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Original Research

Dosimetric Analysis and Effect of Different Definitions of Prescription Point “A” to OAR in High Dose Rate Brachytherapy for Cervical Cancer

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Purpose: Dosimetric analysis and effect of different definitions of prescription point “A” to OAR in high dose rate brachytherapy for cervical cancer.
Methods and Materials: This retrospective comparative dosimetric study is based on the data of 25 patients with histologically proven cervical carcinoma treated with HDR (high-dose-rate) brachytherapy. Patients received 21 Gy in three fractions (7.0 Gy X three fractions) to point A (A_{MAN}, revised Manchester definition). Further, the patients were replanned with the new point A ($A_{ABS)}$ as per the American Brachytherapy Society/ICRU 89 which is defined on CT images. The data compiled was then compared with the data observed from point A (A_{MAN}).
Results: When A_{MAN} normalization method was used, the mean dose to the bladder at 0.1cc, 1cc, 2cc and 5cc obtained was 1121.2±54.5, 1058.7±44.1, 875.0±38.6, 780.5±35.9, and 641.2±29.5 cGy respectively. Likewise, using the ICRU-89 point A (ABS) normalization method, the mean dose to 0.1 cc, 0.2 cc, 1 cc, 2 cc, and 5cc bladder volumes was 1178±156.1,1110.0±130.8, 921.6±111.4, 826.6±101.32, and 673.3±80.9 cGy, respectively. For the rectum, point A (MAN) normalization plans, the mean dose of 0.1 cc, 0.2 cc,1 cc, 2 cc, and 5cc rectum volumes was 680±143.5, 652.53±129.8,574.25±131.1, 530±126.9, and 452.5±121.2cGy, respectively. Likewise, using the $A_{(ABS)}$ plan, the mean dose of 0.1 cc, 0.2cc, 1 cc, 2 cc, and 5cc rectum volume was 707.5±148.1, 678.7±128.7, 596.2±135.6, 551.25±127.44 and 471.25±122.64 cGy respectively. The statistical mean difference of Total Reference Air Kerma rate, V100 (cc), bladder, and rectum, was found significant.
Conclusion: The present study attempts to analyze the differences in rectum and bladder dose, as well as the size of the volume enclosed for prescribed Isodose curve following ICRU 38 and ABS-ICRU 89 recommendations about intracavitary cervix cancer treated with brachytherapy. With Manchester system being more static, i.e., lesser variation with geometric changes, it is preferable in comparison to ABS system.

Introduction

Brachytherapy is used integrally as a part of treatment when carcinoma cervix patients are treated by radiation with a curative intent. It can either be used alone in case of early lesion or combined with external beam radiotherapy in advanced lesions [1-3]. Various systems are devised for dose specification for the treatment of the cervix: the two most typically used are the Manchester system and the other one is ICRU system.

The Manchester system was described by Tod and Meredith in 1938 which was later modified in

1958. It's characterized by doses to four points: A, B, bladder and rectum. The duration of the implant relies on the dose rate at point A, which is marked 2 cm superior to the cervical os and 2 cm lateral to the cervical canal [4]. Point B is defined 3 cm laterally to point A if the central canal isn't displaced. With the displacement of tandem with the central canal, point A moves with the canal, but point B remains fixed at 5 cm from the midline.

The revised Manchester system defined point A as the point 2cm superior to the flange and 2 cm lateral from the center of the tandem. The idea of finding point A was proposed from the bottom of the tandem loaded with radioactive sources or tandem flange since the ovoid surface wasn't visible on plain radiographs. It includes dose specification at point A for absorbed-dose prescription, bladder and rectum dosimetry to limit dose to the organ at risk (OAR), and vaginal packing for positioning of the applicator and to spare the OAR to displace it away from the applicator. The Manchester system is still used predominantly in intracavitary brachytherapy (ICBT) in many centres [5].

There were various limitations for outlining point A because it firstly relates to the position of the sources instead of a specific anatomic structure. Secondly, dose to point A is extremely sensitive to the position of the ovoid sources relative to the tandem sources therefore can't be the determining factor in deciding on implant duration. Thirdly counting on the dimension of the cervix, point A may lie inside or outside the tumour [6, 7].

The commission recommended a system within which the volume of tissue treated to a particular dose and also the reference air kerma (in micrograys [µGy] at 1 meter) are specified. When point A is employed as a reference point for dosing and reporting, attention must also be given to the 3D isodose distributions surrounding the entire implant.

