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ORIGINAL ARTICLE

Comparing ultrasound with computerized tomography images to choose electron energy for radiotherapy boost field in breast cancer patients with breast conserving surgery

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Summary

Purpose: *To compare ultrasonographic (US) with computerized tomographic (CT) images in order to choose electron energy for radiotherapy (RT) boost field in patients with breast conserving surgery (BCS).*

Methods: *Thirty-seven consecutive patients with breast cancer treated by BCS and RT in our department were evaluated. Median age was 49 years (range 32-82). According to the Dokuz Eylul Breast Tumor Group Protocol (DEBTG), in patients with BCS, RT (5000 cGy to the whole breast ± lymphatic area) and boost with electron energy to the primary tumor bed (1000 cGy if surgical margin negative, or 1600 cGy if surgical margin positive was delivered. Before January 2003, the distances between skin-the deepest point of tumor bed (STD), skin-clips (SCD), and skin-fascia (SFD) were measured with US to choose electron energy in boost field. Since then, CT simulation images were used to this purpose. These two imaging systems were compared in this study. Electron energy was selected after measurement of the deepest metallic clips in CT simulation images (90%) or measurement of the STD if no clips were present (10%).*

Results: *Median measurements with US and CT were as follows: STD: US 12 mm (range 4-35), CT 28 mm (range 2-54); SFD: US 25 mm (range 6-57), CT 31 mm (range 2-93); SCD: US 14 mm (range 7-26), CT 29 mm (range 2-68). The median electron energy was 9 MeV é (range 6-12) for US and 12 MeV é (range 6-21) for CT. Concordance in US and CT measurements was 27%.*

Conclusion: *This preliminary study reveals that CT-based SCD measurements are deeper than US measurements, and selected electron energy with CT is 3 MeV higher than US. These two factors can affect local control and side effects. We noticed only one local recurrence in 37 patients. We did not evaluate side effects in this study. These could be a subject of a future study.*

Key words: breast conserving surgery, boost fields, electron energy, radiotherapy, US and CT images

Introduction

Adjuvant RT is the standard treatment in the breast cancer after BCS [1-5]. Conventional RT of the breast is administered with two rectangular tangential fields. Randomized trials show that using additional boost irradiation to the tumor bed reduces the local recurrence rates [2,4,5]. There are various techniques of boost application, such as interstitial brachytherapy, external beam photon or electron RT [6-9]. Precise boost planning is important in terms of local control and cosmetic outcome. Boost irradiation is most commonly given with external electron beams in our department. Methods for assessing the location and depth of the postoperative cavity include inspection of scar, mammography, US, CT and magnetic resonance imaging (MRI). Determination of the depth of the boost field and choosing the right electron energy pose problems. US images have been used for definition of the tumor bed in the last 10 years, however using CT images gains popularity in recent studies [8,10].

In this study, comparison of US with CT images to determine boost cavity and to choose electron energy for boost field in breast cancer patients treated after BCS at Dokuz Eylul University, Department of Radiation Oncology, was carried out.

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Methods

Patient characteristics

Thirty-seven women with breast cancer treated with BCS and RT were evaluated. Median age was 49 years (range 32-82). Twenty-nine (79%) patients had their surgery performed at Dokuz Eylül University, Department of General Surgery. The histopathology was invasive ductal carcinoma (IDC) in 17 (46%) patients, invasive lobular carcinoma (ILC) in 8 (22%), IDC+ILC in 8 (22%), and other histologies in 4 (10%) patients. Pathologically assessed T stages were as follows: T1 in 21 (57%) and T2 in 16 (43%) patients. Patient characteristics are shown in Table 1.

