Volume 17, No 2 | International Journal of Radiation Research, April 2019

Comparison of "heart and lung volume absorbed dose" between electron and photon boost radiotherapy after breast conserving surgery

H.R. Hashemifard[1], R. Anbiaee[2], A. Arbabi[2], S. Bitarafan[3], D. Soltani[3], E. Pirayesh[4*]

[1]Oncology Department, Vasei Hospital, Sabzevar University of Medical Sciences, Sabzevar, Iran
[2]Oncology Department, Imam Hossein Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[3]Iranian Center of Neurological Research, Neuroscience institute, Tehran University of Medical Sciences, Tehran, Iran
[4]Nuclear Medicine Department, Shohada Hospital, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran

► ***Short Report***

***Corresponding authors:**
Elahe Pirayesh, M.D.,
***Fax:** +98 21 2272 3263*
E-mail:
Elahe_Pirayesh@yahoo.com

Revised: April 2018
Accepted: June 2018

Int. J. Radiat. Res., April 2019; 17(2): 363-367

DOI: 10.18869/acadpub.ijrr.17.2.363

ABSTRACT

Background: Breast conserving surgery (BCS) followed by radiotherapy (RT) has been widely accepted as the standard treatment in early stages of invasive breast cancer. The standard technique of RT includes whole breast irradiation (WBI). Additional tumor bed boost irradiation has also an important role in the local tumor control. But there are various controversial delivery methods. The aim of the present study was to compare electron and photon boost techniques in terms of heart and lung volume absorbed dose. ***Materials and Methods:*** Thirty patients with breast cancer were selected. All patients had undergone BCS and had been treated by WBI and boost irradiation. After delineation of gross tumor volume (GTV) two CT based 3D conformal boost plans by photon and electron were created for each patient. In each plan coverage index (CI), external volume index (EI), conformity index (COIN) and, lung volume absorbed dose (LVAD) and heart volume absorbed dose (HVAD) of at least 2Gy were measured. Statistical analysis was done using SPSS 17. Data were compared using a nonparametric test (Mann-Whitney) and p values <0.05 were considered significant. ***Results:*** Photon boost showed statistically significant superior results in terms of mean CI (P=0.002) and COIN (P=0.005). Results of EI revealed no significant difference between two methods (P=0.171). The heart (p=0.01) and lung (P<0.005) volume received 2Gy was lower in photon therapy in comparison with electron therapy. ***Conclusion:*** Our results demonstrated that the heart and lung volume absorbed dose is significantly higher in electron boost technique.

Keywords: *Absorbed dose, breast neoplasm, electron, photon, radiotherapy.*

INTRODUCTION

Breast cancer comprises approximately 25% of the total patient caseload in radiation oncology departments [1]. Radiotherapy (RT) has been known to reduce the risk of locoregional recurrence of breast cancer and improve survival of breast cancer patients. Therefore, RT following breast conserving surgery (BCS) is now the standard treatment for the majority of patients with early stages of breast cancer [2]. Boost radiotherapy to the tumor bed has shown an additional gain in reducing the risk of local recurrence [3].

Several techniques to deliver a boost dose have been introduced, including electron, photon and interstitial boost radiotherapy. Although interstitial implant or electron had been established as standard modalities, by introducing new techniques with photon boost, promising results have been achieved [4]. Comparing of these techniques in some studies showed no significant difference between electron, photon or interstitial boost in terms of fibrosis, local control and cosmetic outcome [5, 6]. However, significant decrease in mean doses received by left lung and heart in photon boost has been shown [4,7].

Kovacs and colleagues compared the photon and electron techniques in terms of dosimetric parameters, including coverage index (CI), external volume index (EI), conformity index (COIN) and lung volume absorbed dose (LVAD). They found no significant difference between EI values, but the photon boost showed better results in terms of CI and COIN. However, LVAD of 2GY for electron was higher than photon [8]. But the heart absorbed dose was not considered.

In this study, we retrospectively analyzed two different techniques for the boost radiotherapy. The major aim of the present study was to compare the photon and electron methods in terms of heart and lung volume absorbed dose.

