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RESEARCH ARTICLE

Pilot study of feasibility and dosimetric comparison of prone versus supine breast radiotherapy

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Abstract
Purpose The aim of this study was to demonstrate feasibility and analyze dosimetric differences in prone and supine position breast cancer radiotherapy in women with large or pendulous breast.
Methods Ten post-lumpectomy breast cancer patients underwent supine and prone computed tomography-based treatment plan. On each data set, the whole breast, the ipsilateral lung and the heart were outlined. Multisegment tangential-fields plans were generated for each position. Target coverage, homogeneity, overdosage outside breast and organ at risk sparing were analyzed and compared for supine and prone position.
Results Coverage and dose homogeneity of the PTV measured by D_{90} and $V_{95\,\%}$ were similar for both plans although breast maximum dose was higher in the supine plan ($p = 0.017$). Prone position reduced the percentage of ipsilateral lung receiving 20 Gy (V_{20Gy}) from 26.5 to 2.9 % ($p = 0.007$), medium lung dose, as well as the percentage of the heart receiving 35 Gy heart (V_{35Gy}) from 3.4 to 1.2 % ($p = 0.038$). Overdosage of areas outside breast PTV was also consistently reduced with prone position ($p = 0.012$). In addition, average number of segments and monitor units needed was reduced in prone position.
Conclusions Prone position in large breast women appears to favor normal tissue sparing in breast radiotherapy as compared to supine position, without diminishing the target coverage.

Keywords Breast radiotherapy · Prone positioning · Dosimetric analysis · Normal-tissue sparing

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Introduction

Breast cancer is the most common malignancy in women comprising 29 % of all new cancers diagnosed in women in the European Union (EU). It is responsible for 17.4 % of cancer deaths in women in the EU [1].

Breast conserving surgery followed by external beam radiotherapy to residual breast has become the standard of care in the management of early-stage breast carcinoma. Several randomized clinical trials and meta-analysis have shown similar survival rates after breast conserving therapy and after mastectomy in patients with early-stage breast cancer, making the combination of limited surgery and axillary dissection (or sentinel node biopsy) with breast irradiation an established, safe and effective alternative to mastectomy [2–4]. However, long-term follow-up of these series has revealed that standard supine radiotherapy regimens led to an increased risk of toxicity, including death from heart disease, presumably due to undesirable irradiation of the lung and cardiac structures [5]. However, more recent studies, using modern techniques of immobilization, simulation, planning, and treatment administration, have not shown a significant increase in long-term cardiovascular complications after completion of breast radiation therapy [6]. Nevertheless, since an increased risk of cardiac toxicity is predictable when modern regimens of chemotherapy containing anthracyclines or trastuzumab-based chemotherapy regimens are employed [7, 8], attempts targeted at reducing heart exposure remain very interesting. In addition, radiation pneumonitis, a rare but potentially threatening condition, appears to be directly related to the lung volume irradiated [9, 10]. Ultimately, the long-term cosmetic outcome, with the appearance of areas of fibrosis, hyperpigmentation or telangiectasia, is related to both the dose homogeneity in the planning target volume (PTV) and the amount of healthy surrounding tissue receiving a significant dose [11].

Investigators at the Department of Radiation Oncology of the New York University (NYU) School of Medicine, Langone Medical Center, have perfected prone breast radiotherapy through a series of clinical trials. They have designed a dedicated mattress board that allows breast radiotherapy in the prone position and reported on its application in a number of publications [12–19, 41]. Based on the experience acquired by one of our researchers (E.F.-L.) during her fellowship at the NYU Clinical Cancer Center, we have developed at our institution the IRMAPRON program for prone breast irradiation, an approach that mimics the NYU technique. In the first phase of the program, we have conducted a feasibility study with dosimetric comparison of treatment plans for supine and prone positioned patients as a proof of concept for the technique. This experience mimics NYU 05-181, a trial of 400 women undergoing both setups [12]. In the present article, we present the feasibility and dosimetry results obtained in the first ten patients.

Patients and methods

The inclusion criteria in the IRMAPRON program were as follows: a histological confirmed breast carcinoma in stages 0, I or II, undergoing breast conserving surgery and whole breast irradiation without irradiation of locoregional lymph nodes areas. The study was approved by the Institutional Review Board and all patients signed an informed consent to participate in this study.

Patient positioning and imaging

Radiotherapy plans were calculated using image sets acquired in a specifically dedicated computed tomography (CT) scan. All patients underwent CT simulation in both prone and supine positions on the same day. First, images were obtained with the patient in the standard supine position. The immobilization of the patients in the supine position was achieved, in most cases, by means of a customized alpha cradles system and a wedged breast board. A radio-opaque wire was placed encompassing circumferentially the breast for clinical reference, although breast contour is mainly defined by CT landmarks. Afterward, patients were repositioned prone using a home-made immobilization device made of combined polystyrene and foam with an opening for positioning the breast, mimicking the NYU Langone Medical Center device [19]. Image acquisition protocol was the same for both positions, consisting of slices of 3 mm thickness obtained every 5 mm from the angle of mandible to 5 cm below the inferior border of the breast. In all cases, the heart and both lungs were completely included in the simulation CT.

