Early experience of accelerated partial breast irradiation using robotic stereotactic or intensity modulated radiation therapy in selected early stage breast cancer

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Background

Traditional conventional RT

• Conventional RT for breast conservation
  • Whole breast radiation therapy
  • Daily for 6-7 weeks depending on boost dose scheme
Background

Partial Breast Irradiation (PBI)

• Rationale
  • Majority of local recurrences after lumpectomy
  • At or near tumor bed
  • Remainder of breast may not need treatment

• PBI
  • Delivery of larger doses to lumpectomy cavity with margin
  • Results comparable with whole breast RT
Various PBI methods

Partial breast irradiation
Difficulties with each method

Potential technical hurdles for clinical implementation

- Very dependent on physicians (Multi-catheter brachytherapy, GEC-ESTRO Lancet 2016)
- Very dependent on surgical placement (Balloon brachytherapy, ASBS registry)
- Risk of device explantation in ~15% due to air gaps (Balloon brachytherapy, ASBS registry)
- Ideal source-to-skin distance ≥7 mm (Balloon brachy, IORT)
- Risk of procedure-related toxicity including infection/seroma
- Worse cosmetic outcomes reported in PBI than WBI (External beam RT, RAPID JCO 2013)
- Complicated by uncertainties in pathology (IORT, ELIOT Lancet Oncol 2013, TARGIT Lancet 2014)

External beam RT based PBI, not feasible in Korean patients (especially with small breast)

Multicenter prospective trial, KROG 0804, Cancer Res Treat 2015
International Guidelines

NCCN 2018

St. Gallen 2017

2017 Korean Survey to breast radiation oncologists

• Only 3/64 hospital (4.7%) responds to question whether providing PBI
Purpose

Yonsei PBI protocol

• PBI either with robotic-stereotactic body radiation therapy (SBRT) or arc-based IMRT (VMAT) since Nov 2015

• Here, we report the early outcomes with dosimetric assessment
**Methods (Individualized RT – YCC protocol)**

### RT extent

- **N0**
  - ASTRO & GEC-ESTRO guidelines + > 45 yrs., lobular histology
  - Z0011 candidate, e.g. SLN 1-2 (+)
  - Consider PBI!

- **N1**
  - EORTC, MA20 candidate: > 2 cm, ER-, G3, LV+/+
  - WB/CW (HypoFx #15)

- **N2-3**
  - NSABP B51 candidate, pN0 after NAC
  - WB/CW + RNI (ESTRO)

### RT technique

**Regional RT**

- **Yes**
  - 3DCRT or IMRT

**Large, pendulous breast**

- **Yes**
  - Prone

**Distance from rib to heart**

- **< 1cm**
  - Free Breathing (FB)
  - 3DCRT or IMRT

- **≥ 1cm**
  - Deep Inspiration Breathing Hold (DIBH)
Methods

Partial Breast Irradiation (PBI)

Eligible patient

Immobilization using
1. Fiducials/clips
2. Real time imaging for alignment
3. Motion tracking

Yes

No
Methods (Robotic-IMRT)

Gold fiducial markers for real-time respiratory tracking during SBRT using Synchrony

- Routine use since 2017.7
Methods (Robotic-IMRT)

Gold fiducial markers

- Post-insertion MMG
- 1 week later, CT simulation
Methods (Arc based IMRT)

2-arc VMAT (4 shuttle sub-arcs) plan
- Two small 40° rotations
Methods (PBI Target/Dose)

CTV = Cavity (surgical clip/scar) + 1 cm
PTV = CTV (R-SBRT) or CTV + 0.3-0.5 cm (VMAT)

<table>
<thead>
<tr>
<th>Name</th>
<th>Dose prescription and constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV</td>
<td>34 Gy in #10 (NSABP B-39)</td>
</tr>
<tr>
<td></td>
<td>30 Gy in #5 (UTSW) since 03/17</td>
</tr>
<tr>
<td></td>
<td>$V_{95%} = 100%$</td>
</tr>
<tr>
<td></td>
<td>$D_{\text{max}} &lt; 105%$ &amp; $D_{\text{min}} = 93%$</td>
</tr>
<tr>
<td>Remained breast</td>
<td>$V_{15\text{Gy}} &lt; 50%$</td>
</tr>
<tr>
<td>Contra breast</td>
<td>$D_{\text{max}} &lt; 1\text{Gy}$</td>
</tr>
<tr>
<td>Lung</td>
<td>$V_{10\text{Gy}} &lt; 20%$ (I), $V_{5\text{Gy}} &lt; 10%$ (C)</td>
</tr>
<tr>
<td>Heart</td>
<td>$V_{3\text{Gy}} &lt; 10%$</td>
</tr>
<tr>
<td>Thyroid</td>
<td>$D_{\text{max}} &lt; 1\text{Gy}$</td>
</tr>
<tr>
<td>Skin, Chest wall</td>
<td>$D_{\text{max}} &lt; 40.8\text{ Gy}$</td>
</tr>
</tbody>
</table>
Methods (Assessment)

