

## QUALITY ASSURANCE OF VARI-SOURCE HIGH DOSE RATE (HDR) BRACHYTHERAPY- REMOTE AFTER LOADER AND COST EFFECTIVENESS OF VARI-SOURCE HDR- BRACHYTHERAPY: NORI, ISLAMABAD EXPERIENCE

N. AHMAD, H. MAHMOOD and S. R. A. JAFRI

Nuclear Medicine, Oncology and Radiotherapy Institute (NORI), Islamabad, Pakistan

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A quality control of Vari-Source high dose rate (HDR) remote after loading brachytherapy machine was carried out and the cost effectiveness of HDR brachytherapy machine was also evaluated considering the cost of ten Iridium-192 wire sources at Nuclear Medicine, Oncology and Radiotherapy Institute (NORI), Islamabad, Pakistan. A total number of 253 intracavitary insertions were done in 98 patients from October 1996 to May 2001. The results of the quality control tests performed during 1996 to 2001 were within the acceptable limits. The cost effectiveness of Vari-Source HDR brachytherapy machine was also evaluated. The average cost per patient was calculated as US\$ 491. Small number of patients was treated as the machine was used for gynecologic malignancies only. The objective was to assess the quality control status of HDR brachytherapy machine on patient treatment day, source exchange day and periodic day (monthly basis). It was found that the cost per patient can be minimized if other type of cancer patients are also treated on Vari-Source HDR machine.

**Keywords:** Quality control, Remote after loader, High dose rate (HDR) brachytherapy, Cost effectiveness.

### 1. Introduction

Brachytherapy also known as curietherapy or endocurietherapy was one of first uses of radiation therapy after the discovery of radium. In 1950s and 1960s, the use of brachytherapy declined due to concern regarding the harmful effects of radiation. It involved the radiation hazard to hospital personnel during the insertion of preloaded sources, followed by hospital stay in an isolation room. The introduction of high energy external beam also caused a decline in the use of brachytherapy in 1950s and 1960s.

In brachytherapy, the sealed radioactive sources are inserted directly into tumour to give high radiation dose locally to the tumour with rapid dose fall off in the surrounding normal tissue due to inverse square law. Thus, with proper geometric placement of sources, the tumour receives far higher doses than the surrounding normal tissues. These advantages can further be augmented by varying the strength of sources or varying the dwell time of remote after- loading sources in order to shape the dose distribution to fit the geometric borders of the tumour. In this mode of radiation therapy interstitial, intracavitary, intraoperative or

surface application methods are used. In the past, the brachytherapy was carried out mostly with radium and now artificially produced radionuclides like Cs-137, Ir-192, Au-198, I-125 are used. The production of artificial isotopes, better instrumentation for source introduction and retention, computerized treatment planning system and dose calculation gave rebirth to the use of brachytherapy. In late 1960s, the after loading devices, which reduced personal exposures and in 1980s automatic remote control to deliver controlled radiation exposure from high activity sources, have increased the interest of oncologists in brachytherapy. Now brachytherapy is relatively safer, easily available and more effective than in the past [4]. The dose rates of brachytherapy are described as low (0.4 to 2 Gy/hr), medium (2 to 12 Gy/hr) and high (> 12 Gy/hr) [1]. Brachytherapy is used either as a single modality to deliver a radical dose or in combination with external beam radiation to deliver a boost dose. The treatment is applicable to a wide range of tumour types and sites [5,10,11]. Although, the electron beam is used as an alternative to interstitial implants, brachytherapy continues to remain an important mode of therapy, either alone or combined with

\* Corresponding author : naim@isd.wol.net.pk

Table 1. Quality assurance tests and their frequency.