Volumes of interest

The CT data set was transferred to the Pinnacle3 v8.0m (Philips, Fitchburg, WI, USA) treatment planning system to outline the volumes of interest according to the Radiation Therapy Oncology Group breast contouring atlas [20].

The structures outlined included the whole ipsilateral breast PTV as well as the heart and both lungs separately (organs at risk, OAR). To reduce inter-observer variability, contouring was performed and checked on both supine and prone scans by two different radiation oncologists (E.F.-L. and A.M.)

Treatment planning

All the patients underwent three-dimensional conformal radiation planning according to the recommendations defined by ICRU documents 50 and 62 [21, 22]. The radiotherapy plan outlined for prone position was used to carry out a comparative analysis of the data obtained from the dose–volume histograms (DVH). In all patients, a technique of two tangential fields with 6–15 MV photons was used. Additional 2–8 segments were created using anatomy-based segmentation when necessary to achieve the dose homogeneity criteria established by the ICRU (Fig. 1). The prescribed dose to the PTV was 50 Gy with a standard fractionation of 2 Gy per day, 5 days per week for 5 weeks. The dose was prescribed to the 95 % isodose. No hot spots, according to ICRU report 50, were allowed. All plans were generated by the same radiation physicist (RM) with the purpose of maintaining similar coverage and target homogeneity criteria.

Data collection and statistical analysis

The results were analyzed using data obtained from the DVH generated for plan evaluation and comparison of both positions, supine and prone (Figs. 2, 3). Coverage of PTV, dose homogeneity, and the doses received by OAR were compared. The minimum dose received by the 90 % of the PTV (D_{90}), the volume of the PTV receiving 95 % of the

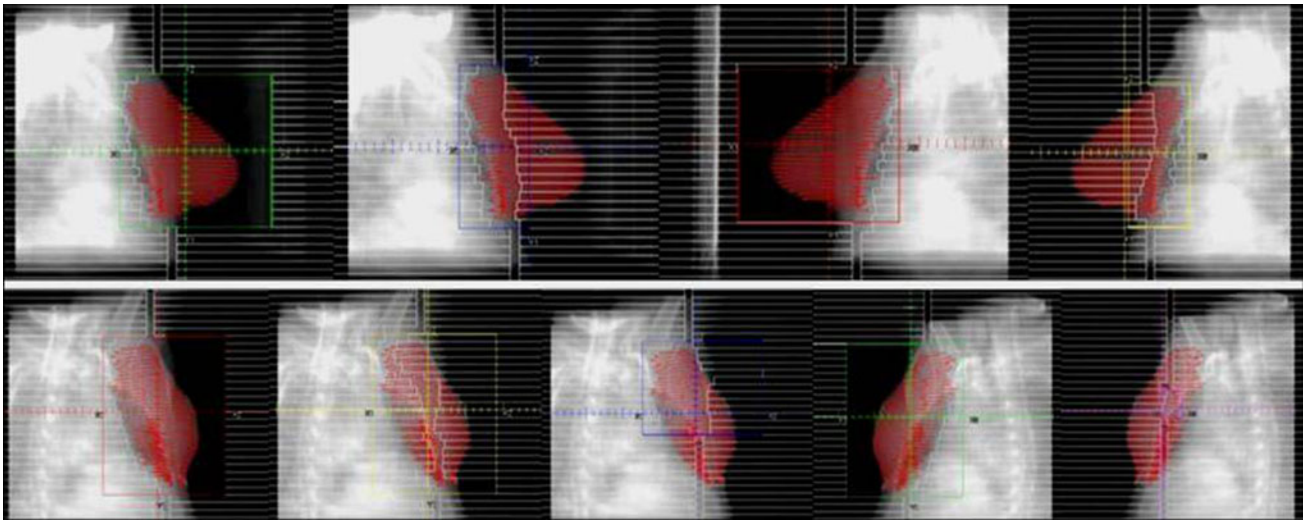

Fig. 1 DRRs showing the differences in the number of segments used for irradiation in prone (*above*) and supine (*below*) plans in a right-breast treatment

prescription dose (V_{95}), the percent of PTV receiving a dose between 95 % ($V_{95\ \%}$) and 107 % ($V_{107\ \%}$) of the prescribed dose and the maximum dose in PTV (D_{max}) were recorded. The homogeneity of the PTV dose was estimated by calculating the volume of breast receiving more than 47.5 Gy and <53.5 Gy (V_{95}–$V_{107\ \%}$). The percentage of the ipsilateral lung receiving a dose equal or above 20 Gy (V_{20Gy}), the heart volume receiving a dose equal or above 35 Gy (V_{35Gy}), the mean doses (D_{med_lung}, D_{med_heart}) for OARs and the percent of extramammary tissues receiving doses above 105 % of prescribed dose ($V_{105\ \%\_ext}$) were collected [23, 24].

Technique-related parameters were also analyzed. Differences between total number of radiation segments and total number of monitor units (MU) calculated for each plan (prone and supine positions) were collected.

