NOWOTWORY Journal of Oncology • 2004 • volume 54
Number 5 • 474–480

Experiences with the mono isocentric irradiation technique in breast cancer patients after conservative surgery

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Introduction. *Standard clinical target volume for irradiation of breast cancer patients with involved axillary nodes after breast conservative surgery includes three areas: the tumor bed, the whole breast and the regional lymph nodes. These targets are localised on different depths, close to organs at risk. Usually we use two tangential fields for the breast and matched nodal fields. On matching, these fields can produce underdoses or overdoses at the junction regions. Linear accelerators with 6 MV energy and multileaf collimators allow for the irradiation of the whole breast and nodal areas using the mono isocentric technique (MIT), thus decreasing the risk of complications at the junction region.*
Aim. *To present early experiences with irradiation of breast cancer patients following conservative surgery with the mono isocentric technique.*
Material and methods. *Eighteen breast cancer patients treated with breast conserving surgery and found to have axillary lymph node metastases were irradiated with MIT at the Maria Sklodowska-Curie Memorial Cancer Center and Institute of Oncology in Warsaw between June 2001 and June 2003. In all cases radiotherapy began 6 weeks after the completion of taxane or anthracycline systemic treatment. Irradiation with MIT was planned with computed tomography in 3 dimensions. Using a multileaf collimator (MLC) and one isocenter, the supraclavicular and axillary fields were irradiated with the upper half of a beam and next, the whole breast was treated with the lower half of a beam. Organs at risk were maximally shielded with MLC. Four patients received 42.5 Gy in 17 fractions (2.5 Gy per fraction) and 14 patients received 45 Gy in 20 fractions (2.25 Gy per fraction).*
Results. *The time of patient set-up was shorter with MIT than with traditional matching techniques, because the therapeutic couch remained in the same position. All patients commenced irradiation according to the prescribed overall treatment time. We observed no enhancement of skin reaction at the field junctions. During a 10 month follow-up period we observed no recurrences and no serious side effects connected with irradiation.*
Conclusion. *Early experience with MIT justifies its routine application in breast cancer patients with axillary lymph nodes metastases who have undergone breast conservative surgery.*

Napromienianie chorych na raka piersi po operacjach oszczędzających techniką jednego izocentrum – doświadczenia wstępne

Wprowadzenie. *U chorych na raka piersi po operacjach oszczędzających z przerzutami do węzłów chłonnych pachowych standardowy teren do napromieniania obejmuje trzy obszary: lożę pooperacyjną, całą pierś i regionalne węzły chłonne. Obszary te leżą na różnej głębokości i blisko narządów krytycznych. Najczęściej stosowana technika polega na napromienianiu piersi z dwóch pól stycznych i oddzielnie centrowanych pól węzłowych. Stwarza to ryzyko przedawkowania lub niedodawkowania w miejscu ich łączenia. Przyspieszacz liniowy z kolimatorem wielolistkowym, generujący fotony X o energii 6 MeV, pozwala na zastosowanie techniki napromieniania piersi i węzłów chłonnych techniką jednego izocentrum, zmniejszając ryzyko powikłań na granicy pól.*
Cel. *Prezentacja metody i wstępnych doświadczeń w napromienianiu chorych na raka piersi po operacji oszczędzającej techniką jednego izocentrum.*
Materiał i metody. *W Centrum Onkologii w Warszawie w okresie czerwiec 2001 r. – czerwiec 2003 r. napromieniano metodą jednego izocentrum 18 chorych na raka piersi po operacjach oszczędzających z przerzutami do węzłów chłonnych pacho-*

