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High conformality radiotherapy in Europe: thirty-one centres participating in the quality assurance programme of the EORTC prostate trial 22991

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Abstract

Today, conformality in radiotherapy is at the centre of many investments in equipment and staffing. To estimate the current situation within the European Organisation for Research and Treatment of Cancer (EORTC) conformal radiotherapy trial for prostate cancer, a technology questionnaire was designed to assess whether participating centres can comply with the required radiotherapy procedures of EORTC trial 22991, where a high dose is prescribed to the prostate. Questions covered various items of computed tomography, data acquisition, treatment planning, delivery and verification. All centres ($n = 31$) replied to the questionnaire. All generate beam's eye views and dose volume histograms. All, but two, centres use digitally reconstructed radiographs to display images. The vast majority of the centres perform at least weekly treatment verification and half have access to individual *in vivo* dosimetry. The results of the questionnaire indicate that participating centres have access to the equipment and apply the procedures that are essential for conformal prostate radiotherapy. The technology questionnaire is the first step in the extensive quality assurance programme dedicated to this high-tech radiotherapy trial.

Keywords: Quality assurance; Questionnaire; EORTC; Prostate cancer; Conformal radiotherapy

1. Introduction

Three-dimensional conformal radiotherapy (3D-CRT) has the potential to decrease normal tissue toxicity and to permit dose escalation to the tumour. In a number of retrospective and prospective studies, 3D-CRT led to an improvement in outcome for intermediate and high-risk patients with prostate cancer [1–4]. Reports from various centres demonstrated excellent tolerance with the administration of higher radiation doses to the conformal prostate fields [5–7]. Therefore, 3D-CRT is replacing conventional techniques for the treatment of prostate cancer. 3D-CRT includes standard conformal radiation and intensity-modulated radiotherapy (IMRT), where dose distributions are even more conformal. The technique typically involves a series of procedures including the acquisition of anatomical information with a computed tomography (CT) scan in the treatment position, precise delineation and

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reconstruction of the target volume and critical organs, treatment planning with beam's eye view (BEV), 3D-dose calculations and frequent treatment verification. The European Organisation for Research and Treatment of Cancer (EORTC) Trial 22991 is designed to evaluate the outcome of localised prostate cancer patients treated with 3D-CRT alone versus 3D-CRT plus short-term hormone therapy [8]. In this trial, 3D-CRT is delivered by standard conformal radiation or by IMRT, depending on the institutional preference.

A quality assurance (QA) programme is essential to identify ambiguities in the protocol and to check the treatment compliance of the various participating centres. This is particularly important in trials involving the use of advanced technology. Based on the large experience of the EORTC Radiotherapy Group with infrastructure, trial and patient-oriented QA [9], we initiated an extensive QA programme within trial 22991. This consisted of four steps: a technology questionnaire, a dummy run, an individual case review and a dosimetry check.

This paper describes the technology questionnaire that was designed to evaluate the infrastructure and the treatment procedures of the participating centres. The questionnaire incorporated questions on the availability and the use of relevant equipment and facilities such as CT, treatment planning systems (TPS), treatment delivery and verification systems, and data acquisition and transfer. Based on these data, we can estimate whether participating centres can comply with all of the requirements of this trial protocol.

2. Patients and methods

A questionnaire was prepared and sent to the participants of the 3D-CRT prostate trial. The questionnaire consisted of 55 questions, divided into six main sections: administrative data, CT data acquisition and transfer, treatment planning system, dose volume histograms (DVH), treatment delivery and treatment verification. Questions enquired about a number of capabilities, some of which were optional for participation in the study. The questionnaire results were received between January 2002 and May 2003. The results were transferred to an Access database, and a descriptive analysis of the data was performed.

3. Results

The response rate to the technology questionnaire project was 100%. We analysed all of the completed questionnaires, coming from 31 centres in 13 countries. Most centres were in France (8), Italy (3), Belgium (3), Switzerland (3) and the Netherlands (3). Except for certain questions concerning DVH, the centres replied to almost all of the questions.