The differences between the parameters studied for supine and prone were calculated for each patient and compared using the Wilcoxon test for non-parametric paired samples [25]. A p value <0.05 was considered significant for all statistical tests. Statistical analysis was performed using the SPSS 15.0 program for Windows (SPSS Inc, Chicago, IL, USA).

Results

Between January 2010 and June 2010, ten consecutive patients with diagnoses of breast adenocarcinoma and medium (750–1,500 cc) or large (>1,500 cc) size breasts were included. Table 1 summarizes the patients' features.

All patients underwent partial breast surgery with sentinel lymph node biopsy. One patient with positive sentinel node underwent a complete axillary clearance with no more affected lymph nodes. The histological diagnosis was ductal adenocarcinoma in 8 out of the 10 patients (80 %) and intraductal adenocarcinoma in two cases (20 %). According to the classification by AJCC stage, 2 patients (20 %) were classified as stage 0, 5 patients (50 %) as stage I and 3 patients (30 %) as a final stage IIA [26] (Table 1).

Seven patients (70 %) received systemic chemotherapy, mainly with regimens containing anthracyclines and taxanes, prior to radiotherapy. All patients had tumors positive for estrogen and progesterone receptors and began the hormone treatment at the end of radiotherapy.

Two plans (for prone and supine-positioned image sets) were calculated for each of the ten patients. Tables 2 and 3 list the results obtained for each patient in relation to the selected positioning, both for the PTV and to the OARs. Table 4 shows the results after application of the Wilcoxon test for comparing the medians of the parameters analyzed in each positioning.

PTV (breast)

The median volume of ten breasts included in this analysis was 948.5 cc. (range 730–1,700 cc). PTV coverage, measured by D_{90} and V_{95} was good for both supine and prone positioning, as shown in Table 2. These parameters present a linear relationship, as shown in Fig. 4a. Patient positioning does not alter this association between D_{90} and V_{95}. The results show no significant differences in terms of

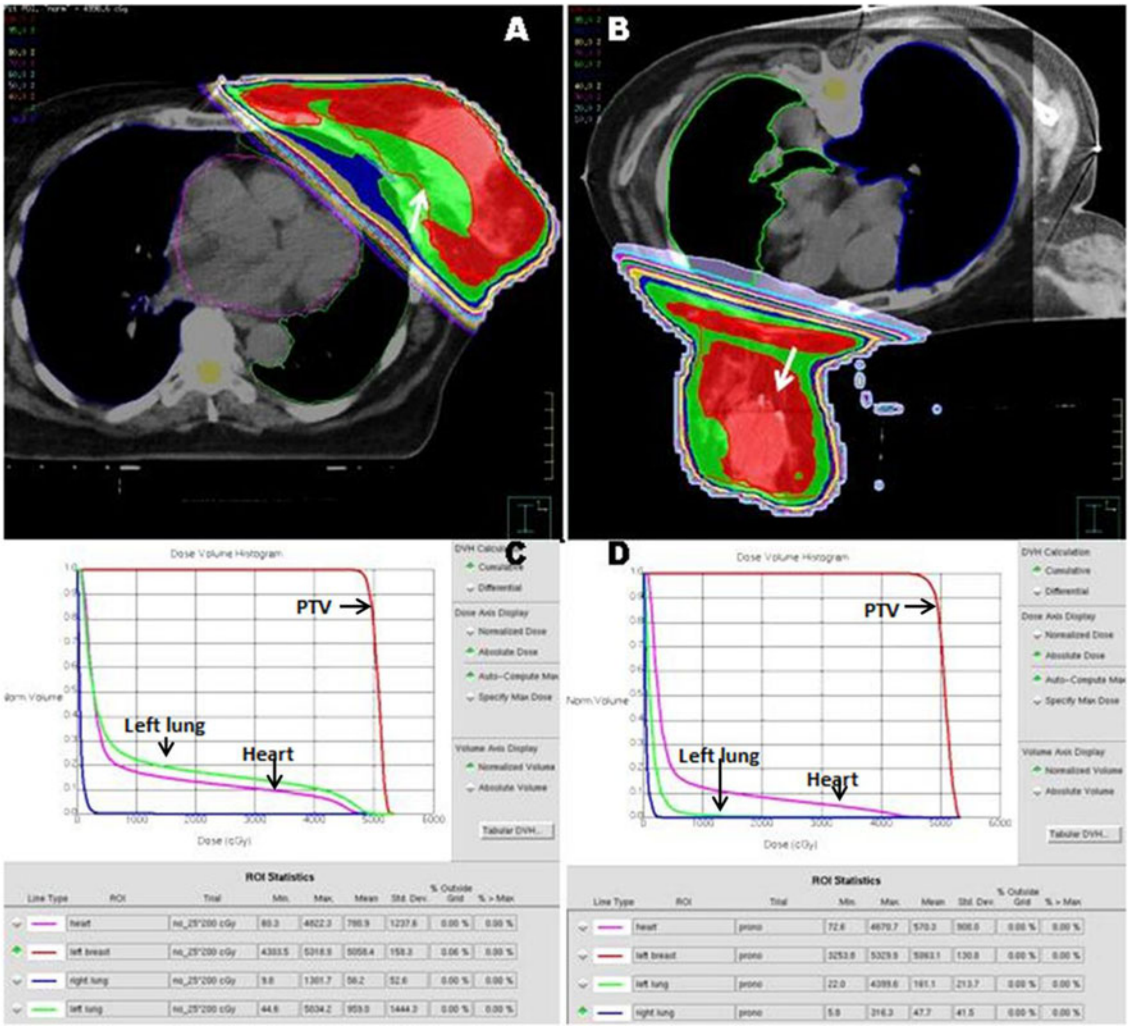

Fig. 2 Dose distributions for a left-breast tumor (**a**, **b**) at the level of surgical bed defined by titanium clips (*arrows*) and the corresponding DVH (**c**, **d**) for supine (*left*) and prone (*right*) positions

