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Quatlity Assurance and Quality Control for Therapeutic Radiology in A Challenging Facility.

M. A AWEDA*, R. O. K. MEINDINYO# KENEKE A. #
** DEPT. OF RADIOTHERPY AND RADIODIAGNOSIS*
 # DEPT OF PHYSICS NIGER DELTA UNIVERSITY AND BAYELSA MEDICAL UNIVERSITY

Abstract:
To forestall radiation accidents and to optimize the quality of treatment administered to patients (and to) with all radiation therapy / diagnostics equipment's a well-designed and quality assurance program must be put in place, maintained and sustained this is seen not to be tradition in many countries in the west African sub region and the consequences of this is obvious this paper which is more of a review tried to recap the necessary:
(I) Dosimetry quality assurance
(II) Field as dosimetry system procedures
(III) Parallel plate ionization and the external beam radiation therapy

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I. Introduction

The major goal of cancer management according to the intersociety council for radiation oncology (ISCRO 1986) is for all concerned to realize that every patient with cancer deserves to receive the best possible management to achieve cure, long term tumor control or palliation.

Hence the quality of radiation oncology can be defined as the totality of features or characteristics to satisfy the stated or implied goal of effective patient care. "Quality assurance" in general is therefore all those planned or systematic actions necessary to provide adequate confidence that the radiation oncology service will satisfy the given requirement quality care.

With this in mind therefore in treating patients with radiation the radiation oncologist prescribes a treatment regimen (including the radiation dose) whose goal is to cure or control the disease while minimizing complication to normal tissues. It is known however that the response of tumor and normal tissues to radiation is highly variable. And that the tumor response curves as well as the normal tissue complication probability curves can be quite steep in the therapeutic dose range i.e a small change in dose can result in a large change in clinical response (Fig 1).

Th is to say that too little cannot kill all the cells, meaning a high chance of local reoccurrence since cell are rapidly dividing. Also too much of the dose leads to very serious complications in normal tissues. It can be seen in the

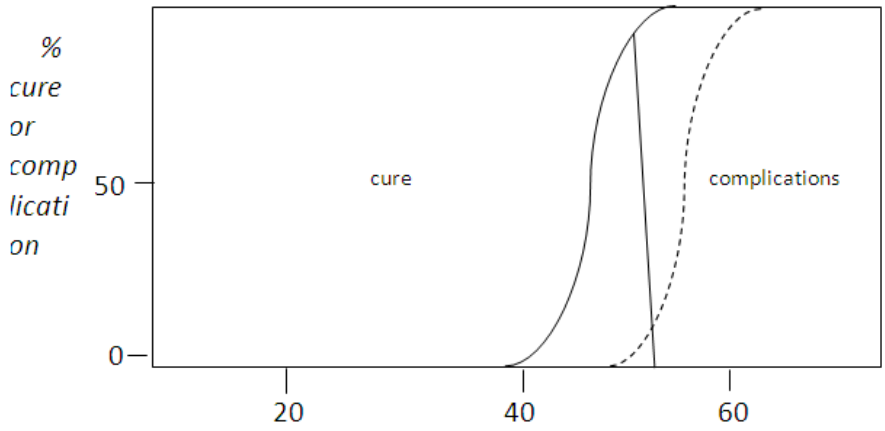

Fig. 1. Tumor cure / complication probability curves. The graph does not represent data for a particular tumor but shows the general trend.

Figure(1) that giving a dose 5% lower than 50Gy reduces the chance of local cure by a factor of nearly 2 while giving a dose 5% higher does not greatly increase the cure rate but does greatly increase the number of major complications.

In addition, the prescribed radiation dose to the tumor is usually by necessity constrained by the tolerance of the surrounding normal tissues. These together with the possibility of equipment failure or malfunction with a resultant over exposure of the patient undergoing radiation therapy (radiation accident) seriously calls for ensuring a precisely (consistently) and accurately delivered radiation treatment. this is a basic prerequisite for achieving an optimum balance between the maximum probability of curve and the accepted level of complications. Therefore, effective quality assurance (Q.A) as well as preventive maintenance program in radiation therapy clinics is an absolute necessity. Although a quality assurance program in radiation therapy has clinical and physical components, only the physical test and procedures intended to help ensure that the dose delivered to the patient by a treatment machine is that prescribed by a radiation oncologist will be address here.

GENERAL DESCRIPTION OF A TREATMENT MACHINE QA PROGRAM

QA of radiation therapy equipment is primarily an ongoing evaluation of functional performance characteristics. These characteristics ultimately influence the geometrical and dosimetric accuracy of the applied dose to the patient. The functional performance of a radiotherapy equipment can change suddenly due to

(i) Electronic malfunction
(ii) Components failure
(iii) Mechanical breakdown
(iv) Can change slowly due to deterioration and aging of the components.

As a result two essential requirement emerges:

QA measurements to be performed periodically on all therapy equipment including the dosimetry and other QA measurement devices themselves, and there should be regular preventive maintenance. Monitoring and correction of the performance of the therapy machines and measurement equipment. The goal of this procedures is to ensure that the performance characteristics, defined by physical parameters and established during commissioning, demonstrates no serious deviations.