MATERIALS AND METHODS

Between April 1, 2013 and October 1, 2013, thirty patients with histologically proven left breast cancer, who had undergone breast-conserving surgery and whole breast radiotherapy, retrospectively were enrolled in this study. For comparison purposes, the boost was re-planned using a standard photon beam technique and an electron beam technique to the tumor bed of the same patients.

For each patient, a planning CT scan had been performed. Then, CT images had been transferred to the treatment planning system (Varian CD2300). The first stage of planning target volume (PTV) included whole breast radiotherapy and the second stage of PTV included the location of lumpectomy with the margin of 1 cm from each sides were assigned. Lumpectomy area was localized by titanium marker clips implanted by surgeons intraoperative and/or by cross sectional images of CT to determine borders of excision cavity and surviving hematoma after surgery with the margin of 1 cm.

Tumor bed boost to a dose of 10 Gy using two oblique, wedged-fields plans, electron and photon radiation, with the minimal coverage of 90% of the target, were applied for each patient. Finally, two plans were evaluated quantitatively, based on doses delivered to organs at risk including heart and lungs. Dosimetric parameters defined as coverage index (CI), external volume index (EI), conformity index (COIN) and, Lung volume absorbed dose (LVAD) and Heart volume absorbed dose (HVAD) of at least 2Gy were measured and compared between two groups.

In our study, all patients had been treated with photon boost technique, previously. But for comparison, electron boost plan was also designed for each patient. Our study was performed in accordance with the ethical standards of the declaration of Helsinki 2013.

Data analysis was done with SPSS 17. Due to not normally distributed data, nonparametric test (Mann-Whitney) was used. P values less than 0.05 were taken as significant.

RESULTS

Patients' characteristics are summarized in table 1. The average age of patients was 42±11 years. All patients had BCS and none of them had history of cardiovascular and respiratory disease. Surgical clips were found in 11 patients. All patients had a good performance status (Eastern Cooperative Oncology Group 0–1).

A comparison of dosimetric parameters is summarized in table 2 and figure 1. The mean CI and COIN in the photon technique was significantly higher than the boost. (P value=0.002, P value=0.005 respectively)

Comparing amounts of LVAD and HVAD demonstrated that photon boost results are less than the electron, significantly. (LVAD photon mean= 69.00±56.8, electron mean=127.03±111.7, P value= 0.004, HVAD photon mean= 44.20±77.09 electron mean= 73.43±53.48, P value=0.010).

The EI in the electron boost is higher than the photon boost. But the difference is not significant (photon mean=1.98±0.90, electron mean=2.4±1.15, P value=0.171).

Table 1. Patient characteristics

age	42±11
Type of breast cancer Invasive ductal carcinoma	 30
Size of tumor T1 T2	 11 19
Grading Grade 1 Garde 2 Garde 3	 2 16 12
Stage I IIA IIB	 2 19 9

Table 2. Comparison of measured indexes (HVAD, EI, COIN, CI, LVAD) between Photon boost and Electron boost therapy. Values are presented as mean+ standard deviation. Significant difference are noted in HVAD, COIN, CI and LVAD parameters.

Indexes	Photon boost[€]	Electron boost[€]	P-Value[¥]
Heart volume absorbed dose (HVAD)	44.20±77.09 (range: 0-343)	73.43±53.48 (range: 0-158)	0.010*
External volume Index (EI)	1.98±0.90 (range: 0.6 – 5.8)	2.4±1.15 (range: 0.2- 6.2)	0.171
Conformality index (COIN)	0.41±0.09 (range: 0.18 -0.59)	0.25±0.12 (range: 0.1-0.47)	0.005*
Coverage index (CI)	91.60±0.05 (range: 0.82-0.97)	83.2±0.08 (range: 0.78-0.95)	0.002*
lung volume absorbed dose (LVAD)[α]	69.00±56.80 (range: 1-533)	127.03±111.7 (range: 0-444)	0.004*

