A feasibility study into reducing treatment delivery times for left sided breast patients receiving deep inspiration breath hold (DIBH) radiotherapy

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Aim

This study compares treatment delivery times of four different techniques for deep inspiration breath hold (DIBH) whole breast radiotherapy. The aim is to minimise the treatment delivery time without compromising the delivered dose distribution.
Methods and materials

Patients

Ten left sided DIBH radiotherapy test patients were selected for this retrospective study.

Patient inclusion criteria included patients who had completed treatment at CCCC for left sided whole breast radiotherapy in 2014 with DIBH, between the ages of 18-85. Patients were excluded if they had radiotherapy to the contralateral breast or secondary metastases.

Radiotherapy Planning

Using an Eclipse treatment planning system (Varian Medical Systems CA, USA), four separate plans were created for each patient. The treatment techniques used were: conventional tangents comprising of open and/or EDW fields (between two to four fields), a forward planned segmented technique (two to four fields), hybrid inverse planned IMRT (four fields) and VMAT (two partial arcs).

Tangents

Conventional tangent fields were limited to less than four to ensure they did not replicate forward planned patients. Coplanar fields creating a half beam block technique are used to cover an oncologist defined PTV. Fields used shielding and dynamic wedges to optimise dose.

Segments

Forward planned segmented fields had between 3-4 segments including the initial open segment. Cardiac shielding was added in the initial open segment and replicated though all segments. Segments were created to reduce hot spots. Segments were added till suitable homogeneity was achieved; then the segments were combined to treat as one field\(^1\). Field size and isocentre remained consistent with conventional tangents.

Hybrid IMRT

Hybrid inversely modulated radiotherapy used a sliding window technique. Two open conformal fields were calculated with two inversely planned fields using a base planning function available on Eclipse. Conformal open plans had cardiac shielding applied when required. Conformal plans made up 50% of the total dose and the other 50% was inversely planned. Field size remained consistent with conventional tangents as well as
isocentre placement. Fluence patterns were extended by at least anteriorly to comply with the results found in Betgen et al's research into the stability of DIBH patients\(^2\).

**VMAT**

Volumetric arc therapy utilised a dual partial arc technique. Arcs generally ranged from 150-300 degrees. A mid breast isocentre was used and field width was set to the maximum whilst still allowing for MLC modulation. The fields were collimated 5 degrees to reduce leakage.

To allow for comparison all plans were prescribed to 5000cGy in 25 fractions and planned so that 95% of the total dose covered 98% of the volume. Plans were then optimised to meet Central Coast Cancer Centre's current breast protocols.

**Treatment Delivery**

When a suitable plan was achieved it was delivered three times on a Varian21iX linear accelerator (Varian Medical Systems, CA, USA) using a Millennium 120 leaf MLC at the maximum dose rate used was 600 MU/min. Beam on time was recorded for each field. Beam on was defined as the time which the therapist pressed the 'beam on' button. Beam off was defined as the time the "Treatment Complete" sign was displayed on the clinac.

**Outcome measures and Statistical analysis**

For each of the techniques statistical analysis was performed to the resulting data using SPSS. It was analysed for statistical difference with repeated measures analysis of variance testing. Measures of mean, maximum and minimum were collected for organs at risk and dose coverage was assessed using point maximum, 2cc maximum and HI index.

Averages were collated for timing data.
Results

Fig. 1 shows representative axial dose distributions for all four techniques

Beam on time

Hybrid IMRT plans had the quickest averaged beam on time for individual fields and VMAT had the slowest. Averages and standard deviation are shown in Fig. 2.

Assuming each field has similar beam on times the hybrid IMRT plans have the fastest fields according to the data, however hybrid IMRT plans contain both modulated and static beams. The modulated beams on average take 13.78sec to deliver, different to the overall average for individual beam on times given in the results. Despite this the beam on time is still quicker than segmented plans. Furthermore significant gains can be made in dose homogeneity using this technique as shown in the results below.

VMAT plans were suboptimal compared to the other three techniques and will not be pursued for whole breast radiotherapy at this present time. VMAT could be advantageous for nodal breast patients or patient with disease that involves the internal mammary chain.

PTV Coverage

All plans met the requirement of D95%=98%. The hybrid IMRT plans had significantly better results in 2cc max and homogeneity index. Results are shown in Table 1.

Heart

The VMAT plans were significantly worse for both V5Gy and V10Gy doses. However there was no significant difference between the treatment techniques for heart point max. Results are shown in Table 1.

Ipsilateral Lung

VMAT plans were significantly worse for V5Gy and mean doses for ipsilateral lung. There was no significant difference for V20Gy in all plans. Results are shown in Table 1.

Contralateral Lung

The VMAT plans were significantly worse in V5Gy and mean dose for contralateral lung. Results are shown in Table 1.
**Combined Lung**

There was no significant difference in mean or V20Gy for the tangent, hybrid IMRT or segment plans for combined lung. The VMAT plans were significantly worse in both mean and V20Gy compared to the three other techniques. Results are shown in Table 1.

