EFFECT OF HYDROGEL SPACER ON RADIATION DOSE DISTRIBUTION IN SBRT TREATMENTS OF THE PROSTATE USING VMAT AS THE TREATMENT TECHNIQUE: A RETROSPECTIVE CLINICAL EVALUATION

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PROSTATE RADIOTHERAPY

- Conventional fractionation
- Hypofractionation
- Extreme hypofractionation (SBRT)
**STRONG CLINICAL PRACTICE!!!**

Begins with proper patient compliance - active role in cancer management

Following treatment related instructions: Diet, H2O, Holding still

Patient eligibility: Prostate volume

Usually up to 60 CCs → 80 CCs

Technologists properly trained

Precise and accurate patient setup

Proper image guidance

No fly zone at the treatment console based on volume: Rectum, Bladder

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**ROLE OF A MEDICAL DOSIMETRIST**

- Contouring
  - Anatomically sound
  - Proper delineation of all OARs

- Treatment Planning
  - Planning methods to augment Dose coverage, Conformality Index (streaking dose), Field arrangement
  - Planning techniques: IMRT 1.0 (Static fields), IMRT 2.0 (VMAT)
  - Meeting standard metrics is so old-school: Use the ALARA principle (mean dose of OARs)
  - Plan evaluation: quality
DOSE & ITS LIMITING STRUCTURES

- Example: NRG-GU005 NCI Protocol (V 11.12.18)
  Arm 2 Rx: 7.25 Gy x 5 Fxs = 36.25 Gy
- OARs: Femoral Heads, Penile Bulb, Bladder, Rectum, Urethra, Small bowel (bowel, in general)
  Rectum – most important!
  Radiation proctitis, Rectal bleeding, Bowel incontinence, etc.

GOING BACK TO THE STRONG CLINICAL PRACTICE!!!

- Target volume delineation
  Proper
  CT/MRI image registration
  GTV to PTV margin to account for uncertainties
  Fiducial markers, Daily CBCT, Calypso tracking
- Rectal manipulation
  Enema
  Rectal balloon
  Hydrogel Spacer
  Rectal balloon + Hydrogel Spacer
PIECES OF A PUZZLE

- Extreme hypofractionation: SBRT
- Body site: Prostate
- Planning Technique: IMRT 2.0 (VMAT)
- Clinical practice: Fiducial markers, Hydrogel Spacer
- Retrospective study
  5 Patients in each category:
  - SBRT alone using VMAT
  - SBRT + Hydrogel Spacer using VMAT

GOALS, OBJECTIVES, EVALUATION...

- Positive changes in radiation dose distribution: more rectal sparing
  - PTV volume vs. conformality: inverse correlation
- Potential for dose escalation due to SpaceOAR:
  - Scope of SpaceOAR for Prostate SBRT
  - Scope of Prostate +SV SBRT using VMAT (based on risk-defined)
- Future consideration/Investigational: Prostate bed SBRT using VMAT
  - Limited role of hydrogel spacer due to the fascial plane reduction
  - Rectal balloon can be practiced

Limited role of hydrogel spacer due to the fascial plane reduction
Rectal balloon can be practiced
IMPORTANT THINGS TO REMEMBER...

Obtain relevant data while being independent to the following:
- Structure volume: Prostate, PTV, OARs, SpaceOAR
- Delineation of the necessary structures: Physician, Dosimetrist
- Planning methods of a dosimetrist

Dependencies:
- Hydrogel spacer process: correct injection placement
- Margin for the PTV volume

DOSE DISTRIBUTION W/O SPACEOAR
PTV VOLUME VS. DOSE CONFORMALITY W/O SPACEOAR

DOSE DISTRIBUTION WITH SPACEOAR
Prostate cancer has a very low alpha-beta ratio (A-B R): 1.4-1.5 Gy

- Late responding OARs (i.e. rectum or bladder) has ~ 3-5 Gy (A-B R)

