Role of Belly Board Device in the Age of Intensity Modulated Radiotherapy for Pelvic Irradiation

2017 AAMD 42\textsuperscript{nd} Annual Meeting

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Conflicts of Interest

• None
Clinical Question

• In the IMRT era, is there a benefit for using a Belly Board Device (BBD) in treating rectal cancer?

• Can we do a better job of protecting Organs At Risk (OAR) if we use both BBD and IMRT?
Outline

• Rectal Cancer statistics
• Why use a BBD?
• Dose Constraints
• Our study looking at BBD and IMRT
• Conclusions
Colorectal Cancer facts

• 3rd most common cancer in the United States.
• For 2017:
  • ~96,000 new cases of colon cancer
  • ~40,000 new cases of rectal cancer
• Lifetime risk about
  – 1 in 21 (4.7%) for men
  – 1 in 23 (4.4%) for women.

From The American Cancer Society 2017
www.cancer.org
Colorectal Cancer facts

- 3rd leading cause of cancer-related deaths in women
- 2nd leading cause in men
- The death rate is dropping in both men and women for several decades.
- 1 million survivors of colorectal cancer in the United States

From The American Cancer Society 2017
www.cancer.org
Why use a BBD for rectal cancer?

Spare Small Bowel when treating the pelvis
Small Bowel Constraints

• Emami TD$_{5/5}$ (Historical Reference)
  – Whole organ: <40 Gy
  – 1/3 organ: <50 Gy

• QUANTEC (<10% chance of Grade 3 Toxicity)
  – Individual Loops: V15Gy < 120 cc
  – Peritoneal Cavity: V45Gy < 195 cc

• ACR Expert Panel for Rectal Cancer and RTOG protocols use 50 Gy as a maximum point dose
Small Bowel Constraints

- Retrospective DVH analysis of rectal cancer patients who developed Grade ≥3 bowel toxicity
- Compared Sm Bowel Loop vs. Peritoneal Space contours
- <10% rate of Grade 3 or more toxicity
  - Bowel Loop V15Gy < 275 cc
  - Peritoneal Space V15Gy < 830 cc
Peritoneal Cavity Contours

“Bowel Bag” per RTOG contouring atlas (blue contour)
Traditional pelvic treatment fields
Methods to spare small bowel

- Invasive
  - Sling
  - Mesh
  - Tissue Expander
  - Insufflation with Nitrous Oxide

- Non-invasive
  - PO contrast
  - Bladder Filling
  - Abdominal compression
  - Patient Positioning
Positioning with a Belly Board

• Custom made styrofoam “Belly Board” described by Frank, et al in 1990

• “Dropout cut... designed to allow maximal anterior/superior displacement of small bowel by bladder distension and gravity”

• Prospective study of 30 patients

• Showed 80 to 100% reduction in small bowel volume in radiation portals
Positioning with a Belly Board

(a)

(c)
ACR Appropriateness Criteria

- American College of Radiology
  – ACR Appropriateness Criteria®, 2012

- Simulation for Resectable Rectal Cancer

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Score</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sm Bowel Contrast</td>
<td>9</td>
<td>Not mandated if using CT for simulation</td>
</tr>
<tr>
<td>Patient Immobilized</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Anal Marker</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Bladder Full</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Patient Prone</td>
<td>9</td>
<td>Unless pt is unable. If IMRT, may prefer Supine</td>
</tr>
<tr>
<td>Use BBD</td>
<td>9</td>
<td>Only needed if patient is Prone</td>
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</table>
ACR Appropriateness Criteria

• American College of Radiology
  – ACR Appropriateness Criteria®, 2012

• Dose for Resectable Rectal Cancer

<table>
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<tr>
<th>Recommendation</th>
<th>Score</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>50.4 Gy in 28 fx</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>54.0 Gy in 30 fx</td>
<td>7</td>
<td>If small bowel is completely excluded after 50.4 Gy</td>
</tr>
</tbody>
</table>

Back to our Clinical Question

• In the IMRT era, is there a benefit for using a Belly Board Device (BBD) in treating rectal cancer?

