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Original Research

Acceptance Testing, Commissioning And Quality Assurance For Bebig Co60 Hdr Brachytherapy Afterloader At Rajshahi Medical College Hospital

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Abstract

In Brachytherapy treatment the accuracy of radiation dose delivered to the cancer patients by using HDR Brachytherapy and to know proposed methods for the initial source installation tests, acceptance testing, and quality assurance program. This work has been done at Rajshahi Medical College Hospital where's new BEBEG Multisource Co-60 HDR Brachytherapy machines are installed. The observation of reference Air Kerma strength (maximum dose distribution) was determined by using well type ionization chamber (model PTW [SN] 000595) and electrometer (model PTW UNODOSE [SN] 082145).A careful radiation survey has been completed around the brachytherapy machine and outer wall of the machine room by using well calibrated radiation survey meter NUCLEONIX [CMP710P].The quality assurance programmed and Acceptance testing, commissioning of the HDR brachytherapy unit has been completed with carefully. The Air Kerma strengthwas calculated and measured values were 15.88 mGy/h and 16.11 mGy/h respectively, and the deviation was 1.42% which does not exceed the tolerance limit ±3%. The calculated and measure source activity were 51.92 GBq and 51.87 GBq, and the deviation was 0.09% respectively, which does not exceed its tolerance limit ±3%. The quality assurance programmed has been done according to ESTRO Booklet 8 and result was satisfactory. The source positional accuracy, Dwell time accuracy and Timer accuracy was measured by following Manufacturer's guideline standard protocol.

Keywords: *Acceptance Testing, Commissioning, Quality Assurance, Co-60 HDR Brachytherapy After loader, RMCH Rajshahi.*

Introduction

The Brachytherapy treatments are well developed in 21st century with modern treatment modality rather than before. Now a day we are used complex software program for brachytherapy treatment with link a simulator like CT, MRI and ultrasonic image for tumor localization. Modern brachytherapy has changed out of all recognition to what it was even 50 years ago [1].

Brachytherapy, also known as curie therapy or endocurietherapy, is a form of internal radiotherapy that is sometimes used in conjunction with External Beam Radiotherapy (EBRT) for treating certain types of cancer. It involves placing a small, encapsulated radioactive source either temporarily or permanently close to or within the tumor, making it particularly effective when the malignant tissue is well-defined.

Brachytherapy is especially useful for intracavitary and interstitial cancer treatments. The radioactive source continuously emits photon energy, allowing for a highly localized radiation dose at the target area, which improves treatment precision compared to EBRT. Typically, about 10 to 20 percent of cancer patients in a radiotherapy department receive Brachytherapy as part of their treatment [2].

In the low-income and middle-income countries the cervix cancer cases increasing day by day and brachytherapy treatment are more effective for well localized tumor and improving both local control and survival rate. In this regards the American brachytherapy society published the recommendation for cervix brachytherapy treatment in low-income and middle-income countries [3].

Brachytherapy is also used in the treatment of coronary artery disease to prevent restenosis (re-narrowing of the artery) following angioplasty. In oncology, it plays a crucial role in managing cancers at various anatomical sites, including the brain, head and neck, uterine cervix, endometrium, and prostate.

It is an essential component of cervical cancer treatment, as it allows the delivery of very high-dose radiation directly to the tumor, while minimizing exposure and potential damage to surrounding healthy organs such as the bladder, rectum, and sigmoid colon.

Brachytherapy also offers additional benefits: it reduces the risk of post-treatment infection, involves shorter treatment durations, and often results in reduced hospital stays. Moreover, it provides patients with a non-surgical alternative, which is a universally appreciated advantage [4].

Compared to conventional external beam therapy, the physical advantage of brachytherapy result's from a superior localization of dose to the tumor volume. On the other hand, the dose gradients around an implant and dose heterogeneity within an implant are much higher than those in external beam radiotherapy.