**BED Calculation**

- 36.25 Gy → 62-63 Gy (enough dose?)
- 40 Gy → 72-73 Gy
- 42.5 Gy → 78 Gy

**WHY ESCALATE THE DOSE?**

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**VOLUMES (CC)**

**W/O SPACEOAR**

- Patient 1: PTV – 87, Rectum – 68
- Patient 2: PTV – 39, Rectum – 60
- Patient 3: PTV – 56, Rectum – 64
- Patient 4: PTV – 36, Rectum – 70
- Patient 5: PTV – 62, Rectum – 85

**W/SPACEOAR (AVG CC = 11)**

- Patient 1: PTV – 54, Rectum – 138
- Patient 2: PTV – 72, Rectum – 67
- Patient 3: PTV – 67, Rectum – 53
- Patient 4: PTV – 78, Rectum – 70
- Patient 5: PTV – 76, Rectum – 49
**SpaceOAR: 10 (5/5) + 1 (HU change) practice**

**Rectum volume: Anorectum**

**PTV volume vs. Prostate volume**
- Sometimes prostate is not a separate structure
- Nevertheless, uniform margin is followed across all physicians

### VOLUMES... DISCUSSION

#### RECTUM DOSES

<table>
<thead>
<tr>
<th></th>
<th>D0.03 cc</th>
<th>D3 cc</th>
<th>D10%</th>
<th>D20%</th>
<th>D50%</th>
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<tbody>
<tr>
<td>NCI GU005 (Acceptable)</td>
<td>&lt;40 Gy</td>
<td>&lt;36 Gy</td>
<td>&lt;34 Gy</td>
<td>&lt;30 Gy</td>
<td>&lt;19 Gy</td>
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<td>Patient 1 w/o:</td>
<td>36.5 Gy</td>
<td>25.7 Gy</td>
<td>14.9 Gy</td>
<td>9.3 Gy</td>
<td>5.2 Gy</td>
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<tr>
<td>Patient 1 w/:</td>
<td>26.6 Gy</td>
<td>20.2 Gy</td>
<td>15.0 Gy</td>
<td>10.0 Gy</td>
<td>1.3 Gy</td>
</tr>
<tr>
<td>Patient 2 w/o:</td>
<td>37.7 Gy</td>
<td>26.8 Gy</td>
<td>20.6 Gy</td>
<td>13.6 Gy</td>
<td>4.1 Gy</td>
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<tr>
<td>Patient 2 w/:</td>
<td>11.6 Gy</td>
<td>8.5 Gy</td>
<td>7.5 Gy</td>
<td>6.3 Gy</td>
<td>4.2 Gy</td>
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<tr>
<td>Patient 3 w/o:</td>
<td>35.3 Gy</td>
<td>24.3 Gy</td>
<td>17.4 Gy</td>
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<tr>
<td>Patient 3 w/:</td>
<td>22.5 Gy</td>
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<td>10.8 Gy</td>
<td>9.0 Gy</td>
<td>3.2 Gy</td>
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<tr>
<td>Patient 4 w/o:</td>
<td>35.7 Gy</td>
<td>25.4 Gy</td>
<td>17.7 Gy</td>
<td>10.9 Gy</td>
<td>3.9 Gy</td>
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<tr>
<td>Patient 4 w/:</td>
<td>26.6 Gy</td>
<td>14.3 Gy</td>
<td>10.9 Gy</td>
<td>8.6 Gy</td>
<td>5.8 Gy</td>
</tr>
<tr>
<td>Patient 5 w/o:</td>
<td>36.6 Gy</td>
<td>27.6 Gy</td>
<td>16.7 Gy</td>
<td>10.0 Gy</td>
<td>2.8 Gy</td>
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<tr>
<td>Patient 5 w/:</td>
<td>37.3 Gy</td>
<td>21.92 Gy</td>
<td>11.7 Gy</td>
<td>10.9 Gy</td>
<td>5.2 Gy</td>
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<td><strong>Average:</strong></td>
<td><strong>36.4 Gy</strong></td>
<td><strong>26.0 Gy</strong></td>
<td><strong>17.5 Gy</strong></td>
<td><strong>11.1 Gy</strong></td>
<td><strong>4.0 Gy</strong></td>
</tr>
<tr>
<td><strong>Patients w/o:</strong></td>
<td><strong>36.4 Gy</strong></td>
<td><strong>26.0 Gy</strong></td>
<td><strong>17.5 Gy</strong></td>
<td><strong>11.1 Gy</strong></td>
<td><strong>4.0 Gy</strong></td>
</tr>
<tr>
<td><strong>Patients w/:</strong></td>
<td><strong>24.9 Gy</strong></td>
<td><strong>15.4 Gy</strong></td>
<td><strong>11.2 Gy</strong></td>
<td><strong>10.0 Gy</strong></td>
<td><strong>3.9 Gy</strong></td>
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</table>
### BLADDER DOSES

