2018 AAMD PLAN STUDY
5 FIELD BREAST CASE

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James Wheeler, MD, PhD, RTU

OUTLINE

1. HISTORY
2. PURPOSE
3. WHAT ARE WE STUDYING?
4. METHODS
5. COMPLEXITIES AND CONSIDERATIONS
6. RESULTS AND DISCUSSIONS
7. CONCLUSIONS
HISTORY PROVIDES US WHAT?

Studying history can provide us with insight into our cultures of origin as well as cultures with which we might be less familiar, thereby increasing cross-cultural awareness and understanding.
What have other Plan Studies shown us?

1. No correlation with:
   - Certification
   - Education Level
   - Experience
   - Confidence
2. No major significance on TPS
3. No dependency of plan complexity
4. Dependency is more on Planner Skill

PURPOSE

HISTORICALLY:
- COMPARE DIFFERENT SYSTEMS
- COMPARE MODALITIES
- IDENTIFY BEST PRACTICES
- SHARE INFORMATION WITH THE WORLD

NEW CONSIDERATIONS:
- ESTABLISH CLINICAL STANDARDS
- LEARN PROCESSES

ULTIMATE GOAL = DRIVE OUT VARIATION AND IMPROVE PLAN QUALITY
WHAT ARE WE STUDYING: VARIATION

VARIATION IN TREATMENT PLANNING IS NOT GOOD

Within A System
Within A Center
Within a Planner

VARIATION IS A BY PRODUCT OF IMPERFECT METHODS AND/OR PROCESSES

Dosimetry is an ART but we need Standards and Processes

VARIATION: MEASURED QUALITY

- High variation
- Average quality is low
- Lots of low quality items
- Few high quality items

- Lower variation
- Average quality is higher
- Fewer low quality items
- More high quality items
Are We Lowering Variance?

Plan Studies Suggest We Are Lowering Variance! That’s Good.

But are we really?

200 – 400 planners per study
8,000 planners worldwide
That is 2.5% - 5% Participation
What would the distribution of scores really look like? I strongly suspect a LARGE VARIATION.

Continue the Push!
Sharing is Caring. Education is Key.
We need to find the time!
WHAT DOES IT MEAN TO GET A MAX SCORE?

What Does It Mean to Score a 150 on the Plan Study?

1. Were the constraints of the study to easy? Answer
2. Are the planners just getting better? Answer
3. Is a score of 150 better than 145? Answer
4. Is this difference clinically relevant? Answer

Need for New Protocols
Need to Tie Score to Toxicity
Need for Physician Engagement
### METHODS: PROJECT PLANNING TEAM

<table>
<thead>
<tr>
<th>TEAM MEMBER</th>
<th>AFFILIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAMES WHEELER, MD, PHD</td>
<td>CENTER FOR CANCER CARE, GOSHEN HEALTH</td>
</tr>
<tr>
<td>BRUCE PHILLIPS, CMD</td>
<td>RTU INSTRUCTOR / TA</td>
</tr>
<tr>
<td>THOMAS COSTANTINO, MS, CMD</td>
<td>RTU FACULTY</td>
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<tr>
<td>SANJEEL PATEL, MS, CMD</td>
<td>RTU INSTRUCTOR / TA</td>
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<tr>
<td>BRENT MURPHY, MS, DABR</td>
<td>RTU FACULTY</td>
</tr>
<tr>
<td>DAVID LITTLEJOHN, CMD</td>
<td>RTU INSTRUCTOR / TA</td>
</tr>
</tbody>
</table>

### METHODS: THE DATASET

![Image of medical dataset]
METHODS: The Prescription

1. RX Dose: 5 Targets: 25 fx x 2 Gy/fx
2. Decision to Not Include the Boost
3. Variability in Boost
   * Integrated vs Successive
   * VMAT, IMRT, Other
   * Photons, Electrons, Mix
4. Ultimately, the composite plan is most important

COMPLEXITIES AND CONSIDERATIONS

1. Variation of Technique
2. Inclusion of IMN
3. Hot Spots / Cold Spots
4. Skin Dose
5. Integral Dose
VARIATION OF TECHNIQUE

