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# Three-dimensional conformal breast irradiation in the prone position

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## Abstract

The prone position can be used for the planning of adjuvant radiotherapy after conservative breast surgery in order to deliver less irradiation to lung and cardiac tissue. In the present study, we compared the results of three-dimensional conformal radiotherapy planning for five patients irradiated in the supine and prone position. Tumor stage was T1N0M0 in four patients and T1N1M0 in one. All patients had been previously submitted to conservative breast surgery. Breast size was large in three patients and moderate in the other two. Irradiation in the prone position was performed using an immobilization foam pad with a hole cut into it to accommodate the breast so that it would hang down away from the chest wall. Dose-volume histograms showed that mean irradiation doses reaching the ipsilateral lung were 8.3 ± 3.6 Gy with the patient in the supine position and 1.4 ± 1.0 Gy with the patient in the prone position (P = 0.043). The values for the contralateral lung were 1.3 ± 0.7 and 0.3 ± 0.1 Gy (P = 0.043) and the values for cardiac tissue were 4.6 ± 1.6 and 3.0 ± 1.7 Gy (P = 0.079), respectively. Thus, the dose-volume histograms demonstrated that lung tissue irradiation was significantly lower with the patient in the prone position than in the supine position. Large-breasted women appeared to benefit most from irradiation in the prone position. Prone position breast irradiation appears to be a simple and effective alternative to the conventional supine position for patients with large breasts, since they are subjected to lower pulmonary doses which may cause less pulmonary side effects in the future.

**Key words**
- Prone position
- Breast cancer
- Radiotherapy

## Introduction

The management of primary breast cancer with conservative surgery and radiation therapy is a widely accepted alternative to mastectomy (1,2). However, standard tangential breast radiotherapy not only treats portions of the chest wall, but also exposes lung and heart tissue to radiation (3,4).

Radiation pneumonitis following conservative surgery and radiation therapy for breast cancer is a rare complication related to treatment technique (5,6). The prone position technique has the same reproducibility characteristics as the supine position technique and combines them with the homogeneity and normal tissue-sparing characteristics of the lateral decubitus position technique. Prone position breast irradiation appears to be a simple and effective alternative to irradiation of the breast in the conventional supine position when the supine position is likely to result in unacceptable dose inhomogeneity or in significant doses delivered to normal tissue (7). In the present study, we describe the results of three-dimensional conformal radiotherapy (3D-CRT) in the prone position.

Table 1. Characteristics of breasts of patients with primary breast cancer.

| Patient number | Breast side | Breast size |
|---|---|---|
| 1 | Left | Moderate |
| 2 | Left | Moderate |
| 3 | Left | Large |
| 4 | Left | Large |
| 5 | Right | Large |

Figure 1. A hole was cut into the foam pad under the breast that allowed the breast to hang down with the patient in the prone position.

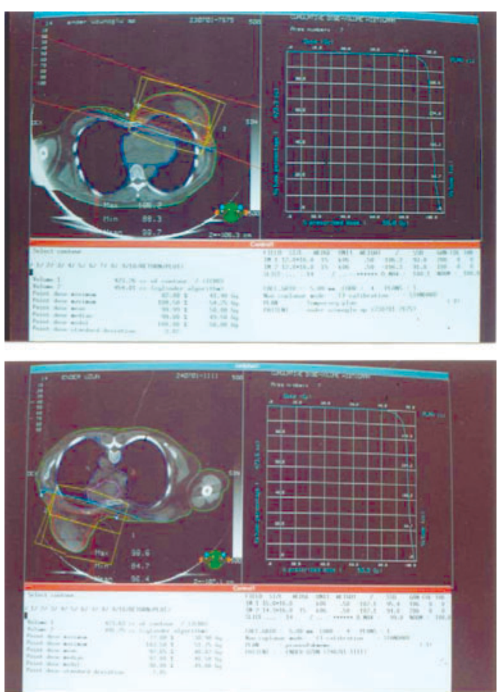

Figure 2. Case 1. Dose-volume histogram and isodose distribution in the target volume in the supine position (top) and in the prone position (bottom).

