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Short communication

Multisegmented radiation therapy as an alternative to 3D conformal radiation therapy therapy, with special reference to breast cancer tangential fields

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Comparison is made in terms of PTV coverage and doses to OARs for the techniques of 3DCRT and MSCRT. The study population is 175 breast cancer patients for whom treatement is analysed when using lateral and medial tangential fields. Although statistical significance at the P=0.05 level could not be established, the results look clinically promising in favour of MSCRT.

Key words: conformal radiotherapy, intensity-modulated radiotherapy, segmented beams

Introduction

The standard treatment planning technique in hospitals is 3D conformal radiation therapy (3DCRT) but the more advanced intensity-modulated radiation therapy (IMRT) is preferred for most cancer body sites when an IMRT facility is available. However, as an alternative to 3DCRT [1] we use a multisegmented conformal radiation therapy (MSCRT) method, which although not a true fully implemented IMRT [2] should theoretically be an improvement on 3DCRT. This article assesses the two techniques and describes our use of MSCRT with special reference to tangential fields for breast cancer (other body sites can of course be treated using MSCRT). The study population is 175 breast cancer patients (all of whom received MSCRT but were also planned for 3DCRT for comparison). We compare a range of treatment parameters for both 3DCRT and MSCRT, including dose coverage of the planning treatment volume (PTV) and doses to organs at risk (OARs) which include the ipsilateral lung and the heart. Treatment of the breast is a good example for comparative purposes between two techniques because of the problems encountered with anatomical curvature and because of the presence of several OARs relatively near to the PTV.

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Materials & methods

Patient population

A total of 175 breast cancer patients were accrued to the study between January 2005 and January 2006**.** 81/175 tumours were left-sided, where the cardiac dose might be a problem with poor treatment plannning, and 94/175 were right-sided. All patients were treated with MSCRT with the 3DCRT calculations performed only for the purposes of this study

3D conformal radiation therapy planning

In 3DCRT the planning process incorporates the use of standard wedges to approximately compensate for the curvature of the breast when the medial and lateral tangential fields (beams) are planned. The method involves (**1**) setting-up the shape of the two beams using multileaf collimators (MLCs) and then (**2**) manually obtain the beam weights. The next stage is to (**3**) use wedged fields and (**4**) manually adjust the beam weights for the presence of the wedges. Finally (**5**) some form of optimisation procedure is applied, which in its simplest form would be a trial & error method. Although this is now usually replaced by the application of some form of optimisation treatment planning software.

The regimen for 3DCRT with medial and lateral tangential fields was 1.8 Gy daily over 28 days to a total dose of 50.4 Gy. The weights of the tangential beams were optimised for a mean PTV dose of 50.4 Gy usaing the optimising module of the PrecisePLAN, with the additional of manual corrections to achieve better OAR sparing.

Multisegmented radiation therapy planning

For both 3DCRT and MSCRT, spiral CT scans were taken with a 10 mm slice increments (Picker Pq 5000 or Siemens Somatom Plus4) for the planning procedure with a PrecisePLAN system (Elekta). For PTV delineation conventional borders for the

whole breast were used. The entire heart, right lung, left lung and contralateral breast were contoured as OARs.

Then for MSCRT, from the optimised isodose distribution for the two-field 3DCRT we derive (individually for each patient) what we term a *dose cloud* at the higher dose levels, i.e., at between 106% and 109% of the prescribed dose. This *dose cloud* should have a relatively large volume: but not so large that it covers more than 50% of the treatment field as seen on the beams eye view (BEV).

The next step in the MSCRT procedure is to set the first field segment for the medial tangential field. This is achieved by matching its shape and size to that of that of the *dose cloud*. The second field segment for the medial fields is the remaining field segment after the first field segment has been taken away from the treatment field as seen in the BEV. A similar procedure is carried out for the lateral tangential field and thus four field-segments are delineated for MSCRT.