1. Modality
   Photon
   Proton

2. Techniques
   VMAT / IMRT
   VMAT / IMRT with 3D Electronic Compensation
   3D Field in Field
   3D Wedges

INCLUSION OF IMN

1. Controversy

2. Length: Depends on protocol.

3. How do you treat?
HOT SPOTS / COLD SPOTS

1. Hot Spots
   * Physicians are now pushing more for homogeneity of breast cases.
   **Hot Spots created by weighting, wedging, modulation, other.
   *** Moving from no breast target to Breast PTV target (contouring)

2. Cold Spots
   * Historical Matching
   * Skin / Build Up Area

SKIN DOSE

1. Definition of the Skin
2. Skin Dependency
3. What affected skin dose:
   - PTV defined
   - Modulated beams
   - Mixed Energies
   - Obliquity Effect
INTEGRAL DOSE

1. Integral Dose Defined
2. General Concept: Lower Integral Dose is Better.
3. Should it be limited?
4. How do we monitor over 15-20 years?

MD Concerns (Dr. Wheeler)

1. Target Coverage: 5 Targets
2. Heart Dose: Mean Dose, Vessels
3. Lung Dose
4. Rib Dose
5. Esophagus
6. Skin Dose: Definition
7. Other Metrics
   * Conformation
   * Dose Homogeneity
   * Integral Dose
A PHYSICIAN’S PERSPECTIVE

Methods: Plan Scoring

- **Identify Critical Metrics.** Dose, DVH, or formulaic metrics selected from a vast library of options.
- **Define Each Metric’s Parameters.** Select applicable structure, dose- or volume- levels, or other input parameters to derive the metric result.
- **Define Each Metric’s Scoring.** For each metric, capture what defines success, i.e. specify priority along with: 1) minimally required result, 2) ideal result, and 3) variable scoring in between.

Composite Plan Score
Using PlanIQ Scoring Methodology
## A REVIEW OF PLAN METRICS

### Library of Available Metrics

![Diagram showing various metrics such as V(%) and D(%) with icons for ROI Min(Gy), ROI Max(Gy), Irradiated Vol(cc), Serial Slice Eval, Cumulative MU, Beam On Time, Conformation Number, Conformation Index, Homogeneity Index, and Inhomogeneity Index.]

### METHODS: THE PLAN OBJECTIVES

#### Key Metrics

<table>
<thead>
<tr>
<th>ID</th>
<th>Metric Description</th>
<th>MAX RCV</th>
<th>OVAL</th>
<th>WEIGHT (OUT)</th>
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<tbody>
<tr>
<td>1</td>
<td>Volume % of the IMRT PTV, ENA, covered by 85%</td>
<td>94</td>
<td>97</td>
<td>20 points</td>
</tr>
<tr>
<td>2</td>
<td>Dose (Gy) covering 90% of the IMRT PTV, OVAL</td>
<td>54</td>
<td>52</td>
<td>3 points</td>
</tr>
<tr>
<td>3</td>
<td>Dose (Gy) covering 90% of the IMRT PTV, ENA</td>
<td>57</td>
<td>56</td>
<td>3.5 points</td>
</tr>
<tr>
<td>4</td>
<td>Volume % of the Lung PTV, ENA, covered by 85%</td>
<td>95</td>
<td>98</td>
<td>20 points</td>
</tr>
<tr>
<td>5</td>
<td>Dose (Gy) covering 90% of the Lung PTV, OVAL</td>
<td>54</td>
<td>52</td>
<td>3 points</td>
</tr>
<tr>
<td>6</td>
<td>Dose (Gy) covering 90% of the Lung PTV, ENA</td>
<td>57</td>
<td>56</td>
<td>3.5 points</td>
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<tr>
<td>7</td>
<td>The area covered by the global max dose point</td>
<td>IMRT PTV, OVAL</td>
<td>2 points</td>
<td></td>
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<tr>
<td>8</td>
<td>Volume % of the Sparing Lung PTV covered by 85%</td>
<td>98</td>
<td>97</td>
<td>15 points</td>
</tr>
<tr>
<td>9</td>
<td>Dose (Gy) covering 90% of the Sparing Lung PTV</td>
<td>55</td>
<td>52</td>
<td>2.5 points</td>
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<tr>
<td>10</td>
<td>Volume % of the Lung PTV, covered by 97%</td>
<td>98</td>
<td>97</td>
<td>45 points</td>
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<tr>
<td>11</td>
<td>Dose (Gy) covering 97% of the Lung PTV</td>
<td>55</td>
<td>52</td>
<td>45 points</td>
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<tr>
<td>12</td>
<td>Volume % of the heart PTV covered by 85%</td>
<td>94</td>
<td>97</td>
<td>15 points</td>
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<tr>
<td>13</td>
<td>Dose (Gy) covering 90% of the heart PTV</td>
<td>55</td>
<td>52</td>
<td>2.5 points</td>
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<td>14</td>
<td>Dose (Gy) covering 97% of the heart PTV</td>
<td>98</td>
<td>97</td>
<td>45 points</td>
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<tr>
<td>15</td>
<td>Mean dose (Gy) to the heart</td>
<td>3</td>
<td>2</td>
<td>5 points</td>
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<td>16</td>
<td>Volume % of the Lung, ENA, covered by 85%</td>
<td>98</td>
<td>97</td>
<td>20 points</td>
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<td>17</td>
<td>Volume % of the Lung, OVAL, covered by 85%</td>
<td>98</td>
<td>97</td>
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<td>18</td>
<td>Volume % of the Lung, ENA, covered by 85%</td>
<td>98</td>
<td>97</td>
<td>20 points</td>
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</table>

