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Original Research Paper

Radiotherapy

A STUDY ON CO-60 BASED HDR BRACHYTHERAPY OF UTERINE CERVIX CANCER PATIENTS

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ABSTRACT

Background: HDR brachytherapy using Co-60 radioisotope is being used widely since past few years because of its few advantages over the Ir-192 radioisotope. The clinical outcome after all other benefits is most important, therefore it is important to analyse the Co-60 base HDR radiotherapy plans based on its dosimetric parameters.

Materials and methods: Twenty patients diagnosed with uterine cervix cancer and treated with 50Gy/25# by external beam radiation therapy (EBRT) were included in this study. After insertion of three channel applicator CT simulation was done for all the patients. Clinical targets and organs at risk were delineated on the CT images and then HDR brachytherapy planning on CT images was done for 7Gy/# to deliver by Co-60 HDR brachytherapy unit. Dosimetric parameters were noted and analysed. All the patients were delivered three fractions on interval of one week between the fractions.

Results: High risk clinical target volume (HRCTV) was well covered with prescribed dose in all the plans with having doses to normal organs well within tolerance limit.

Conclusion: Based on dosimetric parameters and their analysis for all the plans it can be concluded that Co-60 based HDR brachytherapy unit is a good choice for the boost treatment of uterine cervix cancer patients after EBRT.

KEYWORDS : High dose rate brachytherapy, high risk clinical target volume, uterine cervix cancer

Introduction

Uterine cervix cancer is the second most common cancer in women and most common cause of death of cancer patients in developing countries. The biggest cause of cervical cancer is human papilloma virus (HPV) infection which is sexually transmitted.[1] Around 510,000 new cases of cervix cancer are reported annually worldwide which results in approximately 288,000 deaths.[2]

The treatment of cervix cancer is done by external beam radiation therapy (EBRT) with weekly chemotherapy. Usually 50 Gray (Gy) in 25 fractions (#) in five weeks (5#/week) is delivered.[3] Mostly a boost dose of biological equivalent dose to 30 to 35 Gy is delivered by three fractions of 7 to 8.5 Gy /# by high dose rate (HDR) brachytherapy unit. Radiation dose rapidly falls as the distance increases in brachytherapy, because of which the adequate dose to target volume with very minimal dose to bladder and rectum can be delivered, and hence possible to deliver more than 80 Gy to the high risk clinical target volume (HRCTV).[4]

Co-60 based HDR brachytherapy unit has been launched. Because of its long half life, it is being preferred by many of the radiotherapy centers specially those which have less number of patients. The Co-60 sources introduced are having enhanced activity which made possible miniaturized sources with size equivalent to that of Ir-192 HDR brachytherapy sources. The miniaturized Co-60 sources made possible to use it with equivalent size and shape of the applicators as that of used with Ir-192 source.[5] The different physical properties of the Co-60 HDR brachytherapy source are as given in table 1.

Table 1: Physical properties of Co-60 HDR brachytherapy source.[5,6]

Physical Properties	Values
Photon mean energy	1.25 MeV
Half life	5.26 years
Maximum specific activity	41.91 GBq/mg
Exposure rate constant	13.07 R-cm^2/mCi-h
Half value layer	11 mm lead
Outer diameter	1 mm
Inner diameter	0.5 mm
Outer length	5 mm
Inner length	3.5 mm

There are many advantages of Co-60 source like its long half life avails relaxation in repeated source replacement in every few months and thus reduces the administrative and documentation work, but it has higher photon energy which has higher penetration power which may deliver higher dose to the surrounding organs as compared to that by Ir-192 source. Therefore it becomes important to document and analyse the dosimetric parameters of the HDR brachytherapy plans done for Co-60 HDR brachytherapy unit.

Materials and methods

Twenty patients diagnosed with locally advanced cervix cancer were included in this study. All the selected patients were histologically proven locally advanced cervix cancer stage III-b with Karnofsky performance status (KPS) > 70%.

