Permanent Prostate Brachytherapy
Post Procedure Evaluation

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IMPS, San Antonio, Texas
Texas Cancer Clinic, San Antonio, Texas
Implant Evaluation for the Patient

Create Post Plan (Isodose Lines, DVH, Quantifiers)

Adequate Target Coverage?

Yes

Acceptable Critical Structure Doses?

Yes

Normal Follow Up

No

Expected Complications?

Yes

File Post Plan for Programmatic Review

No

Increased Watchfulness
Patient Counseling
Frequent Follow Up

Adjuvant Treatments: Reimplantation External Beam Surgery Chemotherapy Hormonal Deprivation Cryotherapy Hyperthermia Photo Therapies

Appropriate Adjuvant Treatment?

Yes

No
Implant Targets

• “It is a far, far better thing to have a firm anchor in nonsense than to put out on the troubled sea of thought.”

– John Kenneth Galbraith
<table>
<thead>
<tr>
<th>Structure</th>
<th>Intent</th>
<th>Goal</th>
<th>References</th>
</tr>
</thead>
</table>
| Prostate Gland     | Cure                            | \(D_{90}\) for iodine monotherapy \(> 140\) Gy  
\(D_{90}\) for palladium monotherapy \(> 125\) Gy  
\(D_{90}\) for boosts \(>\) reference dose | Stock 1998  
Potters 2001 |
| Prostate Gland     | Urethral complications          | \(D_{90} < 180\) Gy  
\(V_{150} < 60\%\) reference dose                                                 | Stock 2002  
Merrick 2002a |
| Membranous Urethra | Urethral complications          | Dose to the membranous urethra \(<\) reference dose                                  | Merrick 2002a               |
| Rectum             | Rectal complications            | Dose to \(> 1\) cm length of anterior mucosal wall \(<\) reference dose  
Max dose to anterior mucosal wall \(< 120\%\) of reference dose | Merrick 1999           |
| Rectum             | Rectal complications            | Annular DVH of rectum \(< 1.3\) cm\(^3\) to 160 Gy (iodine)                           | Snyder 2001                |
| Rectum             | Rectal complications            | Surface area of outer rectal wall \(< 5\) cm\(^2\) to reference dose                | Han 2001                    |
$D_{90}$ Compared to $V_{100}$

Volumetric versus Dose Conformity Quantifiers (single institution, Palladium to 115 Gy, $n = 28$, Iodine to 144 Gy, $n = 63$)
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| Rectum             | Rectal complications    | Dose to > 1 cm length of anterior mucosal wall < reference dose  
Max dose to anterior mucosal wall < 120% of reference dose | Merrick 1999 |
| Rectum             | Rectal complications    | Annular DVH of rectum < 1.3 cm$^3$ to 160 Gy (iodine)                                     | Snyder 2001 |
| Rectum             | Rectal complications    | Surface area of outer rectal wall < 5 cm$^2$ to reference dose                            | Han 2001 |
Rectal Volume cutpoint for less than 5% incidence of Grade 2 proctitis (cc)

Snyder (Stock), IJROBP 2001
Post Plan Evaluation Targets

- **Isodose evaluation**
- **Coverage**
  - $D_{90} > \text{Rx dose}$
  - $V_{90} > 90\%, \ V_{100} > 87\%$
- **Urethra**
  - $< 150\%$ of Rx dose, 200% maximum
- **Rectum**
  - $< 120\%$ of Rx dose
  - $< 1.5 \text{ cc of rectum} > \text{Rx dose}$
- **Potency**
  - Stay away from the penile bulb and the membranous urethra (watch inferior dose distribution)
A Test on Post Implant Evaluation
Evaluation Exercise

- During an implant review, I come across an implant performed on Mr. Anonymous
- T2a, GSS=6, PSA = 9.4, $^{125}$I monotherapy
- In terms of dosimetric coverage of the gland, is this a good implant (one for which I would not consider salvage—adjuvant—therapy)?
  - $V_{100}$, 90.1%
  - $V_{150}$, 47.3%
  - $D_{90}$, 146 Gy
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<td>Rectal complications</td>
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</table>
More Information

- From the prescription sheet filled out by the radiation oncologist from the pathology report

<table>
<thead>
<tr>
<th>Biopsy Data</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid Gland</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Apex</td>
<td></td>
<td>++</td>
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</table>
A little more information

- Preimplant Ultrasound Volume, 23.4 cc
- Postimplant CT Volume, 30.5 cc
- Volumetric change: +30%
- Base to apex dimension:
  - Preimplant: 3.5 cm
  - Postimplant: 4.2 cm
Post operative imaging

Visualization

Good

Poor

Sources

Prostate

CT

MRI

US
CT based dosimetry: Have we built our house upon the sand?
Expansion Effects on $V_{100}$