Total Points: **150**
Plan Quality Algorithm

- **24 Scored Metrics**
  - 150 Point Totals
  - Target Coverage accounted for 103 of 150 points
  - 24 of 24 used advanced, non-linear scoring

- **4 Unscored Metrics**
  - Conformation Number (PTV All)
  - Homogeneity Index (PTV All)
  - Integral Dose to Body
  - Cumulative Meterset

**METHODS: EXAMPLE PLAN SCORESHEET**
Sanity Check: High Quality VMAT/IMRT

<table>
<thead>
<tr>
<th>Modality</th>
<th>Summary</th>
<th>Total Score</th>
<th>Min. Req. Met</th>
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</thead>
<tbody>
<tr>
<td>VMAT*1st Pass</td>
<td>4 Arcs</td>
<td>124.00 / 150.0</td>
<td>23 / 24</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Modality</th>
<th>Summary</th>
<th>Total Score</th>
<th>Min. Req. Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMRT</td>
<td>11 Beams</td>
<td>144.39 / 150.0</td>
<td>23 / 24</td>
</tr>
</tbody>
</table>

Results

If You Don’t Measure It, You Can’t Manage It
RESULTS

Learning Objectives

- Participation
- Overall Score Distribution
- Ideal VS. Minimum Metrics
- Individual Metrics
- Photons vs. Protons

RESULTS: PARTICIPATION BY ROLE

Submissions by Role

- Dosimetrist
- Physicist
- Student
- Other
- Therapist
- Physician

Physician 46%
Dosimetrist 49%
Other 7%
Therapist 3%
Physician 2%
Student 12%
RESULTS: PARTICIPATION BY TPS

Submissions by TPS

- Eclipse: 51%
- Monaco: 17%
- RayStation: 14%
- Pinnacle3: 11%
- Other TPSs:
  - Astroid
  - Hi-Art
  - Ring Gantry
  - VelocityAI
  - XiO

RESULTS: PARTICIPATION BY MODALITY

Submissions by Modality

- VMAT: 42%
- IMRT: 39%
- Proton: 13%
- Tomotherapy: 3%
- Other Modalities:
  - Other
RESULTS: SCORE DISTRIBUTION (ALL)

Histogram of Total POINTS
N: 240 | Min: 108.43 | Max: 150.00 | Median: 142.31 | Mean: 138.93 | Std Dev: 10.52

RESULTS: Photons VS Protons

Histogram of Total Points for Photons
N: 200 | Min: 108.43 | Max: 150.00 | Median: 137.95 | Mean: 137.39 | Std Dev: 10.44

Histogram of Total Points for Ion Beam
N: 31 | Min: 125.25 | Max: 150.00 | Median: 150.00 | Mean: 138.17 | Std Dev: 2.73
If You Don’t Measure It, You Can’t Manage It

