Breast Cancer: Targets and Therapy

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ORIGINAL RESEARCH

Comparison Of Accelerated Partial Breast Radiation Therapy And External Beam Radiation Therapy By Treatment Planning Indices

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Background: Accelerated partial breast irradiation (APBI) is a method in which just bed of lumpectomy with a margin of 1–2 cm is irradiated. Regarding advantages of APBI to whole-brain radiation therapy (WBRT) and limitations for performing other techniques, we compare external beam radiation therapy (EBRT) with three-dimensional conformal radiation therapy (3DCRT), as a type of APBI technique.

Methods: Dosimetric parameters including uniformity index (UI), conformity index (CI), and homogeneity index (HI) beside heart and lung doses were assessed and compared in two techniques. CT images of 24 patients with left-sided breast cancer after lumpectomy were selected. Patients were categorized into three groups based on the volume of breast, respectively, ≤ 1000 cc, 1000–1500 cc, and ≥ 1500 cc. CI, HI, UI and DVH were calculated by DosiSoftIsogray treatment planning software.

Results: Results show the value of UI in APBI method is more than EBRT method significantly (p=0.004). Moreover, that CI in APBI method was more than EBRT (p=0.0000) and nearer to 1. There was no significant difference between HI values between APBI and EBRT methods. As the volume of breast gets bigger, HI values rise, meaning worse homogeneity.

Conclusion: APBI method may be a good method for minimizing side effect and minimizing treatment periods.

Keywords: partial radiation therapy, external beam radiation therapy, breast cancer

Introduction

The most common cancer in women is breast cancer among other cancer, with probability in order of 28.1 in 100,000.[1] In 2016, 246,660 new cases of breast cancer were diagnosed comprising 29 percent of all cancers within which 40,450 died, meaning 14 percent mortality.[2]

Prognosis and treatment method generally depend on stage and vast of metastasis. Method of treatment principally includes surgery (lumpectomy and mastectomy), radiotherapy and systematic treatment (chemotherapy and hormone therapy).[3,4]

After breast conserves surgery, radiotherapy may reduce the incidence of recurrence to half and mortality rate to 1/6. In many cases, breast-conserving surgery can eliminate any diagnosed microscopic disease. Nevertheless, some microscopic tumors may persist and if not treated result in recurrence or metastasis or both.[5] Radiotherapy after surgery reduces local recurrence from 27.2% to 8.8%.[6]

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Breast-conserving radiotherapy is divided generally into two methods: external beam radiation therapy to the whole breast and partial breast radiation.[7]

External beam radiation therapy (EBRT) involves 50–55 total doses with a daily dose of 1.8–2 Gy to the breast in a period of 5–6 weeks.[8]

Disadvantages of EBRT include cancer induction to contralateral breast,[9] dose receiving by adjacent anatomies like coronary arteries and other sensitive organs[10] and requiring patients to be visited in the department for 6–7 weeks.[9]

Partial breast irradiation (PBI) has been proposed as a solution for the above problems.[11] Accelerated partial breast irradiation (APBI) is the method in which just a bed of lumpectomy with a margin of 1–2 cm is irradiated, while fraction dose is escalated and target volume is diminished. The technique let treatment time to be shortened.[12,13] As a smaller portion of the breast is irradiated, the number of time must have radiation is reduced, making it more comfortable for patients and their family.

Current researches show that PBI results in less local recurrence rate that is comparable to the recurrence rate of whole breast irradiation. Moreover, the cosmetic consequence was better than for most patients making it a worthy option for patients with smaller tumors.

APBI is performed by two methods: brachytherapy and 3D external conformal radiation therapy.[14] Volumetric modulated arc therapy (VMAT), three-dimensional conformal radiation therapy (3DRT), intensity-modulated radiotherapy (IMRT) and proton beam therapy are among 3D external conformal radiation therapy techniques.[15]

Because of the three-dimensional structure of the breast, an accomplishment of uniform dose distribution in breast volume is laborious. Treatment planning to achieve uniform dose, due to the volume and shape of breast and chest wall movement, is challengeable.[16]

Regarding the advantages of APBI to whole-brain radiation therapy (WBRT) and limitations for performing other techniques, we compare EBRT with 3DCRT, as a type of APBI technique. Dosimetric parameters including CI, homogeneity index (HI), and UI beside heart and lung doses were assessed and compared in two techniques.

Materials And Methods

CT images of 24 patients with left-sided breast cancer after lumpectomy were selected. CT slices' thickness were 5 mm. Patients were categorized into three groups based on the volume of breast, respectively, ≤ 1000 cc, 1000–1500 cc, and ≥ 1500 cc. Data gathering was randomly performed and including criteria were the side of involved breast and volume of the breast.

During imaging, patients were rested on a breast board in the supine position while her hands were placed on armrest paddle. The breast limits were determined by the physician by clinical palpation and marked by radio-opaque markers for CT acquisition. The upper border was the lower margin of clavicular head, the medial border was midline of the sternum and the lateral border was the midaxillary line. The lower border was taken 2 cm beneath the lower fold of the breast.

