Short Report

Verification of computerized treatment planning for HDR ^{192}Ir Brachytherapy for Gynaecological Cancer

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Abstract

Treatment planning in both teletherapy and brachytherapy is time consuming practice but accurate determination of planning parameters is more important. This paper aims to verify the dose delivery time for the treatment of vaginal cancer, which is a vital parameter of High Dose Rate (HDR) brachytherapy treatment planning. Treatment time has been calculated by the computerized treatment planning system (ABACUS 3.1), and then it has been compared with the manually calculated time. The results obtained are in good agreement. Independent verification of nominal time by two different protocols assures the quality of treatment. This should always be practiced to increase the accuracy of treatment.

Introduction

High dose rate (HDR) remote afterloading intracavitary brachytherapy is an effective treatment modality which has some advantages over low dose rate (LDR) techniques for gynaecological cancer.[1,2] Independent verification of a computer plan is an essential part of High Dose Rate (HDR) brachytherapy quality assurance. Some of these checks consist of verifying the accuracy of input data such as dose prescription, catheter lengths and current source strength. Others involve independent spot checks of Dwell time calculation, manually or by a second computer programme. Verification of dose at the prescription point (or another suitable point) within 5% is considered reasonable, considering the severe dose gradients encountered in brachytherapy.[3] 192Ir is common as well as effectively used HDR brachytherapy source for different treatment sites, as compared with some other brachytherapy sources.[4,5]

In both types of radiotherapy (external and brachytherapy) the treatment planning process is vital in order to assure an optimum treatment. Treatment planning parameters are chosen to make best possible plan. In brachytherapy, determination of dose distribution, selection of radiation source and to provide a complete dose distribution in the target volume, are important tasks to be performed. The quality assurance of treatment planning has been the subject of several communications, and was extensively reviewed in AAPM TG-59 report.[6] Generally, techniques described in these reports[7-10] apply empiric relations with a stated accuracy of the order of 10% to a particular application. A comparison of the results of two independent treatment-planning systems has also been suggested.[11]

Brachytherapy is in use for many years both in form of Low Dose Rate (LDR) and HDR. Although it is advantageous but also contains a lot of risk chances. Treatment requires great attention, skill, experience as well as resources. Different works have been done to address different constituents of both LDR and HDR[12-15] as well as to concentrate on the need of HDR plan dosimetry verification[16] so that the risk occurrence can be minimized.

Relying on second computer to check the correctness of the HDR plan fails to intercept the most common human errors, such as mistaken data entries in the optimization routine, or incorrectly specified lengths. It is not clear that verification of isodose distributions on particular cases using a second computer serves any purpose. It is also reported elsewhere that computer algorithm may not accurately calculate the dose distribution around 192Ir source by summing the primary and scatter dose components.[17] Further, there is great need for the evaluation of the efficacy of brachytherapy treatment planning in clinical applications especially in the situations where effects of tissue, applicator and shielding material heterogeneities exists.[18] Therefore it is aimed to provide the medical physicist an alternate precise, convenient and prompt means of verification.

Methods

GammaMedplus HDR remote afterloading machine, in Bahawalpur Institute of Nuclear Medicine & Oncology have been used for this study. The method described here was therefore intended to synchronize with the GammaMedplus (but it is equally applicable to other HDR machines, like microSelectron HDR etc.). All dosimetric calculations are performed for a nominal 37 GBq (10 Ci) source activity. The method we present is easily adjustable to other HDR units.

ABACUS 3.1 (Treatment Planning System) has been used for treatment planning and calculation of total nominal time first and then results were compared with the time calculated manually. Treatment planning for Vaginal Cancer using different applicators (2.0, 2.3, 2.6, 3.0, 3.5, and 4 cm diameter vaginal cylinder steel tube) was aimed to be verified with the manual planning. Dose delivery time was calculated manually with the equation,

$$\text{Time} = \frac{(mg \bullet hr/1000cGy)\times(elongationfactor)\times(60\,\text{min}/hr)\times(60\,\text{sec}/\text{min})\times dose}{(Activity)\times(mg/mCi)\times 10^{6}}$$

(Equation-1)

This equation derived from Johns HE et al[19] by using long and away tables and converted to Iridium based on the exposure rate constant.

This equation indicates that the manual calculation of time requires some values as input. These values i.e. mg.hr, elongation factor have been derived from the work of Johns HE et al.[19] On the other hand, the calculations by Abacus used the air kerma strength as input for dose calculations. mg/mCi is the conversion factor from Radium-226 to Iridium-192. Vaginal cylinders of 2.0, 2.3, 2.6, 3.0, 3.5, 4.0 cm diameter have been used for this study.