RESULTS: MEETING IDEAL REQUIREMENTS

<table>
<thead>
<tr>
<th># Ideal Requirements Achieved</th>
<th>N</th>
<th>%</th>
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<tr>
<td>24 (out of 24)</td>
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<td>23</td>
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<td>22</td>
<td>10</td>
<td>4.2</td>
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<td>21</td>
<td>4</td>
<td>1.7</td>
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<td>20</td>
<td>7</td>
<td>2.9</td>
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<tr>
<td>19</td>
<td>6</td>
<td>2.5</td>
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<tr>
<td>&lt; 19</td>
<td>172</td>
<td>71.6</td>
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</table>
# RESULTS: MEETING MIN REQUIREMENTS

<table>
<thead>
<tr>
<th># Min Requirements Achieved</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 (out of 24)</td>
<td>130</td>
<td>54.2</td>
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<td>23</td>
<td>30</td>
<td>12.5</td>
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<td>22</td>
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<td>&lt; 19</td>
<td>23</td>
<td>9.6</td>
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</tbody>
</table>
METRIC: BREAST_PTV_EVAL

Histogram of [Q1] Volume (%) of the BREAST_PTV_EVAL covered by 47.5 Gy
N: 240 | Min: 91.01 | Max: 100.00 | Median: 97.40 | Mean: 97.53 | Std Dev: 1.30

METRIC: BREAST_PTV_EVAL

Histogram of [Q3] Dose (Gy) covering 0.03 (cc) of the BREAST_PTV_EVAL
N: 240 | Min: 91.01 | Max: 97.01 | Median: 95.72 | Mean: 95.81 | Std Dev: 1.02
METRIC: LUMPEC_PTV_EVAL

Histogram of (04) Volume (% of the LUMPEC_PTV_EVAL covered by 47.5 Gy)
N: 240 | Min: 97.26 | Max: 100.00 | Median: 99.91 | Mean: 99.69 | Std Dev: 0.45

METRIC: LUMPEC_PTV_EVAL

Histogram of (06) Dose (Gy) covering 0.03 (cc) of the LUMPEC_PTV_EVAL
N: 240 | Min: 51.05 | Max: 61.02 | Median: 54.95 | Mean: 54.85 | Std Dev: 1.33
METRIC: SUPRACLAV_PTV

Histogram of [06] Volume (%) of the SUPRACLAV_PTV covered by 47.5 (Gy)
N: 240 | Min: 02.57 | Max: 100.00 | Median: 97.00 | Mean: 97.45 | Std Dev: 1.90

METRIC: SUPRACLAV_PTV

Histogram of [09] Dose (Gy) covering 0.03 (cc) of the SUPRACLAV_PTV
N: 240 | Min: 50.00 | Max: 60.85 | Median: 53.25 | Mean: 53.43 | Std Dev: 1.37
BREAST_CONTRA: Photons vs Protons

METRIC: HEART: Photon vs Proton
METRIC: LUNG_IPSI : Photon vs Proton

POPULATION DVH: LUNG_CONTRA
HOMOGENEITY INDEX (PTV ALL)

INTTEGRAL DOSE TO BODY
If You Don’t Measure It, You Can’t Manage It
RESULTS: INDIVIDUAL

- First, a word about individual recognition.
- List of high performers
- “Best in Class” mentions