3.1. Treatment planning

The minimum image matrix size is between 128×128 and 512×512 pixels. The minimum slice thickness is between 0.5 and 3 mm. According to the information received from 87% of the centres, the maximum number of slices the TPS can use is 32–160 per patient, and two-thirds can include $\geqslant 100$ CT slices per patient. CT image transfer is done via a network in 27 (87%) centres. The standard digital imaging and communication in medicine (DICOM) format is available in 29 (94%) centres. The technical features of the TPS such as digitally reconstructed radiographs (DRR), BEV, density corrections and 3D calculation methods are used in most (and for some factors all) of the centres (Fig. 1). Centres use one or more dose calculation algorithms, including pencil beam (74%), collapsed cone (19%) or convolution (23%). Four centres use other calculation methods such as Clarkson, Memorial Sloane Kettering and irregular field calculation algorithms.

Centres can transfer DRR, isodose charts and treatment reports in different export formats. DICOM format is used by one third of the centres (Fig. 2). Approximately two-thirds (68%) of the centres can export treatment reports and data on gross tumour volume (GTV), clinical tumour volume (CTV) and planning target volume (PTV) according to the ICRU requirements [10,11]. Thirty-six percent of the centres can only import and 3% can only export defined volumes, whereas 29% can do both. Centres normalise the dose to the ICRU reference point (84%), the mean dose (26%), a specified dose level (39%) or use other (26%) normalisation methods. Approximately two-thirds (65%) of the centres reported using more than one normalisation method.

Centres stated that they prefer to receive the dummy-run data on a CD-ROM (71%), DAT (32%), Internet (3%) or film (23%).

3.2. Treatment delivery and verification

The participating centres irradiate the prostate cancer using 6–25 MV megavoltage photon beams. All of the centres perform individual beam shaping. This is achieved using customised blocks only (45%), MLC only (23%) or both (32%). Centres use wedges (97%), customised filters (16%) or IMRT (16%) for tissue compensation. Approximately two-thirds (68%) of the centres use only hard wedges, 13% use only soft wedges, 13% of the centres use both, and 4% did not report on the wedge type in use.

Twenty-six centres (84%) completed the data for immobilisation: 7 centres (23%) do not use any kind of

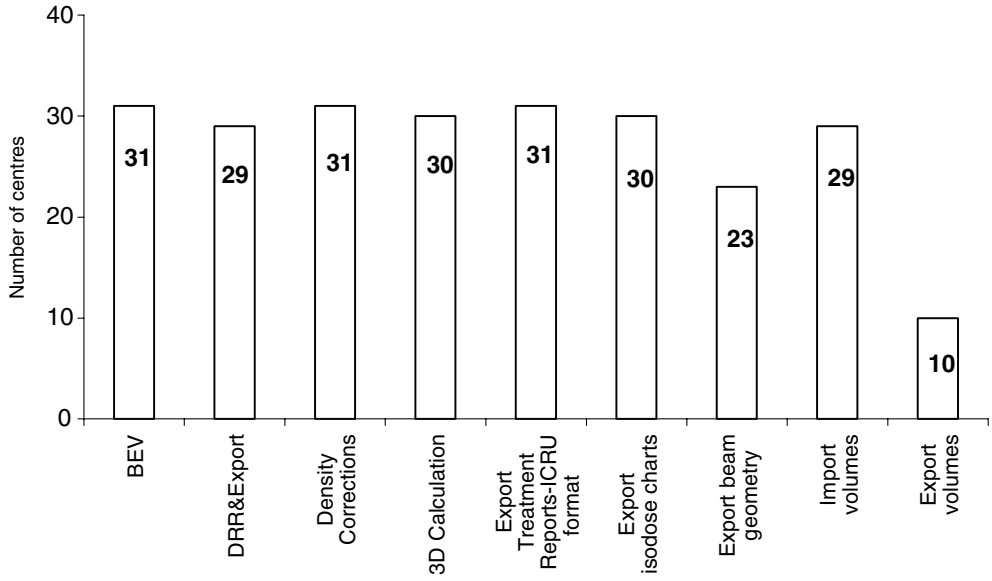

Fig. 1. Technical features of treatment planning systems (TPS). BEV, beam's eye view; 3D, 3-dimensional; DRR, digitally reconstructed radiographs; ICRU, International Commission on Radiation Units and Measurements.

