ACCEPTANCE TESTING, COMMISSIONING AND QUALITY ASSURANCE FOR A NUCLETRON ^{192}IR HDR BRACHYTHERAPY AFTERLOADER AT NAMS, BIR HOSPITAL

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Abstract: To evaluate 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 a quality assurance program are done on Nucletron MicroSelectron ^{192}Ir HDR Brachytherapy Afterloader at NAMS, Bir Hospital. The observation of sweet spots (maximum dose distribution) by using well chamber (SI HDR 1000) and electrometer (SI CDX 2000). On the basis of the observed sweet spot, Air Kerma Strength of the source is determined. Beside this includes the conformation of step size, radioactivity of the nuclides and safety measures of the machine. A careful radiation survey has been undertaken around the brachytherapy by using well calibrated TBM-IC Mark V is a small ion chamber radiation monitor. Acceptance testing and commissioning of the HDR brachytherapy unit has been completed. Air Kerma strength in newly installed source exhibit small variation but within the limit. The step size has standard deviation 0.05 with the planned step size. The measurement of radiation level around brachytherapy shows the level is within the criteria. Nucletron MicroSelectron ^{192}Ir 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.

Keywords: Air kerma strength; Brachytherapy; Quality control; Radiation protection

INTRODUCTION

Bell in 1903 was first suggested implanting the radioactive source directly into a tumor. Brachytherapy is an internal radiation therapy that is applied either in a permanent manner or in a temporary manner, often through the use of catheters into which the radioactive sources are placed. High dose rate (HDR) brachytherapy, whereby the patient usually undergoes several treatments of radiation in a short period of time. Depending on the lesion being treated, brachytherapy can be practiced in following ways: Intra-cavitary Brachytherapy, Interstitial Brachytherapy, surface moulds and Intraluminal[1,2]. Brachytherapy is used in the treatment of various kinds of cancer, including prostate, breast, cervical, and ocular. Brachytherapy is also used to treat coronary artery disease to prevent restenosis after angioplasty. The benefits of brachytherapy vary depending on the patient, their priorities, and preferences, though as a minimally invasive treatment method, the benefits of avoiding surgery are universal. These include a quicker recovery time, less time spent in the hospital, and a reduced risk of postoperative infections.

In HDR brachytherapy, small Irrradium-192 source of high reference of high air kerma rate[3], e.g 4.6 $cGy.h^{-1}.m^{2}$ (10 Ci). This source offer a high dose rate and the potential for superior dose distribution for the patient with radiation safety for working staffs.

MATERIALS AND METHODS

This study was done at the Department of Radiotherapy, at NAMS, Bir Hospital, Kathmandu, mainly deals with the observation of sweet spots (maximum dose distribution) by using well chamber (SI HDR 1000) and electrometer (SI CDX 2000)[4]. On the basis of the observed sweet spot, Air Kerma Strength of the source is determined. Beside this includes the conformation of step size, radioactivity of the nuclides, safety measures of the machine. Radiation survey has been undertaken around the brachytherapy by using well calibrated radiation survey meter[5,6].

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RESULT

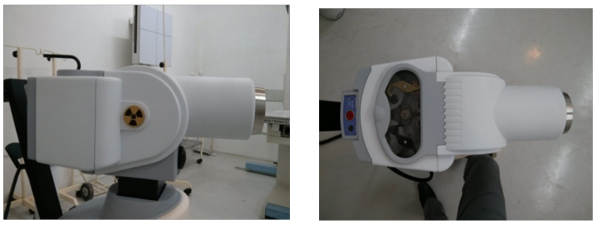
Initial Source Installation

Room & Shielding design

In HDR brachytherapy equipment, it is always best to provide single room accommodation. The layout of room will depend upon local circumstances but it will be necessary to ensure that the room is adequately protected, suitably located, large enough to allow access for patients on beds, enough space for the after-loading equipment and sufficient access for emergencies to be dealt with safely[6,7,8]. Wall shielding is 50cm fully concrete and the door is lead shielded. Room was built accordance to IAEA standards.

Radiation Survey

Measurements were made by Roentgen Gamma Ray Dosimeter (RGD 27091) is a well calibrated radiation survey meter. The TBM-IC Mark V is a small ion chamber radiation monitor. Dose rate measurement range is from 0.1 mR/h to 9999.9 mR/h (mR option) and from 1 µSv/h to 99,999 µSv/h (Sv option) and total dose measurement range is from 0.01mR to 99,999.99 mR (mR option) and from 0.1 µSv to 999,999.9 µSv (Sv option). The maximum reading of 4.2 µSv/hr was found at the wall of control console. The maximum reading at the robot surface with the retracted was was 2.45 µSv/hr for a 7.951 Ci for a mGy. m^2. h^{-1} source strength, which was within the limit[9].



A B

Figure 1: Radiation Survey around HDR unit A. Top view B. Side View.