We then perform a final optimisation procedure now that the four field-segments are defined. To evaluate the dose coverage of the PTV, the ICRU 50 recommendations [3] were followed. The following parameters are recorded: the PTV volume receiving 95%-107% of the prescribed dose, the volume of hot spots (defined as >107%) and the maximum dose level of the hot spots.

In order to compare the radiation burden on the OARs, the mean dose constraints of IMRT [4] were applied to the whole heart (left-sided cancers) <3 Gy, the ipsilateral lung <10 Gy, the contralateral lung <1 Gy and the contralateral breast <1 Gy.

Results

Results for for 3DCRT and MSCRT selected parameters (±1 standard deviation) are given in Table I. The most noticeable numerical difference is the 5.8% in favour of MSCRT for the PTV receiving 95%-107% dose. However, this is not statistically significant and neither are any of the other results in Table I.

This is seen from the standard statistical significance test for the difference between two proportions P_1 and P_2 [5].

Strictly speaking the two samples should be two independent samples of size N1 and N2 and the population from which the samples are drawn is assumed to be normally distributed. In our case N1 = N2 = 175 and the samples are measurements from the same 175 breast patients. However, the measurements for 3DCRT and MSCRT are independent of each other. The computation is as follows. The standard error of the difference in proportions is given by SE_P. Next express the difference in proportions ($P_1 - P_2$) as a multiple of the SE_P. Finally consult a table of probability related to multiples of standard errors (SEs) for a normal distribution, Table II.

Table II. Probability related to multiples of SEs for a normal distribution

No.of SEs	Probability (P) of an observation showing *at least as large a deviation* from the normal population mean
25.25	0.80
0.50	0.62
0.67	0.50
1.00	0.32
1.50	0.133
1.645	0.10
1.96	0.05

$$P_1 = 0.852,\ P_2 = 0.910 \text{ and } P_{1\text{-}2} = (308/350) = 0.880$$

$$SE_P = \sqrt{\{[(0.88 \times 0.12)/175] + [(0.88 \times 0.12)/175]\}} = 0.0347$$

$$(P_1\text{-}P_2)/SE_P = 0.058/0.0347 = 1.67 \text{ multiples of the } SE_P$$

From Table II it is seen that 1.67 SEs gives a probability of P≈0.10 of an observation showing *at least as large a deviation* from the normal population mean. Thus it is concluded that at the P=0.05 level of significance, the difference of 5.8% between 3DCRT and MSCRT for the percentage of the PTV volume in the range 95%-107% could have been due to chance alone. The associated 95% confidence interval (CI) is therefore

Table I. Results for 3DCRT versus MSCRT

Parameter	Parameter value		Difference between parameter values
	3DCRT	MSCRT	
PTV receiving 95%-107% dose	85.2 ± 5.6	91.0 ± 3.1	5.8
Hot spot volumes (as a % of PTV)	4.4 ± 3.2	0.5 ± 1.2	3.9
Maximum dose in PTV (Gy)	56.3 ± 1.0	54.4 ± 0.7	1.9
Ipsilateral lung dose (Gy)	12.0 ± 2.2	11.8 ± 2.1	0.2
Contralateral lung dose (Gy)	0.5 ± 0.2	0.5 ± 0.2	0
Contralateral breast dose (Gy)	0.8 ± 0.4		0
Cardiac dose* (Gy)	5.5 ± 1.4		0.1

* signifies left-sided breast treatment. The mean PTV dose for both techniques is 50.4 Gy

$$CI = 0.058 \pm 1.96 \times \sqrt{\{[(0.852 \times 0.148)/175] + [(0.910 \times 0.090)/175]\}}$$
$$CI = -0.010 \text{ to } +0.126$$

Conclusions

There are no significant differences at the P=0.05 level of statistical significance between 3DCRT and MSCRT for the treatment parameters studied which relate to the PTV or for doses to the selected OARs.

However, *statistical* significance cannot always be equated to *clinical* significance and it could be argued that there is a promising advantage in favour of MSCRT for a more uniform dose distribution coverage of the PTV. However, probably a large increase in the study population from 175 patients would be required for there to be any possibility to demonstrate statistical significance, $P<0.05$.

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