In past brachytherapy treatment performed as Low dose rate (LDR) using the radium 226 and radon source 222. But these radioisotopes are not used longer because of their disadvantage. Today's modern brachytherapy performed as a High dose rate (HDR) using Co.60 and Ir.192 high energy radioisotope with their idle properties [5].

Materials and Methodology

This study was done at department of radiotherapy in Rajshahi medical College Hospital Rajshahi, Bangladesh mainly deals with the machine installation and observation of the source air karma strength by using the well type ionization chamber and electrometer. Beside this includes the conformation of radioactivity of the nuclides, safety measures of the machine. Radiation survey has been undertaken around the brachytherapy by using well calibrated radiation survey meter. Anothercheck was done such as safety check, mechanical check and dosimetrical check.

Result and Discussions

Room design and Shielding

A single room with sufficient space is the best choice for brachytherapy treatment. For the machine room it's very important to ensure that the enough room space for after loader equipment and safety entrance for patient trolley and emergency purposes. The room was built followed IAEA standards. Wall shielding is 50cm fully concrete and the door is lead shielded [6]

HDR Machine Specification

The machine is recommended or not for Brachytherapy treatment its initial step and its IAEA standard or not is need cheeks. The exact method to be used for safety checks has to be adapted to the local situation. The following list of functions or items is test for machine quality. This following function is requiring for Brachytherapy machine. If the machine is fulfilled the require functions, then these machines recommended for Brachytherapy treatment.

Table 1: Machine Specifications List

Test	Requirements
1.	Number of channels of the machine
2.	Functioning of sensors like pressure, torque, optical
3.	Coupling between guide-tube and unit
4.	Coupling between guide- tube and applicator
5.	Coupling between drive cable and source
6.	Time taken to drive the source to" ON" "OFF".
7.	Source guide free of kinks?
8.	Mechanical integrity of applicators & position of shield, if any
9.	Interlocks
10.	Source Safe Display
11.	Control Console Display
12.	Control Console Function

Initially the machine and Source Installation

For the purposes of machine and source installation the manufacturer has own guideline and followed standard protocol. Machine and source installation was done by the manufacturer expert engineer and check the following listed before of installation. These checks are pre installing test when everything is good then machine is ready for installation.

Table 2: Check list before of Installation

Test	Requirements
1	Package indicators activated?
2	Wooden box damaged or forced?
3	Multisource damaged (Resulting from the damaged wooden box or not)?
4	Power supply/potential equalsation according to the specification
5	Installation of Termination boxes
6	Test of computer
7	Software update
8	Operational test with dummy
9	Inspection of multisource unit
10	Inspection of electrical safety

Acceptance Testing and Commissioning

Acceptance tests and commissioning assure that the specifications contained in the purchase order are fulfilled and that the environment is free of radiation and electrical hazards to staff and patients. The tests are performed in the presence of a manufacturer's representative. Upon satisfactory completion of the acceptance tests, the physicist signs a document certifying that these conditions are met.

When the physicist accepts the unit, the final payment is made for the unit, ownership of the unit is transferred to the institution and the warranty period begins. These conditions place a heavy responsibility on the physicist for the correct performance of these tests.

Acceptance tests may be divided into three groups:

i. Safety checks;
ii. Mechanical checks;
iii. Dosimetry measurements.

A number of national and international protocols exist to guide the physicist in the performance of these tests.

Table 3: Safety acceptance tests and result.

Safety:

S. N.	Test	Result
1	Communication equipment	Satisfactory
2	Check of treatment without indexer lock, without applicator attachment	Satisfactory
3.	Door interlock test/ Treatment interrupts/ Emergency stop, Power interrupt	Satisfactory
4.	Emergency equipment (forceps, emergency safe, survey meter, source disposal kit)	Satisfactory
5.	Radiation Monitor detector, light indicators Satisfactory	Satisfactory
6.	Timer, secondary timer	Satisfactory

Table 4: Planning computer acceptance test and results.

