INTERCOMPARISON OF QUALITY CONTROL PROCEDURES IN RADIOTHERAPY IN THE NETHERLANDS

H.J. VAN KLEFFENS, G.J. MEIJER
Iniversity Hospital Utrecht,
Utrecht

B.J. MIJNHEER
The Netherlands Cancer Institute,
Amsterdam

The Netherlands

Abstract

A grant was received from the Dutch government to accomplish the development and implementation of guidelines for quality control (QC) of radiotherapy equipment in The Netherlands. QC of electron accelerators, simulators, CT scanners, mould room equipment, dosimetry equipment and treatment planning systems will be considered in this project. The project started in September 1994 with an investigation of QC of medical electron accelerators as performed in all 21 radiotherapy institutions in The Netherlands. An extensive questionnaire on QC procedures of electron accelerators was sent to all centres with items related to safety systems, mechanical aspects, radiation leakage, beam data and dosimetry equipment (in total about 60 questions). From the answers the following conclusions can be drawn:

- There is a large variation in time spent on QC;
- This QC time strongly depends on the complexity of the linear accelerator;
- There is a large variation in frequency and tolerance levels of the various tests;
- The way QC of an item is performed differs considerably (extensive-comprehensive).

From these data recommendations specific for the situation in The Netherlands are being prepared and compared with other existing national and international reports. Similar procedures are underway for CT scanners and simulators while for the other equipment minimum guidelines still have to be developed.

1. INTRODUCTION

In The Netherlands there are 21 radiotherapy institutions. All these institutions have a quality assurance programme to ensure the safe and efficacious application of radiation for treatment of cancer. Up to now each institution applies its own criteria for such a QC-programme, guided by the many directives published about this subject. Because of the various guidelines employed and the differences in individual interpretation, a large variety of QC protocols is currently applied in The Netherlands.

This report describes the first results of the project 'Development and implementation of guidelines for quality control in radiotherapy in The Netherlands', initiated by the Netherlands Society on Clinical Physics, the Netherlands Society on Radiotherapy, the Dutch Society for Radiographers, the Netherlands Commission on Radiation Dosimetry (NCS) and financed by the ministry of Health, Welfare and Sports of the Dutch government. The principal aim of this project is to achieve a consensus on the different QC programmes and to recommend national minimum guidelines concerning QC procedures in radiotherapy for:

- *phase 1* : medical electron accelerators
- *phase 2* : simulators, CT scanners, dosimetry equipment
- *phase 3* : treatment planning systems

In order to realize this aim a physicist has been recruited for two years (G.J. Meijer). The set of minimum guidelines will be deduced from the currently employed protocols concerning QC in radiotherapy in The Netherlands together with recommendations found in various national and international reports. This report will discuss some of the results of the first phase of the project concerning the QC of medical linear accelerators.

2. INTER-INSTITUTIONAL SURVEY

To achieve insight in the currently employed QC protocols for medical electron accelerators in The Netherlands, an extensive questionnaire, with about 60 questions, has been sent to all radiotherapy institutions. The questionnaire covered many topics such as:

- safety systems
- mechanical parameters
- radiation leakage
- light field - photon field coincidence
- field flatness and symmetry
- beam energy
- absolute dosimetry
- wedge filters
- dose monitoring system
- arc therapy

Questions were asked concerning methods, frequencies, time required for the tests, tolerance levels (wherever relevant) as well as the training of the personnel performing these measurements. The institutions were also asked to return QC protocols and checklists when available, in order to obtain a better insight in the different methods used in the various institutions. Besides topics refering to different physical parameters, questions were asked concerning the overall time spent on QC per accelerator, the size of the institution (expressed as the total number of new patients) and available resources. All 21 radiotherapy institutions answered the questionnaire.

3. RESULTS OF PHASE I

3.1. OVERALL TIME SPENT ON QC

The institutions were asked how much time they monthly spent on QC of their accelerators. When different accelerators within a single institution required a different amount of time spent on QC, each accelerator had to be specified to the modalities available. The accelerators were subdivided into three different classes:

class I : accelerators with one photon beam and no electron beams
class II : accelerators with one photon beam and several electron beams
class III : accelerators with two (or more) photon beams and several electron beams

As expected the time spent on QC increases with the complexity of the accelerator and amounts on average 13.5, 15.5 and 22 hours per month for class I, II and III accelerators, respectively. It is also interesting to note that there exists a lot of variation in time spent on QC within each category, especially for dual (or triple) energy photon accelerators with several electron beam applications. In this category differences occurred from 8 hours up to over 30 hours monthly spent on QC of a single accelerator. Although it was specifically asked to give the time monthly spent on QC without the time spent on preventive maintenance, it might be that different interpretations may have contributed to the spread in the stated times spent on QC. Nevertheless the differences are striking and are probably due to differences in philosophy with regard to QC and the differences in resources and machine time available.

