AbstractID: 12590 Title: Application of 3D Intensity Modulated Brachytherapy for Accelerated Partial Breast Irradiation

Introduction

The advent of electronic brachytherapy sources has shed some light on application of intensity modulation in brachytherapy, known as intensity modulated brachytherapy (IMBT). Previous researchers have investigated the feasibility of utilizing partially shielded sources to irradiate irregular shaped targets[1-2]. However, partially shielding does not fully explore the potential of IMBT. This study applied three dimensinal (3D) IMBT in intracavitory accelerated partial breast irradiation (APBI) cases and proved the benefit of IMBT in improving plan quality with accepetable increase in planning and delivery time.

Material and methods

Treatment planning system for 3D IMBT

A prototype treatment planning system for 3D IMBT was developed under MATLAB environment. The system consists of three main components: (1) a comprehensive source commissioning method for intensity modulated sources based on Monte Carlo (EGSnrc) simulations; (2) a "modified TG43" (mTG43) dose calculation algorithm developed specifically for IMBT dosimetry; mTG43 differs from the TG43 algorithm[3], the standard dosimetry method used in brachytherapy nowadays in that, the anisotropic function of a IMBT source, is a function of both the position of measurement and the intensity distribution of the source; (3) an inverse IMBT treatment planning method based on Dose Volume Histogram (DVH) or Dose Surface Histogram (DSH) constraints and simulated annealing optimization algorithm.

APBI patient studies

Ten patients underwent intracavitary APBI using model S700 Axxent electronic brachytherapy source [4] were studied. An IMBT plan was developed for each patient with the source dwell times and intensity maps of source dwell positions optimized to reduce the high dose region in the target and the maximum dose to skin and ribs. The plan quality, planning and delivery times of IMBT plans were compared with the original plans used for the patients' treatment.

Results and discussion

Of all patients, patient #6 had the smallest breast as well as little skin and rib sparing: the minimum distance from balloon to skin was 1.1 cm and the minimum distance from balloon to ribs was 0.4 cm. Figure 1 compares the DVHs of the IMBT and original plans for patient #6. The coverage to target V100, high dose region in target V200, dose to critical structures and the planning and delivery time of IMBT and original plans are compared quantitatively in Table 1. For this patient, with similar coverage to the target, V200 decreased from 41.2% to 25.1%, maximum dose to skin and ribs was reduced by 56 cGy and 104 cGy in one fraction respectively, mean dose to ipsilateral and contralateral breasts and lungs were also slightly reduced. The main drawback of IMBT is the longer planning and delivery time. However, by using faster computer and increasing the output of the electronic brachytherapy source, the planning and delivery time of IMBT plans can be reduced.

For all 10 patients, Figure 2 compares (a) the coverage PTV V100; (b) the high dose region PTV V200; the maximum dose to (c) skin and (d) ribs and the mean dose to (e) ipsilateral breast and (f) ipsilateral lung in one fraction for the IMBT and original plans. Overall, compared with original plans, IMBT gives better plan quality. On average, with similar coverage (mean PTV V100 was 94.0% for original plans and 93.6% for IMBT plans), the high dose region PTV V200 was reduced from 31.0% to 22.5%, maximum dose to skin was reduced from 462.8 cGy to 388.4 cGy, maximum dose to ribs was reduced from 368.8 cGy to 299.6 cGy, mean dose to ipsilateral breast was reduce from 97.9 cGy to 87.1 cGy and mean dose to ipsilateral lung was reduced from 9.9 cGy to 7.7 cGy.

For different patients, the power of IMBT in improving the plan quality was different. For patient #3 who had the largest breast and the largest balloon to skin distance among all 10 patients studied, the improvement was more subtle than other patients: the maximum dose to skin and ribs was only reduced by 18.0 cGy and 22.0 cGy respectively, less than the average value. Patient #8 had a middle-sized breast and small balloon-to-rib distance. IMBT plan reduced the maximum dose to ribs in one fraction by 90 cGy. IMBT showed the largest improvement for patient 6, as shown in Table 1. The reason is that patient #6 had the smallest breast of all patients studied and small balloon to skin and rib distances.

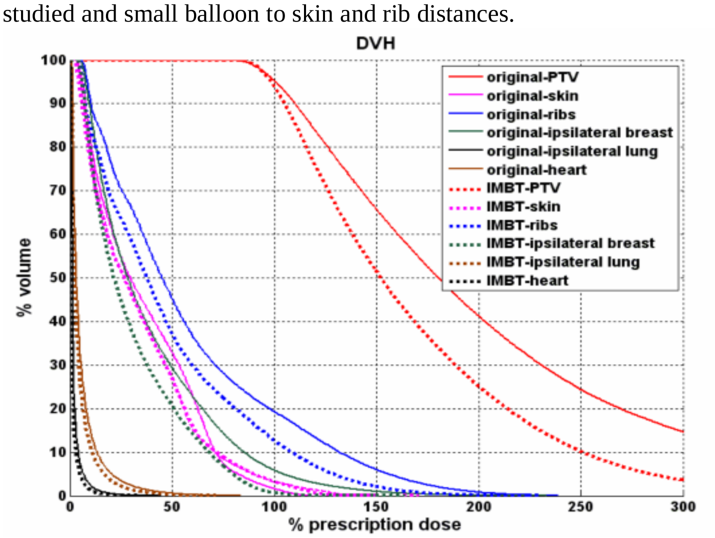

Figure 1: DVH comparisons for patient #6.

