ASTRO eContouring for Lymphoma

Stephanie Terezakis, MD
Disclosures

- No conflicts to disclose
1970 – Total Lymphoid Irradiation (TLI)

1995 – Involved-Field Radiotherapy (IFRT)

2008 – Involved Node Radiotherapy (INRT)
2013 – Involved Site Radiotherapy (ISRT)

Figure courtesy of Dr. Joachim Yahalom
Improving the Therapeutic Ratio

• Decrease RT Dose
• Decrease RT Volume
• Improve Treatment Technique
Decrease RT Dose

Engert et al, NEJM 2010
Decrease RT Volume

- Decrease in treatment field size

Girinsky et al, Radiother Oncol 2006
Improve Treatment Technique

Mendenhall et al, IJROBP 2009
Individualized Estimates of Second Cancer Risks After Contemporary Radiation Therapy for Hodgkin Lymphoma

Hodgson et al, Cancer 2007
Extended Field

- Supradiaphragmatic nodes including cervical, supraclavicular, axillary, and mediastinal/hilar regions
- Treatment of paraaortics, spleen, pelvic, and inguino-femoral nodes
- Significant dose inhomogeneity can result due to differences in patient thickness
Involved Field (~Year 2000)

- The site of the clinically involved lymph node group
- Lymph node grouping not clearly defined
- Bony landmarks used for field definition
The Evolution of INRT and ISRT

- Definitions of IFRT dependent on bony landmarks without 3D target delineation
- Involved-nodal radiotherapy (INRT) was introduced in Europe for Hodgkin Lymphoma and markedly reduced the irradiated volume
- INRT design requires accurate pre-chemo or pre-biopsy information obtained in the treatment position
Principles of ISRT

- ISRT utilizes ICRU definitions
  - Ideal to take advantage of pre-treatment imaging
  - ISRT recognizes detailed pre-treatment evaluation may not always be optimal
    - In most cases, smaller volumes than IFRT
- Planning requirements: CT-based simulation
- Goal to target site of originally involved lymph node(s)
  - Field encompasses the original volume prior to surgery or chemotherapy
  - Spares uninvolved organs once lymph node has regressed
CT Simulation

- CT simulation with IV contrast for accurate identification of vessels, heart, kidneys, and spleen
- Immobilization is site specific
Target Volumes

• Pre-chemotherapy Gross Tumor Volume (GTV)
  ▫ Pre-chemotherapy or pre-surgery volume
  ▫ Should be encompassed by the CTV taking into account change in normal anatomy after initial treatment response

• Post-chemotherapy GTV
  ▫ Potential Boost

• Clinical considerations must ultimately be used to determine the final CTV
Target Volumes

• Certain sites may be subject to internal motion
  ▫ If necessary the CTV may be expanded to the ITV (internal target volume) using either 4D-CT or fluoroscopy

• CTV (or ITV) expansion to the planning target volume (PTV) depends on expected daily setup uncertainty
  ▫ Immobilization device or patient setup
  ▫ Body site
  ▫ Individual characteristics
Treatment Planning

• Organs at risk (OAR) should be identified and contoured

• For many cases, conventional treatment may still be appropriate

• 3D-CRT or IMRT techniques should be considered depending on clinical judgment, individual treatment characteristics and availability considerations
Clinical Example
Case Example

- 37 year old female
- Progressing shortness of breath over 1 month
- Chest CT scan demonstrates large mediastinal mass
- Excisional biopsy performed: Nodular sclerosing Hodgkin lymphoma
- PET/CT = Uptake in bulky mediastinal lymph nodes and right subpectoral region
- Treatment Plan:
  - ABVD x 6 + Involved site RT
Pre-chemotherapy PET/CT
Pre-chemotherapy PET/CT
Post-chemotherapy PET/CT

- PET was negative after cycle 3 and at end of all 6 chemotherapy cycles

- Referral for radiation treatment

- ISRT recommended per new guidelines
Simulation

- CT Simulation performed with IV contrast
- Right arm up
- Patient immobilized in alpha cradle
Treatment Volume Contours
Pre-chemotherapy PET GTV
Treatment Plan
Comparison of IFRT and ISRT
DVH Comparison