[€]Mean±SD, [¥]Mann-Whitney test,*significance: P<0.05

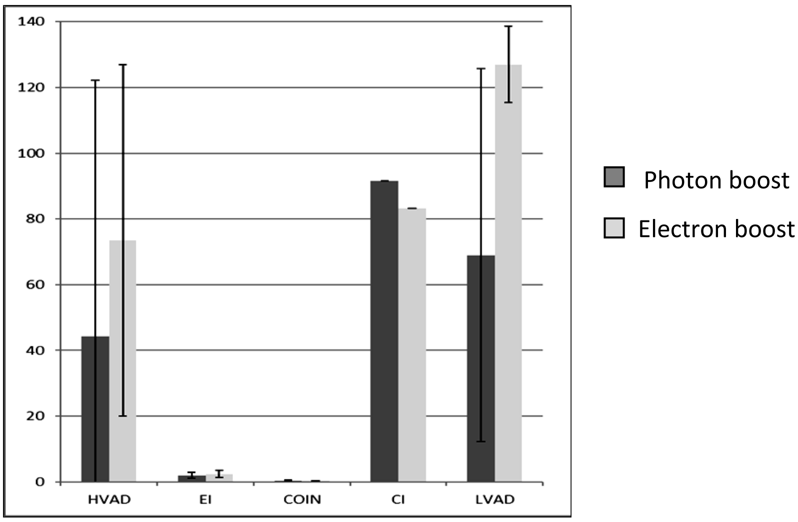

Figure 1. Comparison of measured indexes between Photon boost and Electron boost therapy. Values are mean+ Standard deviation.

DISCUSSION

Radiotherapy followed by BCS is the standard treatment in early stages of breast cancer. The aim of radiotherapy is to supply a constant dose at the site of tumor in the way that lungs and other organs received dose be minimized [9]. In addition, several randomized trials demonstrated tumor bed boost radiation can lead to decrease the rate of local recurrence, significantly [3, 4,10]. There are several techniques of radiation delivery, including electron, photon and interstitial brachytherapy. Different aspects of diversities, advantages and drawbacks of these methods have been evaluated in various studies, consist of cosmetic results, radiation toxicities and some dosimetric variables [4, 8, 11, 12,]. The main aim of this study was to compare the electron and photon boost in terms of heart and lung volume absorbed dose.

Radiation toxicity, such as radiation pneumonitis, cardiac toxicity, lymphedema and secondary malignancy, is a critical problem associated with morbidity and mortality [13]. In many techniques of radiotherapy, anterior wall of heart and left anterior descending artery (LAD) are affected by radiation exposure which can result in higher risk of ischemic heart disease and death in breast cancer patients [11, 14]. So, it is important to reduce the radiation dose of normal tissues, more importantly heart and lungs. In the study of Kovacs and colleagues on 78 patients, the photon and electron boost of radiation were compared and results were in favor of photon boost therapy in the cases of CI and COIN. No significant difference in the case of EI was noted. The mean lung volume receiving 2 Gy was 42.3 and 168.35 cm^3, for the photon and electron, respectively [8]. A study designed by Rajan et al, showed that the photon boost was superior than electron dosimetrically and radiation conformity index (RCI), dose homogeneity index (DHI) and planning target volume (PTV) coverage were significantly better in photon boost technique. Dosimetric results of organs at risk (OAR) also revealed significant decrease in ipsilateral lung and heart dose with 3DCRT plans. Although, there was slightly increased risk of acute skin toxicity with the photon boost, overall cosmetic results at 2 years were similar in both modalities [4]. Similarly, the study of Toscas and colleagues also demonstrated dosimetric advantages of photon therapy over electron radiation in the case of radiation exposure of organs at risk [12]. Our study also confirms these results and shows that the photon boost is superior to electron boost radiation in cases of CI and COIN. In the case of LVAD and HVAD, better results are obtained by photon boost, as well.

We indicate that HVAD in the photon boost therapy is lesser than the electron boost. So, we conclude electron boost therapy results in more absorbed radiation dose in heart and lung. Furthermore, the photon boost is superior to the electron boost in terms of CI and COIN. Subsequently, we advise the photon boost therapy for better coverage and lower absorption within lung and heart.