**Contralateral Breast**

VMAT was significantly worse in both mean and point max for contralateral breast. Segmented plans were significantly better than tangents for point max however there was no significant difference between Hybrid IMRT, segmented plans and tangents for mean contralateral breast dose. Results are shown in Table 1.
**Fig. 1:** Axial representations of dose distributions of all four techniques.

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**Fig. 2:** Graph of mean individual beam on time and standard deviation for each treatment technique.

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<table>
<thead>
<tr>
<th></th>
<th>Tangents</th>
<th>Segments</th>
<th>Hybrid IMRT</th>
<th>VMAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PTV</strong></td>
<td></td>
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<tr>
<td>Point max (%)</td>
<td>110.94 ±2.19</td>
<td>110.27 ±1.48</td>
<td>109.7 ±1.96</td>
<td>112.31 ±2.17</td>
</tr>
<tr>
<td>2cc max (%)</td>
<td>110.10 ±2.15</td>
<td>109.44 ±1.46</td>
<td>107.6* ±1.19</td>
<td>110.08 ±1.95</td>
</tr>
<tr>
<td>Homogeneity Index</td>
<td>0.13 ±0.02</td>
<td>0.13 ±0.01</td>
<td><strong>0.11</strong>* ±0.01</td>
<td>0.14 ±0.02</td>
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<tr>
<td><strong>Heart</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Point Max (cGy)</td>
<td>4292.12 ±1419.60</td>
<td>3851.84 ±15.97</td>
<td>3876.81 ±1669.91</td>
<td>3280.58 ±872.91</td>
</tr>
<tr>
<td>V10Gy (%)</td>
<td>2.72 ±2.7</td>
<td>2.3 ±2.74</td>
<td>2.78 ±2.62</td>
<td><strong>15.41</strong>* ±5.5</td>
</tr>
<tr>
<td>V5Gy (%)</td>
<td>4.52 ±3.44</td>
<td>3.88 ±3.48</td>
<td>4.58 ±3.31</td>
<td><strong>59.98</strong>* ±14.12</td>
</tr>
<tr>
<td>Ipsilateral Lung</td>
<td></td>
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</tr>
<tr>
<td>V5Gy (%)</td>
<td>26.04 ±3.41</td>
<td>25.20 ±3.45</td>
<td>25.59 ±3.38</td>
<td><strong>75.13</strong>* ±11.42</td>
</tr>
<tr>
<td>V20Gy (%)</td>
<td>14.5 ±3.72</td>
<td>13.8 ±3.57</td>
<td>14.6 ±3.56</td>
<td>17.35 ±2.76</td>
</tr>
<tr>
<td>Mean (cGy)</td>
<td>830.58 ±161.15</td>
<td>791.69 ±152.57</td>
<td>785.11 ±152.89</td>
<td><strong>1199.05</strong>* ±116.41</td>
</tr>
<tr>
<td><strong>Contralateral Lung</strong></td>
<td></td>
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</tr>
<tr>
<td>V5Gy (%)</td>
<td>0 ±0</td>
<td>0 ±0</td>
<td>0 ±0</td>
<td><strong>25.62</strong>* ±13.27</td>
</tr>
<tr>
<td>Mean (cGy)</td>
<td>9.16 ±2.49</td>
<td>8.8 ±2.95</td>
<td>8.78 ±2.92</td>
<td><strong>408.17</strong>* ±87.87</td>
</tr>
<tr>
<td><strong>Combined Lung</strong></td>
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<tr>
<td>Mean (cGy)</td>
<td>391.36 ±84.49</td>
<td>373.36 ±79.40</td>
<td>368.51 ±76.57</td>
<td><strong>775.19</strong>* ±87.46</td>
</tr>
<tr>
<td>V20Gy (%)</td>
<td>6.73 ±1.88</td>
<td>6.41 ±1.78</td>
<td>6.6 ±1.76</td>
<td>8.15 ±1.45</td>
</tr>
<tr>
<td><strong>Contralateral Breast</strong></td>
<td></td>
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<tr>
<td>Max (cGy)</td>
<td>529.72 ±144.11</td>
<td>438.44 ±181.57</td>
<td>477.51 ±193.33</td>
<td><strong>743.01</strong>* ±79.34</td>
</tr>
<tr>
<td>Mean (cGy)</td>
<td>29.28 ±12.72</td>
<td>26 ±13.41</td>
<td>26.73 ±26.73</td>
<td><strong>169.63</strong>* ±30.44</td>
</tr>
</tbody>
</table>

*Indicates significance over all other techniques

**Table 1:** Plan comparison parameters for each treatment technique

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Conclusion

In conclusion hybrid IMRT plans for left sided whole breast radiotherapy in patients undergoing DIBH is a quicker and dosimetrically equivalent planning technique. This has the potential to open the DIBH program to more patient and increase compliance rates.
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