Dose Volume Histogram

---PTV-IFRT
PTV-ISRT
---Heart-IFRT
Heart-ISRT
---Left Breast-IFRT
Left Breast-ISRT
---Right Breast-IFRT
Right Breast-ISRT
---Both Lungs-IFRT
Both Lungs-ISRT
Thank You
ASTRO 2013
Annual Meeting
eContouring Session
- Breast-

Frank Vicini, MD,
Julia White, MD
September 21, 2013
Optimal RT for Breast Cancer
-Overall Goals-

- Breast should be thought of in terms of targets at risk and normal tissues to be avoided
- Use published atlas to standardize targets
- Techniques should incorporate 3D CRT/IMRT when clinically possible to optimize dose delivery
  - New, advanced IMRT techniques now available (Tomotherapy/VMAT)
- Supine and prone positions are acceptable
  - Reproducibility is critical/ideal technique varies
- Respiratory motion should be taken into consideration
- Cardiac avoidance should always be assessed and utilized if needed
- Image guidance should be incorporated
Outcomes highly dependent on what is being targeted/avoided:

- **Stage dependent**
  - Positioning
  - Motion management
  - Planning strategy
  - Delivery technique
  - Image guidance

What are the targets?

- Breast
- Heart
- IM Nodes
- S Clav
- Brachial plexus
- L Lung
- R Lung
- R Breast
- Cord
- Vessels
- L Cor. Artery

B. Fraass/R. Marsh
Target Delineation

• Standardized definitions now available
• Allow for consistency of target coverage, normal tissue avoidance:
  ▫ Improved treatment outcomes
  ▫ Reduces toxicities
  ▫ Better assessment of new treatments (consistent metrics used to evaluate efficacy)
  ▫ Accurate evaluation of different treatment regimens
Goals for Today’s Session

• Discuss available resources for optimal contouring of breast cancer for RT
• Review contemporary protocols and how contouring represents a critical component for optimal success
• Review standard contouring and dosimetric nomenclature currently used in research studies
• Review typical cases and important anatomic structures for optimal contouring
Breast Cancer Atlas for Radiation Therapy Planning: Consensus Definitions
Collaborators

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Content

→ Overlying principles: slides 4 - 6
→ Consensus definitions of anatomical boundaries: slides 7 - 12
→ Illustrative cases:
  – A: Stage I intact post-lumpectomy left breast (slides 13 - 30)
  – B: Stage III post-mastectomy left breast (slides 32 - 51)
  – C: Stage III intact post-lumpectomy right breast (slides 54 - 71)
Overlying principles: Breast Contour

Breast CTV:
- Considers referenced clinical breast at time of CT
- Includes the apparent CT glandular breast tissue
- Incorporates consensus definitions of anatomical borders (see table)
- Includes the lumpectomy CTV

Lumpectomy GTV: Includes seroma and surgical clips when present
Overlying principles: Chestwall Contour

Chestwall CTV:

– Considers referenced clinical chestwall at time of CT
– Incorporates consensus definitions of anatomical borders (see table)
– Includes the mastectomy scar (*may not be feasible for occasional cases where the scar extends beyond the typical borders of the chestwall*)
Overlying principles: Nodal volumes

Regional nodal CTV:
- Nodal volumes contoured for targeting will depend on the specific clinical case
- Considers consensus definitions of anatomical borders (see table)
- The three levels of the axilla can overlap caudal to cranial
- “Axillary apex” was considered level III of the axilla
### Breast and 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>Clinical Reference + Second rib insertion</td>
<td>Clinical reference + loss of CT apparent</td>
<td>Skin</td>
<td>Excludes pectoralis muscles, chestwall</td>
<td>Clinical Reference + mid axillary line</td>
<td>Sternal-rib junction</td>
</tr>
<tr>
<td></td>
<td>breast</td>
<td>breast</td>
<td></td>
<td>muscles, ribs</td>
<td>typically excludes latissimus (Lat.) dorsi m.</td>
<td>b</td>
</tr>
<tr>
<td><strong>Breast + Chestwall</strong></td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
<td>Includes pectoralis muscles, chestwall</td>
<td>Same</td>
<td>Same</td>
</tr>
<tr>
<td><strong>Chestwall</strong></td>
<td>Caudal reference + loss of CT apparent</td>
<td>Clinical reference + loss of CT apparent</td>
<td>Skin</td>
<td>Rib-pleural interface. (Includes pectoralis</td>
<td>Clinical Reference/ mid axillary line</td>
<td>Sternal-rib junction</td>
</tr>
<tr>
<td></td>
<td>contralateral breast</td>
<td>contralateral breast</td>
<td></td>
<td>muscles, chestwall muscles, ribs)</td>
<td>typically excludes latissimus dorsi m</td>
<td>b</td>
</tr>
</tbody>
</table>
Case A- Intact post lumpectomy breast