Table 1: Comparison of plan quality for patient #6.

Patients and Plans	Patient 6	
	original	IMBT
PTV V100	95.2	94.0
PTV V200	41.2	25.1
Maximum dose to skin/cGy	459.0	403.0
Mean dose to skin/cGy	122.6	114.6
Maximum dose to ribs/cGy	677.0	573.0
Mean dose to ribs/cGy	198.8	163.0
Mean dose to ipsi-breast/cGy	133.6	101.7
Mean dose to contra-breast/cGy	0.3	0.2
Mean dose to ipsi-lung/cGy	5.6	3.8
Mean dose to contra-lung/cGy	0.6	0.4
Mean dose to heart/cGy	19.0	14.9
Planning time	5 mins	2 hrs
Delivery time/mins	6.3	36.8

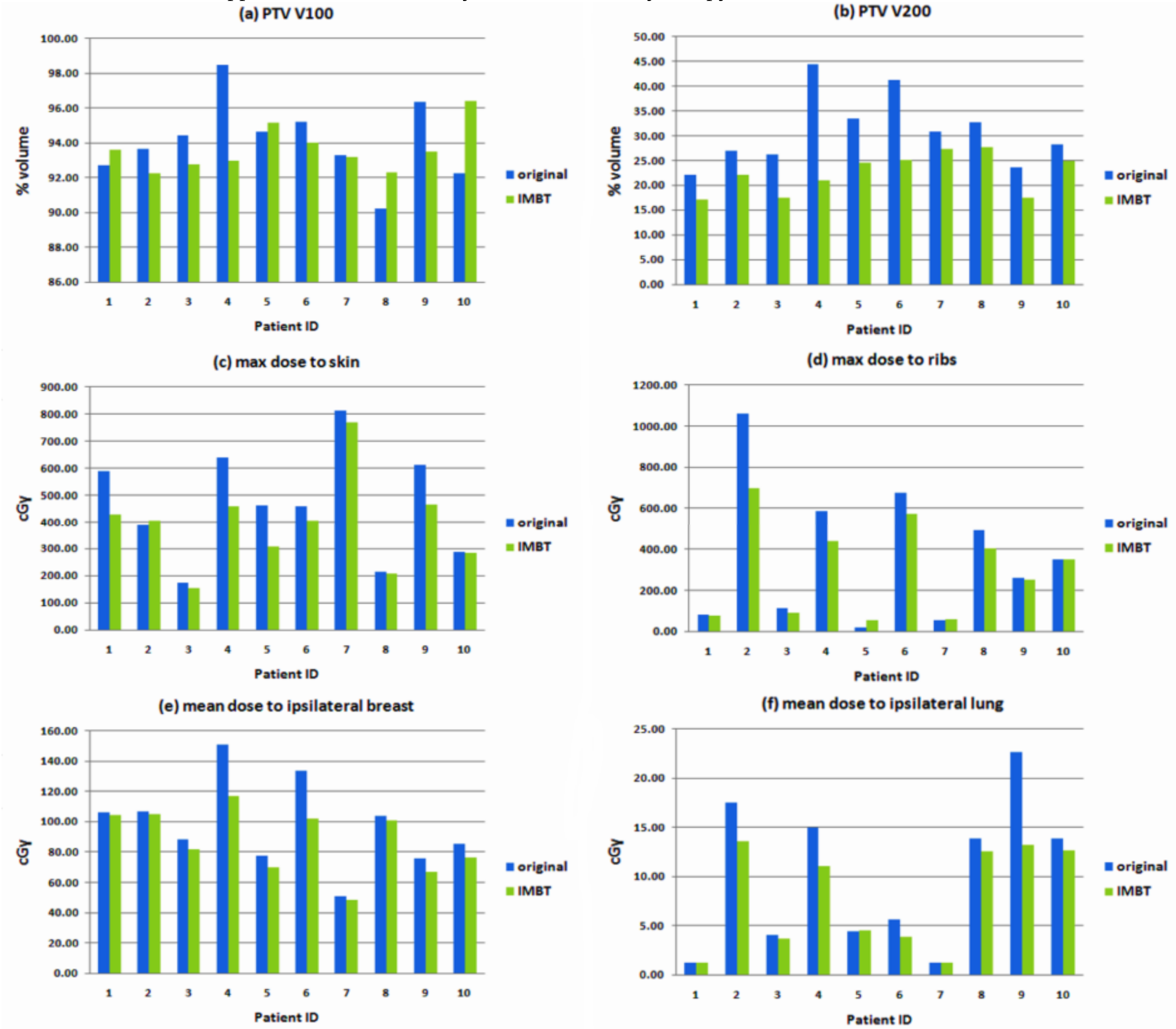

Figure 2: Comparison of the plan quality for all patients. The (a) coverage and (b) high dose region to the target, maximum dose to (c) skin and (d) ribs and mean dose to ipsilateral (e) breast and (f) lung were compared.

Conclusion

Intensity Modulated Brachytherapy has been proved to have the potential to improve plan quality by previous researchers. However, current IMBT studies were restricted to partially shielding, one dimensional angular intensity modulation. In this study, we upgrade IMBT to three-dimensional intensity modulation and studied the influence of IMBT in accelerated partial breast irradiation treatment planning using ten patients. The results proved that IMBT can further improve dose uniformity in target and sparing to normal tissue compared with current clinical practice with acceptable increase of planning and delivery time. IMBT is particularly effective for APBI patients who have relatively small breasts and little sparing to skin or ribs.

Acknowledgement

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References

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