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wych. Wszystkie chore otrzymały leczenie systemowe z użyciem antracyklin i/lub taxanów. Radioterapię fotonami X 6 MeV rozpoczynano 6 tygodni po zakończeniu chemioterapii. Planowanie napromieniania odbywało się w oparciu o tomografię komputerową w systemie trójwymiarowym 3D. Technika jednego izocentrum polegała na wykorzystaniu wielolistkowego kolimatora. Najpierw górną połową wiązki napromieniano węzły chłonne nadobojczykowe i pachowe, a następnie dolną połową wiązki z dwóch pól stycznych napromieniano gruczoł piersiowy. Indywidualnie zaplanowany układ wielolistkowego kolimatora osłaniał jak największy obszar tkanek zdrowych. U czterech chorych podano 17 frakcji po 2,5 Gy do dawki całkowitej 42,5 Gy, a u czternastu chorych 20 frakcji po 2,25 Gy do dawki całkowitej 45 Gy.

Wyniki. Czas realizacji napromieniania jednej frakcji techniką jednego izocentrum był krótszy w porównaniu z napromienianiem tradycyjnym, gdyż nie było potrzeby zmiany położenia stołu terapeutycznego. Wszystkie chore ukończyły napromienianie w zaplanowanym czasie. Nie stwierdzono wzmożonej reakcji skórnej w obszarze łączenia pól. W czasie obserwacji 10 miesięcy nie obserwowano nawrotu choroby nowotworowej i poważnych powikłań związanych z radioterapią.

Wniosek. Wstępne doświadczenia z napromienianiem techniką jednego izocentrum uzasadniają jej rutynowe stosowanie u chorych na raka piersi po operacjach oszczędzających z przerzutami do węzłów chłonnych pachowych.

Key words: breast cancer irradiation, mono isocentric technique
Słowa kluczowe: napromienianie w raku piersi, technika jednego izocentrum

Introduction

In patients with breast cancer who had undergone conservative surgery and who, in the course of histopathological examination, are found to have axillary lymph node metastases, there exist indications for additional irradiation [1]. The standard irradiated area contains three clinical target volumes (CTV). CTV I covers the post-tumorectomy site; CTV II – the whole breast and CTV III the regional lymph nodes – axillary, supraclavicular, subclavicular and parasternal. Such a large and irregularly shaped area is difficult to irradiate – the CTVs are differently shaped and located on different depths, while further difficulties arise from the direct vicinity of organs at risk – the heart, the lungs, the brachial plexus, the larynx and the spinal cord. Literature reports present a number of different radiotherapy techniques used to irradiate the lymph nodes and the breast [2-7]. Breast irradiation techniques have also been presented in Polish literature [8-11]. The most common technique bases on encompassing the volume of the breast by two opposing fields, tangential to the thoracic wall, while the nodes are irradiated from separately centered fields (Figure 1). Difficulties arise when there appears a need to adjust the limits of the divergent beams of the tangential fields and the boundaries of the fields encompassing the axillary and supraclavicular nodes, as it may produce overdoses and/or underdoses within the junction fields [12]. In order to overcome such difficulties one may choose to irradiate with half a beam, rotate the collimator or rotate the couch, however the mono isocentric technique described in the ICRU protocol allows to avoid these difficulties altogether [13]. This technique may only be used in modern accelerators equipped with multileaf collimators. Such equipment has been installed at the Maria Sklodowska-Curie Memorial Cancer Centre and Institute of Oncology in Warsaw. Their use commenced in June 2001.

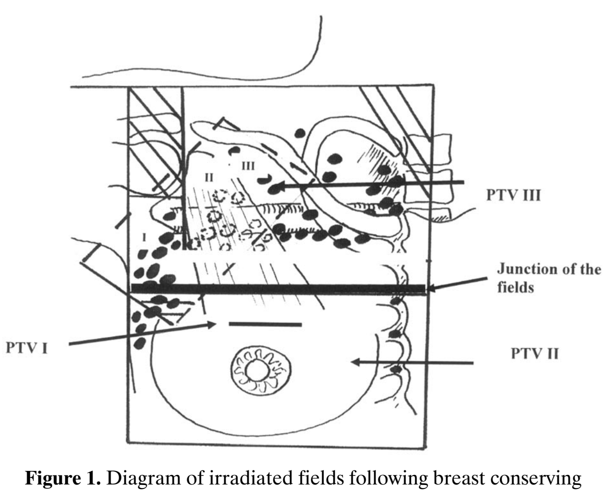

Figure 1. Diagram of irradiated fields following breast conserving surgery with the multi isocentric technique – hazards of overdosage or underdosage in junction of the fields