All the twenty patients were treated with weekly chemotherapy cisplatin 40 mg/m^2 concurred with external beam radiation therapy (EBRT). 50Gy/25# in five weeks was delivered then all the patients were assessed for suitability to intra cavitary radiotherapy (ICRT). After one week of EBRT completion, patients were scheduled for ICRT. Patients were taken in Operation Theater and were administered short general anesthesia, then were put in lithotomy position. In and near parts of vagina were cleaned and draped. Uterine sound was utilized to measure the uterus length. Cervical os was dilated. Three channel applicator set (tandems and ovoids; (BEBIG GyneSource HDR, Eckert & Ziegler BEBIG, Germany) was taken for insertion. The central tandem was inserted in uterine cavity and ovoids fixed on lateral tandems were fixed in lateral fornices. Both the lateral tandems were fixed with central tandem by screwing all three tandems on bridge socket. T bandage tied to abdomen was used to hold the applicator set in position.

All the patients were taken in computed tomography (CT) room for CT simulation by Siemens SOMATOM Definition AS Scanner (Siemens Medical systems, Germany), CT images of 3 mm slice thickness were acquired. CT images were transferred to the HDR Plus planning system (Eckert & Ziegler BEBIG,Germany).

High risk CTV (HRCTV), rectum, bladder and sigmoid were delineated following American Brachytherapy Society (ABS) guidelines. Entire uterine cervix and prametrial extension were marked as HRCTV. All the three tandems viz. left, central and right along with ovoids for lateral tandems were inserted from applicators template and confirmed it's matching with tandems and ovoids visible in CT images. Figure 1 shows the applicators position on the CT images and three dimensional reconstruction of the applicator set.

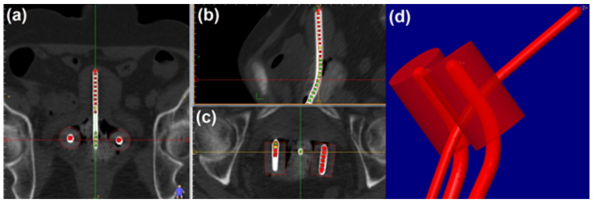

Figure 1: Applicators position on CT images in (a) frontal, (b) sagittal, (c) transversal and (d) 3D reconstruction of the applicators

All the three applicators were given dwell positions spaced with 3 mm distance between dwell positions from tip of applicator to the adequate length as per required for particular patient. Each dwell position was activated uniformly for 10 seconds dwell time.

Point A and point B were marked by Manchester system for easiness in doing planning. Dose was optimized for 100% of prescribed dose (PD) i.e. 7 Gy at point A. By using appropriate tools, 100% isodose line was adjusted to cover HRCTV while saving the bladder and rectum. To save bladder and rectum, HRCTV was not fully covered with 100% isodose line in some of the plans, but it was ensured to cover whole HRCTV with at least 90% of PD. Figure 2 shows the dose distribution and pear shaped dose distribution.

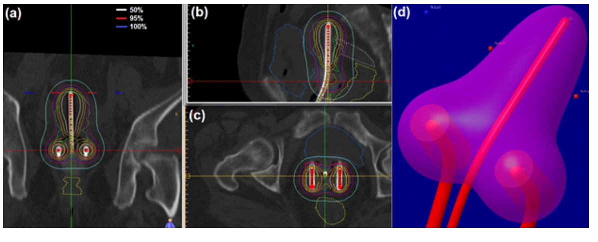

Figure 2: Dose distribution on CT images in (a) frontal, (b) sagittal, (c) transversal view and (d) 3D dose reconstruction in pear shape

Dosimetric parameters were noted and were analysed for all the plans. The doses in plan for one planned fraction were multiplied by three and its biological equivalent dose was added in 50 Gy which was delivered by EBRT. The sum dose to HRCTV, bladder and rectum was analysed as per ABS guidelines. After getting successful analysis, all the plans were approved and transferred to Co-60 HDR brachytherapy unit for delivering to the patients. Patients were shifted to Co-60 HDR brachytherapy room and source guide tubes were connected to the HDR unit and the corresponding applicators inserted in the patient. Such three fractions were delivered to each patient on interval of one week between fractions.