Treatment characteristics

All patients were evaluated at the periodic multidisciplinary meetings of DEBTG, then their treatments were defined according to the DEBTG prospective protocol. Axillary area was evaluated in all patients [axillary dissection in 22 (60%), and sentinel lymph node sampling in 13 (35%)], except 2 (5%) elderly (> 70 years) women. Surgeons placed 3-6 titanium clips during lumpectomies to mark the superior, most inferior, medial, lateral and deepest extend of the residual cavity. Adjuvant RT was planned using CT simulation, and performed with 5000 cGy with Co60 or 6 MVX to the whole breast in two tangential fields (±lymphatics). Boost dose with electron energy was added to the primary tumor bed (1000 cGy in cases with negative surgical margin, and 1600 cGy in cases with positive margins). Before January 2003, the depth of the lumpectomy cavity was defined by US; since then CT simulation images were used for this matter. The depth of the radiation boost volume was determined by adding 0.5 cm to the depth of the deepest clip. STD, SCD, and SFD distances were measured by US and CT images for all patients. Electron energy was chosen according to SCD measurements in cases with clip (Table 2). In patients with no clips in the boost area (4/37, 10%) only the deepest distance of tumor bed was measured (Table 3). These two imaging systems were compared for all measurements. As the sample size was too small, a statistical analysis could not be performed.

Table 1. Patient and tumor characteristics (n= 37)

Characteristics	*Number of patients (%)*
Clinical T	
T1	23 (62)
T2	14 (38)
Clinical N	
N0	31 (84)
N1	6 (16)
Pathological T	
T1	21 (57)
T2	16 (43)
Pathological N	
N0	21 (57)
N1	10 (27)
N2	2 (5)
Others (N3, Nmic, NX)	4 (11)
Histopathology	
Invasive ductal carcinoma (IDC)	17 (45)
Invasive lobular carcinoma (ILC)	8 (22)
IDC+ILC	8 (22)
Others	4 (11)

Results

Local recurrence was noted in only 1 (3%) case.

Table 2. SCD measurements and chosen energy with US and CT in patients with a clip

Patient No.	*SCD (US) (mm)*	*Energy (US)*	*SCD (CT) (mm)*	*Energy (CT)*	*Consistency*
3	17	9	5	9	+
4	8	9	13	9	+
5	21	6	16	9	+
6	9	9	16	9	+
7	7	6	20	9	–
8	15	6	20	9	–
9	28	9	32	9	+
10	18	9	33	9	+
12	10	9	40	9	+
13	18	9	29	9	+
15	14	9	39	12	–
16	10	9	30	12	–
17	16	9	39	12	–
18	13	9	39	12	–
19	10	6	39	12	–
20	26	12	37	12	+
21	22	9	35	12	–
22	24	9	30	12	–
23	25	9	33	12	–
24	15	9	38	12	–
25	25	9	43	12	–
26	24	9	47	15	–
27	29	9	54	15	–
28	24	9	43	12	–
29	25	9	47	15	–
30	23	9	43	15	–
31	28	9	48	15	–
32	42	12	47	15	–
33	30	9	47	15	–
34	27	9	60	18	–
35	26	9	50	18	–
36	26	9	50	18	–
37	21	9	68	21	–

For abbreviations see text

Table 3. STD measurements and chosen é energy with US and CT in patients without a clip

Patient No.	*STD (US)*	*é Energy (US)*	*STD (CT)*	*é Energy (US)*	*Consistency*
1	12	6	11	6	+
2	20	6	29	9	–
14	33	9	35	12	–
11	27	9	27	9	+

For abbreviations see text

One (3%) patient developed distant metastasis without local recurrence during follow-up. At the time of analysis all of the patients were alive and under follow up.

Adjuvant RT with 5000 cGy was performed as follows: 22 (60%) breast, 15 (40%) breast and lymphatic area. RT dose was increased to 6000 cGy in boost field to the tumor bed with electron energy. Both of US and CT were used for choosing electron energy. Median STD 12 mm (range 4-35), SFD 25 mm (range 6-57), and SCD 14 mm (range 7-26) were found with US. Median STD 28 mm (range 2-54), SFD 31 mm (range 2-93), and SCD 29 mm (range 2-68) were found according to CT measurements. Median electron energy was calculated 9 MeV é (range 6-12) as to US and 12 MeV é (range 6-21) as CT measurement. Concordance between US and CT was 27% (9/33) in patients with and 50% (2/4) in patients with a clip (Table 2) and 50% in patients without a clip (Table 3). In 27 cases (73%), patients received a median of 3 MeV higher electron energy when calculated by CT rather than US measurements.