<table>
<thead>
<tr>
<th>Rolland Julien</th>
<th>Jennifer Sillings</th>
<th>Daniel Eiler</th>
</tr>
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<tbody>
<tr>
<td>Drew Granatowicz</td>
<td>Joakim Nilsson</td>
<td>Ian Zoller</td>
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<td>Louis Genet</td>
<td>Joe Simmons</td>
<td>Nguyen Daniel</td>
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<td>Charbel Attieh</td>
<td>Karla Leach</td>
<td>Mok To Wing</td>
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<td>Irina Fotina</td>
<td>Keitt Mobile</td>
<td>AdriÁ MarÁ</td>
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<td>William Starbuck</td>
<td>Kevin Erhart</td>
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<td>Reynald Vanderstraeten</td>
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<td>Shane Gans</td>
<td>Timothy Hancock</td>
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<td>Alex Goughenour</td>
<td>Valerie Coffman</td>
<td>Takuya Ito</td>
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<td>Amber Bryant</td>
<td>Wuyifan</td>
<td>Mark Addington</td>
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<td>Anthony Magliari</td>
<td>Brandon Stone</td>
<td>Kirby DeLozier</td>
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<td>Tiffany Shieder</td>
<td>Jonathan Stenbeck</td>
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<td>David Ly</td>
<td>Ontida Apinoraethkul</td>
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<td>Hongdiong Liu</td>
<td>Alejandro</td>
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<td>Dennie Fransen</td>
<td>Yuriy Filippov</td>
<td>Wesley Groves</td>
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<td>Erin Gittings</td>
<td>Richard “Able” Shores</td>
<td>Adalicia DeGroff</td>
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<td>James Henry</td>
<td>Norifumi Mizuno</td>
<td>Juan Maria Perez Moreno</td>
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<td>Jeff Stamper</td>
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</table>
**RESULTS: “TOP 10 STUDENTS”**

<table>
<thead>
<tr>
<th>Name</th>
<th>Program</th>
<th>TPS</th>
<th>Modality</th>
<th>Score</th>
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<tbody>
<tr>
<td>Amber Bryant</td>
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<td>Proton</td>
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<td>Laura Cutler</td>
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<td>Ray Station</td>
<td>Proton</td>
<td>150.00</td>
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<td>Pinnacle</td>
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<td>Ruth Crawford</td>
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<td>Eclipse</td>
<td>IMRT</td>
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<td>Thomas Jefferson</td>
<td>Pinnacle</td>
<td>IMRT S/S</td>
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<td>SIU</td>
<td>Eclipse</td>
<td>STATIC</td>
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</table>

**RESULTS: “BEST IN MU EFFICIENCY”**

<table>
<thead>
<tr>
<th>Name</th>
<th>Site</th>
<th>Technique &amp; MU</th>
<th>Score</th>
</tr>
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<tr>
<td>ROLLAND Julien</td>
<td>IPC CHICAS</td>
<td>VMAT 566 MU</td>
<td>150</td>
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<td>Drew Granatowicz</td>
<td>Nebraska Medicine</td>
<td>IMRT (Step-and-Shoot) + VMAT 812 MU</td>
<td>150</td>
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<td>Louis Genet</td>
<td>Elekta</td>
<td>VMAT 842 MU</td>
<td>150</td>
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<tr>
<td>Charbel Attieh</td>
<td>KHUH</td>
<td>IMRT (Dynamic) 869 MU</td>
<td>150</td>
</tr>
</tbody>
</table>
RESULTS: INDIVIDUAL DATA ANALYSIS

1. Sign in to www.proknowsystems.com
2. Go to “Plan Studies” and set the filter to “All Studies”
3. Select the 2018 AAMD/RSS Plan Study
4. Select the “Statistical Analysis” tab
5. View your plan’s result relative to the entire population of submitted plans
   - For Total Score (out of 150)
   - For Any Individual Metric (Gy, %, cc, etc.)

What does all this “BIG DATA” mean?
Historical Perspective

“I believe that the more you know about the past, the better you are prepared for the future.”

~ Theodore Roosevelt

Traditional 4 field mono-isocentric breast
**Beams Eye View**

- Typical high tangent with iso just inferior to humeral head
- Scf field 15 degree angle with humeral head blocked
- Traditional PAB with 20 cGy added per fraction to achieve 45 Gy at axillary fossa

**Field Placement**

- Ports designed to pick up contoured PTV’s while still maintaining the traditional setup
Resultant DVH

Although there is good coverage of the breast tissue, the SCF, IMN, and Axillary volumes do not receive the full dose. (Yellow Arrow) Also ipsilateral lung dose is high due to inclusion of IMN in the tangent ports. (Red arrow) Contra-lateral lung dose is very low with no beam exit (white arrow) but contra-lateral breast is partially included in the deep tangent medially to pick up the IMN.

Dose at axillary fossa

Dose at axillary fossa visually is 45-47.5 Gy.
Homogeneity and conformality

Dose is homogenous but not very conformal to the contoured targets due to use of tangential ports only.

