Intensity-Modulated Radiotherapy, Rapid Arc® and Three-dimensional Conformal Radiotherapy for Breast Cancer

Robert Lumsden
Introduction

• 3 different techniques:
  – IMRT
  – 3DCRT
  – RapidArc

• Discuss dosimetry and dose to critical structures

• Investigate possible impact on:
  a). Benefits to patient
  b). Improvements to clinical practice to Epworth Radiation Oncology (ERO)
Methodology

- 6 left-sided breast DIFFICULT breast patients

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<tr>
<th>Organs at Risk (OAR)</th>
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<tr>
<td>Heart</td>
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<td>Left Anterior Descending Coronary Artery (LAD)</td>
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<td>Contralateral Breast</td>
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<td>Ipsilateral Lung</td>
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Methodology

Plan Quality

PTV Coverage:
- Conformity Index (CI)
- Healthy Tissue Conformity index (HTCI)
- Conformation Number (CN)

OAR:
- Mean
- Dmax
- Volumetric dose assessment
ERO IMRT Fields
ERO IMRT Fields

MA.20
Intergroup Trial
ERO IMRT Fields

MA.20
Intergroup Trial
ERO 3DCRT Fields
ERO 3DCRT Fields
ERO 3DCRT Fields
ERO RapidArc Fields
ERO RapidArc Fields
3DCRT 95% Dosimetry
IMRT 95% Dosimetry
RapidArc 95% Dosimetry
3DCRT 95% SCF
IMRT 95% SCF
RapidArc 95% SCF
3DCRT Integral Dosimetry
IMRT Integral Dosimetry
RapidArc Integral Dosimetry
Conformity Index (CI)

Lomax NJ, Scheib SG

\[ CI = \frac{TV_{RI}}{TV} \]
RESULTS

Target Volume.

Patient  Volume cc
1       2500
2       500
3       750
4       1000
5       1250
6       1500
95% coverage - 3DCRT

Patient

Volume cc

PTV vol. cc
3DCRT PTV 95%
95% coverage - IMRT

- PTV vol. cc
- 3DCRT PTV 95%
- IMRT PTV95%

Patient

Volume cc
95% coverage - RapidArc

- PTV vol. cc
- 3DCRT PTV 95%
- IMRT PTV95%
- R ARC  PTV 95%

Patient
Conformity Index

Conformity Index (CI) values for different treatment methods are shown in the graph. The x-axis represents patients, and the y-axis represents the conformity index. The graph compares REFERENCE, 3DCRT CI, IMRT CI, and R ARC CI methods. The CI values are consistently high, indicating good conformity across all patients for all methods.
Healthy Tissue CI
Lomax NJ, Scheib SG$_{13}$

HEALTHY TISSUE

HTCI = 0.9

HTCI = 0.5

HTCI = $\frac{TV_{RI}}{V_{RI}}$
Healthy Tissue CI 95% ref.

The graph shows the conformity index (CI) for healthy tissue with 95% reference. The y-axis represents the conformity index, ranging from 0 to 1.2. The x-axis represents patients, numbered from 1 to 6.

Different methods are compared:
- **REFERENCE**
- 3DCRT HT CI
- IMRT HT CI
- R ARC HT CI

The graph illustrates how each method performs in terms of conformity index across different patients, with variations in the index values for each method.
CI and HTCI NOT Exclusive

CI = 1
HTCI = 0.5

ref%®

HTC1 = 1
CI = 0.5
Conformation Number (CN)

van’t Riet et al\textsuperscript{24}

- How well is the TV covered taking into account amount of healthy tissue irradiated?

\[
\text{Conformation Number} = \frac{TV_{RI}}{TV} \times \frac{TV_{RI}}{V_{RI}}
\]

- Index ranges from 1-0

1 = perfect conformation
0 = total absence of conformation
## Conformation Number

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DOSES TO STRUCTURES

• BIG PICTURE

• Doses to surrounding healthy tissue includes:
  - HEART
  - LAD
  - CONTRALATERAL BREAST
  - IPSILATERAL LUNG
  - CONTRALATERAL LUNG
Contralateral Breast

- **DMAX**: 46.33 Gy (3DCRT), 16.53 Gy (IMRT), 17.05 Gy (RapidARC)
- **MEAN**: 1.57 Gy (3DCRT), 3.17 Gy (IMRT), 3.95 Gy (RapidARC)
- **V2Gy**: 9.83% (3DCRT), 72.34% (IMRT), 90.51% (RapidARC)
Ipsilateral Lung

Volumes at Different Doses:
- **V20Gy:**
  - 3DCRT: 22.07% 21.82%
  - IMRT: 41.23%
  - RapidArc: 38.33%
- **V30Gy:**
  - 3DCRT: 10.19% 11.34%
  - IMRT: 0.00%
  - RapidArc: 0.00%
Contralateral Lung

**DMAX**
- 3DCRT: 27.17 Gy
- IMRT: 23.48 Gy
- RapidARC: 30.58 Gy

**MEAN**
- 3DCRT: 0.88 Gy
- IMRT: 5.12 Gy
- RapidARC: 6.33 Gy
## Discussion

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Conclusion

- Current IMRT solution better than 3DCRT
- RapidArc = IMRT dosimetrically

**VALID CURRENT PRACTICE**

- Popescu, et al British Columbia Cancer Agency

- Shorter treatment time potential
- Time benefits for BOTH patients and dept
- Move to RapidARC in the future
Acknowledgements

Jim Frantzis, Nola Bailey & Paul Fenton
Chris James & Emma Fitzgerald

Professor Chris Hamilton
Staff at Epworth Radiation Oncology

Radiation Oncology Queensland
References

1. Abeyaratne D. Can intensity modulated radiation therapy reduce cardiac dose in left-sided breast patients? The Radiographer 2010; 57: 40.
8. ICRU 83 Report.
References


Thank you