ICRU 89 report provides recommendations on prescribing, recording, and reporting brachytherapy that specializes in volumetric imaging in cervical carcinoma brachytherapy. By using dose volume histogram ICRU 89 report combines prescribing, recording, and reporting for a simpler method of radiotherapy (planar X-ray images with a dose prescription at point A) with a sophisticated method (MR and CT images with dose prescription at D90%).

ICRU 89 and ABS recommendations: "For tandem and ovoids, connect a line through the centre of each ovoid. From the point on the tandem where this line intersects, extend superiorly along the tandem a distance equal to the radius of the ovoids" [8] (Figure 1).

Figure 1. Point A Defined by International Commission on Radiation Units and Measurements (ICRU) 89 Report.

Objective

To study the dosimetric impact of point A on the doses of the following OARs: Bladder, Rectum and Sigmoid while defined by the modified Manchester System and ICRU 89 Recommendations.

Materials and Methods

Study Population

This was a retrospective analysis of patients who received curative radiotherapy with or without concurrent cisplatin chemotherapy for cervical cancer. Patients who had Ca cervix with stages ranging from FIGO [9, 10] IB to IVA were included in this study. All patients were treated by external beam radiotherapy followed by Intracavitary brachytherapy.

Radiotherapy

EBRT was given to all patients via teletherapy cobalt machine using 2 field anterior-posterior/ posterior- anterior treatment. All patients received a dose of 50 Gy in 25 fractions. The brachytherapy was commenced after completion of EBRT. ICBT fractions were given one week apart. To calculate the dose from combined EBRT and ICBT, it was assumed that the whole volume treated with brachytherapy (including the OARs) received 100% of the prescribed EBRT dose.

Brachytherapy applicator

In ICBT, a Fletcher Suit applicator consisting of tandem and ovoids was used. It consisted of a set of two ovoids of different diameters, i.e., 20 mm and 15 mm along with the set of intrauterine tandem having different angles, i.e., 15°, 20°. The cervical stopper was used to decide the length of the intrauterine tandem.

Intracavitary insertion

The patients were well informed about the procedure and informed consent was taken. Each application was performed in the lithotomy position under LA (local anaesthesia). For identification of the ICRU bladder reference point, Foley's catheter was inserted into the bladder, and 7 cc of radio-opaque contrast was injected into the balloon. A gynaecological examination was performed, and that length of the uterine cavity was determined using a uterine sound. The applicators used were Fletcher Suit applicator.

Povidone iodine-soaked gauze was then densely packed into the vagina so that the applicator position was fixed and bladder and rectum are displaced away from the vaginal applicators. Some cotton ribbon was tied around the patients’ pelvis and then united with the applicators through the legs to stabilise the applicators during patient transfers. No systematic prescription was given for bladder filling.

Brachytherapy planning

After placement of brachytherapy applicator and Foley’s catheter, 3D images were acquired from the extent of umbilicus to mid-thigh with 1 mm slice thickness on a 64-slice diagnostic CT scan machine. High risk clinical target volume (HR-CTV) and OARs which include bladder, rectum and sigmoid colon were contoured using GYN GEC-GESTRO guidelines in Oncentra Brachy, v.4.6.0 TPS [11-13].

Contouring

The bladder, rectum, and sigmoid were contoured so as to include the full thickness of the wall of each organ. The bladder contouring started from the dome of bladder up to the junction with the urethra. For the contouring of the rectum, it began from 1 cm above the anus to the sigmoid flexure. The sigmoid colon was contoured from the recto-sigmoid flexure to the point at which the sigmoid colon extended into the anterior pelvis.

Treatment Planning

MAN In the previously treated plans, point A (A_{MAN}) was defined using the revised Manchester

definition, i.e., 2 cm superior to the flange of the tandem and 2 cm lateral to uterine tandem. A dose of 7 Gy was prescribed to point A_{MAN} (Figure 2) and delivered in three fractions.

Figure 2: Absolute Dose Distributions of 700 cGy Prescription to Point A as Per Revised Manchester and ICRU-89.

The optimisation of plans was done if the ICRU bladder dose exceeded 75% or rectal dose exceeded 70% of the prescribed dose. The ICRU bladder point was taken at the most posterior part of the Foley's catheter balloon. The ICRU rectal point was localised at the level of the flange on the tandem, on an anteroposterior line drawn through the tandem, 5 mm behind the posterior vaginal wall.

In addition to the ICRU points, doses to points 2.5, 5, 7.5 and 10 mm above and below these were also recorded. As the step size increases, the dose to bladder and rectum increases, therefore, the step size of 2.5 mm was used. All calculations were performed using the American Association of Physicists in Medicine Task Group – 43 (AAPM-43) algorithm on the Oncentra brachy TPS [14] as the impact of heterogeneity corrected dose calculation for nonshielded applicators is quite small in patients with cervical carcinoma. Dose volume parameters were used for reporting dose to the OAR which includes bladder, rectum, and sigmoid as per the established guidelines [11]. The parameters were estimated from the cumulative dose volume histogram for OARs.