Source Position Film Check

To know the accuracy of source positioning we used GaF Chromic film by entering a reference distance to channel 1 to which the transfer tube is connected and the dwell time was set as 0.5 sec and send the source out. The exposed GaF chromic film was matched with dummy X-ray marker over the GaF chromic film in such a way that the source position of the dummy X-ray marker matches the programmed reference distance marked in the film. In second film check we have verified the exposed active source position with the scale in the GaF chromic film. Accuracy of source positioning, as specified to be _+ 1 mm was found within limit[9]. The standard deviation obtained is 0.05.

QC measures of HDR Machine

Since individual treatment equipment and installation details in the treatment room may differ, the exact method to be used for safety checks has to be adapted to the local situation. The following is a list of functions and/or items were tested.

Pre-Treatment Source Strength Verification Test

The computer and console source strength should be compared with the source decay table. A well calibrated Nucletron 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 10^{th} position in the chamber. After finding out the sweet spot we programmed a treatment 7
reference distance 1385 for 60 sec at this dwell position.

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 6
found -2.088% which was less than tolerance limit[10].

Time Linearity and End Error

The measurement was done by setting the dosimeter into charge in micro coulomb mode and setting time at 300 second. The following graph shows time linearity and end error found as a straight line.

Time Error

Time taken to drive the source to ON and OFF positions was found 5.2 sec. Time error was measured in charge mode with and without interruption of treatment was found 0.6174% which is less than tolerance limit 1%[9,10].

DISCUSSION

In the HDR brachytherapy, it is always best to provide single room accommodation. The layout of room will depend on thickness of the wall, shielding of door. The reason for the maximum peak to be at 10^{th} position is that the most sensitive part of the well chamber is at the center of the chamber. Data provided in above as "action level", reflect the upper limit in clinical conditions. For an acceptance test the design specifications must be compared. Often the design of the system is such that a much better performance can be obtained under reference conditions, such as positional checks with autoradiography. It is the physicist's task to inspect the performance history of the system. Deviation between the calibrated source strength observed with manufacturer's calibration source strength was found -2.088% which was less than tolerance limit[10,11].

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

Table1 : Safety acceptance tests and results.

Planning Computer:

S.N	Test	Result
1.	User Documentation – Nucletron	Satisfactory
2.	Scanner/Printer	Satisfactory
3.	Oncentra 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 2 : Planning computer acceptance test and results.

Treatment Unit Control Console:

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

Table 3: Treatment Unit Control Console acceptance test and results.

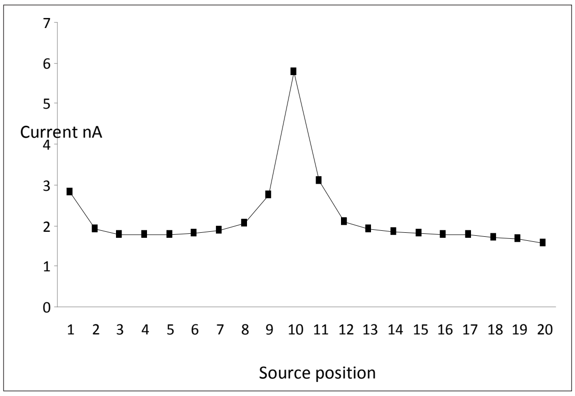


Figure 2: Current in nA at different source positions.

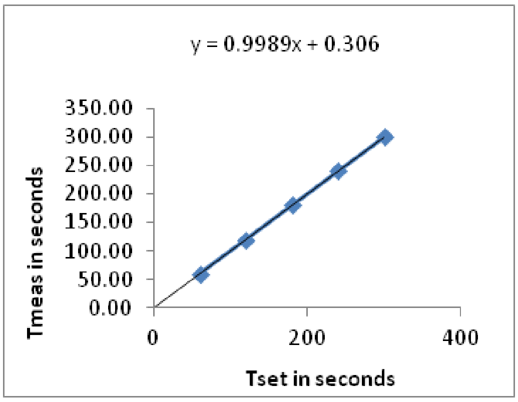


Figure 3: Time linearity and end error.

During survey, slightly high radiation level was found bottom of the head of machine than other positions because source is oriented on the bottom of the head. All observed radiation levels are within the safe limit[12].

CONCLUSION

This paper has presented the response of our institution's to the task of implementing a HDR brachytherapy treatment service. This paper has concentrated on the work carried out by medical physicists in its implementation. Brachytherapy among other radiation therapy for the treatment of cancer diseases is proving itself as a frontline therapy process. Different experiments were conducted to find Air Kerma Strength, confirmation of step size; related procedures were followed for the quality assurance (QA) and safety measure check of the machine. Beside this, for the radiation safety of working personnel, patients and attendants of the hospital, survey of radiation level has been undertaken and found within the limit as described.

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