• Can we do a better job of protecting Organs At Risk (OAR) if we use both BBD and IMRT?
Our study

Role of belly board device in the age of intensity modulated radiotherapy for pelvic irradiation

Neil C. Estabrook, M.D.,* Gregory K. Bartlett, B.S., C.M.D.,* Julia J. Compton, M.D.,*
Our study-Methods

• 11 consecutive patients with Rectal Cancer

• All were candidates for definitive surgery after pre-op chemoradiation

• All had a diagnostic supine CT scans for staging

• Simulation was performed prone on BBD

• No instructions were given for bladder filling
Our study-Methods

• Target Volumes and Organs at Risk (OAR) were contoured
  – both on the supine and prone CT scans

• A 3DCRT plan AND an IMRT plan was then created for each patient in the supine and prone positions

• Therefore, 4 total plans were available for each patient
Planning Methodology

• For 3DCRT, 4-field box technique
• For IMRT, 5 to 7 field step-and-shoot
• Dose prescription and OAR tolerance doses were optimized in each case
• PTV coverage was 100% dose to 95% volume.
• For small bowel, max dose 50 Gy
• Additional SB constraints of 5, 100, and 150 cm$^3$ to dose less than 45, 40, and 35 Gy respectively
4 Plans Generated for Each Patient

• Prone-BBD 3DCRT
• Prone-BBD IMRT
• Supine 3DCRT
• Supine IMRT
From those 4 Plans, We made 5 Dosimetric Comparisons

- (1) Supine 3DCRT vs Supine IMRT
- (2) Prone-BDD 3DCRT vs Supine IMRT
- (3) Prone-BBD 3DCRT vs Prone-BBD IMRT
- (4) Supine IMRT vs Prone-BBD IMRT
- (5) Supine 3DCRT vs Prone-BDD 3DCRT
Methods-Body Dimensional Analysis

- Measured body contour in both the Anterior-Posterior and Lateral dimensions
- At Isocenter plane of the pelvic fields for both Prone and Supine setups
Methods

- Statistical analyses were conducted for maximum, minimum, and mean normalized dose to the GTV, PTV, and small bowel, respectively, using 2-tail paired analysis.
Methods-GTV Homogeneity Index

Homogeneity index ($HI$) = \[
\frac{\text{Dose (GTV}_{\text{max}}) - \text{Dose (GTV}_{\text{min}})}{\text{Dose (GTV}_{\text{mean}})}
\]
Results-Body Dimensional Analysis

• With Prone-BBD compared to Supine
  – Anterior-posterior dimension reduced on average 2.5 +/- 1.9 cm
  – Lateral dimension reduced on average 0.6 +/- 1.7 cm

• Deemed to be dosimetrically insignificant
Results - Homogeneity Index

- HI ranged from 0.13 to 0.17 when comparing the GTV dose averages
- Ideally, for any planning type, HI should be near zero
- This occurs when the maximum target dose is equal to the minimum dose
- This was achieved in our study
Results

- Mean dose to GTV and PTV were within 2.5% of the Prescribed dose in all 4 plans for each patient
Results-Dose to TVs and OARs

A

Supine 3D vs IMRT

B

Prone 3D vs IMRT

C

IMRT Prone vs Supine

Indiana University Health
Results - Volumes of interest, quantified

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Age</th>
<th>Sex</th>
<th>GTV (cm³)</th>
<th>GTV (cm³)</th>
<th>Small bowel volume (cm³)</th>
<th>Small bowel volume (cm³)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Supine</td>
<td>Prone</td>
<td>Supine</td>
<td>Prone</td>
</tr>
<tr>
<td>1</td>
<td>71</td>
<td>M</td>
<td>203.2</td>
<td>204.3</td>
<td>449.3</td>
<td>442.7</td>
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<tr>
<td>2</td>
<td>50</td>
<td>M</td>
<td>211.2</td>
<td>187.8</td>
<td>1330.7</td>
<td>1325.1</td>
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<tr>
<td>3</td>
<td>59</td>
<td>M</td>
<td>499.7</td>
<td>504.9</td>
<td>1630.5</td>
<td>1627.0</td>
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<tr>
<td>4</td>
<td>61</td>
<td>M</td>
<td>256.3</td>
<td>271.6</td>
<td>758.5</td>
<td>792.1</td>
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<tr>
<td>5</td>
<td>61</td>
<td>M</td>
<td>91.6</td>
<td>94.0</td>
<td>2781.0</td>
<td>3077.8</td>
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<tr>
<td>6</td>
<td>47</td>
<td>M</td>
<td>171.7</td>
<td>173.1</td>
<td>954.1</td>
<td>937.7</td>
</tr>
<tr>
<td>7</td>
<td>40</td>
<td>M</td>
<td>243.3</td>
<td>249.1</td>
<td>527.8</td>
<td>528.5</td>
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<tr>
<td>8</td>
<td>53</td>
<td>F</td>
<td>83.0</td>
<td>78.5</td>
<td>2109.8</td>
<td>2102.7</td>
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<tr>
<td>9</td>
<td>68</td>
<td>F</td>
<td>334.4</td>
<td>327.3</td>
<td>735.3</td>
<td>729.8</td>
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<tr>
<td>10</td>
<td>75</td>
<td>M</td>
<td>178.1</td>
<td>179.4</td>
<td>2100.2</td>
<td>2092.2</td>
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<tr>
<td>11</td>
<td>57</td>
<td>M</td>
<td>122.2</td>
<td>124.9</td>
<td>417.7</td>
<td>411.1</td>
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# Results