• Stage I (T1c, N0, M0) Left breast cancer
• Surgery: Lumpectomy and sentinel node biopsy
• Radiation: Breast
• Six surgical clips placed at lumpectomy site
• External markers placed at time of CT:
  – BB at AP set-up point
  – 4 wire markers for clinical estimate of cranial, caudal, medial, and lateral extent of anticipated tangents
  – Wire extending from 9-3 o’clock around the infra-mammary fold
  – Wire over the lumpectomy scar
Advanced Breast Cancer Protocols

Incorporate appropriate breast and normal tissue target contours

- Provide optimal guidance on contouring and dosimetry
  - RTOG 1005
  - RTOG 1304/NSABP B51
NSABP PROTOCOL B-51
RTOG PROTOCOL 1304

A Randomized Phase III Clinical Trial Evaluating Post-Mastectomy Chestwall and Regional Nodal XRT and Post-Lumpectomy Regional Nodal XRT in Patients with Positive Axillary Nodes Before Neoadjuvant Chemotherapy Who Convert to Pathologically Negative Axillary Nodes After Neoadjuvant Chemotherapy

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Version Date: January 11, 2013

This protocol was designed and developed by the NSABP and the RTOG of the American College of Radiology (ACR). It is intended to be used only in conjunction with institution-specific IIRB approval for study entry. No other use or reproduction is authorized by the NSABP or the RTOG nor does the NSABP or the RTOG assume any responsibility for unauthorized use of this protocol.
Figure 1
NSABP B-51/RTOG 1304 Schema

Clinically T1–3, N1 Breast Cancer
Documented Positive Axillary Nodes by FNA
or by Core Needle Biopsy

Minimum of 12 weeks of Standard Neoadjuvant Chemotherapy
Plus Anti-HER2 Therapy for Patients with HER2-Positive Tumors

Definitive Surgery with Histologic Documentation of Negative Axillary Nodes
(Either by Axillary Dissection or by Sentinel Node Biopsy ± Axillary Dissection)

STRATIFICATION
- Type of surgery (mastectomy, lumpectomy)
- Hormone receptor status (ER-positive and/or PgR-positive; ER- and PgR-negative)
- HER2 status (negative, positive)
- Adjuvant chemotherapy (yes, no)
- pCR in breast (yes, no)

RANDOMIZATION

** Arms 1 and 2 **
- Arm 1
  - (Groups 1A and 1B)*, **
  - No Regional Nodal XRT
    - Group 1A Lumpectomy: No regional nodal XRT with WBI
    - Group 1B Mastectomy: No regional nodal XRT and no chest wall XRT

- Arm 2
  - (Groups 2A and 2B)*, **
  - Regional Nodal XRT
    - Group 2A Lumpectomy: Regional nodal XRT with WBI
    - Group 2B Mastectomy: Regional nodal XRT and chest wall XRT

* Patients will be randomized to one of the following:
  - ** Arm 1 **
    - Radiation therapy for Group 1A
      - Whole breast irradiation + boost
    - No radiation therapy for Group 1B
  - ** Arm 2 **
    - Radiation therapy for Group 2A
      - Whole breast irradiation + boost and regional nodal irradiation
    - Radiation therapy for Group 2B
      - Chest wall and regional nodal irradiation

** All patients will receive additional systemic therapy as planned (i.e., hormonal therapy for patients with hormone receptor-positive breast cancer and trastuzumab or other anti-HER2 therapy for patients with breast cancer that is HER2-positive).
NSABP B-51/RTOG 1304 (NRG 9353): Schema

Clinical T1-3N1Mo BC

Axillary Node (+) (FNA or Core Needle Biopsy)

Neoadjuvant Chemo (+ Anti-HER-2 Therapy for HER-2 neu + Pts)

