Research Article

iMedPub Journals
http://www.imedpub.com

Journal of Medical Physics and Applied Sciences
ISSN 2574-285X

2020
Vol. 5 No.2:9

DOI: 10.36648/2574-285X.5.2.9

Dosimetric Effects of CO-60 and IR-192 Source Step Size in Intra Luminal Brachytherapy

Pawan Kumar Jangid, Arvind Kumar Shukla*, Narendra Kumar Rathore, Vikram Singh Rajpurohit, Atul Verma and Suresh Kumar Dangayach

Department of Radiotherapy, RNT Medical College, Udaipur, Rajasthan, India

***Corresponding author:** Arvind Kumar Shukla, Department of Radiotherapy, RNT Medical College, Udaipur, Rajasthan, India, Tel: +918107818558; E-mail: drakshukla@yahoo.com

Citation: Jangid PK, Shukla AK, Rathore NK, Rajpurohit VS, Verma A, et al. (2020) Dosimetric Effects of CO-60 and IR-192 Source Step Size in Intra Luminal Brachytherapy. Insights Med Phys. Vol.5 No.2:9.

Abstract

Purpose: The present work reports the effect of source step size on dose distribution in patients treated with cobalt-60 (Co-60) high-dose-rate after loading brachytherapy in esophagus cancer.

Material and methods: A Bebig Multisource® HDR Brachytherapy unit with cobalt-60 HDR miniature source (Eckert and Ziegler, Bebig, Germany) was used for study. The Co-60 source has an active core 0.5 mm diameter and 3.5 mm active core length. HDR 2.5 plus (Eckert and Ziegler, Bebig, Germany) Treatment planning system was used for the study. 10 patients of carcinoma esophagus were studied for the study of dose distribution around the single intraluminal catheter of 8 cm length. The effect of step size around the catheter was studied for depth doses were calculated at 0, 2.5, 5 mm and 10 mm from the applicator surface. Dose point based optimization and normalization were used to calculate the 4.0 Gy prescription dose at 5 mm depth. Dose distribution and homogeneity for the various source step sizes were evaluated by performing dose computations per step size and calculating the average dose and standard deviation (SD) at each depth.

Results and discussion: The study shows that as the depth increases from 0 to 10 mm, the SD difference decreases with step size for Co-60 and Ir-192 and at the 10 mm depth SD is constant with step size for both sources. The average standard deviation was 0.92, 0.43, 0.27 and 0.14 for depth 0 mm, 2.5 mm, 5 mm and 10 mm respectively. The variation in depth for different step size is decreasing and 2.5 mm step size is more appropriate than 1, 5 and 10 mm step size for both sources. Study in carcinoma esophagus concludes that homogeneity increases as the step size reduces.

Keywords: Step size; Intracavitary brachytherapy; High dose rate; Computed tomography

Received: August 25, 2020; **Accepted:** September 10, 2020; **Published:** September 17, 2020

Introduction

The practice of brachytherapy started soon after the discovery of radium (Ra-226) by Madam Curie in the last decade of 19th century. In the early years of 20th century researchers realized the efficacy of radiation therapy in treating a number of malignant diseases. Brachytherapy also known as internal radiotherapy and curie therapy is that form of radiotherapy where a radioactive source is placed in close vicinity or inside of the area requiring treatment. Brachytherapy is commonly used for effective treatment of cervical, prostate, breast, esophagus, skin cancers and can also be used to treat tumors in many other body sites [1,2]. Brachytherapy can be used alone or in combination with other modalities such as surgery, chemotherapy and external beam radiotherapy (EBRT). Initially treatment was given based in individual experiences and clinical judgment ability. Carcinoma of esophagus is the seventh most common cancer among both sexes in countries with low and medium human development index [3], which can be treated with external beam radiotherapy (EBRT) and intraluminal brachytherapy (IBT).