![Graph showing the relationship between expansion distance (mm) and average $V_{100}$ values. The graph includes a scatter plot with data points indicating a trend.]
Expansion Effects on $D_{90}$

![Graph showing the relationship between expansion distance (mm) and $D_{90}$ values. The graph demonstrates a decrease in $D_{90}$ as the expansion distance increases.]
Expansion Effects on Iodine and Palladium Implants
## DVH/DSH Values

### Dose Volume/Surface Histogram Statistics

**Name:** Anonymous, Mr  
**Prescription Dose:** 14500 cGy

**Expansion Type:** Slice-by-slice Expansion, except posterior  
**Expansion Distances (mm):** -6, -4, -2, 0, 2, 4, 6

<table>
<thead>
<tr>
<th>Expansion (mm)</th>
<th>Prostate Volumes (cc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>17.90 cc</td>
</tr>
<tr>
<td>-4</td>
<td>21.49 cc</td>
</tr>
<tr>
<td>-2</td>
<td>25.79 cc</td>
</tr>
<tr>
<td>0</td>
<td>30.32 cc</td>
</tr>
<tr>
<td>2</td>
<td>35.70 cc</td>
</tr>
<tr>
<td>4</td>
<td>41.88 cc</td>
</tr>
<tr>
<td>6</td>
<td>48.47 cc</td>
</tr>
</tbody>
</table>

### Volume (V) quantifier

<table>
<thead>
<tr>
<th>Dist (mm)</th>
<th>V70</th>
<th>V80</th>
<th>V90</th>
<th>V99</th>
<th>V100</th>
<th>V150</th>
<th>V200</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>97.9%</td>
<td>96.0%</td>
<td>94.4%</td>
<td>91.9%</td>
<td>91.6%</td>
<td>42.2%</td>
<td>10.1%</td>
</tr>
<tr>
<td>-4</td>
<td>97.9%</td>
<td>95.9%</td>
<td>94.2%</td>
<td>91.6%</td>
<td>91.3%</td>
<td>44.5%</td>
<td>11.6%</td>
</tr>
<tr>
<td>-2</td>
<td>98.0%</td>
<td>95.9%</td>
<td>93.8%</td>
<td>91.3%</td>
<td>91.0%</td>
<td>46.6%</td>
<td>13.6%</td>
</tr>
<tr>
<td>0</td>
<td>98.0%</td>
<td>95.9%</td>
<td>93.5%</td>
<td>90.5%</td>
<td>90.1%</td>
<td>47.3%</td>
<td>14.8%</td>
</tr>
<tr>
<td>2</td>
<td>97.9%</td>
<td>95.6%</td>
<td>92.6%</td>
<td>88.9%</td>
<td>88.5%</td>
<td>46.5%</td>
<td>14.6%</td>
</tr>
<tr>
<td>4</td>
<td>97.5%</td>
<td>94.3%</td>
<td>89.9%</td>
<td>85.2%</td>
<td>84.7%</td>
<td>42.6%</td>
<td>13.1%</td>
</tr>
<tr>
<td>6</td>
<td>95.5%</td>
<td>90.2%</td>
<td>84.3%</td>
<td>79.1%</td>
<td>78.6%</td>
<td>37.7%</td>
<td>11.5%</td>
</tr>
<tr>
<td>Average</td>
<td>97.5%</td>
<td>94.8%</td>
<td>91.8%</td>
<td>88.4%</td>
<td>88.0%</td>
<td>43.9%</td>
<td>12.8%</td>
</tr>
<tr>
<td>Std Dev</td>
<td>0.9%</td>
<td>2.1%</td>
<td>3.6%</td>
<td>4.7%</td>
<td>4.8%</td>
<td>3.4%</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

### Dose (D) quantifier (Gy)

<table>
<thead>
<tr>
<th>Dist (mm)</th>
<th>D70</th>
<th>D80</th>
<th>D90</th>
<th>D99</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>184</td>
<td>173</td>
<td>153</td>
<td>92</td>
</tr>
<tr>
<td>-4</td>
<td>185</td>
<td>172</td>
<td>152</td>
<td>93</td>
</tr>
<tr>
<td>-2</td>
<td>185</td>
<td>172</td>
<td>150</td>
<td>94</td>
</tr>
<tr>
<td>0</td>
<td>184</td>
<td>171</td>
<td>146</td>
<td>93</td>
</tr>
<tr>
<td>2</td>
<td>181</td>
<td>167</td>
<td>140</td>
<td>93</td>
</tr>
<tr>
<td>4</td>
<td>175</td>
<td>157</td>
<td>131</td>
<td>91</td>
</tr>
<tr>
<td>6</td>
<td>164</td>
<td>142</td>
<td>118</td>
<td>84</td>
</tr>
<tr>
<td>Average</td>
<td>180</td>
<td>165</td>
<td>142</td>
<td>91</td>
</tr>
<tr>
<td>Std Dev</td>
<td>08</td>
<td>11</td>
<td>13</td>
<td>03</td>
</tr>
</tbody>
</table>

78.6% < V\textsubscript{100} < 91.6% (88.0%)  
118 Gy < D\textsubscript{90} < 153 Gy (142 Gy)
In terms of dosimetric coverage of the gland, is this a good implant?