The aim of this paper – the first in Polish literature to deal with this novel issue – is to present the details of treatment planning and irradiation according to the mono isocentric technique.

Material and method

Methodology

For simulation the patients were immobilised in the supine position, head tilted backwards (no neck rotation) and both arms placed above the head – using the Posiboard 2 (Sinmed) apparatus (Figure 2). Next, three marks were tattooed along the transversal plane at the level of the nipples – two lateral and one anterior. The lateral points were necessary to assure identical positioning of the patient (laser beams) during computed tomography and irradiation. The anterior point served as a reference for the isocentre. Treatment simulation began with defining the length of the field – a wide strip reaching from the cricoid cartilage to 1 cm below the mammary gland. We also marked the preferred limits of the supraclavicular-axillary and the mammary fields. Next, we performed computed tomography of this pre-selected area at 7 mm sections. The topogram sections were then forwarded to the Helax treatment planning system. The planning treatment volume (PTV) and the clinical treatment volume (CTV) were drawn into each section with a 1 cm margin (allowing for ventilatory movement and errors caused by patient repositioning). At this stage of treatment planning it was decided whether to include the parasternal node area within the PTV of tangential fields – the decision depended on a careful analysis of the clinical data and of the likelihood of com-

Figure 2. Planning on simulator (A) and irradiation on accelerator (B) with the mono isocentric technique in the same position

plications). If the entire area appeared too large for the mono isocenter technique we considered the application of a separate field for the parasternal nodes irradiated with an electron beam.

The next stage of treatment planning was performed by the physicist and consisted of setting the sizes of the fields, the angles of beam entries, the shapes of the shields and the positioning of the isocentre in order to provide maximally homogenous doses within the PTV (Figures 3-6). Dose-to-volume histograms were applied in order to assess the homogeneity of the doses and for the choice of isodose distribution [14].

When the plan of treatment was accepted the next stage was to perform it on the Clinac 2300 linear accelerator. The patient was placed in the same position as on the simulator and during computed tomography, using laser beams and the pre-tattooed lateral points. Next, the isocentre point was determined on the patient – i.e. the central beam was placed over the reference point at a distance of 100 cm and the table was moved according to previous treatment planning (Figure 5). The isocentre was found and marked on the patient's skin at the junction regions of the supraclavicular-axillary fields and the mammary fields. In our patients the distance between the source and the skin was 100 cm at a zero degree angle, although this may vary depending on treatment planning.

The first anterior field, irradiated with the lower half of the beam shielded, encompassed the supraclavicular and the subclavicular lymph nodes. The leafs of the collimator shielded the larynx and the head of the humerus. The beam was usually rotated laterally by 15 degrees in order to avoid the pharynx, the oesophagus and the spinal cord. If the PTV contained the axillary fossa, the machine was rotated by 180 degrees and the leafs of the collimator were repositioned, thus allowing to apply a second field from the back with a much lower weight.

The breast was irradiated from two tangential fields, and during this phase the upper half of the beam was shut off. The correct placing of the leaves of the collimator intended to protect part of the heart, the lungs and the liver was assessed on control scans [Fig. 7]. These control scans were performed on day 1, 2 and then once a week. All repositionings exceeding 0.5 cm were corrected.

