Vaginal Sparing with Volumetric Modulated Arc Therapy (VMAT) for Rectal Cancer
Scott Boulet BSc, RT(T)
Outline

- Background
- Objectives
- Design
- Results
- Discussion
- Conclusion
- Acknowledgements
- Questions
Background

- RT for Rectal Cancer
- Anatomical considerations and challenges
- Vaginal side effects following RT
- Sexual Dysfunction: treatment and management
- Vaginal sparing: What is being done?
- Previous studies
Rectum Anatomy

Rectal Cancer

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX</td>
<td>Primary tumor cannot be assessed</td>
</tr>
<tr>
<td>T0</td>
<td>No evidence of primary tumor</td>
</tr>
<tr>
<td>Tis</td>
<td>Carcinoma in situ, intraepithelial or invasion of the lamina propria</td>
</tr>
<tr>
<td>T1</td>
<td>Tumor invades submucosa</td>
</tr>
<tr>
<td>T2</td>
<td>Tumor invades muscularis propria</td>
</tr>
<tr>
<td>T3</td>
<td>Tumor invades through the muscularis propria into perirectal tissue</td>
</tr>
<tr>
<td>T4a</td>
<td>Tumor penetrates to the surface of the visceral peritoneum</td>
</tr>
<tr>
<td>T4b</td>
<td>Tumor directly invades or is adherent to other organs or structures</td>
</tr>
<tr>
<td>N0</td>
<td>No regional lymph node metastasis</td>
</tr>
<tr>
<td>N1a</td>
<td>Metastasis in 1 node</td>
</tr>
<tr>
<td>N1b</td>
<td>Metastasis in 2-3 regional nodes</td>
</tr>
<tr>
<td>N1c</td>
<td>Tumor deposits in the subserosa, mesentery, or nonperitonealized perirectal tissues without regional nodal metastasis</td>
</tr>
<tr>
<td>N2a</td>
<td>Metastasis in 4-6 regional nodes</td>
</tr>
<tr>
<td>N2b</td>
<td>Metastasis in 7 or more regional nodes</td>
</tr>
<tr>
<td>M0</td>
<td>No distant metastasis</td>
</tr>
<tr>
<td>M1a</td>
<td>Metastasis confined to one organ site (liver, lung, ovary, nonregional lymph node)</td>
</tr>
<tr>
<td>M1b</td>
<td>Metastases in more than one organ/site or the peritoneum</td>
</tr>
</tbody>
</table>

Rectal Cancer

- 3D Conformal RT

<table>
<thead>
<tr>
<th>Fields</th>
<th>Borders</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP/PA or PA</td>
<td>Superior: between L5 and S1</td>
</tr>
<tr>
<td></td>
<td>Inferior (in pre-op. setting): 3–5 cm below the palpable disease</td>
</tr>
<tr>
<td></td>
<td>Inferior (in post-op. setting): include perineum after APR or 2–3 cm beyond the anastomosis after LAR</td>
</tr>
<tr>
<td></td>
<td>Lateral: 1.5–2 cm lateral to the pelvic brim</td>
</tr>
<tr>
<td>Lateral</td>
<td>Superior/Inferior: as AP/PA fields</td>
</tr>
<tr>
<td></td>
<td>Anterior (T3 disease): 2- to 3-cm margin to the anterior of rectum or posterior margin of the pubic symphysis to cover internal iliac nodes (which ever is more anterior)</td>
</tr>
<tr>
<td></td>
<td>Anterior (T4 disease): 2- to 3-cm margin to the anterior of rectum or anterior margin of the pubic symphysis to cover external iliac nodes (which ever in more anterior)</td>
</tr>
<tr>
<td></td>
<td>Posterior: 1 cm behind the anterior edge of the sacrum, or many will include the entire sacrum</td>
</tr>
<tr>
<td>Boost</td>
<td>Gross tumor or tumor bed plus 3 cm in all directions</td>
</tr>
</tbody>
</table>

