapsular extension can be easily treated
✓ Favorable Morbidity
✓ The ultimate success depends on expertise of the brachytherapy team and their mutual cooperation
✓ At MUH, we follow …… ….
Thank You
Needle Insertion