NOWOTWORY Journal of Oncology • 2008 • volume 58
Number 5 • 215e–217e

Short communication

Improving patient positioning accuracy for breast cancer radiation therapy by using the infra red based ExacTrac system

Ákos Gulybán[1, 3], Eszter Hortobágyi[1, 3], Zsolt Sebestyén[1], Péter Kovács[1], Gábor Liposits[1], Bernadett Mrázik[1], Róbert Farkas[1], Katalin Hideghéty[1, 2], László Mangel[1], Olga Ésik[1, 3]

We report on a pilot study to investigate for cancer of the breast, the accuracy of patient positioning with the normal standard method (ST) and with the standard method extended with the ExacTrac system (ET). Our work in progress pilot study population consisted of four patients: two positioned using ST and two positioned using ET. The results from the daily electronic portal images showed that with ExacTrac the positional accuracy could be improved by 50% but with a corresponding increase in overall treatment time of about 2 minutes.

Key words: patient positioning, systematic error, random error, safety margin, treatment set-up uncertainties

Introduction

During the past several years, great advances have occurred in the technical aspects of radiotherapy, including immobilisation of the patient, target volume delineation, treatment planning software, treatment delivery technique and treatment verification. This short communication is relevant to treatment verification and to the safety margin derived during the treatment planning process.

The standard treatment verification procedure in most hospitals is to compare the beam's eye view (BEV) digitally reconstructed radiographs (DRRs) with electronic portal images (EPI) in order to be able to evaluate the positioning accuracy of the patient from the treatment field direction. The differences between the planned fields and the treatment delivered fields arise from two different types of error: systematic and random.

A systematic error (SE) remains unaltered during the treatment delivery and is virtually the same for every patient. An example of a SE can be due to the light-defining field causing an error in the actual radiation field definition. A random error (RE) is patient-specific and can change daily. These two types of error are must be taken into account when defining a safety margin (SM), see the work of van Herk et al [1] who defines SM as (2.5 x SE + 0.7 x RE)

In the pilot study reported here, we have compared the standard verification procedure (ST) with the standard procedure extended by using the infrared (IR) reflective-based ExacTrac (ET) positioning method (BrainLAB AG, Heimstetten, Germany). We chose to study treatment of the breast as we considered this to be a good example for comparative purposes between two techniques because the differences between the BEV DRRs and the BEV EPIs could not be translated directly into a correction data table or be anatomically defined.

Materials & methods

Four breast cancer patients were accrued to the study between January 2007 and May 2007**.** All were immobilised with the AIO (All In One) system from ORFIT™ (Orfit Industries, Wijnegem, Belgium) in the supine position with elevated ipsilateral arm. The 10 mm increment computed tomography (CT) scans (HiSpeed Dual, Fairfield, Connecticut, USA) and were performed in this position and were transferred to the treatment planning system (Elekta, PrecisePLAN™ 2.02/2.03, Crawley, United Kingdom). All patients were treated with multisegmental tangential breast fields [2]. The ST method was used for two patients and the ET method for two patients.

Standard positioning

The ST procedure was as follows. (**1**) We set-up the patient using three directional laser pointers. (**2**) We then ensured that

[1] Department of Oncotherapy
University of Pecs
17 Edesanyak utja
Pecs
H-7624 Hungary
[2] Department of Oncotherapy
University of Szeged
16 Koranyi fasor
Szeged
H-6720 Hungary
[3] Department of Radiation & Medical Oncology
Medcenter Ltd., at the Borsod County Hospital
72-76 Szentpeteri kapu
Miskolc
H-3526, Hungary

Table I. Errors and minimum safety margins: standard procedure (ST) versus standard procedure extended with the ExacTrac system (ET). CC: carnio-caudal. ML: medio-lateral. VD: ventro-dorsal. All measurements in the table are in mm. The minimum safety margin was calculated according to van Herk et al [1].