- **W/O SPACEOAR:** 36.25 GY
- **W/ SPACEOAR:** 40 GY

<table>
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<tr>
<th>Patient</th>
<th>D0.03 cc</th>
<th>D50 %</th>
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<tbody>
<tr>
<td>1 w/o</td>
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<td>2.7 Gy</td>
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<tr>
<td>1 w/</td>
<td>41.4 Gy</td>
<td>1.2 Gy</td>
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<tr>
<td>2 w/o</td>
<td>36.4 Gy</td>
<td>1.9 Gy</td>
</tr>
<tr>
<td>2 w/</td>
<td>42.1 Gy</td>
<td>5.6 Gy</td>
</tr>
<tr>
<td>3 w/o</td>
<td>34.4 Gy</td>
<td>0.8 Gy</td>
</tr>
<tr>
<td>3 w/</td>
<td>41.1 Gy</td>
<td>2.5 Gy</td>
</tr>
<tr>
<td>4 w/o</td>
<td>32.0 Gy</td>
<td>0.8 Gy</td>
</tr>
<tr>
<td>4 w/</td>
<td>41.9 Gy</td>
<td>0.7 Gy</td>
</tr>
<tr>
<td>5 w/o</td>
<td>38.5 Gy</td>
<td>2.2 Gy</td>
</tr>
<tr>
<td>5 w/</td>
<td>38.6 Gy</td>
<td>1.1 Gy</td>
</tr>
</tbody>
</table>

**Average:**
- Patients w/o: 35.7 Gy 1.7 Gy
- Patients w/: 41.0 Gy 2.2 Gy

### PENILE BULB DOSES

- **W/O SPACEOAR:** 36.25 GY
- **W/ SPACEOAR:** 40 GY

<table>
<thead>
<tr>
<th>Patient</th>
<th>D0.03 cc</th>
<th>D3 cc</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 w/o</td>
<td>19.7 Gy</td>
<td>0.0 Gy</td>
</tr>
<tr>
<td>1 w/</td>
<td>22.5 Gy</td>
<td>3.9 Gy</td>
</tr>
<tr>
<td>2 w/o</td>
<td>12.8 Gy</td>
<td>2.1 Gy</td>
</tr>
<tr>
<td>2 w/</td>
<td>6.4 Gy</td>
<td>0.0 Gy</td>
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<tr>
<td>3 w/o</td>
<td>15.4 Gy</td>
<td>0.0 Gy</td>
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<tr>
<td>3 w/</td>
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<td>0.0 Gy</td>
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<tr>
<td>4 w/o</td>
<td>2.3 Gy</td>
<td>1.1 Gy</td>
</tr>
<tr>
<td>4 w/</td>
<td>2.0 Gy</td>
<td>0.0 Gy</td>
</tr>
<tr>
<td>5 w/o</td>
<td>26.7 Gy</td>
<td>5.6 Gy</td>
</tr>
<tr>
<td>5 w/</td>
<td>7.0 Gy</td>
<td>0.0 Gy</td>
</tr>
</tbody>
</table>

