Treatment Planning for Breast Cancer: Contouring Targets

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Outline

1. RTOG Breast Cancer Atlas
2. Target development on Clinical Trials
Whole Breast Irradiation
2-D Radiotherapy

Fluoroscopic simulation

Central plane dosimetry
### Whole Breast Irradiation

<table>
<thead>
<tr>
<th>Intact Breast</th>
<th>Central Plane</th>
<th>CT Scan</th>
<th>3-DCRT/ Multiple planes</th>
<th>IMRT</th>
<th>APBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>98 %</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1993-94</td>
<td>94.1%</td>
<td>5%</td>
<td>1%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1998-99</td>
<td>81%</td>
<td>16.6%</td>
<td>13%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2007-2008</td>
<td>0.23%</td>
<td>97%</td>
<td>79.7%</td>
<td>15.8%</td>
<td>4.5%</td>
</tr>
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</table>
Breast Cancer Atlas for Radiation Therapy Planning: Consensus Definitions

Goals: Breast Cancer Atlas

1. Establishes initial consensus about anatomic delineation of target and normal tissue volumes for breast cancer radiation therapy
2. Intended as an anatomical reference to guide CTV definition
3. Provides a common denominator for breast cancer clinical trials when radiation therapy is to be delivered
4. Future goals include establishment of reporting parameters for target and normal tissue dose-volumes to compare outcomes from different clinical trials and institutional series
Atlas Development

- 10 breast radiation oncologists from 9 institutions
- Independently delineated anatomic volumes on three representative CT cases - twice:
  1. First: without any guidance/instruction
  2. Second: with written consensus guidelines developed after the first try
Variability of target and normal structure delineation

Targets: lumpectomy cavity, breast, chest wall, SCL nodes, axillary nodes, IMC nodes
OAR: heart, lung

Li XA, et al, IJROBP 2009
### Comparison of the 1st and 2nd Runs

<table>
<thead>
<tr>
<th></th>
<th>Mean Volume Overlapping</th>
<th>Standard deviation for volume variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st Run</td>
<td>2nd Run</td>
</tr>
<tr>
<td>Breast</td>
<td>85%</td>
<td>91%</td>
</tr>
<tr>
<td>Chestwall</td>
<td>72%</td>
<td>83%</td>
</tr>
<tr>
<td>Heart</td>
<td>86%</td>
<td>89%</td>
</tr>
<tr>
<td>Lumpectomy*</td>
<td>86%</td>
<td>90%</td>
</tr>
<tr>
<td>Axillary nodes*</td>
<td>51%</td>
<td>60%</td>
</tr>
<tr>
<td>Supraclav nodes</td>
<td>55%</td>
<td>58%</td>
</tr>
</tbody>
</table>

* Not significantly different
Case C: Stage IIIA (T2N2M0), 4/18 LN+ Left Nodal and Breast-Chestwall RT

First Run

Second Run
Case C: Stage IIIA (T2N2M0), 4/18 LN+
Left Nodal and Breast RT

First Run

Second Run
RTOG Breast Cancer Atlas

- Geometric Average (Example)
- Consensus Definitions

Case B:

- Chestwall
- Supraclavicular
- Axillary level III
- Axillary level II
- Internal Mammary
- Heart
- Lung

<table>
<thead>
<tr>
<th>Regional Nodal Contours: Anatomical Boundaries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SuprACLavicular</strong></td>
</tr>
<tr>
<td><strong>Axilla-Level I</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Axilla-level III</strong></td>
</tr>
<tr>
<td><strong>Internal mammary</strong></td>
</tr>
</tbody>
</table>
### Breast/ Chestwall Contour: Anatomical Boundaries