A treatment machine QA program requires certain key ingredients if it is to be successful.

- A commitment by the staff of QA
- Adequate Staffing Levels
- Adequate testing instruments
- Regularly scheduled QA and preventive maintenance reviews
- Adequate time on the treatment machine for QA and PM reviews
- Agreed on QA machine performance tests and acceptance criteria.
- Accurate and complete documentation of the treatment machine
- Bound archival records

Also a QA program for radiation therapy equipment is a team effort, the responsibility of performing the various tasks can be divided among physicists, dosimetrists, technologists, (therapist), and maintenance technicians and the exact distribution is not critical although the overall responsibility for the machine quality assurance program is placed on the radiation oncology physicist.

QUALITY ASSURANCE TREATMENT

For a facility to be equipped with a megavoltage radiation therapy medical accelerator, there should be commitment to provide adequate test equipment and instrumentation and the necessary machine time for QA and PM tests in order to ensure that the unit is performing according to specifications.

Table 1. Is giving a general lists of the type of equipment considered most useful in a QA program for treatment machines.

Table 1.

S/N	RECOMMENDED QA TEST EQUIPMENT
1	Secondary standard dosimetry system
2	Field use dosimetry
3	Parallel plate ionization chamber
4	Polystyrene or solid-state water stack phantom
5	Output constancy check device
6	Beam summery constancy check device
7	Water phantom fixed ion chamber hold
8	Light field / radiation field check device
9	Film densitometer
10	Beam data scanning system .

Accurate data acquisition with automated scanning systems and scanning film densitometer requires the system to be subjected to a systematic performance test prior to use and should also undergo periodic QA test thereafter.

QUALITY ASSURANCE ACCEPTANCE CRITERIA

It is necessary to establish QA acceptance criteria for each of the constancy checks performed. The frequency of this depends primarily on the stability of the parameter tested based on experience.

Table 2 and 3 summarizes the recommended QA tests. (adopted from the American college of Medical Physics (ACMP) report2 (radiation control and quality assurance in radiation oncology: a suggested protocol)
The first column of the table lists the parameters been measured, the second column is a brief explanation of why the measurement is appropriate and the third column gives the suggested performance criteria. If the measurement falls outside the criteria, the parameter should be adjusted so as to come into compliance.

QUALITY ASSURANCE TESTS

QA test should be designed to be quick and producible checks on key parameters, if they are to be accepted and performed faithfully. Many excellent guidelines exist for establishing QA programs, including:

(1) ACMP Report #2 radiation control and quality assurance in radiation oncology as suggested protocol (9)

(2) The American association of physicist in medicine (AAMP) Report #13 physical aspect of quality assurance of radiotherapy equipment (11)

a general guideline is discussed below although the external QA test required of a particular institution must be developed by that institution. Also, in summary for QA test for.

DAILY TESTs

A number of tests are recommended to be performed daily on the equipment as indicated in the table 4.

The manufacturer's instructions for startup and operation of the accelerator should be followed and readings of the various meters, dials, gauges, recommended for monitoring and recorded. It is particularly important to check the lamp test which indicates if all indicator lights are operational. The daily readings are to be maintained in a log book.

In checking the photon beam output, use is made of an ion chamber, in a simple plastic phantom which contains a hole at a standard depth from the top surfaces for the chamber and which attaches to the accelerator at the standard. A cylindrical ion chamber (e.g. farmer type) or other type of chamber can be used for the test. The ion chamber reading should be corrected for **temperature** and **pressure** and converted to dose using predetermined factors and the output value compared to the value established at the time of the last full calibration. The radiation output at each electron energy for a single application (e.g. 10cm × 10cm) should be checked once or twice weekly. This can be accomplished using a polystyrene stack phantom and ion chamber dosimetry system.

The plastic constancy phantom used for the photon beam output check is also convenient for checking the ODI and the laser localization lights. The ODI as an annual QA test. It is important to perform a full calibration of the treatment machine task. The basic calibration should be performed in a water phantom using an ion chamber (19). The stability of the dose per monitor unit and beam symmetry should be checked at different gantry angles. verification of the output factors and central axis depth dose should be done for several different field size. In addition, current values for off-axis factors monitor linearity, monitor end effect, all wedge and tray factors and bolus and comp filters attenuation factors should be verified.

To be checked annually also are various mechanical alignments. For example the mechanical isocenter can be checked by observing the position of the front pointer tip in relation to a 2mm diameter rod as the gantry is rotated through 360^{o}.

A "star pattern" is sometimes produced to check radiation isocenter i.e. a film is placed parallel to the radiation beam and one set of collimator jaw is closed to a narrow slit and exposures are made at different gantry angles. All couch movements and table top sag. Under load should be evaluated also.

Finally a continuing education course on the machine operation, safety and QA should be presented on an annual bases. A thorough "hand on" training period for all technologist is important following instruction about the operation of the equipment and prior to assuming treatment responsibility, written instructions should be provided to guide technologist as to a safe response when equipment malfunctions or after any component has been changed or readjusted.

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