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SHORT COMMUNICATION

Breast radiotherapy in women with pectus excavatum (funnel chest): is the lateral decubitus technique an answer? A dosimetric study

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ABSTRACT. Breast radiotherapy is a technical challenge in women with pectus excavatum. We aim to assess isocentric lateral decubitus (ILD) technique as a means to irradiate breasts for patients with pectus excavatum. Four women presenting with left-sided breast cancers and found to have pectus excavatum were offered breast-conserving treatments. Post-operative breast radiotherapy was indicated (50 Gy) in two patients, with an additional boost to the tumour bed (16 Gy). Both ILD and supine techniques were simulated. We report the dosimetric comparison of these techniques and the acute skin toxicity of ILD radiotherapy. ILD permitted the same breast dose-homogeneity as the supine technique while decreasing breast thickness by 4.5–6.8 cm. The width of lung and/or heart receiving $>$ 20 Gy ranged between 2.1 cm and 4.3 cm with the supine technique and between 0.5 cm and 1.1 cm with ILD. The estimated percentage of ipsilateral lung receiving $>$ 20 Gy ranged from 21% to 34% with the supine technique and from 0% to 5% with ILD. Acute skin toxicity was scored 1 for all patients at completion of ILD radiotherapy. ILD is an effective breast radiotherapy technique for patients with pectus excavatum that preserves the underlying heart and lung from unnecessary toxicity.

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Breast conserving treatment is considered as standard management for early-stage breast cancer when technically feasible. Post-operative radiotherapy to the breast is an important part of the treatment and has been shown to significantly diminish the rate of local relapse, the rate of breast cancer mortality and the risk of overall mortality [1]. However, the irradiation of normal tissues, especially of the underlying lung and left ventricle, can lead to lethal complications explaining the increase in non-cancer related deaths. The risk of late toxicities such as radiation-induced pneumonitis or coronary morbidity has been related to the volume of, respectively, underlying lung and left ventricle receiving a dose higher than 20–25 Gy [2–4].

The standard breast radiation technique uses tangential fields delivered to the breast in a supine position [5]. In the case of women presenting with pectus excavatum, a congenital deformation of the anterior chest wall leading to a deep depression of the sternum, also described as funnel chest, this supine technique exposes too much of the underlying lung and/or left ventricle in the treatment fields. To try and comply with the two contradictory breast radiotherapy requirements of breast dose homogeneity and lung/heart preservation presents a particularly difficult technical challenge that, up to now, has been dealt with by using sophisticated three-dimensional, intensity-modulated radiotherapy (IMRT) or proton therapy techniques [6–8]. In this study we present a convenient solution: the isocentric lateral decubitus technique (ILD). Breast irradiation in the lateral decubitus set-up was originally developed for women with large, pendulous breasts and has been used to treat thousands of patients [9]. The need to comply with modern requirements has prompted our department to adapt the technique to an isocentric set-up as described by Campana et al [10]. To ensure a good reproducibility of position, the alignment of the patient is verified by using laser projections marked on the patient's skin. The position of the epoxy breast-support is also marked on the patient's skin. Day-to-day reproducibility is verified using the distance from the top of the treated breast to the corner of the epoxy breast-support. Portal imaging controls are regularly performed.

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Methods and materials

Four women presenting with cancer of the left breast and found to have pectus excavatum were offered breast-conserving treatments at the Institute Curie from October 2002 to September 2004. Surgery consisted of

lumpectomy with either axillary lymph node clearance or sentinel node excision. Breast irradiation alone was indicated (50 Gy at ICRU point in 25 fractions over 5 weeks) with, in the cases of patients A and B who were younger than 50 years old at the time of diagnosis, an additional boost to the tumour bed (16 Gy at ICRU point in 8 fractions over 1.5 weeks). The breast ICRU point was located at the central slice at the mid-bridge for tangents [11, 12].

Both ILD and supine breast radiation techniques were evaluated at the time of simulation in order to decide on the optimal treatment using dose distribution as a criterion.

For practical reasons we decided to focus our interest on the whole-breast irradiation, common to the four patients.