homogeneity in the PTV dose achieved by positioning the patient supine or prone ($p = 0.114$). However, the maximum dose (D_{max}) achieved in the breast volume was higher when the patient was positioned supine compared to prone ($p = 0.017$).

OARs sparing

Plans for prone position significantly reduce ipsilateral lung irradiation. Thus, both V_{20Gy} (26.5 ± 11.1 and 2.9 ± 2.9 % for the supine versus prone position) and D_{med_lung} (13.5 ± 5.1 and 3.0 ± 2.5 Gy for the supine versus prone position) were significantly lower for the prone position compared to the traditional immobilization in a supine position ($p = 0.007$ and $p = 0.006$, respectively). Figure 4b illustrates the relationship between V_{20} and D_{med_lung} for supine and prone. Lung sparing was not affected by the achieved PTV homogeneity (Fig. 4c).

Heart V_{35Gy} was significantly lower for the prone position (3.4 ± 3.8 % for supine versus 1.2 ± 2.5 for prone, $p = 0.038$). Although the cardiac median dose (D_{med_heart}) was also lower in the prone compared to the supine position, this difference was not statistically significant ($p = 0.136$).

Finally, overdosage areas outside the breast tissue, estimated according to the $V_{ext\_105\ \%}$, was 0.1 ± 0.3 cc for the prone and 34.2 ± 31.7 cc for supine position (Fig. 5). This difference was statistically significant ($p = 0.012$).

Physical parameters

Both average numbers of segments used in each tangential field as well as average number of MU administered in each treatment were consistently reduced with the prone plan. The mean number of radiation segments (5.3 ± 2.05, range 2–8) for supine plans was significantly higher than