In recent days the dosimetric comparison of brachytherapy treatment of cervical cancer was outlined for Co-60 and Ir-192 source based high dose rate brachytherapy [4]. Step size based dosimetry study in uterine cervix was described for cobalt-60 based HDR Brachytherapy [5]

To analyze dose distribution and treatment time of endobronchial brachytherapy (EBBT) by changing the position step size of the dwell position using the solid water phantom and an intraluminal catheter and concluded that the 2.5 mm position step was most suitable for EBBT [6].

The primary requirements of brachytherapy is accurate and careful treatment planning for prescribed dose delivery to the target and simultaneously minimize risk of radiation toxicity to the surrounding OARs [7]. Sometimes, to spare the normal tissue, optimization has to be performed that compromises the tumor dose. Iridium-192 is widely used for high-dose rate brachytherapy. Cobalt-60 (Co-60) is a relatively new source for the application of high-dose rate (HDR) brachytherapy with advantage of its longer half-life and its availability in miniaturized form (with dimensions comparable to those of Ir-192 HDR sources) [8,9]. Co-60 sources with dimensions identical to those of 192Ir have recently been made available in clinical brachytherapy and its longer half time reduces demands on logistics and quality assurance and costs [10].

A comparative study of 10 patients of dose distributions of HDR intracavitary brachytherapy for different sources and treatment planning systems depicted the dose discrepancies between the two treatment plans are affected by the differences in the physical characteristics of source and the positioning method in TPS. The average air kerma in the 20-30 cm distance from the source was used to calculate the source's air kerma rate at the reference point of 1 m. However, self-absorption in the source could not affect the air kerma strength's value considerably [11]

The step size plays a significant role in plan optimization for prostate implants. In high dose rate (HDR) brachytherapy, the source dwell times and dwell positions are vital parameters in achieving a desirable implant dose distribution. This study was designed to evaluate the optimum source step size and maximum source dwell time for prostate brachytherapy implants using an Ir 192 source [12]. The simple analytic tool for calculating the dose rate distribution in water for a new BEBIG high dose (HDR) Co-60 brachytherapy source. It is considered that the active source as a point located at the geometric center of the Co-60 material. Using this method, the parameters such as the dose rate constant, radial dose function and anisotropy function are calculated [13].

From last decades many comparative study were performed for Co-60 and Ir-192 source based HDR brachytherapy. There after the potential logistic advantage of Co-60 is that, it uses only 33% of the activity of Ir-192 source needed to yield an equivalent dose rate. In typical brachytherapy application, there is no significant difference between Ir-192 and Co-60 with respect to treatment planning, dose prescription, and resultant isodose distributions to target volume. The relative comparison of radial dose function, qualitative isodose distributions, and dose anisotropy of Co-60 and Ir-192 sources has been reported in literature [14,15]. Many authors have done the dosimetric study of Co-60 and Ir-192 source based HDR brachytherapy but still lack of dosimetric study of esophagus based on step size variation. Therefore present study has been undertaken to assess the impact of source step size on achieving optimal dose distribution in different intraluminal brachytherapy procedures with high dose rate remote after loading unit consisting Co-60 and Ir-192 radioactive sources.

Materials and Methods

The present study has been conducted on 10 patients of Ca-oesophagus with Co-60 HDR Intraluminal brachytherapy. The standard step size is used 2.5 mm for this study. In this study our main concern is on Dosimetric effects of C0-60 and Ir-192 source step size in HDR intra luminal brachytherapy. Bougie applicator with universal applicator is used to treat oesophagus cancer using HDR brachytherapy. Patients were treated on BEBIG Multisource HDR brachytherapy unit equipped with Co-60 miniature source having active core diameter of 0.5 mm and active core length of 3.5 mm (Eckert and Ziegler, BEBIG, Germany). Treatment planning was performed on BEBIG HDR 2.5 plus (Eckert and Ziegler, BEBIG, Germany) treatment planning system (TPS) with option of selecting source step size from 1 to 10 mm. For the study, retrospective treatment planning of each patient was performed for source step size of 1 mm, 2.5 mm, 5 mm, and 10 mm. The dose of 4 Gy was prescribed on 0.5 cm from the oesophagus surface. Dose calculation was done using American Association of Physicists in Medicine (AAPM) Task Group No. 43 Report (TG-43) recommendations [16].

