Int. J. Radiation Oncology Biol. Phys., Vol. 65, No. 4, pp. 1161–1164, 2006

0360-3016/06/$–see front matter

doi:10.1016/j.ijrobp.2006.02.009

CLINICAL INVESTIGATION **Breast**

CHANGE IN VOLUME OF LUMPECTOMY CAVITY DURING EXTERNAL-BEAM IRRADIATION OF THE INTACT BREAST

Geraldine Jacobson, M.D., M.P.H.,* Vicki Betts, B.S., R.T(T).,* and Brian Smith, Ph.D.[†]

*Department of Radiation Oncology, University of Iowa Hospitals and Clinics, Iowa City, IA; and [†]Department of Biostatistics, University of Iowa, Iowa City, IA

Purpose: Definition of the lumpectomy cavity is an important component of irradiation of the breast. We use computed tomography (CT)-based planning and contour the lumpectomy volume on the planning CT. We obtained a second CT in the 4th or 5th week of treatment for boost planning and compared the volume change with the first planning-CT scan.
Methods and Materials: This retrospective study reviewed the planning-CT data for 20 patients. In the first CT, images were obtained from the mandible to 2 cm below the breast in 3-mm slices. In the second CT, for the boost, images were obtained from the top to the bottom of the clinically defined breast, in 3-mm slices. Lumpectomy cavities were contoured on both CT scans and volumes compared.
Results: Sixteen of the 20 patients (80%) had more than a 20% decrease from the first to the second volume, with a corresponding 95% confidence interval. The mean decrease was 16.13 cc, with a standard deviation of 14.05. The Spearman correlation coefficient of 0.18 did not show a significant correlation between the initial volume and the percent change.
Conclusions: During external breast irradiation, many patients will have significant volume reduction in the lumpectomy cavity. Because CT-based definition of the lumpectomy cavity can influence the planning of a boost technique, further study appears warranted. © 2006 Elsevier Inc.

Breast boost, Lumpectomy, Breast conservation.

INTRODUCTION

Treatment of the intact breast offers unique challenges to the radiation oncologist. Shape and size not only varies among women but also varies within individual women because of changes in hormone status, body habitus, and age. The breasts are in close proximity to the lungs and the left breast, to the heart. The change from two-dimensional (2D), fluoroscopic-based planning to three-dimensional (3D), computed tomography (CT)-based planning has improved our definition of organs at risk and dosimetry within the breast but has also revealed the difficulty in defining the appropriate treatment volume of breast tissue. In addition, the position of the breast is subjected to the ongoing tidal motion of respiration.

Definition of the lumpectomy cavity has become an increasingly important aspect of breast irradiation. One of the major randomized early breast-conservation trials, National Surgical Adjuvant Breast and Bowel Project (NSABP) B-06, compared lumpectomy (with or without radiation) to mastectomy and did not require a boost (1). However the concept of including a boost grew rapidly in practice; 2 randomized studies showed improved in-breast control with the addition of a boost (2, 3). As with many aspects of radiation oncology, the boost has varied and evolved. The definition has been clinical, based on scar location and physical examination, or based on a 2D image, when surgical clips were placed at the time of lumpectomy (4, 5). The use of CT-based planning enables the radiation oncologist to define the lumpectomy cavity on the planning CT.

We have used CT-based planning of the intact breast for several years. When identifiable, we have contoured the lumpectomy cavity on the planning CT and used this information to plan the boost. Our clinical observation has been that the size and shape of the lumpectomy site changes during external-beam irradiation. If this change could be defined, it would affect the shape and volume of the boost. We decided to obtain a second treatment-planning CT in the 4th or 5th week of radiation; if a significant change occurred, the second CT would be used for treatment planning of the boost. This study is a review of 20 patients for whom we obtained a pre–treatment-planning CT for the intact breast and a subsequent second CT as described. Our ob-

Reprint requests to: Geraldine Jacobson, M.D., M.P.H., Department of Radiation Oncology, 01502 West Addition, University of Iowa Hospitals and Clinics, Iowa City, IA 52242. Tel: (319) 384-6135; Fax: (319) 356-1530; E-mail: geraldine-jacobson@uiowa.edu

Poster presentation at the 47th Annual Meeting of the American Society for Therapeutic Radiology and Oncology (ASTRO), October 16–20, 2005, Denver, CO.
Received Oct 6, 2005, and in revised form Dec 30, 2005. Accepted for publication Feb 4, 2006.

jective was to define the frequency and magnitude of the volume change.

METHODS AND MATERIALS

This study is a retrospective review of planning-CT scans for the intact breast. Approval was sought and obtained from the institutional review board at the University of Iowa. Treatment-planning CTs were performed with the patient in the treatment position. The supine patients were immobilized on a wingboard or a breastboard, sometimes in combination with a vac-lock (Med-Tech, Orange City, IA). Our current practice is to use a wingboard, with both of the patient's arms raised above the head.

