EVALUATION OF AN ELECTRONIC PORTAL IMAGING DEVICE (TARGET VIEW, GE) AS A QUALITY ASSURANCE TOOL

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SUMMARY

Purpose: A proper control of the geometrical accuracy of treated portals during radiotherapy results in higher quality of treatment and may lead to the increase in the therapeutic gain.
In this work, an evaluation of an electronic portal imaging device (EPID) was made in the following aspects: the quality of images, the estimation of prolongation of the treatment, and the corrections introduced after EPIDs.
Material and methods: We have archived 2430 portal images of 184 patients who were irradiated at our department. The following significant errors were established: a shift in the field along x, y, z axes (more than 5mm in the head and neck region, more than 7mm in the chest tumours and 10 mm in pelvic region), a displacement of shield by the same values, and an erroneous field size assigment by more than 10mm.
Results: The introduction of the EPID into clinical practice involved approximately 10% of the session time. The quality of the electronic portal images received was acceptable for further analysis in 87% of the analysed group of patients. Significant errors have been registered in 33% of monitored patients. Prior to the treatment and during the set-up procedure, corrections were made in 20% of the evaluated patients.
Conclusions: An electronic portal imaging device (EPID) is a useful tool for fast and reliable portal image acquisition.

Key words: radiotherapy, portal imaging, geometric accuracy, an electronic portal image device (EPID).

INTRODUCTION

The results of radiotherapy are determined by many factors such as biology of the tumour, the stage of the disease, dose parameters, and also by the geometric accuracy of irradiation. Therefore, the treatment reproducibility is one of the major criterion of the quality assurance in radiation therapy [1,2]. The reduction of an absorbed dose in a significant portion of the gross tumour volume (GTV) may decrease the probability of tumor local control (TCP). On the other hand, an additional irradiation of healthy tissue due to geometrical inaccuracy may lead to the increase in toxicity of radiotherapy.

Treatment reproducibility depends on the faulty position of a patient and internal organ movements. The latter factor can hardly by eliminated in clinical practice. Geometrical errors are due to inaccurate positioning and immobilization of the patient, setting the light field and blocks according to the surface markers, and to the change of patient's position during treatment [3,4]. The ultimate check of the field placement during the treatment process (the geometrical accuracy) should be made by portal imaging [5].

So far, at the Greatpoland Cancer Centre in Poznań we have been carring out a traditional cassette portal imaging, which was time consuming and yielded low quality images. This technique was used in the minority of cases, approximately 5% of all the irradiated patients, because of the amount of time spent by patients waiting for treatment, and due to the low quality of the traditional cassette portal images.

PURPOSE

In this study, we have evaluated the expected gains of implementing an electronic portal imaging device (EPID) in our clinical practice. The purpose of the study was to assess the following factors: the quality of images, the estimation of the prolongation of the treatment session by the acquisition of electronic portal images, and the corrections performed after applying electronic portal imaging devices (EPIDs).

MATERIALS AND METHODS

Target View (General Electronic) is an electronic portal imaging device system installed with the Saturn 43 linear accelerator. This system consisted of a detector unit (a metal plate, a fluorescence screen, and a video camera), a digital image acquisition, enhancement, storage and analysis device. Between April and September 2000, 184 patients were irradiated with this therapeutic machine. We have archived 2430 portal images obtained during „set up" checks prior to the treatment, those between sessions ("inter treatment images") or during the irradiation sessions ("intra treatment images").

The physicians involved in the treatment procedure based the assessment of the quality of images on a direct, subjective evaluation of images. Major problems with correct interpretations were encountered in the location of tumours when no anatomical bone markers existed. 2114 of 2430 portal images (87%) were of good quality and were approved for further evaluation.

In a group of 20 patients we have assessed the prolongation of the treatment session by measuring of the time of the „set-up" portal imaging acquiring procedure.

Quantitative analyses revealed geometrical errors in 51 out of 105 patients. These errors were ascribed to the following reasons:

- misplacement of shields or fields in proportion to the anatomic reference points;
- improper patient positioning in the succeeding days of treatment,
- erroneous collimator setting and erroneous setting of field dimensions (i.e. 5 cm x 7 cm instead of 7cm x 5cm). We have enhanced the quality of the obtained images, and by using the software supplied with the system we have also calculated, and measured geometric discrepancies. The following errors were considered as significant: a shift of the field along x, y or z axes by more than 5 mm in the head and neck tumors, by 7 mm in the chest tumours and 10 mm in the pelvic malignancies, shield misplacment by the same values, and erroneous field size assigment by more than 10 mm.

RESULTS

The electronic portal images, which were evaluated by physicians, were of better quality than the classical images obtained on the photographic velum. This conclusion was based on the subjective opinions of radiotherapists involved in the evaluation process. Eighty-seven % of the electronic images obtained were qualified for quality analysis.