Path Negative Axillary Nodes at Surgery (Axillary Dissection or SNB ± Axillary Dissection)

Stratification
Type of Surgery
ER-Status, HER-2 Status
pCR in Breast

Randomization

No Regional Nodal XRT with Breast XRT if BCS and No Chest Wall XRT if Mastectomy

Regional Nodal XRT with Breast XRT if BCS and Chest Wall XRT if Mastectomy
Contouring for Breast Cancer: Dr. Frank Vicini, MD – VIGNETTE

Case Description #1 - Dr. Frank Vicini:: Breast: ASTRO 2013

A 62 yo woman with a biopsy proven 3.2cm IDC in her left breast also presents with a clinically palpable axillary node. (Ultrasound guided biopsy of the lymph node confirms metastatic disease). The patient undergoes neo-adjuvant chemotherapy and is enrolled on the NSABP B51/RTOG 1304 phase III trial after a complete pathologic response is documented in her axilla (5 negative axillary nodes found at the time of axillary dissection-assume levels I and II of the axilla were dissected). The protocol randomizes patients with positive axillary nodes prior to neo-adjuvant chemotherapy who convert to pathologically negative axillary nodes to no RT or to comprehensive RT (chest wall or post-lumpectomy plus RNI). This patient chose BCT and the lumpectomy specimen also revealed no evidence of cancer. The patient was randomized to Group 2A (Arm 2) of the trial:

Arm 2: Comprehensive Regional nodal RT (RNI) with whole breast irradiation (WBI)
Breast CTV: Includes the palpable breast tissue demarcated with radio-opaque markers at CT simulation, the apparent CT glandular and fatty breast tissue visualized by CT, consensus definitions of anatomical borders from the RTOG Breast Cancer Atlas, and should include the Lumpectomy CTV. The Breast CTV is limited anteriorly within 5 mm from the skin and posteriorly to the anterior surface of the pectoralis, serratus anterior muscle excluding chestwall, boney thorax, and lung. In general, the pectoralis and/or serratus anterior muscles are excluded from the Breast CTV unless clinically warranted by the patient’s pathology.

Breast PTV: Breast CTV + 7 mm 3D expansion (excludes heart and does not cross midline).

Breast PTV Eval: The Breast PTV Eval is intended to exclude the portion of the Breast PTV that extends outside the patient or into the boney thorax and lungs. The Breast PTV is copied to a Breast PTV Eval

Lumpectomy Gross Target Volume (GTV): Contour using all available clinical and radiographic information including the excision cavity volume, architectural distortion, lumpectomy scar, seroma and/or extent of surgical clips (clips are strongly recommended).

Lumpectomy Clinical Target Volume (CTV): Lumpectomy GTV + 1 cm 3D expansion. Limit the CTV posteriorly at anterior surface of the pectoralis major and anterolaterally 5 mm from skin and should not cross midline. In general, the pectoralis and/or serratus anterior muscles are excluded from the lumpectomy CTV unless clinically warranted by the patient’s pathology.

Lumpectomy Planning Target Volume (PTV): Lumpectomy CTV + 7 mm 3D expansion (excludes heart).

Lumpectomy PTV Eval: Since a substantial part of the Lumpectomy PTV often extends outside the patient (especially for superficial cavities), the Lumpectomy PTV is then copied to a Lumpectomy PTV Eval which is edited. This Lumpectomy PTV Eval is limited to exclude the part outside the ipsilateral breast and the first 5 mm of tissue under the skin (in order to remove most of the build-up region for the DVH analysis) and excluding the Lumpectomy PTV expansion beyond the posterior extent of breast tissue (chestwall, pectoralis muscles, and lung) when pertinent. The lumpectomy PTV should not cross midline.
Breast CTV: Includes the palpable breast tissue demarcated with radio-opaque markers at CT simulation, the apparent CT glandular and fatty breast tissue visualized by CT, consensus definitions of anatomical borders from the RTOG Breast Cancer Atlas, and should include the Lumpectomy CTV. The Breast CTV is limited anteriorly within 5 mm from the skin and posteriorly to the anterior surface of the pectoralis, serratus anterior muscle excluding chestwall, boney thorax, and lung. In general, the pectoralis and/or serratus anterior muscles are excluded from the Breast CTV unless clinically warranted by the patient’s pathology.
Lumpectomy Clinical Target Volume (CTV): Lumpectomy GTV + 1 cm 3D expansion. Limit the CTV posteriorly at anterior surface of the pectoralis major and anterolaterally 5 mm from skin and should not cross midline. In general, the pectoralis and/or serratus anterior muscles are excluded from the lumpectomy CTV unless clinically warranted by the patient’s pathology.
Contouring for Breast Cancer: Dr. Frank Vicini, MD – VIGNETTE