Plan Study Score = 83.26

Score for the traditional plan is very low at 83.26 as the IMN, SCF, and Axillary contours were not covered. Also ipsilateral lung, heart, and contralateral breast minimums were not achieved for this study.
The multi-field IMRT plan on the right is not very homogeneous or conformal. The traditional plan is more visually appealing.

Comparison DVH traditional to IMRT multi-field

Some structures are unapproved or rejected.
Comparison traditional to IMRT multi-field

<table>
<thead>
<tr>
<th>Case</th>
<th>IMRT Case</th>
<th>Plan</th>
<th>Tissue 1</th>
<th>Tissue 2</th>
<th>Tissue 3</th>
<th>Tissue 4</th>
<th>Tissue 5</th>
<th>Tissue 6</th>
<th>Tissue 7</th>
<th>Tissue 8</th>
<th>Tissue 9</th>
<th>Tissue 10</th>
<th>Mean Time (Sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IMRT_01</td>
<td>Plan 1</td>
<td>30.2</td>
<td>29.4</td>
<td>29.6</td>
<td>29.8</td>
<td>30.0</td>
<td>30.2</td>
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<tr>
<td>2</td>
<td>IMRT_02</td>
<td>Plan 2</td>
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<td>30.4</td>
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<td>31.6</td>
<td>31.8</td>
<td>32.0</td>
<td>32.2</td>
</tr>
</tbody>
</table>

Comparison traditional to IMRT multi-field
Other modalities:

Proton, VMAT, IMRT
all had a perfect score utilizing the same treatment planning system

PROTON 4 beam
IMRT 9 fields

VMAT 2 ARCS
Traditional 4 field

Does number of proton beams make a visual difference?
Proton 1 beam

Single Beam: ~120 seconds beam on time (includes layer switching): $G=30, T=0$

Amber Bryant, Erin Gittins, and Laura Cutler RTUVT
Proton 2 beam

2 Beam Plan: ~250 seconds beam on time (includes layer switching):
   Beam 1: G=0, T=0;
   Beam 2: G=38, T=0

Amber Bryant, Erin Gittins, and Laura Cutler RTUVT

Proton 2 beam

Amber Bryant, Erin Gittins, and Laura Cutler RTUVT
PROTON 4 beam

Motion and practicality

1. Use of breath hold and importance with modulation

2. Practical treatment times considering motion management techniques.

3. Planning time
Conclusions and more questions

Based on the outcomes of this small study N=240 It is clear dosimetrically, that modulated fields which ever modality, can achieve better target coverage as well as OAR sparing when compared to traditional approaches.

So why are we still using the old techniques?

Do these new abilities translate to better clinical outcomes?

This study based on NSABP-B51.

Maybe a new study utilizing the latest techniques with a higher metric standard should be initiated.

Conclusions and more questions

This can be very difficult!

Phase III randomized trial
Ten years results of the Canadian breast intensity modulated radiation therapy (IMRT) randomized controlled trial

Jean-Philippe Pignon 1,2,3, Pauline Truong 1, Eileen Rahowich 1, Margaret G. Sattler 1, Timothy J. Whelan 1, Ivo A. Olivotto 1

Conclusions
Breast IMRT cannot be recommended for all patients to reduce long-term side effects. However, late toxicities were significantly correlated with acute side effects, which are increased in patients having poor dose distribution. Breast IMRT may hence be useful for selected patients.
Conclusions and more questions

Insurance and resistance to payments

• Comparison plans? Really needed?
• Proof needed?
• Challenge ASTRO and physicians
• Accepting technology and using it to our patient’s advantage

CONCLUSIONS: What Do We NEED?

• More Participation of Planners
  • Drive Out Variation
• Physician Input
• Tools for Benchmarking
• New Protocols
• Repository of Data / Plans
• Constant Communication / Training
• Big Data Analytics (how to utilize)
Tips & Techniques

- Interviews of High Performers to be conducted and shared On-Line on the ProKnow Website

Thanks

- AAMD
- MDCB
- ProKnow
Questions and Answers

- Questions and Answers
- Share Your Physician’s Opinion
- Share Your Tips / Tricks

- HOW DO YOU TREAT?