Rectal Cancer IMRT

- Improved target coverage, homogeneity, and conformality, while lowering dose to adjacent organs-at-risk.
- The use of preoperative IMRT-IGRT with a SIB resulted in a high 5-year LC rate and non-negligible late toxicity
VMAT

- MLCs moving continuously as gantry rotates
- Delivering a sculpted, tightly-focused beam of radiation directly to a tumor in less than two minutes.
Female Pelvic Anatomy

Vaginal Side Effects

- Sexual Dysfunction
- Dyspareunia
- Dryness
- Stenosis
Management Techniques

- Dilators
- Pelvic Floor Muscle training
- Lubricants
- Moisturizers
- Estrogen
Vaginal Dilators

- includes the use of dilators, sexual intercourse, vibrators, fingers, or similar shaped devices
- commenced 2-8 weeks post radiotherapy,
- Risk of rectovaginal fistulae and psychological consequences
- Non-consistent education and compliance
Vaginal sparing: what is being done?

NOTHING! Why?
- Doesn't effect all people with rectal cancer
- Older women are less interested in sex
- Vagina is difficult to contour
- Not previously possible with 3DCRT
- Lack of literature
- Uncomfortable subject to talk about.
Vaginal sparing: what is being done?

- As vaginal mean dose increases, vaginal stenosis increases.
- Severe vaginal stenosis is significantly reduced at mean doses <43Gy.
Study Objectives

- To investigate whether VMAT treatment plans with, and without, vaginal sparing could significantly reduce the volume of the vagina that receives 20 Gy (V20Gy), 30, 40, 45, or 50 Gy when targeting rectal cancer tumours.
- Determine whether the maximum dose delivered, and the mean dose delivered are significantly different between the two treatment plans.
Methods

- Sample Size = 10 patients (Retrospective)
- Inclusion:
  1) Diagnosed locally advanced rectal cancer
  2) Stage T3, N1-2, MX/MO (Lower 1/3)
  3) Recent pre-op MRI available for delineating the vagina
  4) pre-operative 3D CRT at CancerCare Manitoba
  5) 45G/25 FXs to the primary disease and lymph nodes, Boost 5.4Gy/3 FXs
  6) simulated supine with full bladder and knee rest.
Contouring

- Vagina contoured by single physician
- Pre-op MRI used for delineating vagina
- Target volumes and OARs contoured as per RTOG Anorectal Atlas
Contouring
Contouring
VMAT

- Two 360° coplanar arcs
- 6 MV
- Eclipse® V11 planning software (Varian Medical Systems)
- Rapid Arc® (VMAT)
- 2 phases 45Gy/25 FXs, 5.4Gy/3FXs
Optimization

- Target coverage: D100% = 95% Rx, Dmax <107%
- OARs: Bladder, small bowel, femoral heads

2 VMAT Plans
1) VMAT plan (normal)
   - Goals: Target coverage, OARs ALARA

2) VMAT with vagina objective
   - Goals: Decrease vagina dose without compromising target coverage and OAR sparing.
Results

- Formal comparisons between the two treatment plans were carried using Wilcoxon signed-rank testing.
- All data were available for analysis except the V20 and V30Gy volumes due to a lack of variability.
- Significant differences, even with the Bonferroni correction, were observed for the mean and maximum doses delivered, as well as for the V50Gy volumes.
- The V45Gy volumes also appeared different between the two treatment plans (Table 2) and would normally be considered significant at the P-value ≤ 0.05 threshold, but because the threshold P-value was adjusted using the Bonferroni correction, it was no longer significant.
Results