Case Description #2 - Dr. Frank Vicini: Chest Wall: ASTRO 2013

A 55 yo woman with a 5.3cm IDC tumor in her left breast presents with a clinically palpable axillary node (Ultrasound guided biopsy of the lymph node confirms metastatic disease). The patient undergoes neo-adjuvant chemotherapy and is enrolled on the NSABP B51/RTOG 1304 trial after a complete pathologic response is noted in her axilla (4 negative axillary nodes documented at the time of axillary dissection-assume levels I and II of the axilla were dissected). The patient chose mastectomy and the surgical specimen also revealed no evidence of cancer. The patient was randomized to Group 2B (Arm 2) of the trial:

Arm 2: Comprehensive Regional Nodal RT and Chest Wall RT
**Mastectomy Scar:** To help reproducibility in the design and evaluation of post-mastectomy radiotherapy treatment plans, an initial clinical target volume for the mastectomy scar will be created. The Mastectomy Scar will first be contoured by delineating the radiopaque wire placed over the scar at CT simulation as a surrogate of the scar and including any visible postoperative changes on CT in the subcutaneous tissue deep to the wire per the investigator’s discretion.

**Mastectomy Scar CTV:** Mastectomy Scar and associated surgical change + 1 cm 3D expansion. Limit the CTV expansion posteriorly at anterior surface of the ribs and anterolaterally at skin and should not cross midline.

*(NOTE: Occasionally, the Mastectomy Scar location will lead to a CTV that does cross midline.)*

**Mastectomy Scar PTV:** Mastectomy Scar CTV + 7 mm 3D expansion (excludes heart).

**Mastectomy Scar PTV Eval:** Since a substantial part of the Mastectomy Scar PTV often extends outside the patient – a Mastectomy Scar PTV Eval is created. This Mastectomy Scar PTV Eval is limited to exclude the part that extends outside the ipsilateral body/chestwall and the first 3 mm of tissue under the skin (in order to remove some of the buildup region for the DVH analysis) and posteriorly is limited to exclude lung and heart. The Mastectomy Scar PTV Eval should not cross midline and should be contained within the borders of the Chestwall PTV Eval. This is the structure used for DVH constraints, analysis, and compliance.

*(NOTE: Occasionally, the Mastectomy Scar location will lead to a CTV and PTV Eval that does cross midline. The investigator will have to assess clinically whether adequate radiation can be delivered if the Mastectomy Scar CTV and PTV Eval is truncated at midline. If it is felt that the Mastectomy Scar CTV and PTV Eval must cross midline – this case may have significant challenges in meeting Compliance Criteria for this protocol and might not be suitable for enrollment.)*
**Chestwall CTV:** Includes the Mastectomy Scar CTV, and takes into account the radiopaque markers placed at CT identifying clinical extent of chestwall, surgical changes visualized by CT, and consensus definitions of anatomical borders of chestwall from the RTOG Breast Cancer Atlas [http://www.rtog.org/CoreLab/ContouringAtlases/BreastCancerAtlas.aspx](http://www.rtog.org/CoreLab/ContouringAtlases/BreastCancerAtlas.aspx).

The Chestwall CTV is limited by the skin anteriorly and should not extend deeper than the ribs so that it excludes the lung and heart. Depending on the location of the Mastectomy Scar CTV, it should exclude the sternum medially and the axilla deep to anterior surface of the pectoralis major muscle laterally. In general, the chestwall CTV should not cross midline.

Expanders, implants or autologous tissue present for reconstruction will be included in the Chestwall CTV. The degree of expander expansion present is per the treating physician’s discretion. The expander should remain at the same expansion through the course of treatment that is present for the CT simulation.
3.2.2 **Mastectomy Scar CTV**: See Figure 7. Mastectomy scar and associated surgical change + 1 cm 3D expansion. Limit the CTV expansion posteriorly at anterior surface of the ribs and anterolateral at skin and should not cross midline. The Mastectomy Scar CTV should be contained within the Chestwall CTV.