Full descriptions of the ILD technique and the supine technique can be obtained in the articles of Campana et al and Perez et al, respectively [5, 10]. They both comply with the recommendations of the EORTC quality assurance in conservative treatment of early breast cancer [13]. A schematic presentation of the ILD technique is reproduced in Figure 1. For illustrative purposes Figure 2 shows patient A in both the supine (Figure 2a) and the ILD (Figure 2b) positions. In short, the ILD technique consists of treating a patient in a lateral decubitus position with the treated breast resting on an individually chosen breast support made of a thin layer of carbon fibre and the contralateral breast brought upwards, out of the field, by elastic straps.

For both techniques we used a simulator – CT (Varian Ximascan) to produce localization films of the fields and at least three CT slices, *i.e.* one at the central beam axis and one in each mid-field (z=0; z=+25% of the field size; z=–25% of the field size). The CT images were transferred to the ISIS 3D treatment planning system. After having checked the position of the beams, dose distributions were calculated, without heterogeneity correction, using either 60-cobalt (source–axis distance (SAD) 80 cm) or 4 MV X-ray (SAD 100 cm). Whenever needed, standard wedges were added in order to obtain the best possible dose distributions for both techniques.

Measures on CT slices were done with the ISIS 3D measurement tool. The breast thickness was defined as the distance between the entry and the exit points of the fields at the central axis. The width of lung and/or left ventricle that received a dose equal to or higher than 20 Gy was measured on all CT-scan slices, on an axis perpendicular to that of the lateral field (Figure 3a). Figure 3 shows an example of two CT-scan slices from the same patient (patient B) in both the supine technique (Figure 3a) and the lateral decubitus technique (Figure 3b). The central lung distance (CLD) was measured in centimetres as the perpendicular distance from the field edge to the posterior part of the anterior chest wall at the centre of the field (Figure 4) [14]. The maximal heart distance (MHD) was measured in centimetres as the maximal width of heart in the tangent fields (Figure 4) [15]. The percentage of the ipsilateral lung volume and of heart receiving 20 Gy or more, known respectively as IPV20 and HV20, were estimated using Kong's formulae [15]:

$$\mathrm{IPV20}\,(\%) = 9.8 \times \mathrm{CLD}\,(\mathrm{cm}) - 4.9$$

$$\mathrm{HV20}\,(\%) = 6.1 \times \mathrm{MHD}\,(\mathrm{cm}) - 1.3$$

The acute skin toxicity of the breast alone radiotherapy was assessed on the last day of treatment (50 Gy for patients C and D and 66 Gy for patients A and B) and scored according to the Radiation Therapy Oncology Group (RTOG) acute radiation morbidity scoring criteria [16].

Results

Dosimetry study

Both techniques fulfilled the recommendations of the ICRU 62 report with a dose heterogeneity in the planning