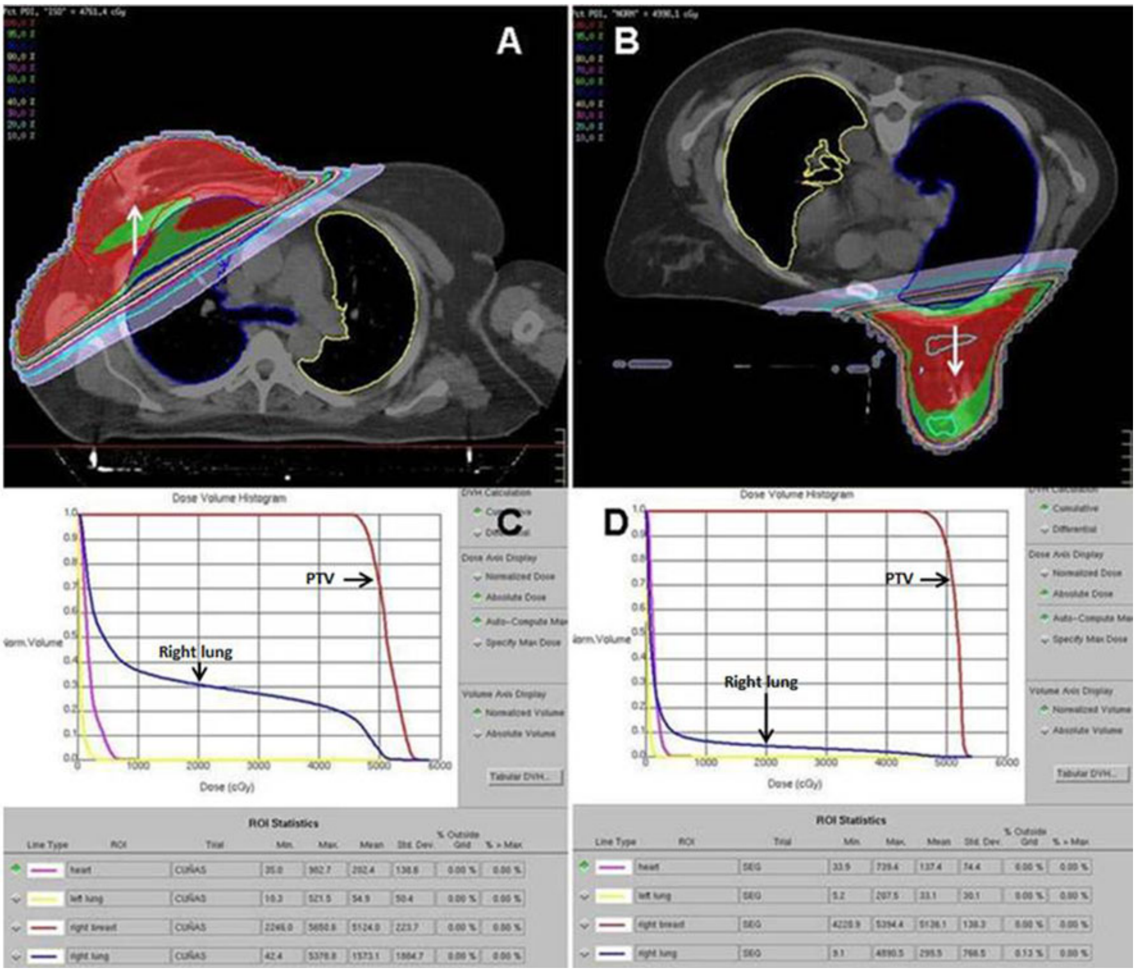

Fig. 3 Dose distributions for a right-breast tumor (**a**, **b**) at the level of surgical bed defined by titanium clips (*arrows*) and the corresponding DVH (**c**, **d**) for supine (*left*) and prone (*right*) positions

those used for the prone plans (4.1 ± 1.5, range 2–6) ($p = 0.042$). The mean total number of MU was 296 ± 92.3 (range 173–464) for the supine plans and 268.8 ± 99 (range 218–543) for the prone plans. The total MU reduction ratio was 11 %.

Discussion

To both improve dose distribution of the irradiated breast and to reduce the toxicity attributable to treatment, some different techniques of breast irradiation have been developed to replace the traditional supine position with prone. Table 5 summarizes the studies published to date on the use of the prone position for radiotherapy after breast conserving surgery.

To test reproducibility of the NYU technique at our institution, we conducted a pilot study of ten patients and report the dosimetric comparison between supine and prone positioning. While the sample size of this study is small and no clinical correlation is provided to verify the impact of the observed dosimetric differences, it is encouraging to notice that we could reproduce the NYU prone approach and confirm the dosimetric benefit of the prone position.

In our series, the target coverage was similar for supine and prone positioning. Gielda et al. described recently their experience with ten patients planned in prone and supine position. No significant differences were found in PTV coverage, with a $V_{95\ \%}$ in breast volume of 89.3 % in prone versus 90.7 % in supine position, and $V_{95\ \%}$ for the nodes volume of 93.8 % in prone and 98 % in supine [27].

We found that the dose distribution in the PTV in the prone position was better than, or at least as, homogeneous as in supine. Reports from larger series of patients have noticed the same trend. Merchant et al., in a study of 56 patients, generated breast dose distributions that were more homogeneous when adopting the prone position. Areas of overdose decreased from 116–118 % in the supine position to 102–103 % in the prone position. The benefit was more evident in patients with very large or pendulous breasts, or deformities of the chest cavity [28, 29]. The same group has published the results observed in 20 patients planned in prone position, either with the tangential-fields technique or with intensity modulated radiotherapy (IMRT). Improved dose homogeneity was found with IMRT, with respect to the conventional technique, especially in patients with bulky breasts, decreasing the maximum dose in treated breast (114–107 %) and overdosed areas (110–105 %, respectively, in 5 % of the PTV) [30]. Griem et al. [31] analyzed the differences between the supine and prone planning in 15 women with localized breast cancer after conservative surgery. The homogeneity of the PTV dose in prone was significantly greater ($p < 0.0074$). Similarly, Mahe et al. reported 35 patients with pendulous breasts in prone position. Three of the patients with morbid obesity were ruled out because it was impossible to maintain posture. The other 32 patients showed acceptable breast dose uniformity without finding areas above 105 % of the prescribed dose at the base of the breast, but dose between 105 and 110 % of the prescribed dose at the apex [32].

The results observed in our series in doses on healthy organs such as lung, heart and extramammary tissue are consistent with the experiences of others. The NYU team reported on the advantages of prone PBI and whole breast radiation in a study that included 91 patients they treated in the prone position with a hypofractionated treatment regimen with concomitant boost [13]. Dose constraints were performed for the ipsilateral lung (V_{20Gy} <10 %) and heart (V_{18Gy} <5 %), proving that the technique was feasible, reproducible, with no worse acute tolerance and respecting the restrictions set out in dosimetric protocol [14, 15]. This group also has studied the feasibility of prone positioning for irradiation of the axilla lymph nodes. In a recent study, Sethi et al. [16] have compared several three-dimensional techniques and IMRT for level III and supraclavicular nodes coverage, and found that the only adequate coverage in prone position was achieved with IMRT. A clinical trial of the same researchers tried to predict individually which patients would be treated optimally in prone and supine. Comparing the CT scans of 400 patients enrolled; they noted that all right-breast patients benefited from the prone treatment position [12]. For the left-breast cancer patients, they measured in prone CT scans the in-field heart volume. When this was <0.1 cc, the prone position was the preferred one for treatment, and when it was >0.1 cc, they developed a model that considers features of heart orientation, distance between heart and tumor, and in-field lung

