Clinical experience with TomoDirect™ System Tangential Mode

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Dept. of Radiotherapy – IEO
University of Milan, Italy
<table>
<thead>
<tr>
<th>Linac</th>
<th>Tumor sites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Vero</strong></td>
<td>Stereotactic body RT prostate IMRT</td>
</tr>
<tr>
<td><strong>1 CyberKnife® System</strong></td>
<td>Brain and spine stereotactic RT</td>
</tr>
<tr>
<td><strong>3 TomoTherapy® System</strong></td>
<td>Breast IMRT</td>
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<tr>
<td></td>
<td>Pelvic</td>
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<tr>
<td></td>
<td>Thoracic</td>
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<tr>
<td><strong>1 Trilogy</strong></td>
<td>Head and neck IMRT</td>
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<tr>
<td></td>
<td>Pelvic IMRT</td>
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<tr>
<td></td>
<td>Various 3D-CRT (palliative 3D)</td>
</tr>
<tr>
<td><strong>2 IORT LIAC, Intrabeam</strong></td>
<td>Breast</td>
</tr>
<tr>
<td></td>
<td>Pelvic</td>
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<tr>
<td></td>
<td>Vertebral metastases</td>
</tr>
<tr>
<td><strong>BRT (HDR/PDR/LDR)</strong></td>
<td>Breast</td>
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<tr>
<td></td>
<td>Sarcomas</td>
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<tr>
<td></td>
<td>Pelvic</td>
</tr>
<tr>
<td></td>
<td>Head and neck</td>
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</table>
Breast cancer in 2016 \( \rightarrow \) 856 patients (29% of the workload)

- Adjuvant RT with simultaneous integrated boost after BCS
  - 652 (76%)

- Locoregional hypofractionated RT
  - 172 (20%)

- Other breast treatments
  - 32 (4%)
The use of IMRT for BC has been increasing (from 0.0% to 12.6% from 1998 to 2007)

Roberts, 2012

More likely to receive IMRT if young and left-sided BC
American College of radiology (ACR) and American Society for radiation oncology (ASTRO) practice Guidelines for intensity-modulated radiation therapy (IMRT). Hartford, 2012

Clinical consensus for breast cancer IMRT has not been achieved yet

The Choosing Wisely(®) campaign

“don’t routinely use intensity modulated radiation therapy to deliver whole-breast radiation therapy as part of breast conservation therapy”.

Hahn, 2014
IMRT implementation and resources

- Planning objectives
- Beam on time

IMRT techniques are significantly more complex than 3D conformal RT

………but they have the potential to achieve superior dose homogeneity and normal tissue sparing, especially for targets and organs at risk with complex shapes, such as the breast and the chest wall

Whitton 2009
TomoDirect™ Treatment Delivery

- The gantry stops rotating to generate tangential-like breast RT
- Up to 12 discrete angles to single or multiple targets for optimal coverage
- Define a modulation level and optimization for tissue-compensated 3D conformal delivery
- Target volume up to 160 cm in length with no need to reposition and no field junction
- Increased throughput
Why use TomoDirect™ Delivery in early stage BC?

- Increased use of accelerated schemes
- More confidence because of homogeneous dose distribution
The minimisation of unwanted dose inhomogeneity in the breast reduces late adverse effects.
Superior dose conformity of TomoDirect™ Delivery
**Triple trouble effect**

<table>
<thead>
<tr>
<th>Dose inhomogeneity</th>
<th>2 Gy</th>
<th>3 Gy</th>
<th>4 Gy</th>
<th>5 Gy</th>
<th>6 Gy</th>
</tr>
</thead>
<tbody>
<tr>
<td>105%</td>
<td>107.1%</td>
<td>107.1%</td>
<td>108.0%</td>
<td>108.3%</td>
<td>108.5%</td>
</tr>
<tr>
<td>110%</td>
<td>114.4%</td>
<td>115.5%</td>
<td>116.3%</td>
<td>116.9%</td>
<td>117.3%</td>
</tr>
<tr>
<td>115%</td>
<td>121.9%</td>
<td>123.6%</td>
<td>124.9%</td>
<td>125.8%</td>
<td>126.5%</td>
</tr>
</tbody>
</table>
Why use TomoDirect™ Delivery in early stage BC?

• more homogeneous dose distribution
decrease in toxicity
What is the role of IMRT compared with standard tangent RT, 3DCRT? Dayes, 2012

If acute toxicity are the main outcome of interest, then IMRT is recommended treatment option over tangent RT.

Key Evidence

All studies in this review reported reductions in at least one measure of acute toxicity as a result of IMRT-based breast radiation. These toxicities typically related to skin reactions during the course of treatment, with reductions being in the order of one third. 1/3 less

If local control or survival endpoints are the main outcomes of interest, there is no evidence to support or refuse IMRT over tangent RT.
Multicenter randomized trial of breast IMRT to reduce acute radiation dermatitis  

Pignol 2008

Breast IMRT significantly improved dose distribution compared to standard RT

Fewer patients had moist desquamation: 31.2% with IMRT vs. 47.8% with standard RT (p 0.002)

10 years later......

Long-term results of the Canadian breast IMRT randomized controlled trial

(Pignol 2016)

Acute moist desquamation was associated with late subcutaneous fibrosis and telangiectasia
Why use TomoDirect™ Delivery in early stage BC?

