Treatment Planning Considerations for Breast Cancer

Jean M. Moran, Ph.D., DABMP, FAAPM
Associate Professor
The University of Michigan
Department of Radiation Oncology

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Objectives

• Describe needs for using advanced beam treatment planning and delivery technologies
Moving from conventional treatment to advanced techniques

• What are the targets? How are they defined?

• Advanced techniques such as IMRT require contoured volumes
  – Allows more control when using optimization methods
  – Need to consider margins

• Planning goals must be clearly identified for planning
Considerations for IMRT/VMAT

- Impact of respiratory motion and target reproducibility
- Target: breast and lumpectomy cavity
  - Planning Target Volume?
- Organs at risk
  - Heart and sub-structures such as the left-anterior descending artery
  - Lungs
  - Contralateral breast
  - Brachial plexus
- Determine beam arrangement
Targets

- Breast
  - Edit back 5 mm from surface
    - Inaccuracies in surface modeling could lead to excess surface dose planned for during optimization
  - Did physician place catheters?

- Nodal regions – if treated
  - Supraclavicular
  - Infraclavicular
  - Internal mammary
Contouring for Breast Cancer

- Contouring of structures is required for inverse planning which is still a change of practice at many centers
- There can be significant variability in the contours by practitioner
Organs at risk

- Heart
- Contralateral breast
- Lungs
- Brachial Plexus
- Left anterior descending artery
  - Sensitive small volume to help push optimization
Contours by 9 physicians from 8 institutions. Structure overlaps as small as 10%. Volumes with standard deviations as high as 60%.

Li et al, IJROBP, 2009
Additional Considerations

• Spectrum of techniques
  – Simple IMRT (missing tissue compensation) to beamlet IMRT to VMAT

• Still need adequate flash
  – Jaws should be open for flash
  – Want intensity in air to be similar to intensity over the breast
Segmental or Field-in-Field Technique

Example lateral segments

Median # = 6 segments

Vicini et al, IJROBP, 2002
Use of Deep Inspiration Breath hold

- Sixel et al IJROBP 2001
- Remouchamps et al 2003
- Dosimetric advantages when using deep inspiration breath hold
  - Move heart away from breast
  - Decrease amount of lung in the field
Effect of breathing on heart position

Moran, ASTRO, 2004
Example breast alignment

Clip box

Exhale 20%

Change in Position of IM Nodes

Exhale

80%

Breast or Chestwall Motion

Motion (cm)

Breathing State

Adapted from Moran et al. IJROBP 68: 541-546, 2007.
Reproducibility of position with ABC

- Up to 0.8 cm movement anteriorly and superiorly of breast/chestwall, ICV, and IMN regions with respect to end exhale
- Individual patient variation was up to 1.3 cm
- The reproducibility with ABC (based on 3 scan sessions) was on the order of 3 mm for all breathing states and directions
Treatment Planning Techniques

• IMRT and VMAT techniques have been applied to:
  – Whole breast
  – Whole breast + nodal
  – Accelerated partial breast
• Sequential or concurrent boost
• Electron beams can play a role when needing to spare organs-at-risk such as the heart and lungs
Whole breast and nodal irradiation
Tangential Technique
Partially Wide Static Fields vs. IMRT
## Objective Function for IMRT Plans

<table>
<thead>
<tr>
<th>Structure</th>
<th>Dose/Volume Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast, Nodal regions (ICV, SCV, IMN)</td>
<td>95% volume, dose ≥ 52.2 Gy</td>
</tr>
<tr>
<td></td>
<td>Min-Max Range: 49.6-60 Gy</td>
</tr>
<tr>
<td>Lumpectomy Cavity with margin</td>
<td>99% volume, dose ≥ 60 Gy</td>
</tr>
<tr>
<td></td>
<td>1% volume, dose ≤ 63 Gy</td>
</tr>
<tr>
<td>Heart and Left Anterior Descending Artery (LAD)</td>
<td>Mean dose ≤ 3 Gy</td>
</tr>
<tr>
<td></td>
<td>Maximum dose &lt; 15 Gy</td>
</tr>
<tr>
<td>Ipsilateral lung</td>
<td>&lt;30% volume, dose ≥ 20Gy</td>
</tr>
<tr>
<td>Brachial plexus</td>
<td>Minimize dose</td>
</tr>
<tr>
<td>Contralateral breast and lung</td>
<td>Minimize dose</td>
</tr>
</tbody>
</table>
Dose Distributions