Contouring of GTV, PTV, and OAR was fulfilled by the physician according to RTOG protocol. Treatment planning was performed for both group of EBRT and APBI as follows (Figure 1):

(a) EBRT: Treatment planning was based on two large and two small subfields. Delivered dose was determined 50 Gy with a daily fraction of 2 Gy. The daily dose was so divided to deliver 180 cGy to a large field and 20 cGy to subfield.
(b) APBI: To reach the optimum dose distribution, beam parameters like gantry and collimator angles and beam weight were changed and modified continuously. Two tangent fields were used to envelop lumpectomy bed, marked by surgical clips, with 1–2 cm margin. The total delivered dose was determined to be 40 Gy with a fraction dose of 4 Gy, twice a day with a minimum spacing of 6 hrs.

Dosimetric factors including CI, HI, UI and DVH were calculated by DosiSoftIsogray treatment planning software.

Definition Of Parameters

Conformity index (CI): It is defined as a ratio between the volume covered by the reference isodose, which according to ICRU is 95% isodose, and the target volume is designated as planned target volume (PTV).

Conformity indexRTOG = TVRI/TV Where TVRI = Reference isodose volume and TV = Target volume.[17]

Homogeneity index (HI): It is defined as a ratio between the dose reached in 95% of the PTV volume (D≥95%) and the dose reached in 50% (D≥5%) of the PTV volume.[18]

$$HI = (D2\% - D98\%)/D50\%$$

Uniformity index (UI): It is defined as a ratio between minimum doses reached in 5% of the PTV volume (D 5%)

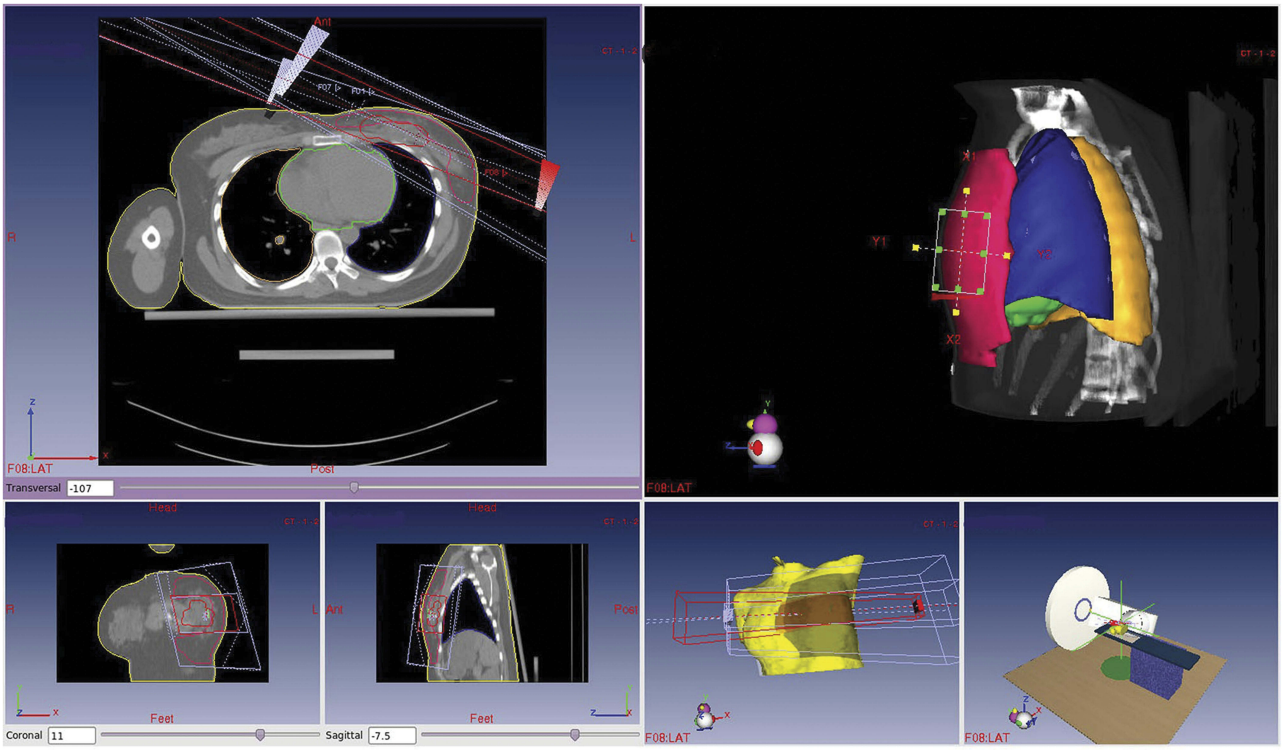

Figure 1 Comparison of EBRT and PBI methods.

and the minimum dose reached in 95% of PTV volume (D 95%).[19]

$$UI = D\ 5\%/D\ 95\%$$

Results

As it is shown in Table 1, uniformity index in APBI method is more than EBRT (P=0.004) for all volume groups. It is clear that CI in APBI method was more than EBRT (P= 0.000) and closer to 1 showing better conformity in APBI method. There was no significant difference between two APBI and EBRT methods. As the volume of breast gets bigger, HI values rise, meaning worse homogeneity. The average dose received by the heart and the lung in the APBI method is less than the EBRT method (P=0.05).

