Material and Methods: After mastectomy with level II axilla dissection, IMN radiation was considered only in medial or central quadrant disease with axilla involvement.

Between June 2000 and November 2002, 203 patients receiving post surgery chest wall radiation (50 Gy/25 fractions/5 wks), were randomized (after informed consent) to: Arm I – receiving additional IMN radiation (n = 94; left breast: 43) and Arm II – no IMN radiation (n = 109; left breast: 55). All patients received 6 cycles of FAC chemotherapy.

CT-based planning was done for each patient to optimize IMN coverage. Volume of heart irradiated and the volume of heart receiving 5 Gy **(V5)** were estimated individually from integral DVH. Maximum heart distance **(MHD)** was measured for majority.

All patients were monitored with ECG, Chest X-ray, Echocardiogram at the start of radiation, on completion and then 6 monthly. TMT and 24 hr. Holter monitoring were performed in selected cases.

Results: After a median follow up of 72 months, 4 had chest wall recurrence – 2 of who received IMN radiation. IMN recurrence was observed in none, whether they received IMN radiation or not.

Regarding cardiac effects, 2 patients of Arm I developed constrictive pericarditis. 3 had LV dysfunction (estimated by EF < 50%) and 3 developed congestive failure – all belonged to Arm I with left sided disease. No toxicity was noted in 55 left breast cases of Arm II ($p < 0.001$). So significant late cardiac effect was observed in 8/43 left breast IMN-treated and in 0/55 left breast IMN-not treated cases ($p < 0.001$). It was absent in right breast patients, even if IMN treated. DVH analysis revealed 50% of heart volume was exposed to 22−25 Gy in Arm I vs. 8−10 Gy in Arm II with left sided disease. MHD ranged between 1.87 and 2.9 cm.

Conclusion: In centers without IMRT or 3DCRT facility, addition of IMN portal is not justifiable at least in left breast cancer, even with axilla positive medial quadrant disease, as it may invite fatal late cardiac toxicity without any additional gain in loco-regional control.

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Prone position breast irradiation for women with larger or pendulous breasts: an intensity modulated radiotherapy (IMRT) planning study

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Background: Supine position breast radiotherapy is most commonly used for whole breast radiotherapy in patients treated with breast-conserving therapy for early breast cancer. In women with larger and/or pendulous breasts, this technique can cause increased dose inhomogeneity and hot spots to skin fold areas, with, as a result, increased skin toxicity and impaired cosmetic outcome. In prone position, with the breast hanging free from the thoracic wall, skin folds can be eliminated and field separation could be reduced. We aimed to evaluate prone position breast radiotherapy by means of a CT planning study.

Materials and Methods: A pilot study was performed including 15 women with large or pendulous breasts. All women had a CT scan in supine and in prone position. The patients were treated conventionally, in supine position. Opposed tangential beam arrangements were set up in both positions. For each position, both a conventional 3D plan and an IMRT plan was developed. Breast coverage, dose homogeneity, and dose to the lung and heart were compared.

Results: In prone position, skin folds can be adequately eliminated. The mean field separation in supine position was 24.7 cm (range 21.5−28.2 cm); this was reduced to 20.8 cm (range 16.2−24.6 cm) in prone position. In prone position, the breast tissue could be adequately covered, but the conformal radiotherapy plan caused underdosage in the medial part of the breast, whereas with IMRT, a homogeneous dose could be obtained. The percentage of the breast receiving >95% of the dose was 93%, 95%, 89% and 96%, for supine conventional, supine IMRT, prone conventional and prone IMRT plans, respectively.

In prone position, the dose to the ipsilateral lung was reduced compared with the supine position (average dose 6.02 Gy, 6.47 Gy, 1.20 Gy, 1.53 Gy for supine conventional, supine IMRT, prone conventional and prone IMRT plans, respectively). The dose given to the heart in prone was similar to that in supine position.