**Average:**
- Patients w/o: 15.4 Gy 1.8 Gy
- Patients w/: 8.0 Gy 0.8 Gy
FEMORAL HEADS DOSES
W/O SPACEOAR: 36.25 GY
W/ SPACEOAR: 40 GY

<table>
<thead>
<tr>
<th></th>
<th>D1 cc</th>
<th>D10 cc</th>
<th>D1 cc</th>
<th>D10 cc</th>
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<tbody>
<tr>
<td>RT FMHD</td>
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<tr>
<td>W/O SPACEOAR</td>
<td>&lt;19.9 Gy</td>
<td>&lt;15.6 Gy</td>
<td>&lt;19.9 Gy</td>
<td>&lt;15.6 Gy</td>
</tr>
<tr>
<td>Patient 1 w/o:</td>
<td>15.8 Gy</td>
<td>13.7 Gy</td>
<td>15.0 Gy</td>
<td>12.9 Gy</td>
</tr>
<tr>
<td>Patient 1 w/ :</td>
<td>12.1 Gy</td>
<td>8.8 Gy</td>
<td>12.0 Gy</td>
<td>9.9 Gy</td>
</tr>
<tr>
<td>Patient 2 w/o:</td>
<td>7.4 Gy</td>
<td>6.2 Gy</td>
<td>7.8 Gy</td>
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<td>Patient 2 w/ :</td>
<td>8.5 Gy</td>
<td>6.5 Gy</td>
<td>15.1 Gy</td>
<td>12.2 Gy</td>
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<tr>
<td>Patient 3 w/o:</td>
<td>13.2 Gy</td>
<td>11.3 Gy</td>
<td>12.0 Gy</td>
<td>10.6 Gy</td>
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<tr>
<td>Patient 3 w/ :</td>
<td>12.8 Gy</td>
<td>11.0 Gy</td>
<td>10.7 Gy</td>
<td>9.5 Gy</td>
</tr>
<tr>
<td>Patient 4 w/o:</td>
<td>10.1 Gy</td>
<td>8.5 Gy</td>
<td>11.1 Gy</td>
<td>9.5 Gy</td>
</tr>
<tr>
<td>Patient 4 w/ :</td>
<td>11.6 Gy</td>
<td>10.3 Gy</td>
<td>13.8 Gy</td>
<td>12.0 Gy</td>
</tr>
<tr>
<td>Patient 5 w/o:</td>
<td>16.5 Gy</td>
<td>14.0 Gy</td>
<td>17.6 Gy</td>
<td>14.6 Gy</td>
</tr>
<tr>
<td>Patient 5 w/ :</td>
<td>14.2 Gy</td>
<td>12.5 Gy</td>
<td>18.3 Gy</td>
<td>15.0 Gy</td>
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<tr>
<td>Average w/o:</td>
<td>12.6 Gy</td>
<td>10.7 Gy</td>
<td>12.7 Gy</td>
<td>10.7 Gy</td>
</tr>
<tr>
<td>Average w/ :</td>
<td>11.8 Gy</td>
<td>9.8 Gy</td>
<td>14.0 Gy</td>
<td>11.7 Gy</td>
</tr>
</tbody>
</table>

OTHER CRITICAL STRUCTURES...

Small bowel:
- Not contoured
- Away from the Tx area

Urethra:
- Not contoured
- PTV Max dose point and its location was evaluated
- As per NCI GU005 <43.5 Gy (<107.5% for patients w/ SpaceOAR)
CONCLUSION

- Hydrogel spacer makes it possible to escalate the dose while maintaining good dose conformality – making it ideal for Prostate SBRT using VMAT
- Doses to the OARs are lower in general (example: rectum)
- Even when data do not show a clear reduction of some doses to these OARs, they are still clinically acceptable (example: bladder)
- We can now prescribe 40Gy over 5 fractions to the Prostate area, depending on patient eligibility
- Irradiation of SV, partially or fully, can be the next logical area of research
- Bowel and urethra evaluation would need to be taken into account
- Prostate bed SBRT is an investigational area of study under rectal manipulation of some sort
- Target margins can be altered optionally