Figure 3A

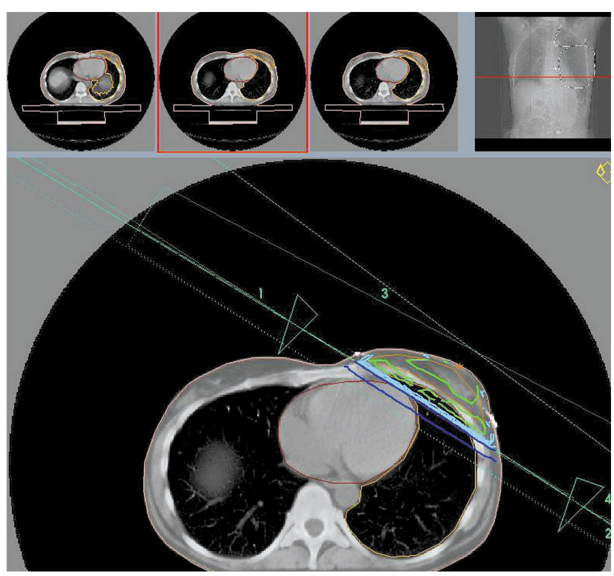

Figure 3B

Figure 3. Irradiation with the mono isocentric technique
A – PTV for supraclavicular field;
B – PTV for breast tangential