Results

The mean dose received by 90% of HRCTV, 2cc of bladder, rectum and sigmoid in three fractions each of 7Gy was found to be 21.19±0.46 Gy, 15.71±0.49 Gy, 11.09±0.93 Gy and 4.04±1.42 Gy respectively. The mean EQD2 by HDR brachytherapy and EBRT to 90% of HRCTV, 2cc of bladder, rectum and sigmoid was found to be 80.14±0.92 Gy, 69.99±0.84 Gy, 62.68±1.36 Gy and 53.86±1.56 Gy respectively.

The detailed dosimetric parameters of HDR brachytherapy plans for twenty patients have been plotted in figure 3 and mean results have been given in table 2.

The EQD2 to HRCTV and normal organs by three fractions of HDR brachytherapy have been plotted in figure 4 and the total EQD2 by HDR brachytherapy and EBRT has been plotted in figure 5. The mean EQD2 for all the twenty patients has been given in table 3.

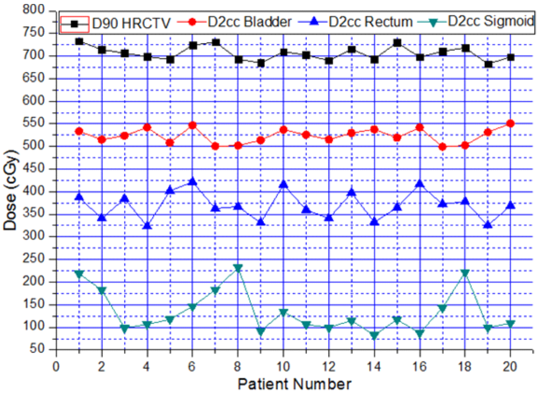

Figure 3: Graph showing dose to (a) 90% of HRCTV, (b) 2 cc of bladder, (c) 2 cc of rectum and (c) 2 cc of sigmoid in HDR brachytherapy plans for 20 patients

Table 2: Dosimetric parameters noted from HDR brachytherapy plans done for twenty patients

Parameters	**Mean value (cGy)**
D_{90} HRCTV	706.23±15.40
D_{2cc} Bladder	523.78±16.30
D_{2cc} Rectum	369.6±30.95
D_{2cc} Sigmoid	134.61±47.46

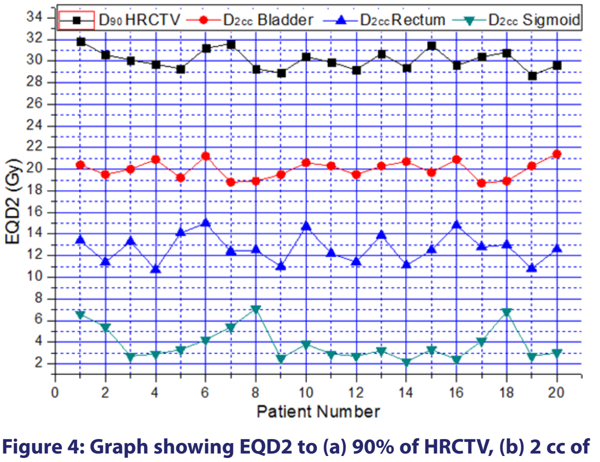

Figure 4: Graph showing EQD2 to (a) 90% of HRCTV, (b) 2 cc of bladder, (c) 2 cc of rectum and (c) 2 cc of sigmoid in HDR brachytherapy plans for 20 patients

Table 3: The total dose received by HDR brachytherapy and EBRT

Parameters	Mean dose of 20 patients by 3# @ 7Gy/# of HDR brachytherapy (Gy)	Mean EQD2 of 20 patients by 3# @ 7Gy/# of HDR brachytherapy (Gy)	Total EQD2 of 20 patients by 3# @ 7Gy/# of HDR brachytherapy and 25# @ 2Gy/# by EBRT
D90 HRCTV	21.19±0.46	30.14±0.92	80.14±0.92
D2cc Bladder	15.71±0.49	19.99±0.84	69.99±0.84
D2cc Rectum	11.09±0.93	12.68±1.36	62.68±1.36
D2cc Sigmoid	4.04±1.42	3.86±1.56	53.86±1.56

HRCTV = high risk clinical target volume; D_{90} = dose to 90% of HCTV; D_{2cc} = dose to 2cc volume; HDR = high dose rate brachytherapy; EQD_2 = dose equivalent to 2 Gy per fraction.