Median Dose Comparison

- VMAT
- VMAT with Vaginal Objective
### Results

Table 1: Descriptive statistics of mean and maximum doses delivered by each of the VMAT treatment plans.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Median</th>
<th>IQR</th>
<th>90th percentile</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMAT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Dose (cGy)</td>
<td>4990.90</td>
<td>71.60</td>
<td>5044.80</td>
<td>4779.20</td>
<td>5048.90</td>
</tr>
<tr>
<td>Maximum Dose (cGy)</td>
<td>5255.85</td>
<td>44.40</td>
<td>5314.60</td>
<td>5150.50</td>
<td>5319.40</td>
</tr>
<tr>
<td>VMAT with vaginal sparing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Dose (cGy)</td>
<td>4779.50</td>
<td>130.4</td>
<td>4876.00</td>
<td>4654.20</td>
<td>4880.20</td>
</tr>
<tr>
<td>Maximum Dose (cGy)</td>
<td>4962.80</td>
<td>65.20</td>
<td>5022.35</td>
<td>4922.3</td>
<td>5025.20</td>
</tr>
</tbody>
</table>
Table 2: Frequency and percent of volumes of the vagina exposed to 20, 30, 40, 45 or 50Gy by each of the two VMAT treatment plans.

<table>
<thead>
<tr>
<th>Values</th>
<th>Frequency</th>
<th>Percent</th>
<th>VMAT with vaginal sparing</th>
<th>Values</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>V20Gy</td>
<td></td>
<td></td>
<td></td>
<td>V20Gy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100.00</td>
<td>10</td>
<td>100.00</td>
<td></td>
<td>100.00</td>
<td>10</td>
<td>100.00</td>
</tr>
<tr>
<td>V30Gy</td>
<td></td>
<td></td>
<td></td>
<td>V30Gy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100.00</td>
<td>10</td>
<td>100.00</td>
<td></td>
<td>100.00</td>
<td>10</td>
<td>100.00</td>
</tr>
<tr>
<td>V40Gy</td>
<td>99.20</td>
<td>10.00</td>
<td></td>
<td>V40Gy</td>
<td>96.90</td>
<td>10.00</td>
</tr>
<tr>
<td>100.00</td>
<td>9</td>
<td>90.00</td>
<td></td>
<td>99.10</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td>100.00</td>
<td>10.00</td>
<td></td>
<td>90.00</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>V45Gy</td>
<td></td>
<td></td>
<td></td>
<td>V45Gy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>93.30</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>95.30</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>95.30</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>98.20</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>99.20</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>99.80</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>100.00</td>
<td>6</td>
<td>60.00</td>
<td></td>
<td>100.00</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>V50Gy</td>
<td></td>
<td></td>
<td></td>
<td>V50Gy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.00</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>99.80</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>36.60</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>100.00</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>37.30</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>43.30</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>43.30</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>46.90</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>46.90</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>48.20</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>48.20</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>60.10</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>60.10</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>64.50</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>64.50</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>67.40</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>67.40</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td>68.60</td>
<td>1</td>
<td>10.00</td>
</tr>
<tr>
<td>68.60</td>
<td>1</td>
<td>10.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results
DVH Comparison
Phase 1: 45 Gy
Plan Sum: 50.4 Gy/28Fx
Discussion

- Significance of decreasing the V50Gy, mean and maximum doses
- Contouring
- Vaginal Motion
- Use of a dilator during RT
- IGRTs role in vaginal sparing
- Concerns
Does Vaginal Sparing translate to decreased toxicity?
VAGINAL MOTION AND BLADDER AND RECTAL VOLUMES DURING PELVIC INTENSITY-MODULATED RADIATION THERAPY AFTER HYSTERECTOMY

ANUJA JHINGRAN, M.D.,* MOHAMMAD SALEHPOUR, PH.D.,† MARIANNE SAM, B.S.,* LARRY LEVY, M.S.,* AND PATRICIA J. EEFEL, M.D.,*†

Departments of * Radiation Oncology and † Radiation Physics, The University of Texas M. D. Anderson Cancer Center, Houston, TX

Purpose: To evaluate variations in bladder and rectal volume and the position of the vaginal vault during a 5-week course of pelvic intensity-modulated radiation therapy (IMRT) after hysterectomy.

Methods and Materials: Twenty-four patients were instructed how to fill their bladders before simulation and treatment. These patients underwent computed tomography simulations with full and empty bladders and then underwent rescanning twice weekly during IMRT; patients were asked to have full bladder for treatment. Bladder and rectal volumes and the positions of vaginal fiducial markers were determined, and changes in volume and position were calculated.