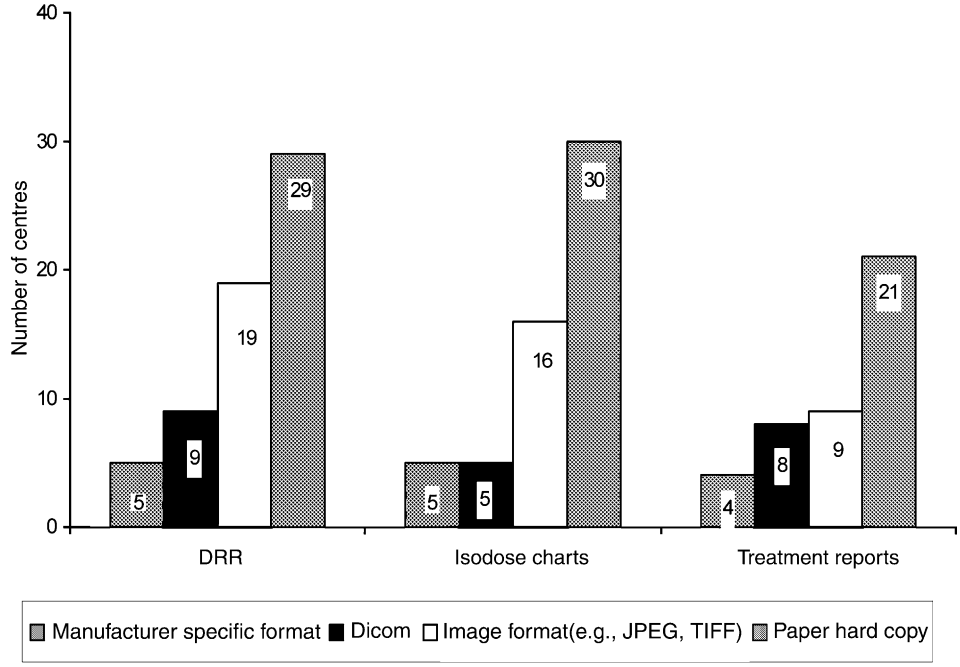

Fig. 2. Export formats for digitally reconstructed radiographs (DRR), treatment reports and isodose charts.

immobilisation, 17 centres (55%) use commercially available knee or pelvic fixation devices and two centres (6%) use individualised immobilisation devices during conformal irradiation of the prostate cancer.

For treatment verification, only port films, only electronic portal imaging (EPID) or both systems are used in 19%, 29% and 52% of the centres, respectively. Of the 84% of the centres that reported their frequency of portal imaging, all perform weekly checks, except for two centres that perform twice weekly or daily checks. Twenty-nine centres forwarded information on *in vivo* dosimetry; centres have an access to diodes only (6), thermoluminescent dosimeters (TLD) only (1), diodes and TLD (7), ion chamber and TLD (1), diode and TLD and EPID (1). Thirteen centres do not perform individual *in vivo* dosimetry.

4. Discussion

Delivering high-quality 3D-CRT involves a complex process with numerous parameters in the various procedures. The superior performance of modern equipment can only be fully exploited with a high degree of accuracy and reliability through comprehensive QA analysis where all aspects of the treatment preparation and execution are adequately investigated. We acquired complete and direct information about the 3D-CRT procedures of the participating centres on the vast majority of the issues enquired about in this questionnaire.