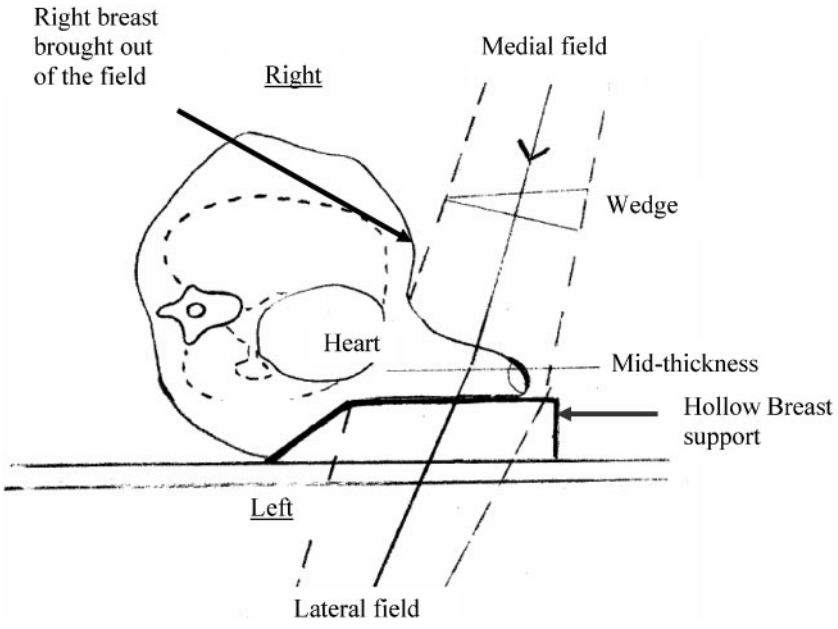
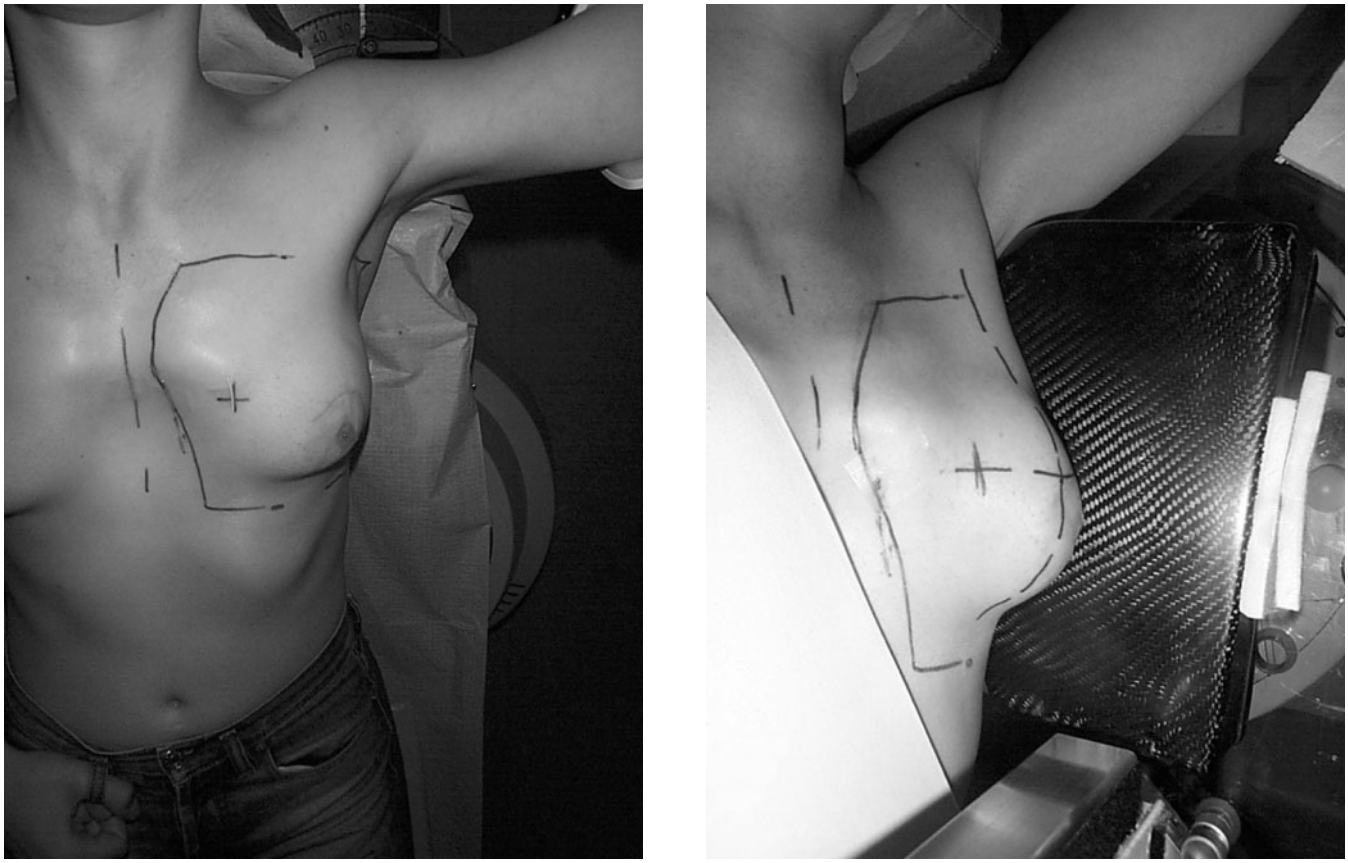


Figure 1. Schematic presentation of the isocentric lateral decubitus (ILD) technique for radiotherapy of the left breast.