Figure 7. Axial CT slice illustrating **Mastectomy Scar CTV**
Mastectomy Scar PTV

Mastectomy Scar CTV

Wire on Mastectomy Scar Contoured

7 mm expansion

Mastectomy scar PTV
**Chest Wall CTV Contour**


The Chestwall CTV is limited by the skin anteriorly and should not extend deeper than the ribs so that it excludes the lung and heart. Depending on the location of the Mastectomy Scar CTV, it should exclude the sternum medially and the axilla deep to anterior surface of the pectoralis major muscle laterally. In general, the chestwall CTV should not cross midline.
**Chest Wall PTV-eval Contour**

- **Mastectomy Scar PTV-eval (cyan)**
- **Mastectomy Scar CTV (yellow)**
- **Chestwall CTV (blue)**
- **Chestwall PTV**

**Chestwall PTV-eval (red)**
- Excludes sternum, intrathoracic structures: vessels, lung, heart
- Extends within 3 mm skin
Chest Wall CTV Contour

Chestwall PTV-eval (red)
- Excludes sternum, intrathoracic structures: vessels, lung, heart
- Extends within 3 mm skin
Chest Wall CTV Contour

- Chestwall PTV-eval (red)
- Chestwall CTV (blue)
- Mastectomy Scar PTV-eval (cyan)
- Mastectomy Scar CTV (yellow)
Figure 14. Coronal CT slice illustrating Mastectomy scar targets – **Mastectomy scar CTV** (yellow) and **Mastectomy Scar PTV-eval** (cyan), and Chestwall targets- **Chestwall CTV** (blue), **Chestwall PTV** (white), and **Chestwall PTV-eval** (red).
Expanders, implants or autologous tissue present for reconstruction will be included in the Chestwall CTV. The degree of expander expansion present is per the treating physician’s discretion. The expander should remain at the same expansion through the course of treatment that is present for the CT simulation.
10.6.4.1 *Supraclavicular CTV*: Based on consensus definitions from RTOG Breast Cancer Atlas. Superior extent typically is below the level of the cricoid; medially excludes thyroid, trachea, and esophagus. The lateral border extends to the lateral edge of the sternocleidomastoid muscle superiorly and the clavicle at its more inferior extent, and the inferior border extends to the caudal aspect of the clavicular head.
16A. Non-contiguous Axial CT slices illustrating the Supraclavicular (SCL) CTV and SCL PTV. The SCL PTV is a 5 mm expansion on the SCL CTV. Note that the SCL PTV excludes thyroid, trachea, etc., medially and therefore some or all of it can have a similar medial extent as the SCL CTV.

**Regional Nodal Contours:** Anatomical Boundaries

<table>
<thead>
<tr>
<th>Cranium</th>
<th>Caudal</th>
<th>Anterior</th>
<th>Posterior</th>
<th>Lateral</th>
<th>Medial</th>
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</thead>
<tbody>
<tr>
<td>Supraclavicular</td>
<td>Caudal to the cricoid cartilage</td>
<td>Junction of brachioph.-axillary vns./caudal edge clavicle head</td>
<td>Sternocleidomastoid (SCM) muscle (m.)</td>
<td>Anterior aspect of the scalene m.</td>
<td>Cranial: lateral edge of SCM m.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Caudal: junction 1st rib-clavicle</td>
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</tbody>
</table>
10.6.4.3 *Axillary CTV:* The extent of axilla to be targeted for regional nodal irradiation will depend on the extent of axillary surgery performed. The axillary CTV consists of the portion of the axilla that remains "undissected." When an axillary node dissection has been done, the inferior border of the axillary CTV will be the most cephalic extent of the dissection. Review of the operative report, postoperative changes on the planning CT, and discussion with the patient’s surgeon can be used for determining the most cephalic extent of the dissection and inferior border of the Axillary CTV. Axillary dissection typically removes level 1–2 axillary nodes, so that the Axillary CTV in these cases is expected to include level 3 primarily and some of level 2 of the axilla. When a sentinel node biopsy alone is done without completion axillary dissection, the axillary CTV will then include all 3 levels of the axilla as all three levels are "undissected." The consensus definitions for anatomical borders of the axillary levels are from the RTOG Breast Cancer Atlas [http://www.rtog.org/CoreLab/ContouringAtlases/BreastCancerAtlas.aspx](http://www.rtog.org/CoreLab/ContouringAtlases/BreastCancerAtlas.aspx).
16B. Coronal CT slice illustrating the SCL CTV and SCL PTV in relation to the Axillary CTV and Axillary PTV.
17A. Non-contiguous Axial CT slices illustrating **Axillary CTV and Axillary PTV**. **Axillary PTV** is a 5 mm expansion on the **Axillary CTV**. Axillary PTV excludes the lung.

