Technical “Advances” in RT for Breast Cancer

Lawrence B. Marks, M.D.
Professor and Chairman
University of North Carolina at Chapel Hill, NC
Disclaimer

- Varian Medical: grant, speaker
- Siemens Medical: grant
- NIH, Lance Armstrong: grants
Outline

• What is Radiation: types & origins
• Depth dose curve
• What we aim at and why; Target Volume
• How we aim and shoot (alphabet of hope)
  • Conventional
  • 3D
  • Image guided (IGRT)
  • Intensity Modulated (IMRT)
Types of Radiation

Teletherapy (external beam)
  - Radioactive Co$^{60}$
    - Emits high-energy photons ($\sim 1$ MeV)
  - Electrons
  - X-rays (photons)
    - High or very high energy (5-20 MeV)

Brachytherapy (implants)
  - Emits low-energy photons ($\sim 400$ KeV)
  - Minimal penetration
  - High or low dose rate

Gamma-rays (photons)
RT goal: historically

- Post-lumpectomy
  - Emulate mastectomy
- Post-mastectomy
  - Operative bed
  - Nodal drainage
  - Spread pattern
Textbook of Radiotherapy,
Gilbert Fletcher
electrons
Technical “Advances”

• If it isn’t broke..
• Whole breast RT techniques: good
• Need not compromise efficacy
• “Old” techniques work

• Is whole breast RT needed?
Gross Tumor Volume (GTV) + Microscopic Spread + Internal Motion + Set-up Errors

Clinical Target Volume (CTV)

Internal Target Volume (ITV)

Planning Target Volume (PTV) - treated volume
Gross Tumor Volume (GTV) + Microscopic Spread + Internal Motion + Set-up Errors

Clinical Target Volume (CTV)

Internal Target Volume (ITV)

Planning Target Volume (PTV)- treated volume

Imaging- CT, PET

Respiratory gating

On board imaging

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Gross Tumor Volume (GTV) + Microscopic Spread + Internal Motion + Set-up Errors

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Imaging-CT, PET

biology

UNC
Marks IJROBP, 1994.
QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.
### Impact of CT Planning: Intact Breast or Chest Wall

<table>
<thead>
<tr>
<th>Border</th>
<th>Shifts (%)</th>
<th>Magnitude (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial</td>
<td>27%</td>
<td>5–20</td>
</tr>
<tr>
<td></td>
<td>(27/104)</td>
<td>(16 mean)</td>
</tr>
<tr>
<td>Lateral</td>
<td>62%</td>
<td>5–60</td>
</tr>
<tr>
<td></td>
<td>(62/104)</td>
<td>(16 mean)</td>
</tr>
</tbody>
</table>

Bentel et al. 1998

UNC
QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.
Standard AP SCV RT Field

SCV nodal volume

Intraclavicular nodal volume

Madu, Pierce et al, U Mich Radiology, 2001
Heart Block Examples

Marks IJROBP 1994.

Recent Patient
CT-Based Treatment Planning
Large Benefit!!

- Target borders (± IMN)
- Electron depths
- S/C, axilla depths
- Lung toxicity studies
- Block heart
Imaging-
CT, PET + biology

Gross Tumor Volume (GTV) + Microscopic Spread + Internal Motion + Set-up Errors

Clinical Target Volume (CTV) + Internal Motion + Set-up Errors

Internal Target Volume (ITV) + Set-up Errors

Planning Target Volume (PTV)- treated volume

Respiratory gating

On board imaging
Exhalation

Left Ventricle Apex

Deep Inspiration

Left Ventricle Apex

Harvard JCRT
Definition of Axial Levels and Points of Measurement

Superior vena cava
Aorta
Sternum
Superior
Middle
Inferior
Diaphragm

Supine CT
Prone MRI

Chino and Marks IJROBP, 2008
**Imaging** - CT, PET

**Gross Tumor Volume (GTV)**

**Microscopic Spread**

**Clinical Target Volume (CTV)**

**Respiratory gating**

**Internal Motion**

**Set-up Errors**

**Internal Target Volume (ITV)**

**Planning Target Volume (PTV)** - treated volume

**On board imaging**

**UNC**
Simulation
Fluoroscopy or
CT-based 3D

Mark field
borders on
skin

Treatment room:
“set up” marks

Imaging = simulator

Weekly port
film to check
Simulation
Fluoroscopy or CT-based 3D

→ Mark field borders on skin

Treatment room: “set up” marks

Imaging = simulator

Weekly port film to check
Simulation
Fluoroscopy or
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Imaging = simulator

Fluoroscopy or
CT on treatment
machine

Mark field
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Image Guided
Therapy

UNC
Simulation
Fluoroscopy or CT-based 3D

Mark field borders on skin

Treatment room: “set up” marks

Imaging = simulator

Fluoroscopy or CT on treatment machine

Image Guided Therapy

Utility = f (set-up uncertainty)
Internal: e.g. Prostate Breast? Less useful?

Weekly port film to check
QuickTime™ and a TIFF (LZW) decompressor are needed to see this picture.
Continuous OBI to document heart sparing

Real-Time Verification
Partial Breast External Beam RT (Beam Bouquet)

CBCT-Based Target Localization for Partial Breast Treatment
Daily verification, continuously during RT, of heart sparing
Intensity Modulated Radiation Therapy (IMRT)
• Open fields

Hot
Wedge

Removes Hot Spot
• Wedge ≈ breast contour
• Differences at axial levels
3D compensator, MLC’s

Removes Hot Spots

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Transverse View

Images from William Beaumont Hospital
2 Randomized trials of IMRT

- Acute effects

- Late effects
## Acute effects (N=331)

<table>
<thead>
<tr>
<th></th>
<th>“standard”</th>
<th>IMRT</th>
<th>( p )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade 3-4 skin toxicity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>37%</td>
<td>27%</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Moist Desquamation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>anywhere</td>
<td>48%</td>
<td>31%</td>
<td>0.002</td>
</tr>
<tr>
<td>infra-mammary fold</td>
<td>44%</td>
<td>27%</td>
<td>0.001</td>
</tr>
</tbody>
</table>

## Late effects (N=240)

<table>
<thead>
<tr>
<th></th>
<th>“standard”</th>
<th>3D/IMRT</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breast appearance</strong></td>
<td>58%</td>
<td>40%</td>
<td>0.008</td>
</tr>
<tr>
<td><strong>photo</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MD-detected induration</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boost site</td>
<td>61%</td>
<td>37%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Elsewhere</td>
<td>24-32%</td>
<td>17-22%</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Patient reported discomfort, hardness, or quality of life</strong></td>
<td>NS differences</td>
<td>Data shown is 5 yrs, similar at 2 yrs</td>
<td></td>
</tr>
</tbody>
</table>

Donovan Radio Onc 82: 254, 2007
Chemo ↔ RT

• Better chemo is an RT “advance”
RT and chemo are synergistic

Impact of Local Therapy on Cure

Lung Breast

Chemotherapy Activity (Systemic Control)

Lymphoma Germ Cell
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