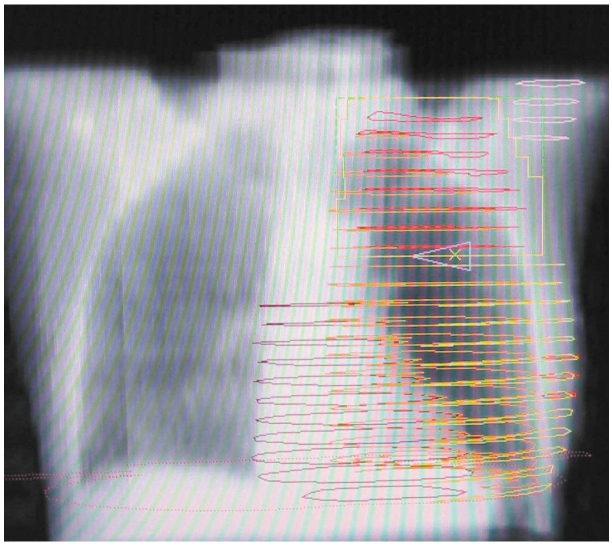

Figure 4A

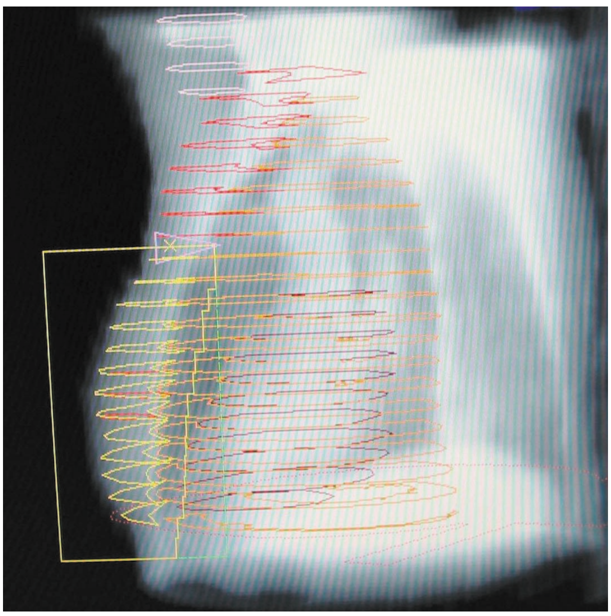

Figure 4B

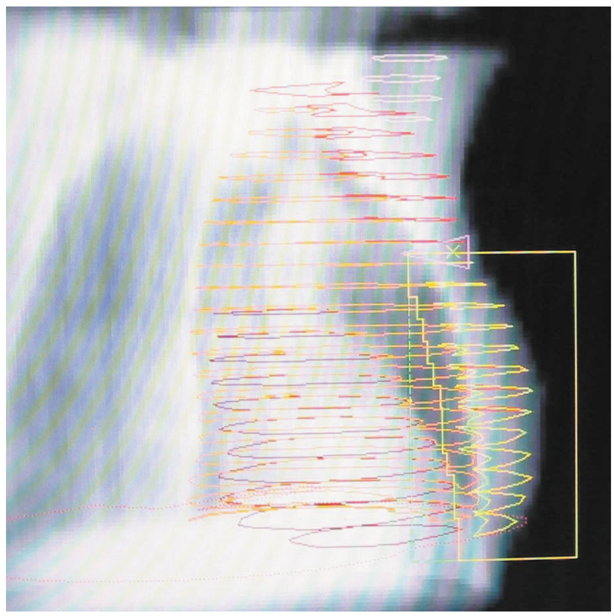

Figure 4C

Figure 4. DRR – digital reconstructive radiographs for the mono isocentric technique with multileaf shields. A- supraclavicular field BC – breast tangential fields

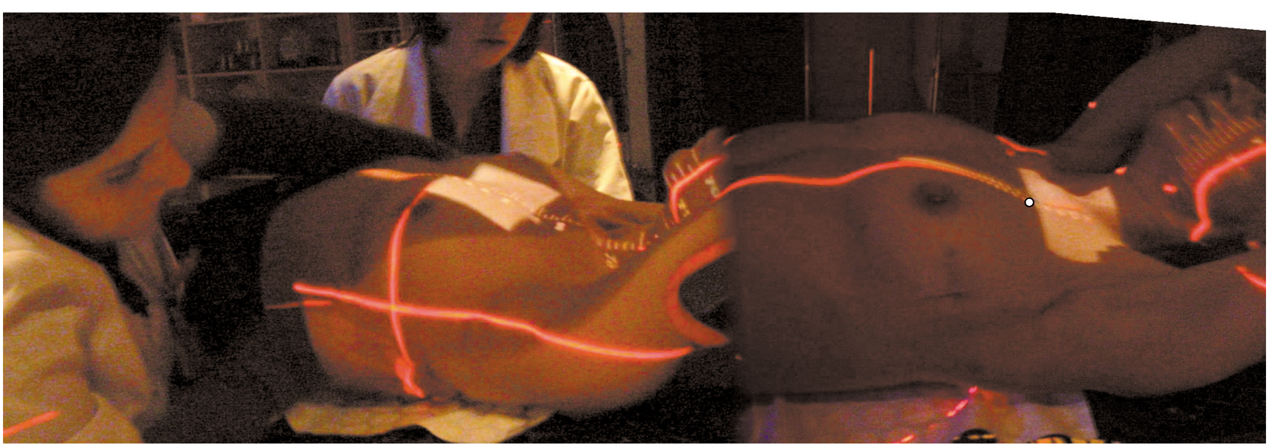

Figure 5A Figure 5B

Figure 5. Irradiation with the mono isocentric technique
A – positioning of the patient under accelerator, B – marking of the isocenter point (white point) and irradiation of the supraclavicular field