**Regional Nodal Contours: Anatomical Boundaries**

<table>
<thead>
<tr>
<th>Axilla-Level I</th>
<th>Cranial</th>
<th>Caudal</th>
<th>Anterior</th>
<th>Posterior</th>
<th>Lateral</th>
<th>Medial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Axillary vessels cross lateral edge of Pec. Minor m.</td>
<td>Pectoralis (Pec.) major muscle insert into ribs</td>
<td>Plane defined by: anterior surface of Pec. Maj. m. and Lat. Dorsi m.</td>
<td>Anterior surface of subscapularis m.</td>
<td>Medial border of lat. dorsi m.</td>
<td>Lateral border of Pec. minor m.</td>
</tr>
<tr>
<td>Axilla-Level III</td>
<td>Pec. Minor m. insert on cricoid</td>
<td>Axillary vessels cross medial edge of Pec. Minor m.</td>
<td>Posterior surface Pec. Minor m.</td>
<td>Ribs and intercostal muscles</td>
<td>Medial border of Pec. Minor m.</td>
<td>Thoracic inlet</td>
</tr>
</tbody>
</table>
### Regional Nodal Contours: Anatomical Boundaries

<table>
<thead>
<tr>
<th>Region</th>
<th>Cranial</th>
<th>Caudal</th>
<th>Anterior</th>
<th>Posterior</th>
<th>Lateral</th>
<th>Medial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axilla-Level I</td>
<td>Axillary vessels cross lateral edge of Pec. Minor m.</td>
<td>Pectoralis (Pec.) major muscle insert into ribs b</td>
<td>Plane defined by: anterior surface of Pec. Maj. m. and Lat. Dorsl m.</td>
<td>Anterior surface of subscapularis m.</td>
<td>Medial border of lat. dorsi m.</td>
<td>Lateral border of Pec. minor m.</td>
</tr>
<tr>
<td>Axilla-Level III</td>
<td>Pec. Minor m. insert on cricoid</td>
<td>Axillary vessels cross medial edge of Pec. Minor m. d</td>
<td>Posterior surface Pec. Major m.</td>
<td>Ribs and intercostal muscles</td>
<td>Medial border of Pec. Minor m.</td>
<td>Thoracic inlet</td>
</tr>
</tbody>
</table>

**Axilla PTV**

**Axilla CTV**

Area of axillary dissection excluded from CTV
Figure 18A and Figure 18B. Axillary CTV and Axillary PTV after AXILLARY DISSECTION

18A. Non-contiguous Axial CT slices illustrating Axillary CTV and Axillary PTV. Axillary PTV is a 5 mm expansion on the Axillary CTV. Axillary PTV excludes the lung.

Axilla PTV (white)

Axilla CTV (magenta)