Planning Computer:

S. N.	Test	Result
1.	User Documentation – BEBIG	Satisfactory
2.	Scanner/Printer	Satisfactory
3.	HDRs planning software	Satisfactory
4.	Standard plan – Calculation check	Satisfactory
5.	Plan Reproducibility	Satisfactory
6.	Time, date & decay check	Satisfactory
7.	Patient file backup	Satisfactory
8.	Patient data transfer	Satisfactory

Table 5: Treatment Unit Control Console acceptance test and results.

Treatment Unit Control Console:

S. N.	Test	Result
1.	User Documentation – BEBIG	Satisfactory
2.	Printer Satisfactory	Satisfactory
3.	Patient file transfer, Treatment	Satisfactory
4.	Robot control	Satisfactory
5.	Interrupts	Satisfactory

Acceptance testing and annual remote after loader QA:

The annual review of remote after loader function should be comprehensive, approaching the thoroughness of initial acceptance testing in this regard. For remote after loaders, all source and applicator tests should be performed, including verification of source strength and radiographic examination of intracavitary applicators. Timer accuracy and linearity should be measured more comprehensively although measurement over range of use may be practical. Positional accuracy should be checked carefully, including the condition and dimensions of all dummy simulation sources. The radioactive source locations should be compared directly to their dummy source counterparts, possibly by superposing auto radiographic images with transmission radiographs of dummy sources on the same film for various types of applicators.

Additional HDR tests include comprehensive assessment of positional accuracy, including all positional accuracy tests, measurement of transfer tube lengths, and direct verification of all simulation source localization protocols. Additional temporal accuracy tests include assessment of transit dose. The AAPM Task Group No. 59 is currently developing guidelines for patient-specific QA of brachytherapy suing HDR remote after loaders [7].

Radiation Survey

After the machine and source installation the radiation measurements is very important around the machine, inside and outside of machine room with wall in both sides. Radiation measurements were undertaken around the brachytherapy machine by using well calibrated digital contamination radiation survey meter NUCLEONIX [CMP710P]. The digital contamination monitor (micro) is a portable micro-controller-based battery-operated instrument designed primarily for measurement of Beta/ Gamma radiation. It can be used for measurement in three modes CPS, CPM, Preset and Dose rate modes. The unit can measure up to 0-200mR/hr with end window detector. The maximum reading 0.04 mR/hr was found at the wall of control console. The maximum reading was found 0.20 in at front of the machine surface which was within the limit.

Table 6: Radiation Survey check

Test position	Measured data (mR/h)
Top	0.17
Button	0.12
Front	0.32
Back	0.15
Right	0.11
Left	0.20

A. QC measure of HDR machine
B. Timer accuracy and calibration

After the survey its need to checks the source activity, decay and timer accuracy. This is the machine function checks by connecting source guide tube with after loader indexer.

Source Position Check

To know the accuracy of source positioning visual camera or film is used. The camera has contained a scale in millimetre. For check of source positioning, the camera and Dummy need to connect with indexer by the source guide tube. Accuracy of source positioning with tolerance as specified to be ±1 mm.

Pre-Treatment Source Strength Verification Test

The computer and console source strength should be compared with the source decay table. A well calibrated Nucleation SDS and Unidos E dosimeter is used to find out the source strength tests.

The sweet spot was recorded by using well chamber and electrometer. All the instructions given in the manual were followed. The time exposure is 20 second and biasing voltage is -300V. The sweet position observed at the 10th position in the chamber. The dwell time was set 60seceond.

The calibrated source strength trial observed at various date was compared with the respective manufacturer's calibration source strength. Deviation between the calibrated source strength observed with manufacturer's calibration source strength was found 1.42% which was less than tolerance limit.

Time Error

Time taken to drive the source to ON and OFF positions was found 6 sec. Time error was measured in charge mode with and without interruption of treatment was found 0.5368% which is less than tolerance limit 1%.