Conclusions: Prone position breast radiotherapy is a feasible technique for women with pendulous breasts, if IMRT is used. With this technique a homogeneous dose to a larger breast can be given, and skin folds are eliminated thereby reducing the risk of epidermolysis. Also, the irradiated lung volume is reduced compared with supine breast irradiation. The dose delivered to the heart is similar in both positions due to the heart moving anteriorly in prone position.

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Treatment position verification in tangential breast irradiation

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Purpose: As part of a joint study to improve heart sparing during whole breast irradiation the Leiden University Medical Centre and Medical Centre Haaglanden have prospectively investigated inter- and intra-fraction variability during tangential breast irradiation.

An important part of this study consists of a precise registration of the 3-D variability of the treatment position verification. By correction of the patient variation we hope to determine an optimal CTV (Clinical Target Volume) – PTV (Planning Target Volume) margin.

Methods and Materials: A combination of anatomical structures and 5 skin markers have prospectively been used to quantify changes in all directions. During the whole treatment period electronic portal movies of 26 patients were taken (± 4 frames) two days a week. This enabled us to quantify the degree of both intra- and interfraction variability. We also investigated changes in patients having lifted either one arm or both arms during irradiation.

Results: The mean value of the intrafraction variability (n = 91), for marker as well as for anatomical match, is less than 2 mm (SD 1 mm).

The interfraction variability for patients with one arm (n = 84) and two arms (n = 105) lifted is shown in the table.

	Skin markers								Anatomical structures							
	Horizontal				Vertical				First EPI as ref. image				DRR as ref. image			
	Cran	Caud	Med	Lat	Cran	Caud	Med	Lat	CLD	CCD	MHD	BD	CLD	CCD	MHD	BD
1 arm																
μ:	−1.0	−0.8	−2.5	−1.9	0.7	1.7	−1.4	1.7	0.0	0.1	−0.6	−0.6	2.7	−2.3	2.1	2.6
Σ:	2.7	3.1	3.1	5.2	3.9	4.0	5.1	5.6	2.5	2.4	2.7	2.7	3.0	3.9	2.3	4.9
σ:	2.2	2.6	3.3	2.9	2.8	3.0	2.9	3.0	2.0	2.5	3.2	3.2	2.0	2.6	3.1	2.1
2 arms																
μ:	0.4	0.0	0.4	−0.4	0.3	0.8	0.6	−0.1	−1.4	−0.2	−1.4	0.2	0.2	−1.0	−0.7	1.5
Σ:	2.2	2.0	3.0	3.5	4.0	3.0	3.3	6.1	2.2	2.5	2.8	1.9	3.5	2.7	2.0	4.3
σ:	2.1	3.2	2.5	3.7	2.9	2.0	2.1	3.4	2.2	2.1	2.2	1.8	2.2	2.2	2.2	1.8

μ = mean of means; Σ = SD of means; σ = mean of SD; CLD = Central Lung Distance; CCD = Cranial Caudal Distance; MHD = Max. Heart Distance; BD = Breast Depth.

Conclusion: Our results point out that the intrafraction variability is limited: <2 mm. For the interfraction variability a difference appears in the patient outline between the DRR and EPI, and that μ doesn't correspond.

A potential pitfall for clinical use of the marker data is the recurring diversity in marker placement from day to day. There is no correlation between the movement of the skin markers and the anatomical structures, both visualised on the EPI.

The data enabled us to analyse the patient variability and develop a position verification protocol. Thus we were able to determine the optimal CTV-PTV margin for breast irradiation in our institute.

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Prone versus supine breast irradiation in early stage breast cancer patients

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Introduction: External beam radiotherapy for breast cancer patients is necessary after breast conserving therapy. Volume of breast tissue which needs to be irradiated is close to critical structures such as lung, heart; therefore an alternative prone position could be used to improve dose homogeneity during radiotherapy. The purpose of this study was to compare dose distribution within target and normal tissue volumes between two radiotherapy plans in prone and supine position in women with large and small breasts.