3.2. TEST FREQUENCIES

The test frequencies depend mainly on criteria such as the seriousness of the possible consequences of a malfunction and the likelihood of this malfunction. A number of reports has been published concerning QC of medical accelerators. Due to different interpretations, experience and available resources, a wide variety exists in the applied test frequencies of the various parameters. The smallest spread in test frequencies is found for the absolute dosimetry for photon

beams. About 60% of the institutions verifies the photon dose calibration on a weekly basis, four institutions have a(n) (additional) daily check procedure, often performed by the radiographers. Three institutions determine the absorbed dose only once every two weeks. An extreme large variation can be found in the beam quality check for photon beams as can be seen in Figure 1. One way to explain the wide spread of test frequencies is that the photon beam energy is implicitly checked by a symmetry interlock system. Consequently, different conceptions may occur concerning the need for additional tests.

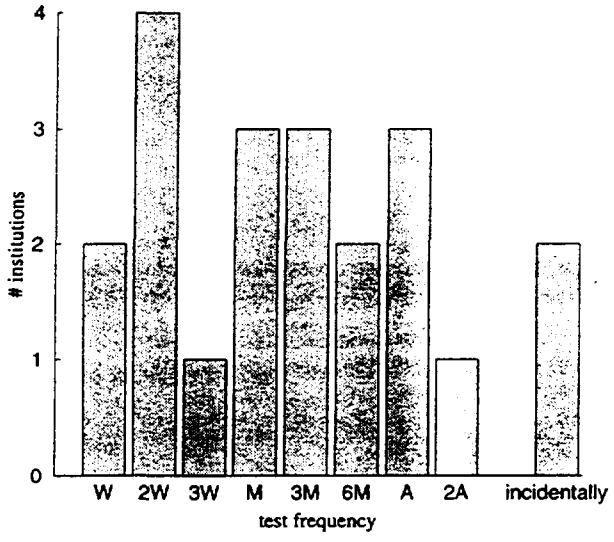

Figure 1: *Frequency distribution of the beam quality check of photon beams*

3.3. TOLERANCE LEVELS

A tolerance level can be defined in such a way that, whenever the equipment is tested and found in the range below the tolerance level, the equipment is suitable for high quality radiation therapy. The tolerance levels for dosimetric, geometric and mechanical parameters are limited by technical boundaries. The allowed uncertainties though have to be perceived as clinically acceptable. Because the technical boundaries are more or less the same within all institutions no extreme differences were found. When a parameter exceeds the tolerance level suitable actions should be taken. However, in special cases it might be very difficult to adjust a parameter or to repair a part of the accelerator easily and quickly. For this reason some institutions define an action level in addition to a tolerance level for some parameters. Whenever this action level is reached, it is essential that appropriate corrective action *immediately* is taken and no treatments will be given until suitable corrections have been performed.

3.4. TEST METHODS

A detailed description of the test procedures is essential when evaluating different QC-programmes, since a particular physical parameter can be tested in various ways, e.g. beam symmetry and field flatness. Many devices are nowadays commercially available for this purpose, such as linear detector arrays and quick check devices which easily check the dose rate in two orthogonal directions in a limited number of points. It should be noted that a check with such a device cannot directly be compared with a more time consuming test with a water phantom with a scanning mechanism, although both tests do provide valuable information.

4. NATIONAL RECOMMENDATIONS

The Netherlands Commission on Radiation Dosimetry (NCS) has recently drafted a comprehensive report on methods for QC of medical linear accelerators[7]. This NCS report covers a large number of QC aspects, including extensive descriptions of test methods, test frequencies and tolerance levels and is meant to serve as a model for good clinical practice. The results from the questionnaire were compared with this NCS report and with national and international recommendations [1, 2, 4, 5, 6, 8] and subsequently a minimum set of guidelines specific for the situation in The Netherlands was deduced.

5. CONCLUSIONS

The results of the questionnaire show a large variation in test frequencies, test methods and overall time spent on QC of electron accelerators and a somewhat smaller variation in tolerance levels. No correlation could be found between test frequency and tolerance level of a certain parameter and the type or make of the accelerator since the number of institutions was too small compared with the number and distribution of accelerators. From these data, together with national and international recommendations, a set of minimum requirements has been formulated specific for the situation in The Netherlands containing more than 30 test procedures including test frequencies and tolerance levels. These guidelines will be elucidated at various meetings and be compared with current practice in each situation. As a consequence the current large dispersal in test frequencies and test parameters might decrease. Phase 1 of the project has now been completed and phase 2 and 3 have been started to accomplish minimum guidelines for QC procedures for simulators, CT-scanners, dosimetry equipment and treatment planning systems.

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