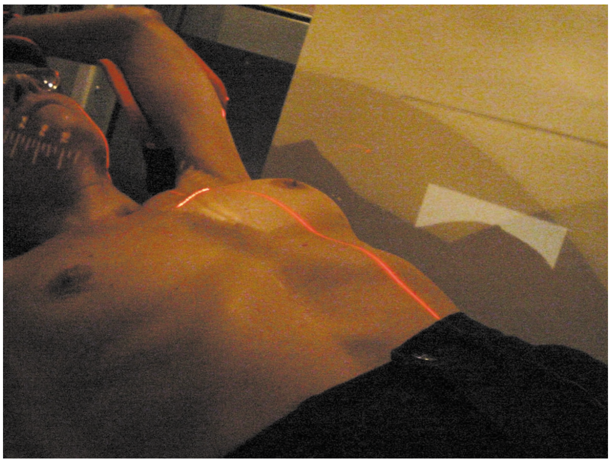

Figure 6A

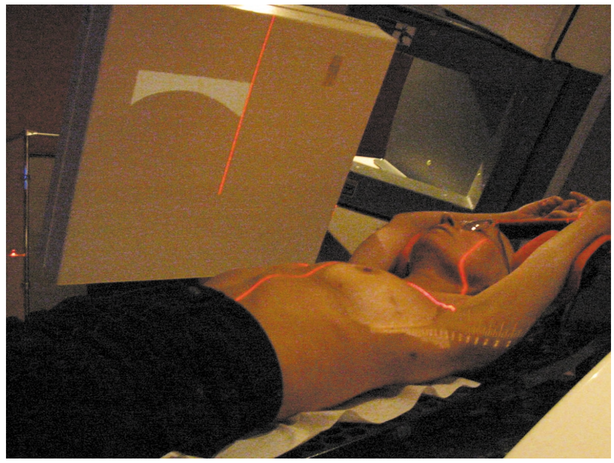

Figure 6B

Figure 6. Breast tangential fields irradiation with the mono isocentric technique and portal control

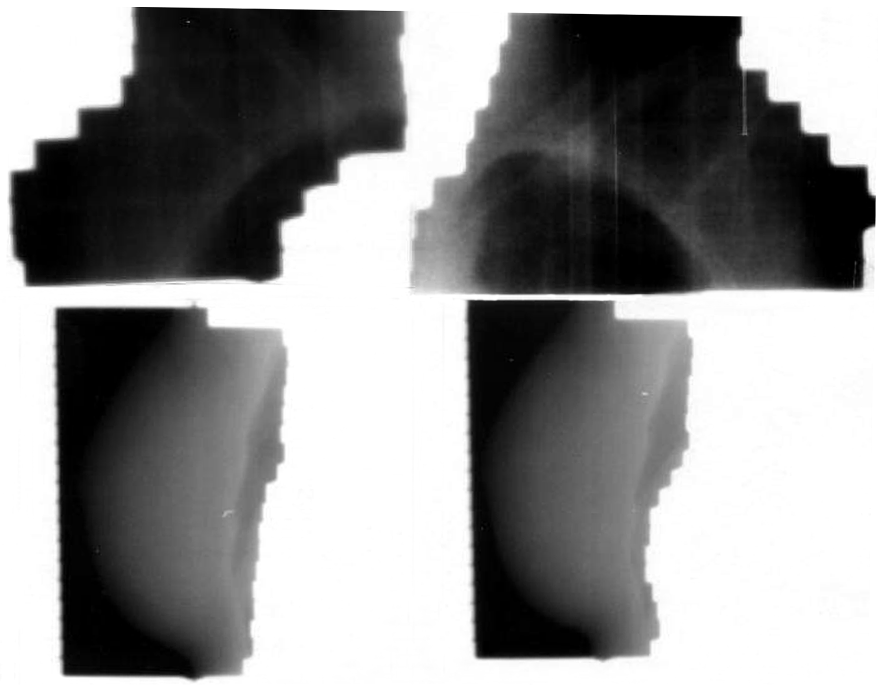

Figure 7. Portal films: axillary, supraclavicular and breast tangential fields with multileaf shields

Clinical material

Between June 2001 and June 2003 we used the mono isocentric technique irradiation in 18 breast cancer patients who had undergone conservative surgery and were found to have axillary node metastases. The youngest patient was 45, the oldest – 64 years of age; median age – 51 years. All patients received systemic anthracycline and/or taxane therapy. Radiotherapy commenced 6 weeks after the completion of chemotherapy. We used accelerated radiotherapy over a shortened time period. Four patients were administered 17 fractions of 2.5 Gy (total dose – 42.5 Gy), while the remaining fourteen patients received 20 fractions of 2.25 Gy (total dose – 45 Gy). In one case the tumour was placed medially and the parasternal nodes irradiated from a separate electrone field were included in the PTV. In all the other cases the parasternal lymph nodes were not irradiated due to the increased risk of cardiac complications associated with combined radiotherapy and systemic anthracycline treatment.