Eligible patient → Cosmesis assessment → PBI →

- Early toxicity
- Cosmesis assessment
- Physically rated (subjective)
- Software rated BCCT.core (objective)

Dosimetric parameters

Study End-points

Software rated BCCT.core (objective)
- will be presented in KSRO 2018
Results

• Study period: 2015-2017
• Total, 114 consecutive patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Characteristics</th>
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</thead>
<tbody>
<tr>
<td>Year</td>
<td>2015 (1), 2016 (51), 2017 (62)</td>
</tr>
<tr>
<td>Age, year</td>
<td>Median 62 (range, 49-84)</td>
</tr>
<tr>
<td>ECOG PS</td>
<td>PS 0-1 100%</td>
</tr>
<tr>
<td>Pathology</td>
<td>DCIS 9.6%, IDC 74.6%, others 15.8%</td>
</tr>
<tr>
<td>T size, cm</td>
<td>Median 1.2 (range, 0.1-2.7)</td>
</tr>
<tr>
<td>N stage</td>
<td>N0 93%, N1 (SLN 1+) 7%</td>
</tr>
<tr>
<td>Margin</td>
<td>Clear 100%</td>
</tr>
<tr>
<td>Grade</td>
<td>G1-2 88.6%, G3 11.4%</td>
</tr>
<tr>
<td>LVSI</td>
<td>Negative 98.2%</td>
</tr>
<tr>
<td>EIC</td>
<td>Negative 75.4%</td>
</tr>
<tr>
<td>ER</td>
<td>Positive 96.5%</td>
</tr>
</tbody>
</table>
Results

**Suitability test** by ASTRO consensus 2.0


<table>
<thead>
<tr>
<th>Suitability</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitable</td>
<td>74</td>
<td>64.9%</td>
</tr>
<tr>
<td>Cautionary</td>
<td>40</td>
<td>35.1%</td>
</tr>
<tr>
<td>Unsuitable</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reasons</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIC &lt; 3cm</td>
<td>28</td>
<td>24.6%</td>
</tr>
<tr>
<td>2.1~3 cm</td>
<td>8</td>
<td>7%</td>
</tr>
<tr>
<td>ER negative</td>
<td>4</td>
<td>3.5%</td>
</tr>
<tr>
<td>LVSI</td>
<td>3</td>
<td>2.6%</td>
</tr>
<tr>
<td>ILC</td>
<td>2</td>
<td>1.7%</td>
</tr>
<tr>
<td>DCIS high grade</td>
<td>1</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

- EIC: Estrogen receptor-positive invasive carcinoma
- LVSI: Lymphovascular space invasion
- ILC: Invasive lobular carcinoma
- DCIS: Ductal carcinoma in situ
Results

**PBI treatment characteristics**

- **Total 114 cases**
  - Robotic-SBRT: N = 41 (36%)
    - 30Gy/5fx: N = 48 (42.1%)
  - Arc-based IMRT: N = 73 (64%)
    - 34Gy/10fx: N = 66 (57.9%)

- PTV vol. = 103 ± 46 ml
- Breast vol. = 617 ± 134 ml
- PTV/breast ratio = 17 ± 4%
Results

Dosimetric parameters

* Statistical significance
Results

Toxicity assessment

Grade of radiation-dermatitis

Grade of radiation-induration
Results

**Cosmesis assessment**

Software (n = 112) | Physician rated (n = 112)
--- | ---
Excellent | 21% | 46%
Good | 30% | 56%
Fair | 4% | 18%
Poor | 1% | 1%

Physician rated

Post-RT 0m (n = 112) | Post-RT 6m (n = 43)
--- | ---
Excellent/Good | 81% | 86%
Results

Other treatment outcomes

• Median follow-up = 13 months
• Only 1 case who experienced rib fracture (post-RT 6m), but spontaneously resolved
• Otherwise, no radiation pneumonitis, arm/breast edema
• No recurrence or metastasis
Summary

• Unlike the result from KROG-0804 trial, PBI with advanced technologies seems feasible in Korean women with selected early stage breast cancer

• The goal of sparing normal organs was achieved with either robotic-SBRT or VMAT RT plan

• 34/10 or 30/5 regimen showed almost no radiation-related toxicities and deterioration of breast cosmesis at this short-term follow-up
Summary

• Robotic-SBRT PBI had dosimetric advantages over VMAT-based PBI regarding smaller PTV, more homogenous dose coverage to PTV, and conformal dose distribution to spare normal organs (e.g. remaining breasts, skin, and chest wall).

• 30/5 has the advantage of reducing treatment days to 5 days over 34/10 dose scheme
Conclusions

• Although longer follow-up and larger scale study is warranted, our results show feasibility, minimal toxicity, and excellent cosmesis of PBI with a cutting-edge technology in Korean women with small breast size.

• Prospective observational study is planned to investigate the influence of S-PBI with 30/5 on patients’ quality of life and satisfaction.
Yonsei Cancer Center – Radiation Oncology, Stereotactic-PBI team

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