(a) (b)

Figure 2. Pictures of the same patient with pectus excavatum at simulation in both (a) the supine and (b) the lateral decubitus set-ups.

target volume within a range corresponding to 95–107% of the prescription dose. In the case of patient D, the dose coverage of the breast with the supine technique was optimal when only 48 Gy were prescribed at the ICRU point in 24 fractions.

Breast thickness ranged between 3.6 cm and 6.4 cm with the ILD technique and between 9.4 cm and 12 cm with the supine technique.

The internal tangent fields' simulation films of both techniques are shown in Figure 4. An overview of the results of the dosimetry study is reported in Table 1. The central lung distance ranged from 2.6 cm to 4 cm with the supine technique and from 0 cm to 1 cm with the ILD technique. The estimation of ILV20 ranged from 21% to 34% with the supine technique and from 0% to 5% with the ILD technique. The maximal heart distance ranged between 0 cm and 1.7 cm and the estimation of the HV20 from 0% to 9% with the supine technique. They were both zero with the ILD technique.

The maximal width of lung and/or left ventricle that received 20 Gy or more ranged between 2.1 cm and 4.3 cm with the supine technique and between 0.5 cm and 1.1 cm with the ILD technique.

Acute toxicity

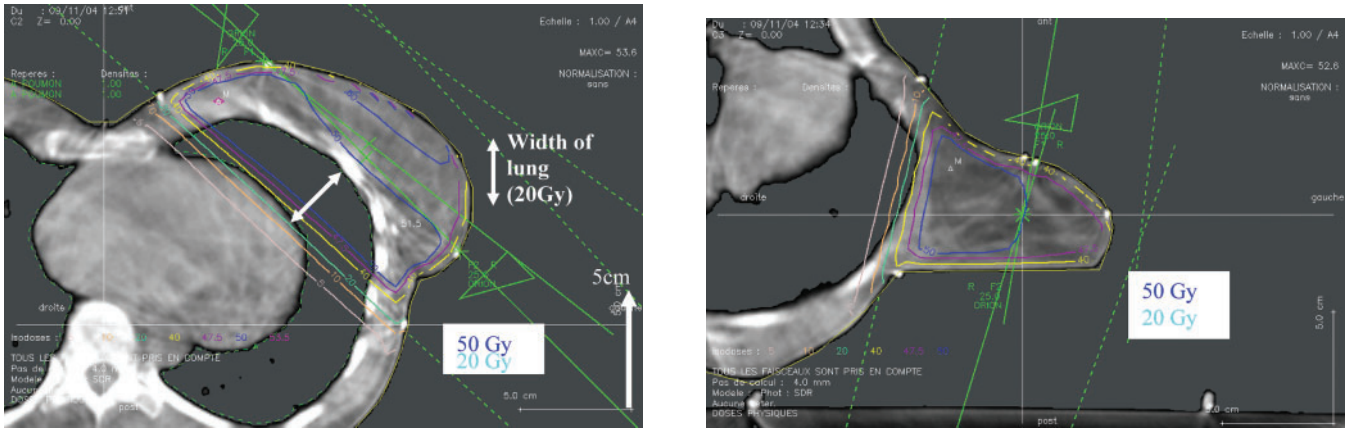
No patient needed to have her radiotherapy suspended.

Acute skin toxicity at the completion of treatment was mild and scored 1 (RTOG) for all four patients.

Discussion

Breast conserving treatments for breast cancers can sometimes be denied to women with pectus excavatum, where radiotherapy would involve too high a risk of pulmonary or cardiac toxicity.