DISCLOSURE

This paper was adapted from a student thesis at Shahid Beheshti University of Medical Sciences (registration number: 426). It has been *approved* by the research *ethics committee* of *Shahid Beheshti University* of *medical sciences, too.*

ACKNOWLEDGEMENT

We sincerely appreciate our colleagues Nafise Farzi, Navid Khaledi and Manije Beigi for their kind helpful contribution to the data collection.

Conflicts of interest: *Declared none.*

REFERENCES

1. Haffty BG, Buchholz TA, Perez CA (2008) Early stage breast cancer. In: principles and practice of radiation oncology, (Halperin EC, Perez CA, Brady LW, eds.), Lippincott Wil-

liams and Wilkins, Philadelphia, USA.
2. Clarke M, Collins R, Darby S, Davies C, Elphinstone P, Evans V (2006) Effects of radiotherapy and of differences in the extent of surgery for early breast cancer on local recurrence and 15-year survival: an overview of the randomised trial. *Lancet*, ***366(9503)****: 2087-106.*
3. Bartelink H, Maingon P, Poortmans P, Weltens C, Fourquet A, Jager J (2015) Whole breast irradiation with or without a boost for patients treated with breast-conserving surgery for early breast cancer: 20-year follow-up of a randomised phase 3 trial. *Lancet Oncol,* ***16****: 47–56.*
4. Rajan S, Sharma S, Kumar N, Kumar R, Singh G, Singh R (2014) Clinical and cosmetic results of breast boost radiotherapy in early breast cancer: a randomized study between electron and photon. *J Cancer Res Ther,* ***10(4)****: 889-95.*
5. Poortmans P, Bartelink H, Horiot J, Struikmans H, Van den Bogaert W, Fourquet A (2004) The influence of the boost technique on local control in breast conserving treatment in the EORTC 'boost versus no boost' randomised trial. *Radiother Oncol,* ***72(1)****: 25-33.*
6. Frazier R, Kestin L, Kini V, Martinez A, Chen P, Baglan K (2001) Impact of boost technique on outcome in early-stage breast cancer patients treated with breast-conserving therapy. *Am J Clin Oncol*, ***24(1)****: 26-32.*
7. De Santis MC ,Nardone L ,Diletto B ,Canna R ,Dispinzieri M ,Marino L ,Lozza L ,Valentini V (2016) Comparison of two radiation techniques for the breast boost in patients undergoing neoadjuvant treatment for breast cancer. *Br J Radiol,* ***89(1066)****: 20160264*
8. Kovacs A, Hadjiev J, Lakosi F, Glavak C, Antal G, Bogner P (2008) Comparison of photon with electron boost in treatment of early stage breast cancer. *Pathol Oncol Res,* ***14 (2)****:193-7.*
9. Fisher B, Anderson S, Bryant J, Margolese R, Deutsch M, Fisher E (2002) Twenty-year follow-up of a randomized trial comparing total mastectomy, lumpectomy, and lumpectomy plus irradiation for the treatment of invasive breast cancer. *N Engl J Med*, ***347(16)****: 1233-41*
10. Polgár C, Fodor J, Major T, Orosz Z, Németh G (2001) The role of boost irradiation in the conservative treatment of stage I-II breast cancer. *Pathol Oncol Res,* ***7(4)****: 241-50.*
11. Park K, Lee Y, Cha J, You SH, Kim S, Lee JY (2015) Influence of different boost techniques on radiation dose to the left anterior descending coronary artery. *Radiat Oncol J,* ***33(3)****: 242-9.*
12. Toscas J, Linero D, Rubio I, Hidalgo A, Arnalte R, Escudé L (2010) Boosting the tumor bed from deep-seated tumors in early-stage breast cancer: a planning study between electron, photon, and proton beams. *Radiother Oncol,* ***96 (2)****: 192-8.*
13. Brown LC, Mutter RW, Halyard MY (2015) Benefits, risks, and safety of external beam radiation therapy for breast cancer. Int J Womens Health, **7**: 449-58.
14. Valachis A and Nilsson C (2015) Cardiac risk in the treatment of breast cancer: assessment and management. *Breast Cancer*, ***7****: 21-35.*