<table>
<thead>
<tr>
<th></th>
<th>Cranial</th>
<th>Caudal</th>
<th>Anterior</th>
<th>Posterior</th>
<th>Lateral</th>
<th>Medial</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breast</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical Reference + Second rib insertion&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Clinical reference + loss of CT apparent breast</td>
<td>Skin</td>
<td>Excludes pectoralis muscles, chestwall muscles, ribs</td>
<td>Clinical Reference + mid axillary line typically, excludes lattismus (Lat.) dorsi m. &lt;sup&gt;b&lt;/sup&gt;</td>
<td>Sternal-rib junction &lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td><strong>Breast-Chestwall&lt;sup&gt;2&lt;/sup&gt;</strong></td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
<td>Includes pectoralis muscles, chestwall muscles, ribs</td>
<td>Same</td>
<td>Same</td>
</tr>
<tr>
<td><strong>Chestwall&lt;sup&gt;3&lt;/sup&gt;</strong></td>
<td>Caudal border of the clavicle head</td>
<td>Clinical reference+ loss of CT apparent contralateral breast</td>
<td>Skin</td>
<td>Rib-pleural interface. (Includes pectoralis muscles, chestwall muscles, ribs)</td>
<td>Clinical Reference/ mid axillary line typically, excludes lattismus dorsi m. &lt;sup&gt;a&lt;/sup&gt;</td>
<td>Sternal-rib junction &lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Nanoparticle-enhanced MRI To Evaluate Regional Lymphatics For Patients With Breast Cancer

- MGH: 23 patients
- LN-MRI: Lymphotrophic nanoparticle–enhanced MRI to identify benign versus malignant lymph nodes

→ No consistent relationship between malignant and/or benign lymph nodes and bony and/or vascular anatomy was determined.

MacDonald et al, IJROBP 77:2010
Nanoparticle-enhanced MRI To Evaluate Regional Lymphatics concordance with RTOG Contouring ATLAS

- Lymph node regions were contoured on CT according to RTOG guidelines
- % LN-MRI lymph nodes contained within these contours determined
- 86% of actual lymph nodes and 89% of sampled lymph nodes were within contoured RTOG consistent nodal volumes
- 99% of actual and sampled lymph nodes were included when a 5-mm expansion was added.

<table>
<thead>
<tr>
<th></th>
<th>Within contour</th>
<th>% Outside contour</th>
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<tbody>
<tr>
<td>Malignant actual</td>
<td>82.40</td>
<td>17.60</td>
</tr>
<tr>
<td>Benign actual</td>
<td>87.70</td>
<td>12.30</td>
</tr>
<tr>
<td>Malignant sampled</td>
<td>85.50</td>
<td>14.50</td>
</tr>
<tr>
<td>Benign sampled</td>
<td>89.60</td>
<td>10.40</td>
</tr>
<tr>
<td>Total actual</td>
<td>86.30</td>
<td>13.70</td>
</tr>
<tr>
<td>Total sampled</td>
<td>88.60</td>
<td>11.40</td>
</tr>
<tr>
<td>Year</td>
<td>Targets</td>
<td>Clinical Trial</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>2003</td>
<td>• Lump CTV</td>
<td>- RTOG 0319</td>
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<tr>
<td></td>
<td>• Lump PTV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lump PTV_eval</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>• Breast CTV</td>
<td>- NSABP B39/RTOG 0413</td>
</tr>
<tr>
<td></td>
<td>• Breast PTV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Breast PTV_eval</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>• Chestwall CTV</td>
<td>- RTOG 1005</td>
</tr>
<tr>
<td></td>
<td>• Breast Wall PTV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Breast Wall PTV_eval</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>• Chestwall CTV</td>
<td>-NSABP B51/ RTOG 1304</td>
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<tr>
<td></td>
<td>• Chestwall PTV</td>
<td>- ALLIANCE A011202</td>
</tr>
<tr>
<td></td>
<td>• Chestwall PTV_eval</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Axilla CTV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Axilla PTV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• IMN CTV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• IMN PTV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• SCL CTV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• SCL PTV</td>
<td></td>
</tr>
</tbody>
</table>
NSABP B-39/RTOG 0413 Trial
Phase III

Stage 0, I-II breast cancer treated by lumpectomy

Randomization

WBI
- 50-50.4 Gy (1.8-2.0 Gy)
  Fractions to the whole breast followed by boost to 60 -66.6 Gy