Results and Discussion

Figure 1 shows that as depth increases standard deviation (SD) decreases and constant for all step sizes, so the dose distribution is homogenous for both sources although SD is higher for Co-60 source compared to Ir-192 for 0 mm, 2.5 mm and 5 mm depth. At 10 mm depth it is almost same. In Figure 1, at the 0 mm prescription depth the difference in SD is constant up to 5 mm depth and increases beyond 5 mm and the SD difference of Co-60 and Ir-192 is 0.158. As the depth increases at 2.5 mm to 5 mm the SD difference of Co-60 and Ir-192 is 0.032 and 0.011 respectively. Whenever the SD of Co-60 is comparatively higher to Ir-192 at 0 mm to 5 mm depth. As we increase the depth beyond 5 mm SD difference decreases and becomes 0 at 10 mm depth for both Co-60 and Ir-192 source.

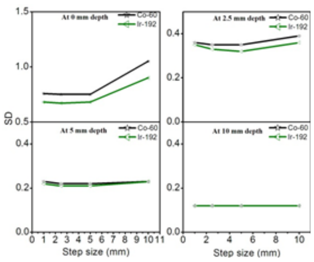

Figure 1: Relation between depth and standard deviations (SD).

Difference in Co-60 and Ir-192 is shown in Figure 2. From Figure 2, as the depth increases 0 to 10 mm the SD differences decreases with step size for Co-60 and Ir-192 and at the 10 mm depth SD is constant with step size for both sources.

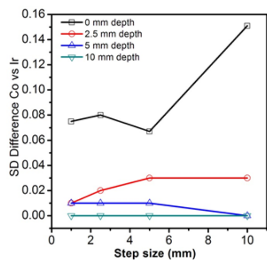

Figure 2: Difference in Co-60 and Ir-192.

Figure 3 shows the comparison of Dose vs. Depth for different step size for Co-60 and Ir-192. In Figure 3 at 0 mm depth it is showing significant dose variation as changing step size from 1 -10 mm. For both sources Co-60 and Ir-192 the maximum dose is due to of 10 mm step size, which is 20.42 and 19.54 Gy respectively. At same depth and step size the dose of Co-60 is slightly higher because of its energy higher than Ir-192. From 1-5 mm step size there is no such variation in dose at same depth.

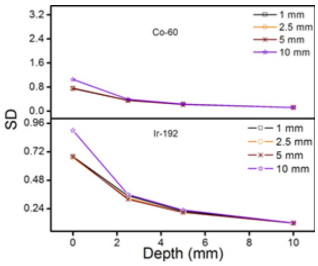

Figure 3: Shows the comparison of Dose vs. Depth for different step size for Co-60 and Ir-192.

At 2.5 mm depth the dose variation is little and showing higher and lower dose at 10 mm and 5 mm step size for both sources and no variation at 1 and 2.5 mm step size at same depth. At the depth 5-10 mm there is no difference for 1-10 mm step size for both sources. Whereas from Figure 3, showing that Co-60 is slightly higher dose for all step sizes in compare to Ir-192.

Tables 1 and 2 shows dose variation at different depth change with 0 mm, 2.5 mm, 5 mm and 10 mm step sizes for Co-60 and Ir-192 sources, respectively.

Conclusion

So it is concluded that the dose variation is decreasing with depth for different step size for both sources and 2.5 mm step size is more appropriate than 1, 5 and 10 mm step size for both sources.

References

1 Chao KS, Perez CA, Brady LW. Physics and Dosimetry of High-Dose-Rate Brachytherapy in Radiation Oncology Management Decisions (2nd Edition). Lippincott Williams & Wilkins. Philadelphia. 2002:89-94.