Error or Margin	ST EPI-DRR difference			ET EPI-DRR difference			ET Using the IR system
	CC	VD	ML	CC	VD	ML	
Systematic error	-2.9	1.9	1.5	-0.7	0	0	2.1
Random error	3.6	4.6	4.8	1.4	1.7	2.1	0.9
Safety margin	9.8	8.0	7.1	2.7	1.2	1.5	5.7

the projection of the light field and the breast tissue border were parallel. (**3**) We then checked and documented the difference between the BEV DRR and the BEV EPI using iView software (version 3.1, Elekta, Crawley, UK). For every beam on each day the vertical and horizontal displacements were documented.

Standard positioning extended with IR-based ExacTrac

For the ET procedure the standard positioning was extended with the ExacTrac system. Following the comparison of the planned (ideal) and the treated (actual) DRRs for the first treatment fraction, all differences were corrected to set-up the patient in the ideal position. We set five IR reflective markers on the patient's skin, using the following guidelines (Figure 1). (**1**) No markers were allowed inside the treatment field. (**2**) The five markers were not all positioned in the same plane. (**3**) We considered it to be advantageous to use relative large distances between the markers: and not to obscure each other from the camera. (**4**) For improved daily reproduction, we aimed to set the markers on bony structures.

After the markers were set, we saved the configuration as a reference for the ExacTrac system. On every treatment day the patients' position were based on the markers. The accuracy of the position was indicated by three defined levels by ET: >3 mm {low accuracy}, <3 mm but >1 mm {reduced accuracy}, <1 mm {OK}. If the system indicated the OK accuracy level, the positioning was considered to be completed and during the treatment DRR-EPI comparisons were performed and the vertical and horizontal differences were documented. Based on the movement of the markers the ET system was able to note and record the displacement with time. This was also documented as a part of the extended positioning.

Evaluation of vertical & horizontal differences

All patients were treated with coplanar fields, and hence the vertical and horizontal differences were able to be converted into a data table and into anatomical vectors. The vertical error could be caused in extreme cases only from medio-lateral or only from ventro-dorsal differences. However, we decided to base our investigation on the fact that on average, the vertical error is the largest error and that it is a combination of the medio-lateral and ventro-dorsal differences with respect to the gantry angle (φ) (Figure 2). The following terminology was used for every medial and lateral tangent.

$$\text{Horizontal} = \text{Cranio-caudal (CC)}$$
$$\text{Vertical} \cdot |\sin\varphi| = \text{Medio-lateral (ML)}$$
$$\text{Vertical} \cdot |\cos\varphi| = \text{Ventro-dorsal (VD)}$$

From geometrical considerations we have ($VD^2+ML^2 = Vertical^2$). With this relationship the systematic & random errors and the safety margins can be easily derived separately for each anatomical direction. In addition the IR marker based accuracy was also evaluated. In the case of ET, the accuracy of the isocentre was also studied according to the average maximal and minimal values of the displacement projected automatically by the system onto a generated time scale. Following the daily