In the case of one patient with particularly large breasts, in whom dose non-homogeneity reached 20-30%, we applied an additional pair of smaller tangential fields, thus limiting the non-homogeneity of the dose to 15%. An additional dose (the so-called boost) was applied to the post-tumorectomy site in all 18 cases. In 10 cases the electron beam dose was increased by 10-12 Gy in 5-6 fractions, while in the 8 remaining cases we applied the HDR brachytherapy technique increasing the dose by 10 Gy.

Results

The irradiation time necessary for the application of one fraction was shorter when using the mono isocentric technique, as there was no need to reposition the therapeutic table. All patients completed radiotherapy without any delays. Early post-radiation skin reactions were assessed as stage I acc. to the RTOG/EORTC scale. We did not observe exacerbated skin reactions in the areas of field junctions. During a mean follow-up of 10 months we observed no recurrences, nor any serious complications associated with radiation therapy in all the 18 patients treated with the mono isocentric technique.

Discussion

In Poland breast conserving therapy is becoming a more and more common procedure among patients in early stages of the disease. Such a procedure is intended to improve the quality of life and decrease the traumatic experiences associated with radical mastectomy. However, in some cases histopathological examination reveals the presence of metastases within the axillary lymph nodes. These patients need not only systemic therapy, but also irradiation of the breast and the regional lymph nodes. It is difficult to irradiate such a large, irregularly shaped area. Techniques consisting of the application of a number of independently centered fields are associated with a high risk of over- or underdosage in the areas where the fields adjoin. This, in turn, may lead to either ineffectual treatment or to an increase in the risk of late complications, such as fibrosis, endoprosthesis damage and impaired cosmetic effect.

According to ICRU 50 recommendations dose dispersion within the PTV calculated from the point of normalisation should not exceed + 7% and – 5% [13]. It is well known that although these criteria are possible to achieve in the case of the breast, yet within the nodal fields dose non-homogeneity reaches some 10-20%. In patients with large breasts the curvature of the chest is increased, which causes significant differences in the localisation and density of the designed target, again often causing dose non-homogeneity of 10-20%. In the case of fields located relatively far from the mid-line, especially within the sub-mammary fold, at the boundary of the lung, dose non-homogeneity may be highly significant (Figures 8 A, B). Within the breast dose non-homogeneity may impair the cosmetic effect and decrease the chances of effective therapy [15, 16]. The application of a second pair of tagential fields improves does homogeneity. Usually these fields carry a weight of some 15 to 20%. The first pair of beams encompasses the entire shield area, the second pair of beams, with an identical centering point, covers a differently shaped field minus the areas characterised by an intensified dose (as calculated from dose distribution within the first two fields) (Figure 8 C). Thus, we apply a complete set of fields in pairs with different positioning of the leaves of the collimator, while