Results: The mean full and empty bladder volumes at simulation were 480 cc (range, 122–1,052) and 155 cc (range, 49–371), respectively. Bladder volumes varied widely during IMRT; the median difference between the maximum and minimum volumes was 247 cc (range, 96–585). Variations in rectal volume during IMRT were less pronounced. For the 16 patients with vaginal fiducial markers in place throughout IMRT, the median maximum movement of the markers during IMRT was 0.59 cm in the right–left direction (range, 0–0.9), 1.46 cm in the anterior–posterior direction (range, 0.8–2.79), and 1.2 cm in the superior–inferior direction (range, 0.6–2.1). Large variations in rectal or bladder volume frequently correlated with significant displacement of the vaginal apex.

Conclusion: Although treatment with a full bladder is usually preferred because of greater sparing of small bowel, our data demonstrate that even with detailed instruction, patients are unable to maintain consistent bladder filling. Variations in organ position during IMRT can result in marked changes in the position of the target volume and the volume of small bowel exposed to high doses of radiation. © 2012 Elsevier Inc.
Vagina Contouring

- Image registration issues
- Need to generate consistent guidelines
Dilator during RT

Reproducibility and genital sparing with a vaginal dilator used for female anal cancer patients

Tina Marie Briere a,*, Christopher H. Crane b, Sam Beddar a, Priya Bhosale c, Henry Mok b, Marc E. Delclos b, Sunil Krishnan b, Prajnan Das b

a Department of Radiation Physics; b Department of Radiation Oncology; and c Department of Diagnostic Radiology, UT MD Anderson Cancer Center, Houston, TX, USA

Purpose: Acute vulvitis, acute urethritis, and permanent sexual dysfunction are common among patients treated with chemoradiation for squamous cell carcinoma of the anal canal. Avoidance of the genitalia may reduce sexual dysfunction. A vaginal dilator may help delineate and displace the vulva and lower vagina away from the primary tumor. The goal of this study was to evaluate the positional reproducibility and vaginal sparing with the use of a vaginal dilator.

Materials and methods: Ten female patients treated with IMRT for anal cancer were included in this study. A silicone vaginal dilator measuring 29 mm in diameter and 114 mm in length was inserted into the vagina before simulation and each treatment. The reproducibility of dilator placement was investigated with antero-posterior and lateral images acquired daily. Weekly cone beam CT (CBCT) imaging was used to confirm coverage of the GTV, which was typically posterior and inferior to the dilator apex. Finally, a planning study was performed to compare the vaginal doses for these 10 patients to a comparable group of 10 female patients who were treated for anal cancer with IMRT without vaginal dilators.

Results: The absolute values of the location of the dilator apex were 7.0 ± 7.8 mm in the supero-inferior direction, 7.5 ± 5.5 mm in the antero-posterior, and 3.8 ± 3.1 mm in the lateral direction. Coverage of the GTV and CTV was confirmed from CBCT images. The mean dose to the vagina was lower by 5.5 Gy, on average, for the vaginal dilator patients, compared to patients treated without vaginal dilators.

Conclusion: The vaginal dilator tended to be inserted more inferiorly during treatment than during simulation. For these ten patients, this did not compromise tumor coverage. Combined with IMRT treatment planning, use of a vaginal dilator could allow for maximum sparing of female genitalia for patients undergoing radiation therapy for anal cancer.

Published by Elsevier Ireland Ltd. Radiotherapy and Oncology 104 (2012) 161–166
IG RT

- IGRT improvements → Smaller margins → Less vagina in field
- Daily vagina assessment
- Adaptive radiotherapy
- Bladder filling
Concerns

- Potential risk of marginal relapse
Conclusion

- VMAT planning using an objective to spare the vagina can significantly reduce the volume of vagina receiving 50 Gy, as well as the Dmax and Dmean, without compromising target coverage or adjacent organs at risk dose constraints.
Acknowledgment

- Bashir Bashir MD
- Oliver Bucher
- Eric VanUytven
- Junaid Khan
- John Ioculano
Thank you!