Table 1 Patients' features

	n (%)
Age (median)	50.5 (range 44–78)
Side	
Left	6 (60)
Right	4 (40)
T	
Tis	2 (20)
T1	6 (60)
T2	2 (20)
N	
N0	8 (80)
N1	2 (20)
Breast volume	
Median	948.5 cc (range 750–1,700 cc)
Medium (750–1,500 cc)	9 (90)
Big (>1,500 cc)	1 (10)
Systemic treatment	
Chemotherapy	7 (70)
Hormone	10 (100)

Table 2 Dosimetry and treatment condition differences for PTV between supine and prone positions

	Volume (cc)	Supine					Prone				
		D_{max} (Gy)	$V_{95–107\ \%}$ (%)	D_{90} (Gy)	$V_{95\ \%}$	RT segments/MU	D_{max} Gy	$V_{95–107\ \%}$ (%)	D_{90} (Gy)	$V_{95\ \%}$	RT segments/MU
1	1,700	55.89	97.4	48.3	95.6	5/421	52.76	98	46.60	87.2	5/543
2	855	54.7	73	49.5	97.2	8/253	55.6	77.8	47.90	91.45	6/244
3	1,083	53.18	99	49.25	99.3	4/173	53	98	49.15	97.40	4/233
4	906	55.84	94	47.40	94.9	2/327	53.94	97	49.40	97.80	2/300
5	750	54.73	95.3	49.50	98.5	7/464	53.7	92	47.80	91.20	5/232
6	903	55.46	95.24	49.85	99.1	2/355	50.76	97.53	49.05	96.40	2/222
7	1,170	54.29	73	49	97.9	6/235	53.69	81	49	97.50	6/237
8	900	53.88	92	48.20	94.3	7/241	53.40	89.4	48.15	92.70	3/229
9	991	55.61	77.2	48.80	95	6/254	53.10	87.8	47.40	89.60	5/230
10	1,092	54.64	85.6	49.80	98.6	6/242	52.92	90.7	47.80	91.10	3/218

Table 3 Dosimetry differences for OAR between supine and prone positions

n	Side	Supine					Prone				
		MLD (Gy)	V_{20Gy} (%)	MHD (Gy)	V_{35Gy} (%)	$V_{105\ \%\_ext}$ (cc)	MLD (Gy)	V_{20Gy} (%)	MHD (Gy)	V_{35Gy} (%)	$V_{105\ \%\_ext}$ (cc)
1	L	18.35	35	7.7	8	92.4	1	0	2.8	0	0
2	L	9.17	18	5.5	5	0	2.4	5	2.7	1	0
3	L	9.6	18	7.8	9	1.2	1.6	0	5.7	3	0
4	R	14.5	29	1.9	0	0	3	5	1.3	0	0
5	R	11	22	1.8	0	70.4	4	8	2.2	0	0
6	L	24	50	1.8	4	20	1.5	0	2.5	0	0
7	L	7.5	13	6.93	8	21.57	1.5	1	6.34	8	0
8	R	17.32	35	2.23	0	55	2.39	5	1.06	0	0
9	R	10.20	18	1.63	0	34.88	3.61	5	1.66	0	1
10	L	14.24	27	9.59	0	47	9.7	0	1.57	0	0

MLD median ipsilateral lung dose, *MHD* median heart dose, $V_{105\ \%\_ext}$ extramammary volume receiving a dose above 105 % of the prescribed dose

Table 4 Comparative analysis (Wilcoxon test) of dose homogeneity parameters for PTV, dose at OAR and number of radiation segments and MU (mean values ± SD)

Breast		Ipsilateral lung		Heart		Extramammary tissue	RT segments/ MU
D_{max}	$V_{95-107\ \%}$	V_{20Gy}	D_{med_lung}	V_{35Gy}	D_{med_heart}	$V_{105\ \%\_ext}$	
Supine							
54.822 ± 0.889	88.174 ± 10.217	26.5 ± 11.167	13.588 ± 5.130	3.4 ± 3.864	4.688 ± 3.132	34.245 ± 31.778	5.3 ± 2.05/ 296.5 ± 92.3
Prone							
53.287 ± 1.203	90.923 ± 7.185	2.9 ± 2.998	3.070 ± 2.525	1.2 ± 2.573	2.783 ± 1.810	0.1 ± 0.316	4.1 ± 1.5/ 268.8 ± 99
$p = 0.017$	$p = 0.114$	$p = 0.005$	$p = 0.005$	$p = 0.066$	$p = 0.047$	$p = 0.012$	$p = 0.042$/ $p = 0.24$

and predicts which ones do not have to undergo the supine CT scan [17].

One of the main limitations to adopting prone breast radiotherapy is the possible uncertainties in patient immobilization and daily repositioning for treatment. The NYU group studied the interfraction and intrafraction set-up variability for prone breast radiotherapy in ten consecutive patients enrolled in a protocol of hypofractionated breast treatment. Using external fiducial markers, and comparing daily portal images with the digitally reconstructed radiographs, the authors concluded that acceptable interfraction and intrafraction variability were observed, confirming the safety of their current requirement of a clinical target volume (CTV) to PTV expansion of 1.5 cm [18]. Huppert et al. [19] analyzed the most common set-up errors for prone position, including incorrect position at planning CT scan, axial rotation of the patient when prone, and incorrect breast volume definition. Other institutions with less experience in the prone set-up reported greater set-up errors in prone position compared with supine position [33].