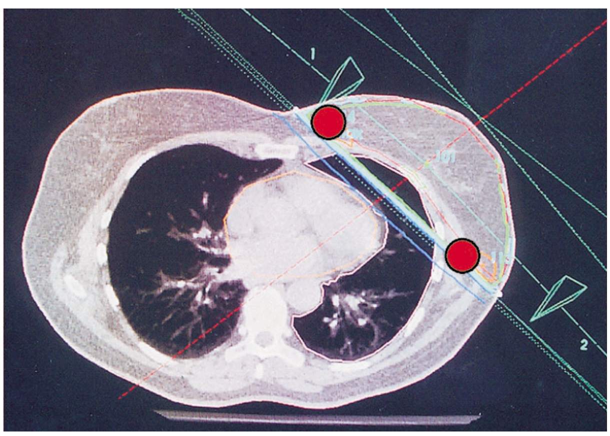

Figure 8A

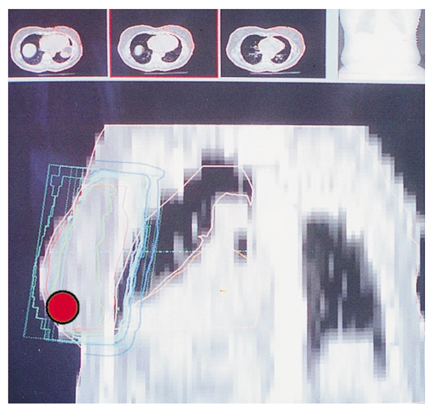

Figure 8B

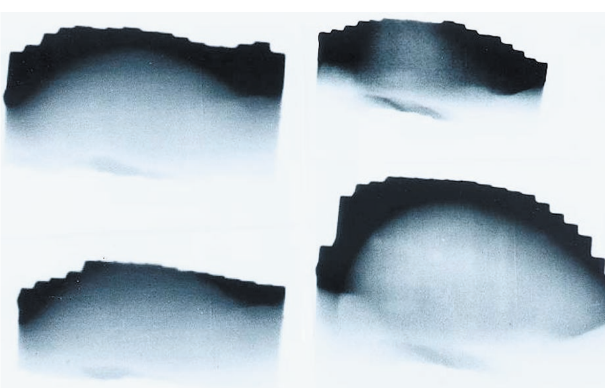

Figure 8C

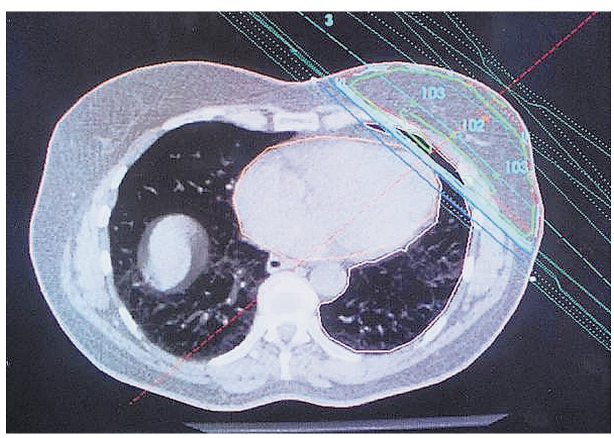

Figure 8D

Figure 8. Mono isocentric technique with additional two small fields improving the dose homogeneity
A, B – apparent overdosage areas – red points
C – portals films of the 4 irradiated fields – two large and two small
D – improvement in the homogeneity dose – description in text

retaining the position of the head of the machine and, eventually, we modify the dose while, at the same time, we improve its distribution (Figure 8D).

The mono isocentric technique is easily repeated on a day-after-day basis because once the isocenter point is assessed the following fields are set by rotating the probe and altering the multileaf collimator, which also significantly reduces the time, which the patients spend in the radiotherapy cabin. The method enables to irradiate patients without altering their position.

The application of half-beams achieved by the multileaf collimator allows to avoid overdosage at field junctions, while the individual shielding of organs at risk assures high treatment quality and decreases the risk of late complications.

The method may be limited by the size of the patient and by the dimentions of the breasts. The "active" parts of the fields cannot exceed 20 cm x 20 cm. (The size of the field on the accelerator at the range of the isocenter is 40 cm x 40 cm, but the use of a wedge and the application of half-beams decreases the width of the field to 20 cm). We must, however, mention that we have never yet had to face the above-mentioned limits of the method.

Conclusion

Initial experiences with the mono isocentric irradiation technique support its routine application in breast cancer patients who had undergone conservative surgery and were found to have axillary metastases.

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Paper received: 3 February 2004
Accepted: 4 May 2004