Results and Discussion

The intention was to verify the total nominal time calculated by using Abacus treatment planning system through the alternate (manual) method, for different treatment lengths and treatment depths by developing and implementing a fast and accurate secondary dose-calculation method for QA of HDR treatment planning. Percentage difference between the results of both the methods for different diameter cylinders, treatment depths and lengths has been calculated and results are presented in the Tables 1 and 2. For 10 Ci Activity of Iridium-192 and 0.5648 conversions factor (Radium to Iridium), the treatment time comparison for different diameter cylinders is presented in Table 3.

Activity = 10 Ci, mg/mCi Conversion Factor = 0.5648

Table 1: Percentage difference between total nominal time calculated by the manual method and Abacus 3.1 on Treatment Depth (h) of 1.5cm for 2cm and 2.3cm Diameter cylinders.

Treatment length (L) (cm)	Ratio (L/h)	Elongation Factor	RL	Manual calculated Time (sec)	Abacus Time (sec)	% diff
			2 cm Diameter Cylinder			
4.0	2.67	1.175	417.0	218.61	217	-0.74
4.5	3.00	1.180	444.0	233.76	231	-1.19
5.0	3.33	1.180	471.0	247.98	246	-0.80
5.5	3.67	1.160	510.5	264.22	260	-1.62
6.0	4.00	1.120	550.0	274.84	274	-0.31
			2.3 cm Diameter Cylinder			
4.0	2.67	1.175	417.0	218.61	217	-0.74
4.5	3.00	1.180	444.0	233.76	231	-1.19
5.0	3.33	1.180	471.0	247.98	246	-0.80
5.5	3.67	1.160	510.5	264.22	260	-1.62
6.0	4.00	1.120	550.0	274.84	274	-0.31

RL = (mg.hr to deliver 1000 rads) to a point h cm from the center of a linear source of active length L.

Table 2: Percentage difference between total nominal time calculated by the manual method and Abacus 3.1 on Treatment Depth (h) of 2cm for 2.6cm and 3cm Diameter cylinders.

Treatment length (L) (cm)	Ratio (L/h)	Elongation Factor	RL	Manual calculated Time (sec)	Abacus Time (sec)	% diff
			2.6 cm Diameter Cylinder			
4.0	2.00	1.142	650.0	331.20	333	0.54
4.5	2.25	1.140	684.0	347.91	351	0.88
5.0	2.50	1.160	718.0	371.61	369	-0.71
5.5	2.75	1.165	753.5	391.67	388	-0.94
6.0	3.00	1.170	780.0	407.18	406	-0.29
			3 cm Diameter Cylinder			
4.0	2.67	1.175	650.0	331.20	333	0.54
4.5	3.00	1.180	684.0	347.91	351	0.88
5.0	3.33	1.180	718.0	371.61	369	-0.71
5.5	3.67	1.160	753.5	391.67	388	-0.94
6.0	4.00	1.120	780.0	407.18	406	-0.29

Table 3: Percentage difference between total nominal time calculated by the manual method and Abacus 3.1 on Treatment Depth (h) of 2.5cm for 3.5cm and 4.0cm Diameter cylinders.

Treatment length (L) (cm)	Ratio (L/h)	Elongation Factor	RL	Manual calculated Time (sec)	Abacus Time (sec)	% diff
			3.5 cm Diameter Cylinder			
4.0	1.60	1.120	945.0	472.23	472	-0.05
4.5	1.80	1.130	981.5	494.85	494	-0.17
5.0	2.00	1.142	1018.0	518.70	516	-0.52
5.5	2.20	1.140	1059.5	538.90	539	0.02
6.0	2.40	1.150	1101.0	564.93	561	-0.70
			4 cm Diameter Cylinder			
4.0	2.67	1.175	945.0	472.23	472	-0.05
4.5	3.00	1.180	981.5	494.85	494	-0.17
5.0	3.33	1.180	1018.0	518.70	516	-0.52
5.5	3.67	1.160	1059.5	538.90	539	0.02
6.0	4.00	1.120	1101.0	564.93	561	-0.70
4.0	2.67	1.175	945.0	472.23	472	-0.05

These tables indicating an accurate verification of the treatment times, which have been obtained by two different methods (Abacus treatment planning system and manual calculation). One important feature of this verification is that it takes only one minute to perform this important QA task.

The total nominal dwell times calculated manually by equation 1 and that by planning system are typically within 2%, which are well within acceptable tolerance.

The results can be compared for different applicators as well. Treatment planning has always been an essential object for all kinds of radiation therapy. The quality assurance demands to have a very careful, accurate and precise measurement of all the treatment planning quantities. Verification must be made to ensure the accuracy and precision of the planning.

Conclusion

Confirmation of the accuracy of optimized calculations with verification evaluation techniques is vital in order to assure the quality of treatment. This independent verification of the computer plan of High Dose Rate (HDR) brachytherapy provides a solid base to apply the plan for brachytherapy treatment. Similar kind of verification should be carried out for all other tumour sites and applicators.

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