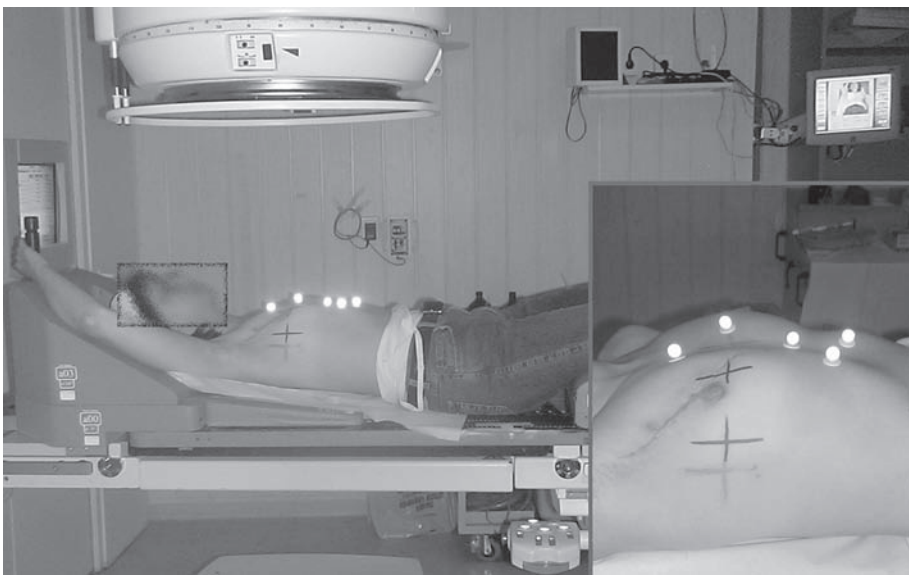

Figure 1. Patient with the IR markers on the skin following the correct set-up

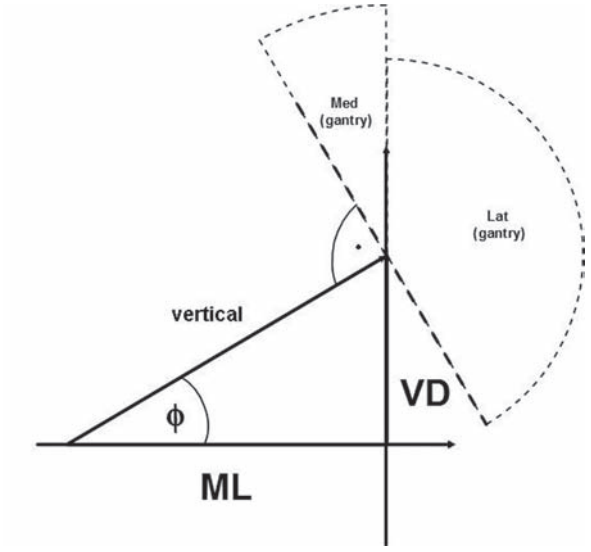

Figure 2. Schematic diagram illustrating the theoretical relationship used between the vertical, the centro-dorsal (VD) and the medio-lateral (ML) errors.

displacement errors two non-uniform SE, RE and SM were calculated and compared.

Results

The ET positioning procedure resulted in a better accuracy than could be achieved with ST for every observation. The most important result was that when using ET the systematic error could be reduced to zero in the ventro-dorsal and medio-lateral directions. Thus all vertical inaccuracy is resulted from random errors. The average reductions of the minimal safety margins were in the range 6.6-7.1 mm Results for the two positioning methods, ST and ET, are given in Table I. These results from the daily electronic portal images showed that with ExacTrac the positional accuracy could be improved by 50% but with a corresponding increased in overall treatment time of some 20%.

Conclusions

The ET system, which is independent of the radiation fields, increases the accuracy of daily patient positioning and it the possibility of decreasing the necessary minimum safety margin. The approximately 2 minute increase in overall treatment procedure time is acceptable. We emphasise that we report a work in progress pilot study with only four patients and to increase the value of this investigation a larger number of patients should be studied.

Akos Gulyban MSc
Medical Physicist
Department of Radiation & Medical Oncology
Medcenter Ltd., at the Borsod County Hospital
72-76 Szentpeteri kapu
Miskolc
H-3526, Hungary
E-mail: akos.gulyban@gmail.com

References

1. van Herk M, Remeijer P, Rasch C et al. The probability of correct target dosage: dose-population histograms for deriving treatment margins in radiotherapy. *Int J Radiat Oncol Biol Phys* 2000; 47: 1121-35.
2. Gulyban A, Kovacs P, Farkas R et al. Multisegmented radiation therapy as an alternative to 3D conformal radiation therapy, with special reference to breast cancer tangential fields. *Nowotwory J Oncol* 2007; 57: 125e-8e.

Received: 12 March 2008
Accepted: 07 April 2008