We concentrated on developing this technique for women with large breast size, a setting where dose homogeneity is often difficult to achieve. McKinnon et al. reported results for 40 patients with large pendulous breasts. The authors observed a significant decrease in the median dose to the ipsilateral lung compared to historical series treated in supine position (lung mean maximum dose 5.4 Gy, lung mean dose 2.4 Gy) [34]. Kurtman et al. analyzed the results in five patients comparing supine versus prone position. Average dose reduction was found for the ipsilateral lung (8.3 and 1.4 Gy in supine and prone respectively, $p < 0.043$) and heart (4.6 and 3.6 Gy in supine and prone respectively, $p < 0.079$) [35]. Griem et al. also analyzed doses to the OAR. The ipsilateral lung V_{10} and V_{20} were significantly lower in the prone position ($p < 0.001$). There were no significant differences in heart volume irradiated between the planning done in prone and

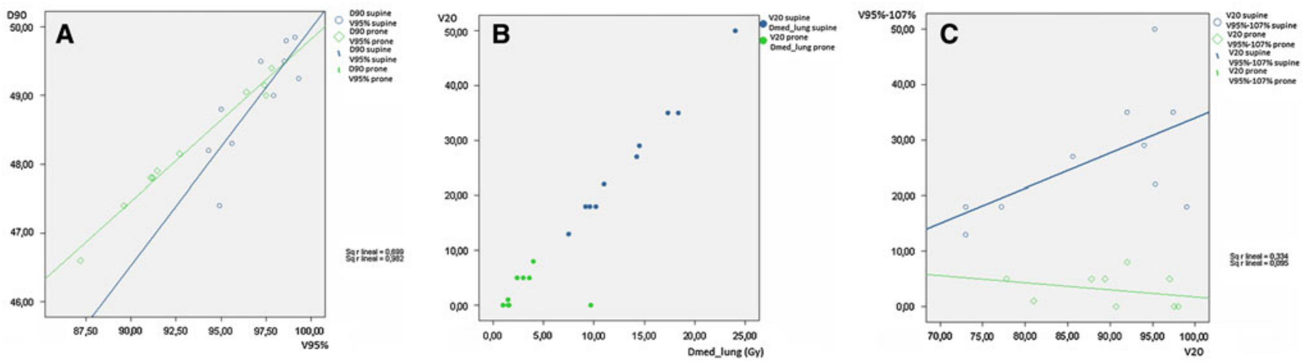

Fig. 4 Comparative relationships for supine versus prone between: **a** D_{90} and $V_{95\ \%}$ for supine (*circle*) and prone (*square*); **b** V_{20} (lung) and $D_{\mathrm{med\_lung}}$ for supine (*blue circle*) and prone (*green circle*) positioning and **c** V_{20} (lung) and $V_{95\text{–}107\ \%}$ for supine (*circle*) and prone (*square*) positioning

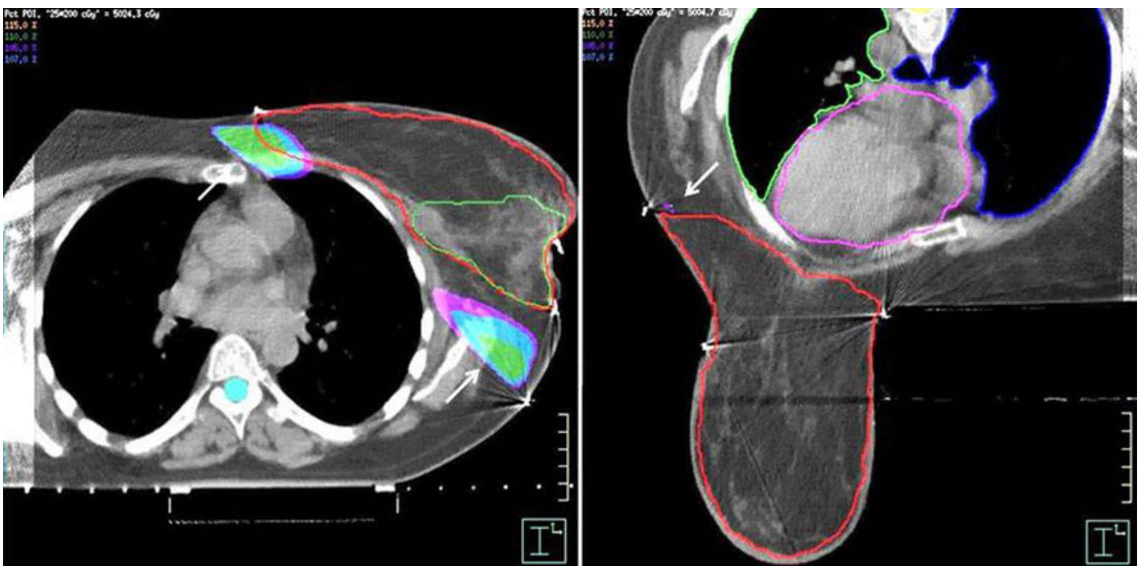

Fig. 5 Volume of out of breast tissue receiving a dose above 105 % (Vext_105 %) of the prescribed dose for supine (*left*) and prone (*right*) positions