1. First-time referential images obtained prior to the treatment only sightly increased the duration of the radiotherapy session by 10 - 20%, i.e. 1-2 minute(s).
2. Monitoring of the treatment was carried out in a considerable number of the irradiated patients: first time images, weekly verification images, and everyday images were obtained in 57% (105/184), 78% (143/184), and 18% (33/184) of all monitored patients.
3. The errors defined as important were registered in 33% of all monitored patients (weekly images, everyday, and sets of images during treatment). Corrections were made in 20% of mo-

nitored patients prior to the treatment on the basis of the first-time images.

DISCUSSION

The outcome of radiotherapy is determined by many important factors: the total dose, the way of fractionation, the biology of the tumour, distant metastases, the geometrical accuracy of irradiation, and many others [6,7]. The curve of the tumour control probability (TCP) is sigmoidal. It means that a slight increase in the radiation dose is correleted with a more marked increase in the same range of the TCP. A decrease in the dose in the gross and clinical tumour volume (GTV, and CTV) by 200 cGy may result in an decrease in the TCP by 5% - 8% [8]. In radiation therapy with a curative aim the dose of 200 cGy amounts to only 3% of the administered total dose. On the other hand, TCP has the same shape (sigomidal) as the curve of the normal tissue complication probability (NTCP). The overdose in a healthy tissue may increase the radiation toxicity (acute and late) and diminish the therapeutic gain.

According to our department's experience and data from literature [9] regular monitoring of radiation therapy and verification of all possible errors using simple X-ray images is impossible in routine practice due to the large number of irradiated patients and a very low quality of these images. That is why in the past, we did not have even approximate data on the frequency and dimension of geometrical errors, which appeared during irradiation. We asked the physicians involved in the treatment to evaluate these images because we wanted to estimate the quality of the set up EPID. The evaluated images were technically satisfactory. Physicians had no doubt that EPID images were of better quality than X-ray checks, but it was emphasized that the opinion was subjective without any objective comparisons.

In many patients irradiated, the time spent on the verification procedure is a very important factor. Set up EPID images were not time consuming and rarely required correction for proper evaluation. No prolongation of the irradiation session has been observed. The quality of treatment was increased without any decrease in the number of irradiated patients.

When the Target View was introduced in our department, radiation therapists were asked to obtain a set – up image in each case. Then, each patient had everyday and weekly images done to him. Set –up checks were performed in only 57% of all the irradiated patients (105/184) due to the problems involving the software, and the staff who found using the software quite difficult.

The verification system should lead to the introduction of corrections of observed errors. An electronic portal imaging system enabled us to find some systemic differences between the set-up on the simulator and the therapeutic machine. The estimation of the images obtained also made it possible to detect, discriminate, and make quantitative description of systematic and random errors, occurring during irradiation. These errors had no impact on the outcome of radiotherapy treatment due to occasionall appearance (random), and could not be corrected.

In a few patients, many errors were observed due to different positioning during the succeeding days of treatment. However, these were not patients with head and neck tumours irradiated in a mask. The abnormal situation was found in a group of women with breast cancer and in patients with pelvis malignances when some individuals were positioned slightly differently everyday. It seems that these were the patients who could not remember their previous exact positions. Therefore, they required a special care and were monitored everyday with the use of the EPID. However, when chest or pelvis malignacies were irradiated we used additional devices to immobilization of the patient very rarely. There is no doubt, that in this group of these patients better immobilisation should be introduced. The majority of registered geometrical errors was of a random nature, so on an ideal image should be made every day and at the same time possible correction should be estimated by the radiotherapist. The analysis of the set of images taken during treatment helped us to evaluate patient's movements and those of internal organs in the irradiated area. In the monitored group a set of images was taken during irradiation (intra- treatment images) in women with a breast cancer. That the amplitudes of patient's movements as well as those of the movements due to breathing were found to be small and there was no need to correct the treatment plan.

The archived portal images may be compared by superposition. Most of the discrepancies were found to involve inter-treatment. Since significant inter- treatment errors were not found on single daily checks of the treatment process, the EPID provided the best option in carring out control quality.

The introduction of an electronic imaging system has also resulted in closer collaboration between doctors and technicians. The technicians responsible for everyday images have become more precise in positioning the patient and shields, and reveal errors more often because they know that the images will be reviewed and evaluted by the doctors.

CONCLUSIONS

An electronic portal imaging device is a useful tool for fast and reliable portal image acquisition. The EPID makes it possible to record and correct various geometrical errors just before and during radiotherapy in most patients without compromising the number of patients treated. This option of monitoring and veryfication of radiotherapy should be applied in these radiation departments where conformal treatment will be introduced.

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