Dosimetric Concerns of Post-Mastectomy Tissue Expanders during External Beam Radiation Therapy

Seng Boh (Gary) Lim, PhD
Assistant Attending Physicist
Director of Radiation Dosimetry Core

AAPM Annual Meeting July 11, 2022

Disclosure

- Nothing to disclose
Background

- Breast cancer: Surgery and Radiation Therapy extends life expectancy\textsuperscript{1,2}

- Surgical options: Lumpectomy and Mastectomy

- Post-mastectomy:
  - Reconstruction
    - Two-stage technique preferred\textsuperscript{2}
  - Post-mastectomy radiation therapy (PMRT)
    - Make skin tighter and tougher
    - Require tissue expander
  - PMRT Timing\textsuperscript{3}


Tissue Expanders

- Saline-based tissue expander
- Weekly injection
- 6-8 weeks

- Air tissue expander
- Self-administered
- Up to 3 times a day
- 4-6 weeks

Dziemianowicz E et al. JACMP. 2019
MRI Safety

• Concerns
  – Heating
  – Projectile effect
  – Artifacts

• Saline with magnetic injection port
  – MR unsafe
  – Port dislodgement¹

• Air Tissue Expander
  – MR unsafe
  – Stainless steel
  – CO₂ canister
  – Not recommended


AAPM Annual Meeting, July 11, 2022

CT Challenges

AAPM Annual Meeting, July 11, 2022
External Beam Radiation Therapy Consideration

- Radiation dose homogeneity is important
  - Correlated to the outcome
  - Coverage (Chest wall to the skin)
  - OAR (Contralateral breast, heart, lung)

- Techniques
  - Parallel oppose
  - VMAT / IMRT

- Treatment
  - Photon
  - Proton
  - Brachytherapy


Expander Dosimetric Complications

- CT curve
  - 12-bit limit
  - High Z material calibration
  - Inaccurate HU
  - Delineation challenge

- Coverage
  - Affect dose homogeneity
  - Increase uncertainty

- Dose calculation algorithm accuracy*
  - Z, energy, and field size dependent
  - E > 10MV
    - neutron dose may not be included
  - Algorithm

AAPM Annual Meeting, July 11, 2022
**Dosimetry - IMP**

1. Significant transmission reduction behind the magnet (shadow)
2. Without correction, dose error >20% (6x) and > 10% (15x)
3. Parallel to the beam is significantly worse
4. 15x less attenuation than 6x
5. Average skin dose error: -14% to +1%

---

**Dosimetry - IMP**

- Clinical beam dosimetric error
  - Less significant with multiple beams
- Algorithm
  - AAA and CCC tend to overestimate
- Chest wall
  - IMP typically > 1 cm away
  - Not too critical
- Skin
  - Potential underdose
- Saline Cavity
  - Significant dose inhomogeneity
  - Not critical

**Dose error (%)**

<table>
<thead>
<tr>
<th></th>
<th>AAA¹</th>
<th>CCC²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin</td>
<td>~7%  (0°)</td>
<td>5-10%</td>
</tr>
<tr>
<td>Chest Wall</td>
<td>Not sig</td>
<td>&lt; 1.0%</td>
</tr>
</tbody>
</table>

---

Air Tissue Expander

- Complex high Z structure

Dosimetry (with 16 bits and O-MAR)

<table>
<thead>
<tr>
<th>OSLD Analysis</th>
<th>6x (VMAT)</th>
<th>15x (Tangent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>AXB</td>
<td>AAA</td>
</tr>
<tr>
<td>min</td>
<td>-2.2%</td>
<td>-2.9%</td>
</tr>
<tr>
<td>max</td>
<td>13.8%</td>
<td>11.0%</td>
</tr>
<tr>
<td>&lt;DD&gt;</td>
<td>4.6%</td>
<td>1.6%</td>
</tr>
</tbody>
</table>

Lim, S.B. et al. JACMP 2000
Some Final Thoughts

- Avoid high Z if possible

- CT curve
  - 16 bits if available
  - Appropriate density correction
  - Metal Artifact Reduction (MAR)
    - imAR (Siemens)
    - O-MAR (Philips)
    - SmartMAR (GE)
    - SEMAR (Toshiba)

- Algorithm
  - With inhomogeneity correction\(^1\)
    - AAA, AXB, CCC
  - Classic algorithms should be avoided\(^2\)
    - AAA and CCC tend to be inferior\(^3,4\) with high Z or low density than AXB or MC

- Evaluate TE

---