As the above table shows, there is no relation between UI, HI and volume of the breast in both methods of irradiation (Table 2).

Discussion

Partial breast irradiation (PBI) has been proposed as a solution for reducing radiotherapy side effects while putting the less mental burden for cancer patients.[11] Accelerated partial breast irradiation (APBI) is the method in which just a bed of lumpectomy with a margin of 1–2 cm receives radiation, while fraction dose is escalated and target volume is diminished. This technique caused treatment time to be shortened.[12,13] As a smaller portion of the breast is irradiated, the number of time must have radiation is reduced, making it more comfortable for patients and their family.

Current researches show that PBI results in less local recurrence rate that is comparable to the recurrence rate of whole breast irradiation. Moreover, the cosmetic consequence was better than for most patients making it a worthy option for patients with smaller tumors.[20]

The uniformity index (UI), conformity index (CI) and homogeneity index are three tools for assessment of treatment plans. Of course, there are different definitions for them by different authors. APBI method has been introduced primarily to reduce the radiation side effects.[12]

Uniformity index gives an idea of total volume homogeneity inside a given prescription isodose which its ideal value is 1 and any value above 1 shows the presence of a high dose region. Our results show that the value of UI in the APBI method is more than the EBRT method significantly (p=0.004) delineating that the first one is not successful regarding uniformity.

Table 1 Comparison Of Uniformity Index (UI), Conformity Index (CI), And Homogeneity Index (HI) Between APBI And EBRT Methods For Three Volumes Of The Breast (Sample Size In Each Volume Group Is 8 Patients)

Dosimetric Parameters/Breast Volume	Methods (Mean ± SD)	
	APBI	EBRT
UI		
< 1000 cc	1.12±0.034	1.10±0.029
1000 cc–1500 cc	1.09±0.018	1.08±0.021
> 1500 cc	1.11±0.049	1.10±0.034
CI		
< 1000 cc	0.96±0.022	0.9413±0.022
1000 cc–1500 cc	0.92±0.037	0.88±0.058
> 1500 cc	0.95±0.047	0.89±0.079
HI		
< 1000 cc	0.28±0.073	0.26±0.064
1000 cc–1500 cc	0.45±0.15	0.44±0.16
> 1500 cc	0.32±0.10	0.31±0.11
Received dose by heart and lung		
< 1000 cc	3.09±2.8	3.28±2.84
1000 cc–1500 cc	6.95±5.12	7.64±5.16
> 1500 cc	5.85±3.4	6.14±3.35

Abbreviations: UI, uniformity index; CI, conformity index; HI, homogeneity index; APBI, accelerated partial breast irradiation; EBRT, external beam radiation therapy.

Table 2 The Correlation Coefficient Between Dosimetric Parameters (UI, HI) And Breast Volume In Two Methods And Significant P Value

Methods/Dosimetric Parameters And Breast Volume	Correlation	Sig.
APBI		
UI and volume	0.143	0.505
HI and volume	0.161	0.454
EBRT		
UI and volume	0.192	0.369
HI and volume	0.243	0.253

Abbreviations: UI, uniformity index; CI, conformity index; HI, homogeneity index; APBI, accelerated partial breast irradiation; EBRT, external beam radiation therapy.

Conformity index also can help in the comparison and selection of the best treatment plan. The conformity index equal to 1 shows ideal dose coverage or high conformity. In the case where the conformity index is less than 1, it means the target volume is incompletely radiated. Of course, values up to 1 can rarely be reached. Our results showed that CI in the APBI method was more than EBRT (p= 0.000) and closer to 1. In the higher volume of the breast, there was a greater deviation from RTOG protocol as it was less than 0.9 in the EBRT group.[10,11]

Homogeneity index (HI) verified that the dose distribution within the target volume is uniform. The ideal value is zero. There was no significant difference between the APBI and EBRT methods. As the volume of breast gets bigger, HI values rise, meaning worse homogeneity. Stewart and colleagues concluded that partial breast irradiation can be a suitable treatment alternative for breast cancer at early stages.[21]

In 2003, Vicini et al showed that average and median volume of heart and lung received 10, 20 and 30 Gy of prescribed doses, which were less in partial irradiation than EBRT,[22] the same result we got in our experience.

Taghian et al showed the PBI method result in suitable coverage of PTV,[23] the same result we did take. In 2004, Weed concluded that 3DRT way for APBI approach can better cover PTV while lung dose was a bit higher than other PBI,[24] which we did not examine.

Finally, the APBI method may be a good method for minimizing side effects and minimizing treatment periods. Its clinical outcome must be examined more.

Ethics Approval And Consent To Participate

The study is approved by the ethical committee of Golestan University of Medical Sciences. We confirm that participant consent was written informed consent and that the study was conducted in accordance with the Declaration of Helsinki.

Disclosure

The authors report no conflicts of interest in this work.

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