Different institutional policies exist regarding patient immobilisation systems, which were not mandatory in this trial. However, we would encourage its use, since it improves patient immobilisation, which can help to minimise the volume of bladder and rectum in the treatment fields [12,13]. By contrast, other studies have shown no significant effect of fixation devices, such as alpha-cradle, aqua-plast and vacuum-moulded bags [14,15]. Due to these contradictory reports on the effects of immobilisation on set-up reproducibility, the necessity for, and the preferred type of, an immobilisation system remains to be determined.

The trial protocol did not specify the slice thickness or the matrix size. However, in all of the participating centres the minimum CT slice thickness and the minimum matrix size enables high quality 3D-reconstruction. A slice thickness of 5–10 mm might be sufficient for CT planning, but thinner slices of 2–3 mm are preferred for 3D-reconstruction and calculation [16]. Electronic transfer of the CT-data is possible in nearly all of the centres, which provides uncorrupted data transfer from CT scan to TPS. All centres use BEV to shape the treatment fields. BEV display of organs at risk (OAR) and target volumes is an important feature of 3D-treatment planning, enabling better target coverage and normal tissue protection. The use of BEV was reported to improve treatment optimisation in 3D-CRT of the prostate, and this was confirmed by DVH evaluation [17]. As strongly recommended in this study, almost all centres use DRR. DRR allows bones, air and other structures to be highlighted by different windows, brightness and contrast settings so that high quality pictures can be produced for comparison with portal images [18].

3D-calculation methods can define the radiation dose more accurately than 2D-calculation, because they take into account scattered photon interactions. The accuracy of treatment planning can be further improved with the conversion of the CT number to electron density. The ensuing dose calculation gives a more realistic picture of the dose to the patient [19]. 3D-dose calculation and heterogeneity corrections can be done in nearly all the participating centres.

DICOM-RT enables the storage and transmission of radiotherapy data including treatment plans, delineated structures and verification images with a high accuracy. Although most radiotherapy vendors are in the process of implementing DICOM-RT into their products, current implementations are incomplete due to the various complex aspects involved.

The evaluation of a 3D-dose distribution with transverse, sagittal and coronal isodose plots is useful, but gives rough and incomplete information. DVH, which is available in all the participating centres, provides a complete summary of the entire 3D-dose matrix, including dose–volume information on target volumes and OAR.

As the margins around treatment volumes become tighter and conform more to the shape of target volumes in 3D-CRT, the need for precise treatment verification increases. This can be done with conventional film-based portal imaging with off-line correction or EPID, which allows on-line, as well as off-line, correction for patient-positioning. For treatments requiring a high level of precision, repetitive portal imaging was recommended during the entire radiation [20]. All participating centres perform treatment verification, either by conventional and/or EPID. Most of the centres reported to perform portal imaging weekly, as required in the protocol.

Even in well-equipped radiotherapy departments with active QA systems, a certain percentage of systematic errors in dose delivery occur due to the numerous steps involved in the radiotherapy process [21]. Dose verification by *in vivo* dosimetry enables the verification of the final result of radiation treatment execution, therefore, it is highly recommended [22,23]. Diodes are preferred because of their better reproducibility and immediate availability for on-line dose monitoring. TLD is useful for inter-comparisons of dose values, but less convenient for individualised dosimetry because the results are not immediately available. Although it is not required in this trial, the accuracy of dose calculations with 3D-planning systems can be checked by *in vivo* dosimetry.

This technology questionnaire is the first step in an extensive QA programme that was designed prospectively for this trial. We confirmed that centres participating in the EORTC trial 22991 have access to the key items and procedures needed to execute 3D-CRT properly, with a good compliance with the protocol requirements. A dummy-run procedure was also initiated to identify discrepancies among the centres and to improve their compliance with the protocol requirements. Currently, an individual case review and a TLD dosimetry check are also being performed. A small percentage of centres will use IMRT for conformal prostate irradiation, which requires complex QA procedures. A specially designed IMRT QA programme was

implemented to validate the calculated dose distribution in target volume and critical structures. Complimentary data on these trial-specific QA procedures will be reported as the work evolves.

Conflict of interest statement

None declared.

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