Discussion

BCS is equivalent to mastectomy with regard to local recurrence and overall survival in women with early-stage breast cancer in randomized trials [1,2]. Most recurrences in patients with early breast cancer occur in the primary tumor bed [3]. An additional radiation boost to the tumor bed after whole-breast irradiation has been proved to improve the local control rates in the prospective randomized multicentric EORTC trial [4,5].

The accurate delineation of the primary tumor site emerges as the critical parameter for successful prevention of local recurrence. Many techniques have been discussed in several studies because of the significance of the geographic miss in the actual postoperative cavity. Nowadays surgical clips, US, CT scans and mammography are used alone or combined for the accuracy of electron boost planning [8-10].

According to the DEBTG protocol, in patients with BCS RT (5000 cGy) was delivered to the breast (± lymphatic area) and boosted with electron energy to the primary tumor bed (1000 cGy if negative surgical margins, or 1600 cGy if positive surgical margins). Before January 2003 US, and that year after CT simulation images were used to determine the tumor bed depth and choose electron energy for the boost field. Both techniques were evaluated for accuracy in several studies. In the Goldberg et al. study [11], CT was compared with surgical clips in patients for defining the location and extend of the tumor bed for RT boost field. The authors concluded that the maximal depth of the tumor bed was similar in both techniques, although the extent and centers of the clip- and the CT-determined beds were significantly different. In a study by Warszawski et al. 77 patients underwent 102 sonographic examinations after BCS before and after RT. They concluded that sonography is a useful and reproducible tool in electron boost planning, helping avoid underdosage to the postoperative cavity [12]. In our study, the depth of cavity was measured on CT and US images and these two techniques were compared in terms of consistency.

There are difficulties to define and plan the electron field and energy in patients who have no clips. In our study there were 4 (10%) women lacking clips in the operation field. In the Ringash et al. study the authors discussed that using diagnostic US could improve the accuracy if surgical clips were not present [2]. The surgical clips are thought to be very useful tools for boost planning in many studies. However, the postoperative cavity is sufficiently marked by clips only in a minority of cases [3,12,13]. US might be a reliable, simple, and effective method in these patients [12]. Sonography should be carried out in the treatment position to identify the depth of the surgical cavity [12,13]. In our study, patients without clips in the boost field had the deepest distance of tumor bed measured both with US and CT to define the electron energy.

These two imaging systems were compared for measurements of STD, SCD and the electron energy in this study. US and CT consistency was 27% in patients with, and 50% in those without clip and a median of 3 (range 3-12) MeV é higher electron energy was chosen with CT in 27 (73%) patients compared to US measurement. In our study, CT-based SCD measurements were found to be deeper than US.

In a Ringash et al. study, diagnostic US was compared with orthogonal simulator films for surgical SCD to define the localization of the lumpectomy site [2]. US was found to be particularly useful for determining the depth of the excision cavity; in 96% of localizations, the deepest clip was within the 80% isodose curve. Regine et al. [14] demonstrated the potential geographic miss of the postoperative cavity if the direction of the surgical approach is not sufficiently taken into account. They placed the patient in the treatment position during sonography to simulate gantry angle. In our study we also placed the patient in the treatment position during CT simulation but this positioning could not be achieved during US.

Sedlmayer et al. reported that the postoperative cavity can be misinterpreted because of the mobility and variability of the site, depending on the patients' position, particularly in large and adipose breast. The tumor bed depth was determined in a single plan or point, based on single US image but the depth of the tumor bed from the skin surface varied from slice to slice, so 3-dimensional definition of the tumor bed with CT simulation was critical [7]. These three factors could be a reason of inconsistency between CT and US measurements in our study. On the other hand, pressure to the breast tissue with US probe and cutaneous and subcutaneous alterations due to RT could be other components causing inconsistency. In our study the number of patients without clip was too small to make any statement.

Conclusion

This preliminary study reveals that CT-based SCD measurements are deeper than US measurements, and selected electron energy with CT is 3 MeV higher than US. These two factors can affect local control and side effects. We noted only one local recurrence in a small patient population. High electron energy can increase early and late side effects. We did not evaluate side effects in this study. This could be a subject of a future study.

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