As previously discussed, the ILD is a simple, reproducible breast irradiation technique that can easily be implemented in radiotherapy departments [10]. More than 500 patients have already been treated using this technique in our centre. Most often, this technique was decided on in the case of patients with large pendulous breasts who needed breast alone irradiation. In this study, we address the possibility of using this technique for women with pectus excavatum who need breast-alone irradiation. We performed dosimetric studies on four women and report here the acute toxicity of this technique. Because the set-up device we used was too cumbersome to fit into our dosimetric CT-scan, we could not perform whole lung and heart scanning and thus dose–volume histogram comparisons were not available. We could nevertheless perform a number of CT slices that accurately reflected the dosimetry of both the supine and the ILD breast radiotherapy techniques. In addition, we used the two-dimensional information available from the simulation field to estimate the percentage of the ipsilateral lung and heart receiving 20 Gy or more [15]. The formula we used was generated by Kong et al from data of 40 patients simulated for breast radiotherapy (22 left side) in a supine position with a prescribed dose of



(a) (b)

Figure 3. CT-scan slices at the level of the central axis (z=0) of the same patient with pectus excavatum taken in (a) the supine and in (b) the lateral decubitus set-ups. Dosimetry of whole-breast radiotherapy was made for a prescribed dose of 50 Gy at mid-thickness using 4 MV photons.

46.8 Gy at the central slice at the mid-bridge for tangents. This formula is to be handled with caution when it comes to estimating the lung and heart volumetric doses in our patients. First, because we prescribed 50 Gy, *i.e.* 7% more than in Kong et al series. Second, because this formula was not meant to be applied to ILD. We assumed that, if anything, the results using this formula would underestimate the difference between the supine and the ILD techniques in terms of volumes of lung and heart receiving 20 Gy or more as the craniocaudal lengths of either lung or heart within the simulation field were diminished in the lateral position (data not shown).

Pectus excavatum is a rare condition and therefore this study suffers from a small number of patients making a formal statistical comparison of the two techniques inappropriate. We can nevertheless observe that, as expected, the change of position from the supine to the lateral decubitus position, with the breast spread out on an individually chosen dedicated breast support, made the thickness of breast smaller by 41–62% and thus also made the dose in depth more homogeneous. The breast took the shape of a parallelogram making it easier to obtain a homogeneous dose with the use of a single wedge (Figure 3b). The most important benefit is that the breast