2 Limbergen VE, Potter R, Gerbaulet A (2002) GEC-ESTRO Handbook of brachytherapy.

3 Cancer today. World Health Organization.

4 Shukla AK, Jangid PK, Rajpurohit VK, (2019) Dosimetric comparison of 60Co and 192Ir high dose rate source used in brachytherapy treatment of cervical cancer. J Can Res Ther 15: 1212-1215.

5 Shukla AK, Rana BS, Singh NP, Kumar S (2019) Dosimetric study of CO-60 source step size in uterine cervix intracavitary HDR brachytherapy. Brachytherapy 18: 180-185.

6 Zaman ZK, Ung NM, Malik RA (2014) Comparison of planned and measured rectal dose in vivo during high dose rate Cobalt-60 brachytherapy of cervical cancer. Physica Medica 30: 980-984.

Table 1: Dose variation at different depth with step size for Co-60 HDR brachytherapy source.

Patient No↓	At 0 mm depth				At 2.5 mm depth				At 5 mm depth				At 10 mm depth			
step size (mm)→	1	2.5	5	10	1	2.5	5	10	1	2.5	5	10	1	2.5	5	10
1	13.26	13.32	13.76	18.26	6.31	6.31	6.31	6.68	4	4	4	4	2.17	2.18	2.18	2.16
2	14.36	14.24	14.71	19.87	6.83	6.74	6.75	7.27	4.33	4.28	4.28	4.35	2.35	2.33	2.33	2.35
3	14.59	14.62	15.08	20.53	6.94	6.92	6.91	7.51	4.4	4.39	4.38	4.5	2.39	2.39	2.39	2.43
4	14.39	14.9	15.17	20.08	6.84	7.06	6.96	7.35	4.34	4.48	4.41	4.4	2.36	2.44	2.4	2.37
5	15.44	15.12	15.52	20.74	7.34	7.16	7.12	7.59	4.66	4.54	4.51	4.54	2.53	2.47	2.46	2.45
6	15.12	14.28	14.75	19.78	7.19	6.76	6.76	7.24	4.56	4.29	4.29	4.33	2.48	2.33	2.34	2.34
7	14.89	15.49	15.99	21.43	7.08	7.34	7.33	7.84	4.49	4.65	4.65	4.69	2.44	2.53	2.54	2.53
8	15.61	15.42	15.9	21.54	7.42	7.3	7.29	7.88	4.71	4.63	4.62	4.72	2.56	2.52	2.52	2.55
9	15.91	15.93	16.39	21.86	7.57	7.54	7.52	8	4.8	4.78	4.77	4.79	2.61	2.6	2.6	2.58
10	14.78	14.64	15.09	20.12	7.03	6.93	6.92	7.36	4.46	4.4	4.39	4.41	2.42	2.39	2.39	2.38
Average	14.83	14.79	15.23	20.421	7.055	7	6.98	7.472	4.47	4.44	4.43	4.47	2.43	2.49	2.41	2.41
SD	0.76	0.75	0.75	1.05	0.36	0.35	0.35	0.39	0.23	0.22	0.22	0.23	0.12	0.12	0.12	0.12
%Diff	0.26		2.97	38.01	0.69		-0.27	6.651	0.697		-0.315	0.65	0.537		-0.12	-0.16

Table 2: Dose variation at different depth with step size for Ir-192 HDR brachytherapy source.