9 field: Concerns re: dose to other organs

Clinical Practice at Our Center

6 MV photons Electrons (6, 9, or 12 MeV) used as deemed necessary for normal tissue sparing or for nodal coverage

Min Dose to 5% Volume - Targets

Dose (Gy)

Rotational Techniques

• Demonstrated improved minimum dose to the target with a TomoTherapy technique

• Also static gantry technique

VMAT: Arc span + Field Considerations

2 cm overlap to distribute dose for arcs so no sharp gradient or match

Two VMAT arcs of 190 deg:
- CW: 300 to 130
- CCW: 130-300

Fig. 2 Popescu et al, IJROBP 289, 2010.
VMAT – Breast + Nodes

- Beware of increased dose to contralateral breast and lung in addition to heart and ipsilateral lung
- Partial arcs are typically used to keep some sparing of tissues not normally irradiated with tangential arcs

Accelerated Partial Breast Techniques
Volumes

- Expansion from Clinical Target Volume (CTV) to Planning Target Volume (PTV) depends on
  - Immobilization
  - Breath hold technique used
    - Device or voluntary?
  - Localization
  - Concerns re: seroma cavity position
Volumes

Lumpectomy cavity
Clinical Target Volume
Planning Target Volume

Breast contour

Additional contours: Heart, lungs, contralateral breast

Excluded region 5 mm from surface for all volumes
Volumes – 10 patients

- **Mean volume of the contoured breast (cc):**
  - FB: 722±389
  - DIBH: 731±382

- **Mean PTV volumes (cc)**
  - FB: 202 cc
  - DIBH: 185 cc
  - Volumes are different because expansions are different

Example beam arrangement

Contoured breast, CTV, heart, LAD

Technique: 3 or 4 beams per patient

Mean PTV volumes in cc:
FB: 202 cc
DIBH: 185 cc
## Cost Function for IMRT Plans: Treatment Planning Study

<table>
<thead>
<tr>
<th>Structure</th>
<th>Dose/Volume Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CTV</strong></td>
<td>100% volume, dose $\geq 38.5$ Gy</td>
</tr>
<tr>
<td></td>
<td>99% volume, dose $\leq 40.4$ Gy</td>
</tr>
<tr>
<td><strong>PTV</strong></td>
<td>95% volume, dose $\geq 38.5$ Gy</td>
</tr>
<tr>
<td></td>
<td>99% volume, dose $\leq 40.4$ Gy</td>
</tr>
<tr>
<td><strong>Heart and LAD</strong></td>
<td>Mean dose $\leq 3$ Gy</td>
</tr>
<tr>
<td><strong>Uninvolved ipsilateral breast</strong></td>
<td>Minimize dose</td>
</tr>
<tr>
<td><strong>Lungs</strong></td>
<td>90% volume, dose $\leq 5$ Gy</td>
</tr>
</tbody>
</table>

Example Oblique Dose Distributions

WBRT FB
- 38-42
- 34-38
- 31-34
- 27-31
- 23-27
- 20-23
- 16-20
- 12-16
- 8-12

3DCRT FB

3DCRT DIBH

IMRT DIBH

PBI Technique Comparison

• Acceptable target coverage with all PBI techniques
  – IMRT can be used improve dose homogeneity to the PTV and reduce the maximum dose
  – The use of DIBH result in further dose reductions of heart dose when compared to free-breathing 3DCRT

• Dose to uninvolved left breast can be reduced with IMRT
IMRT Techniques
Summary – Advanced Tx Planning

• Targets must be defined to use DVH constraints
  – Use RTOG atlas as a guide to improve consistency of targets

• Beware when using beam arrangements that involve irradiation of contralateral structures
  – Limit arc range to reduce likelihood of extraneous dose to contralateral structures

• When transitioning from previous techniques the treatment team must work together
  – Reproducibility of techniques, implementation of breath hold or gating technology, margin evaluation, assessment of patient changes
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