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

Regional Nodal Contours: Anatomical Boundaries

<table>
<thead>
<tr>
<th>Axilla-Level I</th>
<th>Axilla-Level II</th>
<th>Axilla-Level III</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cranial</strong></td>
<td><strong>Caudal</strong></td>
<td><strong>Anterior</strong></td>
</tr>
<tr>
<td>Axillary vessels cross lateral edge of Pec. Minor m.</td>
<td>Axillary vessels cross lateral edge of Pec. Minor m.</td>
<td>Plane defined by: anterior surface of Pec. Maj. m. and Lat. Dorsi m.</td>
</tr>
<tr>
<td><strong>Posterior</strong></td>
<td><strong>Lateral</strong></td>
<td><strong>Medial</strong></td>
</tr>
<tr>
<td>Anterior surface of subscapularis m.</td>
<td>Medial border of lat. dorsi m.</td>
<td>Lateral border of Pec. minor m.</td>
</tr>
<tr>
<td><strong>Medial</strong></td>
<td><strong>Lateral</strong></td>
<td><strong>Posterior</strong></td>
</tr>
<tr>
<td>Lateral border of Pec. minor m.</td>
<td>Medial border of Pec. Minor m.</td>
<td>ribs and intercostal muscles</td>
</tr>
<tr>
<td><strong>Lateral</strong></td>
<td><strong>Posterior</strong></td>
<td><strong>Medial</strong></td>
</tr>
<tr>
<td>Medial border of Pec. Minor m.</td>
<td>Ribs and intercostal muscles</td>
<td>Thoracic inlet</td>
</tr>
</tbody>
</table>

- a
- b
- c
- d
**Regional Nodal Contours: Anatomical Boundaries**

<table>
<thead>
<tr>
<th>Axilla-Level I</th>
<th>Cranial</th>
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<tr>
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<td>Axillary vessels cross medial edge of Pec. Minor m.</td>
<td>Posterior surface Pec. Minor m.</td>
<td>Ribs and intercostal muscles</td>
<td>Medial border of Pec. Minor m.</td>
<td>Thoracic inlet</td>
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</tbody>
</table>

**18B. Coronal CT slice illustrating Axillary CTV and Axillary PTV in setting of SENTINEL NODE BIOSY ONLY WITHOUT AXILLARY DISSECTION**

- Axilla PTV
- Axilla CTV (magenta)

Low or level 1 axilla included in the CTV with levels 2-3 after sentinel node biopsy only.
10.6.4.5 *Internal mammary node (IMN) CTV*: Includes the internal mammary/thoracic vessels in the first three intercostal spaces.
Figure 19A and Figure 19B. IMN CTV and IMN PTV

19A. Non-contiguous Axial CT slices illustrating IMN CTV and IMN PTV. IMN PTV is a 5 mm medial and lateral expansion of the IMN CTV. IMN PTV excludes the lung, heart, sternum, chestwall and/or breast.

<table>
<thead>
<tr>
<th>Internal mammary</th>
<th>Cranial</th>
<th>Caudal</th>
<th>Anterior</th>
<th>Posterior</th>
<th>Lateral</th>
<th>Medial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior aspect of the medial 1st rib.</td>
<td>Cranial aspect of the 4th rib</td>
<td>- e.</td>
<td>- e.</td>
<td>- e.</td>
<td>- e.</td>
<td></td>
</tr>
</tbody>
</table>
19B. Sagittal CT slice illustrating IMN CTV and IMN PTV are limited to the first 3 intercostal spaces.
### Regional Nodal Contours: Anatomical Boundaries

<table>
<thead>
<tr>
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<th>Cranial</th>
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<th>Posterior</th>
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<th>Medial</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SuprACLavicular</strong></td>
<td>Caudal to the cricoid cartilage</td>
<td>Junction of brachioceph.-axillary vns./caudal edge clavicle head</td>
<td>Sternocleido mastoid (SCM) muscle (m.)</td>
<td>Anterior aspect of the scalene m.</td>
<td>Cranial: lateral edge of SCM m. Caudal: junction 1st rib-clavicle</td>
<td>Excludes thyroid and trachea</td>
</tr>
<tr>
<td><strong>Axilla-Level I</strong></td>
<td>Axillary vessels cross lateral edge of Pec. Minor m.</td>
<td>Pectoralis (Pec.) major muscle insert into ribs</td>
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</tr>
<tr>
<td><strong>Axilla-level III</strong></td>
<td>Pec. Minor m. insert on cricoid</td>
<td>Axillary vessels cross medial edge of Pec. Minor m.</td>
<td>Posterior surface Pec. Major m.</td>
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<td>Superior aspect of the medial 1st rib</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

• Optimal delivery of contemporary radiation therapy requires a thorough understanding of contouring and dosimetric nomenclature currently in use
• Standardized definitions readily exist (RTOG Breast Atlas) for quick reference
• Current research protocols require an optimal understanding of standard contouring principles/definitions and provide useful appendices and contouring tools for optimal success (even in clinical practice)