The borders of the breast were clinically defined and marked with radiopaque wire. The axillary and lumpectomy scars were wired. Images were obtained from the mandible to 2 cm below the lowest level of breast tissue. The images were obtained with 3-mm spacing. The lumpectomy cavity was contoured and volume determined. Treatment planning was done with Pinnacle version 7.4 (Phillips/ADAC, Milpitas, CA). Preset soft-tissue windows were used on the planning CT for contouring the lumpectomy volumes. Surgical clips were not routinely used by our referring surgeons. In some cases, a fluid collection was identified and contoured; in other cases, increased density thought to represent the operative bed was contoured. The volumes were drawn by the resident, and then checked and modified as necessary by the attending physician. All lumpectomy contours were reviewed by a single physician (GJ). The volumes were not recontoured for this study. Our rationale is that we wanted to use the same volumes that we used for treatment planning. The standard prescription was 46.8 to 50.4 Gy to the entire breast. Our initial criterion for selection was that the patients were referred for radiation within 3 to 10 weeks of surgery. We excluded patients who had chemotherapy before radiation on the basis of our observation that their lumpectomy site was often contracted and sometimes hard to define on CT. We excluded patients whose initial lumpectomy volume was less than 10 cc. In the selected patients, a second planning CT was done during the 4th or 5th week of radiation therapy. Images were obtained from the top to the bottom of the clinically defined breast field. Wires were placed on the lumpectomy scar and axillary scar. CT slices were obtained at 3-mm intervals. The lumpectomy cavity was contoured. The volume was determined. The lumpectomy site volumes of the pretreatment CT (CT1) and the second CT (CT2) were compared (Table 1 and Fig. 1). The data on the 2 CT volumes for 20 patients were included in this study.

Statistical methods

The CT images obtained before and during radiation therapy were used to calculate the percent change in the volume of the lumpectomy cavity for each patient. The percent of patients who experienced a volume decrease of at least 20% was estimated with a binomial proportion. Exact methods were used to compute a 95% confidence interval and test the null hypothesis that 65% or fewer of the patients experience a decrease of at least 20%. The Spearman correlation coefficient was used to determine whether a correlation existed between volume before radiation and percent change.

RESULTS

The volume data for the lumpectomy cavity from 20 patients was reviewed. Among the 20 patients, 16 (80%) had more than 20% decrease from the first to the second volume, with a corresponding 95% confidence interval of (56.3%, 94.3%). The volume change ranged from an increase of 4.93 cc to a decrease of 45.68 cc. The mean decrease was 16.13 cc, with a standard deviation of 14.05 (Table 1). The Spearman correlation coefficient of 0.18 ($p = 0.44$) did not show a significant correlation between the initial volume and the percent change.

DISCUSSION

Breast-conservation surgery followed by adjuvant irradiation of the intact breast has been a standard treatment of early breast cancer for almost 20 years. The efficacy of this treatment is well documented. Two randomized studies have shown improved local control with the addition of a boost—additional radiation directed to the surgical site (2, 3). Boost radiation has been delivered by different techniques, including external photons, external electrons, and interstitial techniques. An important aspect of this treatment is accurate definition of the boost volume. Enface electron beam directed to the scar has been a widely used boost technique. However several authors have shown this method leads to inaccurate and inadequate coverage of the lumpectomy site when contrasted with definition by surgical clips or CT-defined tumor volumes (4–7). As CT-based treatment planning has become more widely available, it can be used to identify the lumpectomy cavity and define the boost volume. A recent study by Goldberg *et al.* (8) described patients who had surgical clips placed at the time of lumpectomy. The maximum depth of the tumor bed was determined on the basis of clip location and CT-defined location of the tumor bed. They found the extent and depth of the tumor bed,

Table 1. Change in volume between initial CT (CT1) and boost CT (CT2)

Patient number	Volume (cubic centimeters)			
	Initial (CT1)	Boost (CT2)	Change	Change (%)
1	25.17	12.70	12.47	49.54
2	8.54	7.33	1.21	14.17
3	40.28	25.20	15.08	37.44
4	39.61	10.49	29.12	73.52
5	24.39	24.91	−0.52	−2.13
6	46.10	41.00	5.10	11.06
7	22.92	13.93	8.99	39.22
8	55.32	60.25	−4.93	−8.91
9	25.40	14.70	10.70	42.13
10	108.58	63.09	45.49	41.90
11	28.33	7.75	20.58	72.64
12	7.71	5.72	1.99	25.81
13	40.98	17.82	23.16	56.52
14	38.42	16.41	22.01	57.29
15	25.21	4.97	20.24	80.29
16	26.75	20.01	6.74	25.20
17	60.21	14.53	45.68	75.87
18	38.19	23.40	14.79	38.73
19	44.49	12.22	32.27	72.53
20	25.17	12.69	12.48	49.58