Material and Methods: 35 early breast cancer patients in clinical stage T1−2N0 were treated with breast conserving therapy and were dedicated for further radiotherapy. Planning CT was performed in a prone and supine position and two treatment plans for each patient were developed using conventional tangents technique. Dose volume histograms were produced and plans were compared with regard to dose volumes parameters.

Results: The mean doses to the target volume were (50.9±0.59 Gy for supine position and 50.3±0.81 Gy for prone position), minimum dose (39.2±4.1 Gy vs. 40±5.4 Gy) and maximum dose (54.9±0.76 Gy vs. 54.3±1.0 Gy), the dose in 95% of PTV was significantly higher in supine compare to prone position (48.4±1.05 vs. 47.1±1.34). The percentage of ipsilateral lung receiving >5, 10 and 20 Gy were significantly higher in supine position compare to prone position. Furthermore, the maximum and mean dose to the ipsilateral lung and heart was lower in prone position compare to supine position.

Conclusion: Irradiation of patients in prone positions compare to supine positions did not improved dose distribution within target volume. Using plans generated in prone position we were able to reduce the dose to the organ at risk especially ipsilateral lung and heart.

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Titanium clip placement to allow accurate tumour bed localisation following breast conserving surgery – audit on behalf of the IMPORT Trial Management Group

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Background: Accurate tumour bed (TB) localisation is a key requirement for the national IMPORT LOW (Intensity Modulated Partial Organ Radiotherapy) trial testing risk-adapted radiotherapy (RT). We audited the use of titanium clips for TB localisation in breast RT planning.

Methods: Audit standards were set as follows: (i) 5/6 pairs of clips identified on RT planning computed tomography (CT) scan – 100%; (ii) possible clip migration – <10%; (iii) TB localisation improved with clips – >50%. At surgery, paired clips were positioned around the TB as follows: 1. Medial, lateral, superior & inferior: half-way between skin & fascia; 2. Deep: midpoint, usually the pectoral fascia (posterior); 3. Anterior: close to the suture line, avoiding skin dimpling. 30 consecutive patients with clips inserted were audited at the time of the RT planning CT scan.

Results: The median time from surgery to RT planning CT was 29 days (range 17 to 98 days). The TB could be successfully identified using CT seroma alone in only 8/30 (27%) patients. However, the titanium clips gave additional information for the remaining cases, and thus improved TB localisation around 22/30 (73%) of patients. There was no evidence of clip migration in any of the cases. TB localisation modified field borders in 18/30 (60%) patients. 5 of these patients had clearly defined seromas, so the addition of clips modified field borders in 13/30 (43%) patients (7 left and 6 right breast cancers).

Conclusion: Titanium clips provide an accurate and reliable method of TB localisation. The CT seroma cannot be used alone for TB localisation in the majority of patients. Accurate TB localisation is important for standard whole breast radiotherapy, as well as being essential for planning the RT boost and for partial breast RT. We anticipate that the audit results will lead to clips being adopted as best practice by the Association of Breast Surgeons at BASO (British Association of Surgical Oncology).

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A multidisciplinary approach to boost the breast tumor bed in 8 phases

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Purpose: To describe a new procedure for breast radiotherapy (RT) that will improve tumor bed localization and RT treatment using multidisciplinary approach.

Patients and methods: This pilot study was conducted by the department of radiation oncology, surgery and radiology. A new procedure has been implemented summarized into 8 phases from pre-surgery contrast CT to surgery, tumor bed planning treatment volume (PTV) determination and lastly breast and tumor bed irradiation.