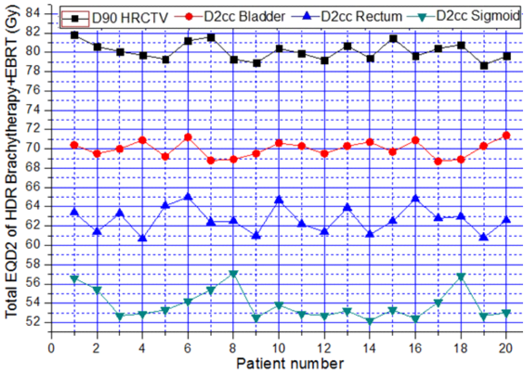

Figure 5: Graph showing the total EQD2 (Gy) delivered to twenty patients by HDR Brachytherapy and EBRT

Discussion

As per ABS guidelines, D90 for HRCTV should be 80-90 Gy, the dose to 2cc of bladder should be restricted to 90 Gy and dose to 2 cc of rectum and sigmoid should be 70-75 Gy.[7,8] The HRCTV in all the plans of current study are well covered without exceeding the dose limits of bladder, rectum and sigmoid, even all these three organs have very less doses than the doses mentioned above as per ABS guidelines.

The results of current study are in well agreement with the results presented by other studies on Ir-192 HDR brachytherapy planning.[9] Based on the dosimetric parameters of this study Co-60 HDR brachytherapy unit can be used as substitute of Ir-192 HDR brachytherapy unit. Palmer *et al*.[10] also have presented in their study that Co-60 radioisotope can be used as an alternative of Ir-192 for HDR brachytherapy procedures for ICRT, which may produce equivalent plans with D90 of HRCTV and D2cc of bladder, rectum and sigmoid.

The one big disadvantage in Co-60 based HDR brachytherapy is that if similar dwell positions are given similar dwell time in the plans with Co-60 source and with Ir-192 source, then there will be small dose increase along extension of axis of source, although this can be managed by minimizing by proper dose optimization. The treatment time by Co-60 HDR source is 1.7 times than that by Ir-192 HDR source with their initial activities.[5] Although the half life of Co-60 source is 5.26 years but for ICRT, the treatment time reaches to 30 minutes after four years, while HDR brachytherapy loses radiobiological effectiveness if the treatment time exceeds 30 minutes. Therefore after four years, the Co-60 source should be used for those brachytherapy procedures only which would have treatment time lesser than 30 minutes.

Another most important point in using Co-60 source is its higher mean energy. For larger distances the doses by Co-60 source is higher than that by Ir-192 source with the ration 1.16, 1.68 and 2.57 at the distances 30 cm, 45 cm and 60 cm respectively. But in the short distances up to 20 cm, the doses by Ir-192 are higher as compared to that by Co-60 with the ration 1.14 and 1.05 at the distances 10 cm and 20 cm respectively.[11]

Already presented studies on acute gastrointestinal and genitourinary toxicities related with Co-60 radioisotope in ICRT presented that the biological effective dose for rectum was 124.4. Grade-3 gastrointestinal toxicity was noted in only 3% of total treated patients, while rests of the patients were reported with ≤ grade-2 and genitourinary toxicities. These toxicities are in concurred with the toxicities already presented with Ir-192 HDR brachytherapy.[12]

Already presented studies on toxicities by using Co-60 source in HDR brachytherapy procedure and the dosimetric data of present study shows that Co-60 source can be used for ICRT.

Conclusion

Dosimetric parameters of all the plans done for Co-60 HDR brachytherapy are well acceptable as per ABS guidelines. The clinical target volume in all the plans is well covered as per requirement with very less doses to surrounding critical organs as compared to their tolerance limits. Therefore it can be concluded that the Co-60 source can be used for HDR brachytherapy treatment in the cases of cervix cancer.

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