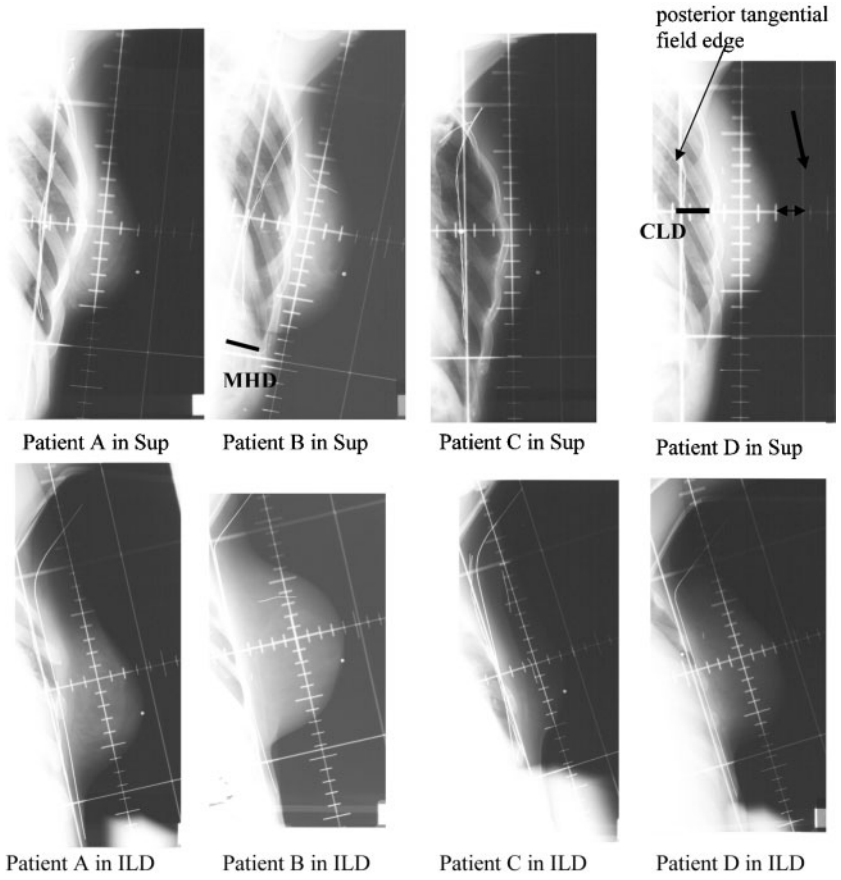


Figure 4. Simulation films of the internal fields of the four patients presenting pectus excavatum both with the isocentric lateral decubitus (ILD) and the standard supine (Sup) radiotherapy techniques. Each graduation represents a centimetre. Central lung distance (CLD) is the perpendicular distance from the tangential field edge to the posterior part of the anterior chest wall at the centre of the field. Maximal heart distance (MHD) is the maximal width of heart in the fields.

Table 1. Dosimetric study comparing the isocentric lateral decubitus (ILD) and the supine breast radiotherapy techniques in four women presenting with pectus excavatum. Dosimetries of whole-breast radiotherapy were made for a prescribed dose of 50 Gy at mid-thickness using either 60-Cobalt gammas or 4 MV photons

Patient	Breast thickness (cm)		Central lung distance (cm)		20 Gy ipsilateral lung volume (%)		Maximal heart distance (cm)		20 Gy heart volume (%)		Maximal dose to breast (Gy)	
	Supine	ILD	Supine	ILD	Supine	ILD	Supine	ILD	Supine	ILD	Supine	ILD
A	10.9	6.4	2.6	1.0	21	5	0.0	0.0	0	0	52	52
B	12.0	5.2	4.0	0.0	34	0	1.7	0.0	9	0	54	53
C	9.4	3.6	3.2	0.0	26	0	0.0	0.0	0	0	53	52
D*	11.4	5.6	2.7	0.4	22	0	0.8	0.0	4	0	54	52

*For the dosimetry study of this patient, we chose to reduce the prescribed dose to 48 Gy in 24 fractions with the supine technique in order to keep the maximum dose below 54 Gy (this patient has however been treated with the ILD technique to a total dose of 50 Gy in 25 fractions).

tissue is located at a greater distance from the chest wall, making it easier to encompass the whole breast within the radiation field without taking in any of the heart and less than 1 cm of the underlying lung. The resultant estimated percentage of ipsilateral heart and lung are thus reduced to a maximum of 0% and 5%, respectively. In contrast to this, the standard supine position had central lung depths of at least 2.5 cm resulting in the estimated volume of lung receiving 20 Gy always being greater than 20%. The protocols in use at the Institut Curie define the maximum depth of lung and/or left ventricle receiving greater than 20 Gy to be 2 cm, thus the standard supine technique would be unacceptable.

IMRT has been proposed as a means to decrease the volume of the ipsilateral lung receiving a radiation dose that is above the tolerance threshold [6, 7]. Fogliata et al have suggested that three-field conformal radiotherapy technique permitted a reduction of the ipsilateral lung volume receiving more than 20 Gy from 24% with two-field tangential treatment to less than 20%. This reduction was the same whether using IMRT or not [8]. The drawback of IMRT and the 3D conformal technique described by Fogliata et al, contrary to the ILD technique, is that it increases the volume of surrounding normal tissues (the heart, spinal cord, and contralateral breast and lung) receiving low-dose irradiation compared with the supine technique [6]. The other advantage the ILD technique has over a three-dimensional radiotherapy approach is its cost-effectiveness, both financially and time-wise. However, we have to bear in mind that the ILD technique is not designed to treat the breast in the case of a treatment with radiotherapy to the lymph node bearing areas; in such cases, IMRT with or without active breathing control, or even proton therapy [8], could be considered.

The acute skin toxicity of the ILD technique was good, with no need for a suspension of treatment and only a grade I RTOG skin toxicity in all of our four patients of whom two were treated with a boost of up to 66 Gy.

Conclusions

The ILD technique is an easy, cost-effective means to offer breast preservation to patients with pectus excavatum, without exposing the underlying heart and, more particularly, ipsilateral lung to unnecessary toxicity.

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