Results: Twenty patients (pts) presenting T1N0M0 tumors were enrolled in the study. All patients underwent lumpectomy with the placement of surgical clips in the tumor bed region. During the surgery, 1 to 5 clips were placed in the cavity of lumpectomy before the plastic procedure. All patients underwent their pre- and post operative CT scan in treatment position. The 2 sets of images were registered using a match-point registration. All volumes were contoured and the results were evaluated. The PTV was including: the clips region, the gross tumor volume (GTV) and the surgical scar, with an overall margin of 5−10 mm in all directions corresponding to localization and set-up uncertainties. For each patient the boost PTV was discussed and compared to our standard forward planned PTV.

Conclusion: We have demonstrated here the feasibility using multidisciplinary approach of a tumor bed localization and treatment procedure which seems adapted to routine practice. The use of more than one clip associated with a pre to post operative CT image registration allows a better definition of the PTV boost volume.

Table 1: Tumor bed localization and treatment workflow

Phase	Actors	Week
I – Pt's selection	Surgeon, Radiation oncologist	−2
II – Pre-surgery CT scan	Radiologist, Radiation oncologist RT technologists	−1
III – Surgery with placement of clips	Surgeon	0
IV – Post-operative CT scan	Radiologist, Radiation oncologist RT technologists	+4
V – Pre-to-post surgery CT registration	Dosimetrist	+4
VI – Volume delineation	Radiation oncologist	+4.5−5
VII – Treatment volume definition	Radiation oncologist	+4.5−5
VIII – Treatment planning	Dosimetrist, Physicist, Radiation oncologist	+5.5−6

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Voluntary deep-inspiration breath-hold radiotherapy for left sided breast cancer patients – first clinical results of a fluoroscopy guided method with retrospectively dose calculation

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Background: Heart related death is observed at long term follow up for left sided irradiated breast cancer patients. Breath hold (BH) position creates a larger distance between the thoracic wall and the heart and reduces the irradiation dose to the heart. We developed a fluoroscopy guided voluntary deep-inspiration breath-hold (DIBH) radiotherapy (RT) treatment protocol.

Methods: RT planning for the breast or thoracic wall was performed in BH position. Prior to irradiation a Cone-Beam CT scan (CBCT) was acquired and used for patient setup. During irradiation the BH position was guided by kV (kilovoltage) fluoroscopy, visually validating alignment of ribs and diaphragm. In addition, images of the treatment field were acquired using the megavoltage (MV) photons of the irradiation. kV and MV images were used to retrospectively analyze the actual set-up error and stability during irradiation.

The total delivered dose to the breast or thoracic wall and to the heart, left ventricle, left anterior descending artery (LAD) and the lungs were calculated by accumulating dose distributions for each field and fraction whereby the observed position errors were taken into account. The dose in BH position was compared to the dose planned on the free breathing (FB) CT scan.

Results: To date, 10 patients were incorporated within this protocol.

The intra-fractional reproducibility of the BH position is high and the localization accuracy was about 2 mm (1SD) systematic and random. By introducing these errors into the delivered dose no decrease compared to the planned dose was observed for the volume of the breast which received more than 95% of the prescribed dose ($p > 0.05$).

The maximum heart distance within the irradiation field was reduced from an average of 1.6 cm to 0.2 cm ($p < 0.001$).

DIBH reduced significant the mean and maximum dose to the heart, left ventricle and the LAD compared to the planned dose on the FB scan. The mean lung dose was not significant different between the BH irradiation and FB planning

Conclusion: First clinical results of online CBCT and fluoroscopy guided voluntary DIBH RT showed a high localization accuracy providing good coverage of the target area and a substantially decreases of dose to the heart, left ventricle and LAD.

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Dose received by the sentinel lymph node (SLN) clip – prospective comparative study of two radiotherapy (RT) techniques of breast irradiation

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Background: SLN biopsy is now frequently used for breast cancer (BC) conservative treatment especially for small tumors. The purpose of this study is to evaluate the prophylactic dose received to the region of SLN, marked by clip.

Methods and Materials: Between August 2001 and April 2004, for 152 patients (pts), who underwent a lumpectomy with SLN biopsy followed by