Serial No.	QA Test	Treatment Day	Exchange Day	Periodic Day
Test-1	Door Interlock Test	Yes	Yes	Yes
Test-2	Door Stop Test	Yes	Yes	Yes
Test-3	Console Stop Test	Yes	Yes	Yes
Test-4	Console Key Test	Yes	Yes	Yes
Test-5	After Loader Key Test	Yes	Yes	Yes
Test-6	Lamps Test	Yes	Yes	Yes
Test-7	Intercom Test	Yes	Yes	Yes
Test-8	Radiation Monitor Test	Yes	Yes	Yes
Test-9	Applicator Inspection Test	Yes	No	Yes
Test-10	Radiation Leakage Test	No	Yes	Yes
Test-11	Treatment Room Radiation Test	No	Yes	No
Test-12	Source Exchange Radiation Test	No	Yes	No
Test-13	Wipe Test	No	Yes	Yes
Test-14	Obstruction Detection Test	Yes	Yes	Yes
Test-15	Position Verification Test	Yes	Yes	Yes
Test-16	Dwell Timer Test	No	Yes	Yes
Test-17	Source Calibration Test	No	Yes	Yes
Test-18	Decay Test	Yes	No	Yes

external beam in certain malignancies.

The high dose rate Vari-Source remote after loading machine at Nuclear Medicine, Oncology and Radiotherapy Institute (NORI), Islamabad, Pakistan was installed in October 1996. A system of quality assurance checks is compulsory and routinely performed with Vari-Source HDR to ensure a high level of accuracy of treatment delivery and verify all its basic operational safety [2,3]. The cost effectiveness of HDR was evaluated considering the cost of ten Ir-192 wire sources only used from 1996 to 2001.

## 2. Materials and Methods

Various quality control tests were performed to assess the quality control of HDR brachytherapy machine on patient treatment day, source exchange day and periodic day (monthly basis) as shown in Table 1. The patient day and periodic day checks were performed by the physicist. The source exchange day tests were performed by the service engineer and physicist on the day of source exchange in the after loader.

### 2.1. Source position verification

Source positioning within the applicator was checked with the help of camscale which is a mobile unit with three permanently attached catheters of 70cm, 100cm and 130cm lengths, an illuminated scale and a video camera. A standard quality assurance programme was recalled and run on the computer. A radiation survey meter was kept near the control unit. The source was programmed to reach all specified lengths and video camera focused on the scale sent the image of the wire via coax cable to the frame grabber board in the console computer. The experimental arrangements are shown in Figure 1. The frame grabber digitised the image of the source wire and images were stored and displayed on the computer monitor. The accuracy with which the system positions the wire was determined by comparing the programmed target position (pre-set for 70cm, 100cm and 130 cm in channels 1, 2, and 3 respectively) with the actual (measured) position on the scale. Both the target position and the actual measured position were recorded and print