APBI
- 34 Gy in 3.4 Gy fxs bid
  Mammosite®, Contura, SAVI or Multicatheter brachytherapy
  OR
- 38.5 Gy in 3.85 Gy fxs bid
  3D-CRT

March 2005- April 2013 accrual = 4,216
NSABP B-39/RTOG 0413
Defined Lumpectomy Targets and Dose Volume Constraints for APBI

Planning Target Volume for evaluation (PTV_EVAL)
- excludes chest wall/pectoralis muscles
- extends to within 5mm of skin

Planning Target Volume (PTV)

Clinical Target Volume (CTV)

1 cm expansion around CTV

1.5 cm expansion around surgical cavity

5mm inside skin

Excludes pectoralis muscles and chest wall
RTOG 1005
Phase III

“High risk” Stage 0, I-II, breast cancer treated by lumpectomy

Randomization

Standard WBI-
Sequential boost
• WBI: 50 Gy (2.0 Gy)
  42.56 Gy (2.67 Gy)
• Boost: 12-14 Gy (2 Gy)
  22-33 Fractions
  4.5-6.5 weeks

Hypofractionated WBI-
Concomitant boost
• WB PTV: 40 Gy/2.7 Gy
• Lumpectomy PTV: 48 Gy/3.2 Gy
  15 Fractions
  3 weeks

Targeted accrual = 2312
Opened May 2011

STRATIFICATION:
Age: < 50 vs > 50
Chemo: yes vs no
ER: + vs -
RTOG 1005: Defined Breast Targets and Dose Volume Constraints

Breast Planning Target Volume for evaluation (PTV-eval)
- excludes boney thorax from anterior rib surface
- extends within 5 mm of skin

Breast Planning Target Volume (PTV)

Breast Clinical Target Volume (CTV)
NSABP B-51/RTOG 1304 Trial  Phase III

- Clinical T1-3N1M0 breast cancer
- Pathology positive axillary node (FNA/Core)
- Neoadjuvant CT + anti HER2

 ypN0 at definitive Breast Surgery  + AND or SNB

Randomization

Arm 1
No Regional Nodal XRT
A. Lumpectomy: Breast XRT.
B. Mastectomy: Observation

Arm 2
Regional Nodal XRT
A. Lump.: Breast/Nodal XRT
B. Mast: Chestwall/ Nodal XRT

Targeted accrual = 1636
Opens 8-2013

Stratification: Type of Surgery (Mast v. Lump), ER-Status (+ v. –), HER2 Status (+ v. –), pCR in Breast (yes v. no)
Alliance A011202 Trial (select): Phase III

- Clinical T1-3N1M0 breast cancer
- Pathology positive axillary node (FNA/Core)
  - Neoadjuvant CT + anti HER2
  - Surgery with sentinel lymph node biopsy

Positive Sentinel LN Identified

Intra OP Reg + Randomization

Arm 1
ALND + Nodal XRT

Arm 2
No ALND + Nodal XRT

Targeted accrual = 1576
NSABP B-51/RTOG 1304

Defines Chest Wall And Regional Nodal Targets and Dose Volume Constraints

Contralateral breast

Radio opaque wire on Mastectomy Scar

Radio opaque wires placed at CT Simulation outlining clinical judgment of the area of Chestwall to be treated

Mastectomy Scar PTV-eval (cyan)
Mastectomy Scar CTV (yellow)

Implant reconstruction

Chestwall CTV (blue)

Chestwall PTV-eval (red)

IMN PTV (light green)

IMN CTV (magenta)

Chestwall PTV-eval
NSABP B-51/RTOG 1304: Contouring Appendix

Axilla CTV:
- Most caudal extent
- Excludes Level 1/2 surgical changes from axillary dissection

SCL PTV (white)

SCL CTV (green)

Axilla PTV (white)

Axilla CTV (magenta)

Axilla PTV

Axilla CTV

Area of axillary dissection excluded from CTV
Thank you!