## Material and Methods

When the patient is irradiated in the prone position the treated breast hangs down away from the chest wall and the radiation dose to normal tissue is minimized. We studied five patients with a diagnosis of infiltrative ductal carcinoma of the breast subjected to conservative surgery and referred to our radiotherapy clinic. Tumor stage was T1, N0, M0 in four patients and T1, N1, M0 in one. Patient characteristics are listed in Table 1. The patients were positioned on an immobilization foam pad both in the supine position and in the prone position. The ipsilateral arm was placed above the head and the contralateral arm on the immobilization foam pad. A breast ring was fixed on the breast to hold it in an upright position. A hole cut into the pad under the breast permitted the breast to hang down during treatment in the prone position (Figure 1).

Computed tomography images were obtained with a Picker® I.Q. T/C computed tomography apparatus (Picker International, Inc., Cleveland, OH, USA) both in the supine and prone positions. The target volume, body outline, left lung tissue, right lung tissue and cardiac tissue were drawn, the target isocenter was fixed, and virtual simulation was performed with a Picker Voxel Q virtual simulation workstation. Beam's eye view, isodose distribution, inhomogeneity correction, multileaf collimators and dose volume histogram were obtained with a Varian® Cad-plan treatment-modeling workstation (Varian Associates Inc., Oncology Systems, Palo Alto, CA, USA). The median and lateral borders of the breast tissue determined clinically and with beam's eye view were included in the fields using tangential parallel-opposed photon beams. 3D-CRT planning was done for each position. Patient treatment was planned using a 6-mV photon power Varian® Clinac 2300 C/D apparatus, with one daily session of 2 Gy, five sessions per week and a total dose of 50 Gy over five weeks. Wedges were used to enhance the best isodose distribution and the treatment plans, and dose volume histograms obtained for the supine position and the prone position were compared.

The Wilcoxon test was applied to compare the results obtained in the two positions.

## Results

The plans were performed using the isocentric technique and the isodose distributions were observed for the five cases in the supine position and in the prone position. The isodose distributions were optimized with wedges on the transverse plane. Dose volume histograms were constructed for the target volume, left lung tissue volume, right lung tissue volume and cardiac tissue volume in each case for both the supine and the prone positions (Figures 2 and 3).

The isodoses covering target volumes at the base and on the lateral edge of the breast and the mean target doses for both the supine and the prone positions are listed in Table 2.

The mean doses delivered to lung and cardiac tissues in each case in the supine and prone positions are shown in Table 3. The ipsilateral lung was the left one in four patients and the right one in the fifth patient (Table 3).

The mean doses delivered to normal tissues in the supine position compared to the prone position are listed in Table 4. The mean doses to the ipsilateral lung were 8.3 ± 3.6 Gy for the supine position and 1.4 ± 1.0 Gy for the prone position (P = 0.043). The values for the contralateral lung were 1.3 ± 0.7 and 0.3 ± 0.1 Gy (P = 0.043) and the values for cardiac tissue were 4.6 ± 1.6 and 3.0 ± 1.7 Gy (P = 0.079), respectively. The results showed that the mean doses delivered to the lungs were significantly lower in the prone position than in the supine position.

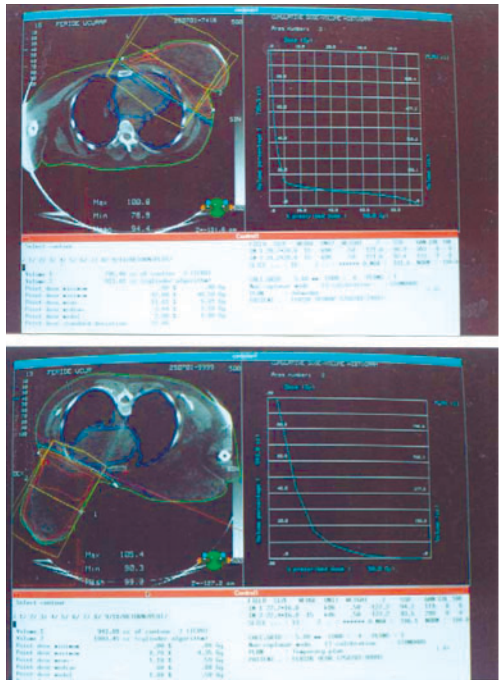

Figure 3. Case 3. Dose-volume histogram and isodose distribution for the ipsilateral left lung tissue volume in the supine position (top) and in the prone position (bottom).