Patient No↓	At 0 mm depth				At 2.5 mm depth				At 5 mm depth				At 10 mm depth			
step size (mm)→	1	2.5	5	10	1	2.5	5	10		2.5	5	10	1	2.5	5	10
1	12.62	12.59	13.05	17.47	6.1	6.15	6.16	6.53	4	4	4	4	2.24	2.25	2.26	2.23
2	13.61	13.56	14.03	19.9	6.64	6.62	6.62	7.14	4.31	4.31	4.3	4.37	2.42	2.42	2.43	2.44
3	13.82	13.76	14.22	19.53	6.74	6.72	6.71	7.13	4.38	4.37	4.36	4.47	2.46	2.46	2.46	2.49
4	13.61	14.04	14.46	19.29	6.64	6.86	6.83	7.21	4.31	4.46	4.43	4.42	2.42	2.51	2.5	2.46
5	14.56	14.25	14.65	19.73	7.1	6.96	6.91	7.37	4.61	4.53	4.49	4.52	2.59	2.54	2.53	2.52
6	14.35	13.59	14.06	19	7	6.64	6.64	7.1	4.55	4.32	4.31	4.35	2.55	2.43	2.43	2.43
7	14.1	14.53	15.04	20.33	6.88	7.1	7.1	7.6	4.47	4.61	4.61	4.66	2.51	2.59	2.6	2.6
8	14.72	14.68	15.16	20.17	7.18	7.17	7.16	7.74	4.66	4.66	4.65	4.74	2.62	2.62	2.62	2.64
9	15.01	14.94	15.4	20.72	7.32	7.3	7.27	7.75	4.76	4.74	4.72	4.74	2.67	2.67	2.66	2.65
10	14.02	13.94	14.39	19.33	6.84	6.81	6.79	7.23	4.44	4.43	4.41	4.73	2.49	2.49	2.49	2.47
Average	14.04	13.99	14.44	19.54	6.84	6.83	6.82	7.28	4.449	4.44	4.43	4.5	2.497	2.5	2.5	2.49
SD	0.68	0.67	0.68	0.9	0.35	0.33	0.32	0.36	0.22	0.21	0.21	0.23	0.12	0.12	0.12	0.12
% Diff	0.38		3.27	39.74	0.16		-0.2	6.54	0.14		-0.33	1.28	-0.04		0	-0.2

7 Ntekim A, Adenipekun A, Akinlade B (2010) High dose rate brachytherapy in the treatment of cervical cancer: Preliminary experience with cobalt-60 radionuclide sourced-A prospective study. Clin Med Insights Oncol 4: 89-94.

8 Granero D, Perez-Calatayud J, Ballester F (2007) Technical note: Dosimetric study of a new Co-60 source used in brachytherapy. Med Phys 34: 3485-3488.

9 Richter J, Baier K, Flentje M (2008) Technical note: Comparison of 60 Cobalt and 192 Iridium Sources in High Dose Rate Afterloading Brachytherapy. Strahlenther Onkol 4: 187-192.

10 Park DW, Kim YS, Park SH, Choi EK (2009) A comparison of dose distribution of HDR intracavitary brachytherapy using different sources and treatment planning system. Technical note: Appl. Radiat Isot 67: 1426-1431.

11 Toossi TB, Mohammad, Ghorbani M (2010) Air Kerma strength characterization of a GZP6 Cobalt-60 brachytherapy source. Reports of practical oncology and radiotherapy 15: 190-194.

12 Manikandan A, Sarkar B, Rajendran VT, King PR, Sresty NM, et al. (2013) Role of step size and max dwell time in anatomy based inverse optimization for prostate implants. J Med Phys 38:148-154.

13 Bhola S, Selvam TP, Sridhar S, Vishwakarma RS (2012) An analytic approach to the dosimetry of a new BEBIG 60Co high dose- rate brachytherapy source. J Med Phys 37: 129-137.

14 Richter J, Baier K, Flentje M (2008) Comparison of 60Co and 192Ir sources in high dose rate afterloading brachytherapy. Strahlenther Onkol 184: 187-192.

15 Strohmaier S, Zwierzchowski G (2011) Comparison of 60Co and 192Ir sources in HDR brachytherapy. J Contemp Brachytherapy 3: 199-208.

16 Nath R, Anderson L, Luxton G (1995) Dosimetry of interstitial brachytherapy source: Recommendation of the AAPM radiation therapy committee task group No. 43. Med Phys 22: 209-234.