supine [31]. Similarly, Veldeman et al. described their experience in 18 patients treated in prone position lateralized with intent to avoid irradiation of the contralateral breast and the heart, using a commercial breast immobilization system. A significant decrease in both heart volume ($V_{20\mathrm{Gy}}$ 1.4 % supine vs. $V_{20\mathrm{Gy}}$ 3.4 % prone, $p < 0.01$) and ipsilateral lung irradiated (0.7 % prone $V_{20\mathrm{Gy}}$ supine vs 8.3 %, $p < 0.00001$) was observed [36]. Gielda et al. reported a dosimetric comparison for a three-field mono-isocentric technique planned in supine versus prone in ten patients. For the eight patients with left-side tumors, no differences were found in cardiac doses for both techniques. However, lung V_{20} in prone position was 21.2 versus 9.3 % for supine ($p < 0.0001$) [27]. In a recent paper, Kirby et al. [37] reported a comparison between prone and supine positioning in 65 patients. The authors find for prone positioning a reduced ipsilateral lung mean dose for all the cases and statistically significant reduction of cardiac doses in women with larger breast size (>1,000 cc).

Finally, in our experience, prone showed an advantage over supine positioning in terms of number of MU needed for treatment delivery. The multisegment approach used for treatment plan resulted in increased PTV homogeneity. However, both the total treatment delivery time and the number of MU increased considerably for the supine positioning. Growing concern exists regarding the association between the number of MU and the risk of radiation-induced malignancies probably related to the volume of healthy tissue receiving low radiation doses [38–40]. NYU showed, in a comparison between three-dimensional conformal radiation and IMRT, that the 3-D technique is

Table 5 Comparison of published trials of prone position for breast radiotherapy

References	*n*	Study objectives	Inclusion criteria	Observed results
Merchant and McCormick and Grann et al. [28, 29]	56	Prone treatment	Breast irradiation exclusive	Improve dose homogeneity for breast; improve DVHs for pendulous breast. Good cosmetic results
Mahe et al. [32]	35	Prone treatment	Big size (≥95C cup) and/ or pendulous	The position is easily reproducible. PTV coverage correct
Kurtman et al. [35]	5	Planning comparison prone versus supine	Moderate to big breast	Significant improve lung DVH, no differences for heart
Griem et al. [31]	15	Planning comparison prone versus supine	Breast irradiation exclusive	Significant improve lung DVH, no differences for heart. Improves breast homogeneity
Goodman et al. [30]	20	Tangentials versus IMRT in prone	Big breast, smoking history, patient wishes	Improve breast homogeneity with IMRT
Formenti et al. [13]	50	Partial breast irradiation in prone	Postmenopausal T1N0	Good lung and heart DVH
Formenti et al. [14]	91	Hypofractionated radiation in prone	Breast irradiation exclusive	Improve lung and heart DVH
McKinnon et al. [34]	36	Prone treatment	Big or pendulous breast	Improve lung and heart DVH; improves breast homogeneity
Sethi et al. [16]	12	Axillary coverage in prone, 3DvsIMRT	Breast irradiation	Inadequate coverage in prone in 3D, adequate IMRT
Mitchell et al. [18]	10	Interfraction and intrafraction set-up variability for prone position	Accelerated hypofractionated whole breast irradiation	Acceptable interfraction and intrafraction set-up variability
Veldeman et al. [36]	18	Planning comparison prone versus supine	Breast radiation exclusive	Improve lung and heart DVH; improves breast homogeneity
Gielda et al. [27]	10	Planning comparison prone versus supine	Breast and nodal irradiation	Adequate PTV coverage. Improve lung DHV in prone
Kirby et al. [37]	65	Planning comparison prone versus supine	Partial or total breast irradiation	Improve lung DVH; improve heart DVH for big breast
Hardee et al. [41]	100	Planning in prone 3D versus IMRT	Hypofractionated breast irradiation	3D adequate for no boost patients
Fernández-Lizarbe (2011, Current series)	10	Planning comparison prone versus supine	Breast radiation exclusive	Improve lung and heart DVH

NS not specified, *DVH* dose-volume histogram, *PTV* planning target volume

adequate when no concomitant boost irradiation for tumor bed is going to be applied [41].

Conclusions

In conclusion, radiation treatment planning in either position, prone or supine, allows obtaining an adequate PTV coverage with good homogeneity. Dosimetric analyses show a decrease of doses in the OAR using the prone position. This technique offers an alternative for radiotherapy of the breast in patients with large or pendulous breasts requiring breast-only irradiation after surgery. Moreover, although its real value has yet to be proven, integral dose to the normal anatomy, as measured by the number of MU, is lower for prone irradiation. Further studies to measure treatment reproducibility are ongoing, testing our dedicated immobilization devices with daily measurements by cone-beam CT based IGRT.

Conflict of interest All the authors declare no conflict of interest regarding any aspect reflected in the manuscript.

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