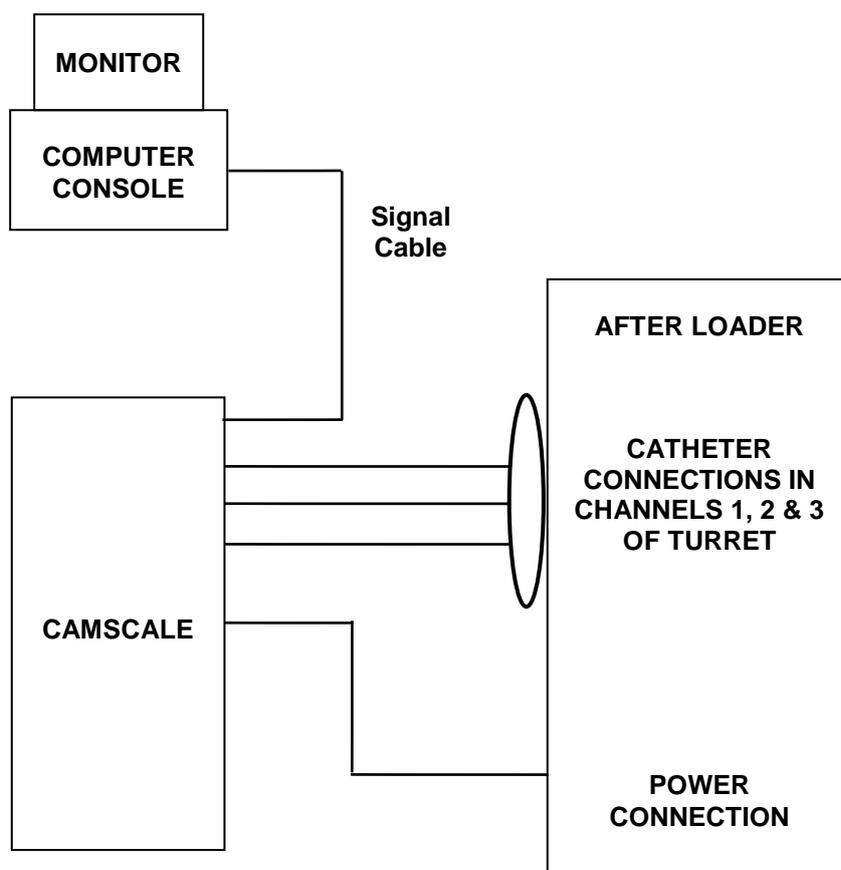


Figure 1. Connections of camscale with computer and after-loader.

out of image of each dummy and active wires superimposed on the scale was taken.

## 2.2. Source calibration

Source calibration was performed on source exchange day and monthly basis with the help of well type ionization chamber and electrometer supplied by the manufacturer. The chamber is equipped with a catheter-guide insert which accepts a standard catheter and has a shield cable for connection to electrometer. The electrometer was connected to the ionization chamber containing the source, gave a digital read out in nanoAmperes whose value depended upon the activity of the Ir-192 source and its position in the chamber. The computer-assisted program was used to move the source automatically to the required number of dwell positions in the chamber. The peak value on the electrometer, current room temperature, pressure and chamber calibration factor were used to calculate the source activity in curies.

## 2.3. Cost effectiveness

The cost effectiveness of Vari-Source HDR remote after loading brachytherapy machine was evaluated considering the cost of ten Iridium-192 sources which were installed from October 1996 to May 2001 as shown in table 3. Two hundred and fifty-three intracavitary insertions were done in ninety eight gynecological patients. Only the intracavitary mode of brachytherapy was used in all the patients.

## 3. Results and Conclusions

The quality assurance experience with Vari-Source HDR brachytherapy machine showed a great accuracy and precision. All the quality control tests performed during 1996 to 2001 were within the acceptable limits. In source positioning test, one millimeter precision was acceptable [2] and it was always found less than this limit for both dummy and active wires in Vari-Source HDR brachytherapy machine. The results of position

Table 2 (a). Results of position verification test for the dummy wire.

Target Positions (preset ) (cm)	Dummy wire actual (measured) positions (cm)	Difference between target and measured positions (cm)
70	70.03	+ 0.03
100	99.96	- 0.04
130	130.04	+ 0.04

Table 2 (b). Results of Position Verification test for the active wire.

Target positions (preset ) (cm)	Active wire actual (measured) positions (cm)	Difference between target and measured positions (cm)
70	70.08	+ 0.08
100	99.98	- 0.02
130	130.09	+ 0.09

verification for dummy and active wires shown in table 2 (a) and table 2 (b) respectively represent the difference between target (pre-set) and actual (measured) positions during 1996-2001. The source calibration test was performed on source exchange day and periodic day (monthly basis) as shown in table 1 and this was also within the acceptable limits. The measured activity should be within the 5% accuracy agreement quoted by the source manufacturer [2,3]. The percentage difference between measured and specified activity ranged from 2% to 5% at NORI, Islamabad.