- OAR sparing heart, lung, contralateral breast
Dosimetric comparative analysis of TomoDirect™ Delivery and 3DCRT in breast cancer

Chung, 2015
4 Gy x 8 fx after 12 Gy IORT boost
Estimation of the risk of secondary malignancy arising from WBRT: comparison of 5 RT modalities

- The lifetime attributable risk of secondary malignancy in each organ at risk for the five treatment modalities. 
  a. Ipsilateral lung, contralateral lung, contralateral breast, and thyroid. 
  b. Liver, stomach, colon, gonad, and rectum.

- The tangential field arrangements reduce the low-dose spread seen in the typical multi-directional IMRT field arrangements.
Why use TomoDirect™ Delivery in early stage BC?

- Delivery of SIB → shorten overall treatment time
2 schedules of accelerated whole breast irradiation with hypofractionation plus concurrent boost for early-stage BC at IEO

Same constraints as those of RADIATION THERAPY ONCOLOGY GROUP RTOG 1005

<table>
<thead>
<tr>
<th>SIB study -OARs</th>
<th>Ideal</th>
<th>Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart</td>
<td>$D_{\text{max}} &lt; 16 \text{ Gy}$</td>
<td>$D_{\text{max}} &lt; 20 \text{ Gy}$</td>
</tr>
<tr>
<td>Right breast</td>
<td>$V_{8\text{Gy}} &lt; 10 %$</td>
<td>$V_{8\text{Gy}} &lt; 15 %$</td>
</tr>
<tr>
<td>Heart</td>
<td>$D_{5%} &lt; 16 \text{ Gy}$</td>
<td>$D_{5%} &lt; 20 \text{ Gy}$</td>
</tr>
<tr>
<td>Left breast</td>
<td>$V_{8\text{Gy}} &lt; 30 %$</td>
<td>$V_{8\text{Gy}} &lt; 35 %$</td>
</tr>
<tr>
<td>Heart</td>
<td>$D_{\text{mean}} &lt; 3,2 \text{ Gy}$</td>
<td>$D_{\text{mean}} &lt; 4 \text{ Gy}$</td>
</tr>
<tr>
<td>Ipsilateral lung</td>
<td>$V_{16\text{Gy}} &lt; 15%$</td>
<td>$V_{16\text{Gy}} &lt; 20%$</td>
</tr>
<tr>
<td></td>
<td>$V_{8\text{Gy}} &lt; 35%$</td>
<td>$V_{8\text{Gy}} &lt; 40%$</td>
</tr>
<tr>
<td></td>
<td>$V_{4\text{Gy}} &lt; 50%$</td>
<td></td>
</tr>
<tr>
<td>Contralateral lung</td>
<td>$V_{4\text{Gy}} &lt; 10%$</td>
<td>$V_{4\text{Gy}} &lt; 15%$</td>
</tr>
<tr>
<td>Contralateral breast</td>
<td>$D_{\text{max}} &lt; 2,4 \text{ Gy}$</td>
<td>$D_{\text{max}} &lt; 2,64 \text{ Gy}$</td>
</tr>
</tbody>
</table>

4 weeks

Whole breast
2.25 Gy x 20 fr
Tumor bed
2.50 Gy x 20 fr

3 weeks

Whole breast
2.67 Gy x 15 fr
Tumor bed
3.2 Gy x 15 fr
High conformality

Comparison of conformal radiotherapy and intensity-modulated radiation therapy plan conformity indices for the excision cavity planning target volume.

(Small, 2013)
TomoDirect™ Treatment
Delivery planning

Whole breast

Total dose distribution

Tumor bed
High-dose SIB using IMRT simultaneously boost is dosimetrically better than sequential.

Prediction model for Grade≥2 fibrosis using 3DCRT SIB: age, volume of the breast receiving ≥ 55 Gy and maximum dose (Hammer, 2017)
Why use TomoDirect™ Delivery in early stage BC?

• Great flexibility expand the use of TomoDirect to treatments usually done with Helical
Breast radiotherapy at EIO

Bilateral breast with SIB

TomoDirect™

Helical TomoTherapy®
TomoDirect™ Delivery for synchronous bilateral BC: OAR sparing
TomoDirect™ Delivery for locoregional treatment
TomoDirect™ Delivery for breast cancer patients with supraclavicular nodes involvement

<table>
<thead>
<tr>
<th>OAR</th>
<th>Ipsilat lung</th>
<th>Heart</th>
<th>Contral breast</th>
<th>Contral body</th>
<th>Contral lung</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V5 (%)</td>
<td>V20 (%)</td>
<td>V40(%)</td>
<td>V5(%)</td>
<td>V25(%)</td>
</tr>
<tr>
<td>TD average</td>
<td>25</td>
<td>11</td>
<td>3.8</td>
<td>4.8</td>
<td>2</td>
</tr>
<tr>
<td>HT average</td>
<td>53</td>
<td>14</td>
<td>0.7</td>
<td>71</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Significant reduction in the volumes receiving low dose

PTV coverages equivalent in TomoDirect and Helical

High Target dose homogeneity with TomoDirect in both breast and node PTVs

Arrichiello, 2°ESTRO Forum 2013
Why use TomoDirect™ Delivery in early stage BC?

- Better dose distribution (ideally suited for hypofractionated schemes)
- Less acute toxicity, fewer late toxicities
- Shortened overall treatment time by using SIB
- OAR sparing
Thank You for Your Attention!