Quality assurance: Quality assurance means all he procedure that ensure consistency of the medical prescription, and safe fulfilment of the prescription, as regards to fulfil the radiotherapy aimed and minimal exposure of personnel and adequate patient monitoring aimed at determining the end result of the treatment [8].

Table 7 Frequencies and tolerances of quality control tests for HDR / PDR after loading equipment. (3M- quarterly; 6M- biannual; A- annual; SE- source exchange).**Planning Computer:**

Description	Minimum Requirement	
	Test frequency	Action Level
Safety System		
Warning lights	Daily/3Month	Satisfactory
Room monitors	Daily/3Month	Satisfactory
Communication Equipment	Daily/3Month	Functioning
Emergency Stop	3Month	Functioning
Treatment interrupts	3Month	Functioning

Description	Minimum Requirement	
	Test frequency	Action Level
Door interlock	3Month	Functioning
wer loss	3Month	Satisfactory
Applicator and catheter attachment	6Month	Satisfactory
Obstructed catheter	3Month	Satisfactory
Integrity of transfer tubes and applicator	3Month	Satisfactory
Timer termination	Daily	Satisfactory
Contamination Test	Annually	Satisfactory
Leakage radiation	Annually	Satisfactory
Emergency equipment (forceps, emergency safe, survey meter)	Daily/3Month	Functioning
Practicing emergency procedure	Annually	Functioning
Hand cranks functioning	Annually	Functioning
Hand held monitor	3Month/ Annually	Satisfactory
Physical Parameter		
Source position	Daily/3Month	>2mm
Source calibration	SE	>5%
Length of treatment tube	Annually	>1mm
Irradiation timer	Annually	>1%
Date time, Source strength in treatment unit	Daily	Satisfactory
Transit time effect	Annually	Satisfactory

Discussion:

In brachytherapy a single room accommodation is best choice. The room layout will depend on the thickness of wall and shielding door for radiation protection. The room layout also depends on the use of radioisotope. The60Co half-life is 5.26 years and its high specific activity with undergoes β- decay to the excited states of 60Ni (94.4%). The Co-60 radioisotope emits γ-rays of 1.173 MeV and 1.332 MeV energy averages 1.25MeV. The main β-rays emitted (99.88%) have a maximum energy of 0.318 MeV and an average energy of 0.096 MeV. Physical dimensions of HDR 60Co brachytherapy sources are 3.5 mm length and 0.6 mm diameter. The Air Kerma strength was compared with TPS value and practical measured value. The deviation was 1.42% which does not exceed the tolerance limit ±3%. The acceptance test, commissioning and quality assurance was completed perfectly according to manufacturers' guideline and result was within acceptable range. BEBEG Multisource Co-60 HDR brachytherapy system has been implemented in our unit. The acceptance test shows that status of brachytherapy and its components are functioning well. Radiation dose which will be delivered to the cancer patients are within planned dose.

Conclusion

Cervical cancer is a large and growing problem in low and middle-income countries. Traditionally, brachytherapy was performed as a low-dose rate (LDR)therapy using radium (226Ra) or its daughter element radon (222Rn). Radium has the advantage of a very long half-life, but it also has the disadvantage of producing the alpha-emitting gaseous daughter product radon. By modern radiation safety standards, radium, and radon sources are considered to be unsafe and are no longer used. Today, the vast majority of interstitial brachytherapy treatments are being performed as a high-dose rate (HDR) temporary implant brachytherapy with 192Ir or 60Co, or LDR permanent implant brachytherapy with 125I, or 103Pd sources. The choice of radionuclides that can be used for brachytherapy, however, is limited because only a few have all the desirable properties of the ideal brachytherapy source.

Authors Contributions

The main research title selection, research design, and writing were conducted by Shahidul Miah and Polash Chandra Sarker, while data collection and data analysis were carried out with the assistance of Amir Hamza.

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Conflict of interest

The authors declare that they do not have any conflict of interest.

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