<table>
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<tr>
<th></th>
<th>Supine 3DCRT</th>
<th>Supine IMRT</th>
<th>Prone-BBD 3DCRT</th>
<th>Prone-BBD IMRT</th>
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<tbody>
<tr>
<td>GTV Mean*</td>
<td>1.017</td>
<td>1.022</td>
<td>1.013</td>
<td>1.023</td>
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<tr>
<td>GTV Std Dev</td>
<td>0.022</td>
<td>0.021</td>
<td>0.027</td>
<td>0.022</td>
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<tr>
<td>Small Bowel Mean*</td>
<td>0.328</td>
<td>0.310</td>
<td>0.307</td>
<td>0.216</td>
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<tr>
<td>Small Bowel Std Dev</td>
<td>0.175</td>
<td>0.192</td>
<td>0.138</td>
<td>0.121</td>
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<tr>
<td>Sm Bowel Mean % Dose reduction**</td>
<td>0.0%</td>
<td>5.5%</td>
<td>6.4%</td>
<td>34.1%</td>
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*Normalized doses

**Baseline for comparison is Supine 3DCRT
Results – GTV coverage

• No Statistically Significant Differences in GTV coverage when comparing between planning types
Results – Small Bowel Dose

• Supine 3DCRT had the highest mean small bowel dose of all treatment options.
• Prone-BBD with IMRT gave the lowest dose
Results - 5 Dosimetric Comparisons
-Small Bowel Sparing

Prone-BBD 3DCRT * Prone-BBD IMRT

Supine 3DCRT * Supine IMRT
Results – Small Bowel Sparing

• Significant difference when using:
  – Prone-BBD 3DCRT compared to Prone-BBD IMRT, favoring Prone-BBD IMRT
  – 29.6% reduction in dose (p = 0.007)
  – Supine IMRT compared to Prone-BBD IMRT, favoring Prone-BBD IMRT
  – 30.3% reduction in dose (p = 0.002)

• No other statistically significant differences in mean small bowel dose were found
Discussion

• Data surprisingly did not show a small bowel dose advantage when comparing Supine 3DCRT vs. Prone-BBD 3DCRT

• This has been previously documented in the literature
  – Gyn, GU, and GI cancers
  – Small pt numbers in many studies (Most are between n = 10 to 20)

Discussion

• Why no difference here between Supine and Prone positioning with 3DCRT?
• Likely, too small of a sample size
• Also, rectal cancer can be found anywhere along the length of the organ from the anal verge to the sigmoid near the abdomen.
• Analyzed our data for small bowel dose relating to primary tumor size and distance from the anal verge and could find no correlation
Summary

• First study we know of for rectal cancer that makes multiple comparisons between patient setup and treatment planning type.

• Additional sparing of small bowel is achieved when IMRT is used in prone position with BBD.

• When we considered the baseline for small bowel dose as supine position and treated with 3DCRT, small bowel dose reduction of 34% was achieved when BBD and IMRT used together.
Summary

• Positioning on BBD is critical—especially if IMRT is used

• Oral contrast and bladder filling can be very helpful for sparing small bowel and we recommend it if using IMRT with a BBD
Conclusions

• For rectal cancer when small bowel could be a limiting factor, our data indicate BBD in prone position provides a superior treatment option.

• Prone position using the BBD along with IMRT provides the best sparing of the small bowel.

• We conclude that whenever a dose escalation in rectal cancer is desired where small bowel could be limiting factor, IMRT in conjunction with BBD should be selected.
Thank you for your attention!