Table 2. Isodose percentage in the target volume and mean target dose for each patient in the prone and supine positions.

| | Isodose percentage in the target volume | | Mean target dose (Gy) |
|---|---|---|---|
| | At the base of the breast | At the lateral edge of the breast | |
| Patient 1 | | | |
| Supine | 82.8 | 108.5 | 50.0 (99.9 ± 3.0%) |
| Prone | 77.8 | 103.5 | 48.8 (97.6 ± 2.8%) |
| Patient 2 | | | |
| Supine | 96.6 | 111.2 | 48.4 (96.8 ± 4.9%) |
| Prone | 94.7 | 106.1 | 49.1 (98.3 ± 3.5%) |
| Patient 3 | | | |
| Supine | 75.0 | 108.8 | 47.5 (95.0 ± 4.3%) |
| Prone | 67.1 | 109.0 | 49.5 (99.0 ± 5.2%) |
| Patient 4 | | | |
| Supine | 93.8 | 109.2 | 51.1 (102.2 ± 4.7%) |
| Prone | 96.0 | 111.9 | 49.2 (98.5 ± 5.5%) |
| Patient 5 | | | |
| Supine | 95.8 | 117.1 | 50.3 (100.7 ± 3.7%) |
| Prone | 95.6 | 115.3 | 51.3 (102.6 ± 5.9%) |

The values in parentheses are the mean percentage ± SD of dose distribution in the target volume.

## Discussion

The management of primary breast cancer with conservative surgery and radiation therapy is a widely accepted alternative to mastectomy (1). There is an increasing interest in the late effects of therapy on the survival of patients treated for breast cancer (8-11). The long-term complications following conservative surgery and radiation therapy for early stage breast cancer are low, and changes in radiation technique may reduce their occurrence (12).

Table 3. Mean radiation dose delivered to normal tissue in each patient in the supine and prone positions.

| | Mean radiation dose (covering isodose) | |
|---|---|---|
| | Supine | Prone |
| Patient 1 | | |
| Ipsilateral lung | 7.6 (15.2 ± 29.8%) | 3.2 (6.4 ± 16.5%) |
| Contralateral lung | 0.8 (1.6 ± 1.2%) | 0.5 (1.0 ± 0.8%) |
| Heart | 5.5 (11.1 ± 18.8%) | 4.8 (9.7 ± 17.3%) |
| Patient 2 | | |
| Ipsilateral lung | 5.3 (10.6 ± 19%) | 0.9 (1.9 ± 2.3%) |
| Contralateral lung | 0.8 (1.7 ± 0.5%) | 0.3 (0.6 ± 0.6%) |
| Heart | 4.9 (8.1 ± 11.2%) | 3.2 (6.4 ± 9.1%) |
| Patient 3 | | |
| Ipsilateral lung | 5.8 (11.6 ± 22.6%) | 0.5 (1.1 ± 0.8%) |
| Contralateral lung | 0.6 (1.2 ± 0.6%) | 0.1 (0.3 ± 0.3%) |
| Heart | 6.3 (12.6 ± 19.5%) | 1.7 (3.5 ± 2.8%) |
| Patient 4 | | |
| Ipsilateral lung | 8.8 (17.7 ± 28.7%) | 0.9 (1.8 ± 3.4%) |
| Contralateral lung | 1.1 (2.2 ± 2.0%) | 0.4 (0.9 ± 0.6%) |
| Heart | 3.9 (7.8 ± 8.2%) | 4.4 (8.8 ± 12.2%) |
| Patient 5 | | |
| Ipsilateral lung | 14.2 (28.4 ± 36.0%) | 1.3 (2.6 ± 4.5%) |
| Contralateral lung | 2.1 (4.3 ± 2.3%) | 0.1 (0.2 ± 0.1%) |
| Heart | 2.1 (4.3 ± 2.3%) | 0.7 (1.5 ± 0.6%) |

The values in parentheses are the mean percentage ± SD of dose distribution in the target volume.

Table 4. Mean radiation dose delivered to normal tissue in the supine and prone positions for the patient group as a whole.

| | Mean radiation dose (Gy) | |
|---|---|---|
| | Supine | Prone |
| Ipsilateral lung tissue | 8.3 ± 3.60 | 1.4 ± 1.05* |
| Cardiac tissue | 4.6 ± 1.60 | 3.0 ± 1.70 |
| Contralateral lung tissue | 1.3 ± 0.70 | 0.3 ± 0.10* |

*P < 0.05 compared to the supine position (Wilcoxon test).