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Coregistration Results

Doses are in cGy

Doses are in cGy

Doses are in cGy

Doses are in cGy

Doses are in cGy

Doses are in cGy
One last bit of information

- The CT and MRI scan were performed on the day of the implant (Day 0 dosimetry)
In terms of dosimetric coverage of the gland, is this a good implant?

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Implant Evaluation for the Program

1. Collect Files for Review
2. Make and Record Changes
3. Waiting Period
4. Checklist for Regulatory Compliance
5. Extract Data:
   - Implant Characteristics
   - Quantifier Values
6. Unacceptable Quantifiers?
   - Yes
     - Correlate with Implant Characteristics
     - Suggest Possible Changes in Implant Technique
   - No
     - Implant Characteristics:
       - Target Volume
       - Target Volume Ratio
       - Isotope
       - Applicator
       - Implant Technique
       - Reference Dose
       - Imaging Technique
       - Design Criteria
       - Source Strength
       - Number of Sources
       - Location of sources
     - Quantifier Values:
       - Target Doses—Coverage (D90, V100)
       - Inhomogeneity (V150)
       - Sector Coverage
       - Critical Structure Doses—Reference Dose Values (e.g., R100, B100)
       - High Dose Values (e.g., R150, U200)
       - Low Dose Values (e.g., PB50)
       - Dose Trace Values
       - Point Dose Values (e.g., Bladder Neck)
7. Waiting Period
8. Collect Files for Review
9. Make and Record Changes
10. Waiting Period
Story Title: Serendipity
Scene: The Big Apple
The Year: 1995
Story #1, The Big Apple

- Wicked step mother
- Princess
- Knights in shining armor
- Wizard
- Happily-ever-after ending
Two institutions in New York performing post implant dosimetry

MSKCC (WSM)

Mt. Sinai (Princess)
Scene

• 1995 (Seattle—Great Western Horde—raises the prostate brachytherapy bar)
  – Implant quality
  – Clinical outcomes
• MSK (WSM) does prostate brachytherapy and has since the early 70s
• Mt. Sinai marches to the sound of the guns
  – Richard Stock (KSA) and Nelson Stone (Frog Prince)
  – Kieth DeWyngaert (Wizard)
Action

• Mt. Sinai implant technique
  – Nomogram (WSM)
  – Implant rules (KSA, Wizard)
  – Patients (Frog Prince)
• CT-based post implant dosimetry (KSA, Wizard)
• Implant review, tough questions (KSA)
I - 125 PROSTATE IMPLANTS: ACTIVITIES PER VOLUME

TOTAL ACTIVITY - MILLCURIES

+30%

+15%

VOLUME - CUBIC CENTIMETERS

MSK

R. Stock
A Dose Response Study for I-125 Implants

- 134 patients
- T1-T2 prostate cancer
- Follow-up 12-74 months (median 32)
- PSA 1.9-180 ng/ml (median 7.8)
- Gleason score 2-6
- CT based dosimetry

Effect of Dose on Biochemical Failure

<table>
<thead>
<tr>
<th>Dose</th>
<th>No.</th>
</tr>
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<tbody>
<tr>
<td>&lt; 140 Gy</td>
<td>65</td>
</tr>
<tr>
<td>≥ 140 Gy</td>
<td>69</td>
</tr>
</tbody>
</table>

(p=0.02)
Story #2, Contemplation
Scene: San Antonio, Texas
The Year: 2002
Subtitle: Loose Seed Needles vs. Mick Applicator using Sector Analysis

Bice, Med Phys, 2001
Story #3, Motivation
Improvement of coverage

Coverage of the Prostate by the Reference Dose

Prostate $V_{100}$ for 250 patients

upper bound on $V_{100}$
Don't forget non-volume based quantifiers
Total Activity (mCi) by US Prostate Volume (cc)

Bice, et al., IJROBP, 1998
Post Implant Planning and Evaluation

- Review is required by law (some places)
- Standard of care
- It gives your physics staff something to do
- You cannot improve without it
- You get paid for it
Concluding Thoughts

• You have to perform the regulatory requirements
• In order to achieve and maintain a high level of implant quality
  – Post plan
  – Evaluate
    • Each patient
    • Patient groups
  – Set goals (change and re-evaluate)