Only the source obstruction test # 14 gave some problem during the patient treatment day QC test. This problem was due to the expansion/shrinkage of catheters over the time and usage. This problem was solved by cutting the damaged part of the old catheters and measuring their exact length by a special calibration ruler and/or by having a new set of catheters. The transit time measurements of Vari-Source HDR afterloader was not performed in this study during 1996-2001. The transit time tolerance of the Vari-Source system was kept at 10% when the source wire was not constricted by tight curves. When constriction was encountered and inability to overcome this constriction caused an automatic retract of wire in the Vari-Source HDR afterloader. However, accurate transit time determination should be included in the routine quality assurance

check and clinical use of HDR remote after loader [6]. Emergency procedure was carried out at regular intervals. This was to minimize radiation exposure risks if the source failed to return to its safe position.

The cost effectiveness per patient of Ir-192 sources is shown in Table 3. This cost included only ten Ir-192 sources used from 1996 to 2001. The aim was to calculate the cost per patient and to minimize the cost per patient once the HDR system has been installed/purchased. Four sources were used during 1996-97, three each in 1998-99 and 2000-01. Only 32, 25 and 41 patients were treated during 1996-97, 1998-1999 and 2000-2001 respectively. The total cost of ten Ir-192 wire sources was US\$ 48,124. This cost includes ten Ir-192 wire sources only. It does not include the cost of patient's stay in the hospital and services of the Vari-Source HDR brachytherapy machine etc. The total cost effectiveness of ten Ir-192 sources is presented in table-3 last row. The average number of intracavitary insertions per patient was 2.58. The average cost per intracavitary insertion was US\$190 and the average cost per patient was calculated as US\$ 491. This cost of treatment per patient would further reduce if larger number of patients than those treated during the period under consideration becomes available at this facility. Only intracavitary mode of brachytherapy treatments was used in 98 gynaecological patients

Table 3. The detail of cost effectiveness of ten Ir-192 wire sources.

Number of Iridium-192 sources	Period	Number of insertions	Number of patients	Average insertion per patient	Cost of the sources (US\$)	Average cost per insertion (US\$)	Average cost per patient (US\$)
04	28-10-1996 to 20-10-1997	80	32	2.50	15,500	194	484
03	03-10-1998 to 06-10-1999	72	25	2.88	16,124	224	645
03	10-05-2000 to 10-05-2001	101	41	2.46	16,500	163	402
All Sources 10	28-10-1996 to 10-05-2001	253	98	2.58	48,124	190	491

during 1996-2001. 82 patients out of 98 were from Islamabad / Rawalpindi and its vicinity. The patients from other part of the country were only 16.

Comparison of HDR, MDR and LDR was not done in this study as it has already been studied by clinical practice and trial that HDR is as effective as LDR and has more physical advantages [7,8,9]. The HDR brachytherapy minimizes the cost of the treatment relative to LDR/MDR [13, 14]. The indications of HDR treatments have been extended to esophagus, bronchus, prostate, breast, head and neck, bile duct etc. and are successfully being used for these sites [4,5,11]. The incidence of gynecological malignancies in Pakistan is very low. According to the statistics of NORI over a period of 10 years, gynecological malignancies have been found to constitute 7.78% of all the cancer cases. Whereas breast cancer constitutes more than 30% of all cancer cases and head & neck cases rank second among all the malignancies registered at NORI [12]. Considering the relatively low incidence of gynecological cancer, the use of Vari-Source HDR brachytherapy facility should be extended to other types of cancer. The training of radiation oncologist, medical physicist and availability of specific types of applicators are essential to introduce new techniques and sites for HDR brachytherapy treatment in developing countries [10]. Thus treating more types of non-gynecological patients as well can minimize the cost per patient. Other radiotherapy centres in the country need to be informed again about the availability of the facility at NORI, Islamabad and this will not only increase the number of patients

treated at HDR brachytherapy machine but also help more cancer patients to avail this sort of treatment so as to improve the treatment outcome.

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