Lingos et al. (5) assessed a large number of patients regarding the factors contributing to radiation pneumonitis. They concluded that radiation pneumonitis following conservative surgery and radiation therapy for breast cancer was a rare complication and more likely to occur in patients treated with both a 3-field technique and chemotherapy. Three percent of patients treated with a 3-field technique and with chemotherapy developed radiation pneumonitis compared to 0.5% for all other patients (P = 0.0001). When patients were treated with combined chemoradiotherapy and the 3-field technique, the incidence of radiation pneumonitis was 8.8% for concurrent chemotherapy compared with 1.3% for patients who received sequential chemotherapy and radiation therapy (P = 0.002). Over the limited range of volumes treated, irradiated lung volume was not associated with an increased risk of radiation pneumonitis. On the other hand, the risk of radiation pneumonitis appeared to be related to the volume of lung irradiated in two other studies (13,14). The use of computed tomography in tangential breast irradiation provides a detailed picture of the dose distributions throughout the breast volume and surrounding normal tissue. Three-dimensional treatment planning allows dose escalation to the target volume without significantly increasing the dose received by surrounding normal tissue (15). The full scale computed tomography scan with a true three-dimensional dose algorithm is more accurate than the three-slice model (16).

Gyenes et al. (17) reported that the computed tomography-based three-dimensional treatment planning system might be conformed to reduce the irradiated cardiac volume. In the cited study, most of the patients with left-sided T1, N0, M0 breast cancer did not receive irradiation to a substantial cardiac volume (17).

A dose to the contralateral breast due to primary breast irradiation is possible as a function of the technique used for the primary treated breast. Several factors contribute significantly to the opposite breast dose and the situation can be improved by good techniques (18).

Gray et al. (19) documented a slightly yet measurably inferior cosmetic result in large-breasted or heavy women. However, the difference between the large-breasted group and the others was not great and should not exclude these women from consideration for breast conservation techniques.

Cross et al. (20) described a technique for the conservative irradiation of women with very large breasts. Patients were treated in a modified lateral decubitus technique which offered breast-conserving therapy to women with large breasts, without poor cosmesis.

Merchant and McCormick (7) reported that prone position breast irradiation appears to be a simple and effective alternative to irradiation of the breast in the conventional supine position when the supine position is likely to result in unacceptable dose inhomogeneity or significant doses delivered to normal tissues. Large-breasted women appeared to benefit most from this treatment.

Bieri et al. (21) determined the effects of treatment techniques, such as supine and prone positioning, on the absorbed dose in organs at a distance from the irradiated breast. Peripheral doses delivered to the abdomen, pelvic organs, bone marrow and lung were significantly higher for supine than for prone tangential breast irradiation.

Recently, Mahe et al. (22) used the prone position technique for breast irradiation after conservative surgery with the help of a special Plexiglas platform in 35 patients with large pendulous breasts. The feasibility was excellent for positioning, dosimetric studies, and immediate tolerance in more than 90% of the patients. This system had the major advantage of ensuring a similar and reproducible position for computed tomography scanning and treatment.

In the present study, 3D-CRT planning was used to deliver a lower dose to normal tissue in the prone position compared to the supine position. In the prone position, the ipsilateral breast tissue was allowed to hang down away from the chest wall and the contralateral breast tissue was pressed to a lateral position. The mean doses reaching the ipsilateral lung were $8.3 \pm 3.6$ Gy for the supine position and $1.4 \pm 1.0$ Gy for the prone position. The values for the contralateral lung were $1.3 \pm 0.7$ and $0.3 \pm 0.1$ Gy and the values for cardiac tissue were $4.6 \pm 1.6$ and $3.0 \pm 1.7$ Gy, respectively. The doses delivered to the ipsilateral lung tissue ($P = 0.043$), cardiac tissue ($P = 0.079$) and contralateral lung tissue ($P = 0.043$) were lower in the prone position than in the supine position. Large-breasted women appeared to benefit most from the planning in the prone position. This result will be better evaluated in the future by increasing the number of patients, also permitting us to reach a conclusion based on clinical follow-up data.

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