Dose received by both point A_{MAN} and A_{ABS}, 2cc volume of OARs (D_{2CC}) and minimum dose received by 90% and 100% of HR-CTV, i.e., D_{90} and D_{10C} were recorded in both plans. Treatment volumes enclosed by 100% isodose line (V_{100}), total reference air kerma (TRAK), and geometric shifts between point A_{MAN} and A_{ABS} were also reported.

For comparison of the bladder, rectum and sigmoid doses between both the plans, mean dose of D0.1cc, D1cc and D2cc were recorded. For estimating the dose variation, difference was calculated between the 2 plans for bladder, rectum and sigmoid 0.1cc, 1cc and 2cc volumes. To see the variation in dose to point A_{MAN} when it moves superior or inferior with respect to point A_{ABS} we prescribed the 100% dose to point A_{ABS} and noted the dose received at point A_{MAN} (Figure 3) for all the patients The distance was taken positive and negative when point A_{MAN} moves superior and inferior, respectively, to point A_{ABS}.

Figure 3. Variation in Dose to Point A when 100% Dose is Prescribed at Point A (ABS) and A (MAN).

Results

The mean dose of 0.1 cc, 1 cc, and 2 cc volumes of the bladder, rectum are shown in Table 1 and 2.

		Bladder		P value
	A (MAN)		A (ABS)	
DB0.1cc	1121.2±54.5		1178±156.1	t= 1.718, Df= 48, P value= 0.092
DB0.2cc	1058.7±44.1		1110.0±130.8	t= 1.858, Df= 48, P value= 0.069
DB0 1cc	875.0±38.6		921.6±111.4	t= 1.976, Df= 48, P value= 0.054
DB0 2cc	780.5±35.9		826.6±101.32	t= 2.144, Df= 48, P value= 0.037
DB0 5cc	641.2±29.5		673.3±80.9	t= 1.864, Df= 48, P

				value= 0.068

Table 1. Dose to Bladder at Various Points in both Systems.

		Rectum		P value
	A (MAN)		A (ABS)	
DB0.1cc	680±143.5		707.5±148.1	t= 0.667, Df= 48, P value= 0.508
DB0.2cc	652.53±129.8		678.7±128.7	t= 0.716, Df= 48, P value= 0.478
DB0 1cc	574.25±131.1		596.2±135.6	t= .582, Df= 48, P value= 0.563
DB0 2cc	530±126.9		551.25±127.44	t= .591, Df= 48, P value= 0.557
DB0 5cc	452.5±121.2		471.25±122.64	t= .544, Df= 48, P value= 0.589

Table 2. Dose to Rectum at Various Points in both Systems.

Using the A (MAN) plan normalization method, the mean dose of 0.1 cc, 0.2 cc, 1 cc, 2 cc and 5cc bladder volumes was 1121.2±54.5, 1058.7±44.1, 875.0±38.6, 780.5±35.9 and 641.2±29.5 cGy respectively. Likewise, using the ICRU-89 point A (ABS) normalization method, the mean dose of 0.1 cc, 0.2 cc, 1 cc, 2 cc and 5cc bladder volumes was 1178±156.1, 1110.0±130.8, 921.6±111.4, 826.6±101.32 and 673.3±80.9 cGy, respectively, as shown in Table 1 and 2. The mean dose difference of 0.1 cc, 1 cc, and 2 cc bladder volumes has been found significant ($p < 0.05$) as shown in Table 1 and Figure 4.

Figure 4. Comparison of Doses at Various Bladder Points in both Manchester and ABS System.

For the rectum, point A (MAN) normalization plans, the mean dose of 0.1 cc, 0.2 cc ,1 cc, 2 cc and 5cc rectum volumes was 680±143.5, 652.53±129.8, 574.25±131.1, 530±126.9 and 452.5±121.2cGy, respectively. Likewise, using the A (ABS) plan, the mean dose of 0.1 cc, 0.2cc, 1 cc, 2 cc and 5cc rectum volume was 707.5±148.1, 678.7±128.7, 596.2±135.6, 551.25±127.44 and 471.25±122.64 cGy respectively (Figure 5).

Figure 5. Comparison of Variation of Doses to Rectal Points in both Manchester and ABS System.

Discussion

Manchester point A has been used for decades as prescription point in ICBT of cervix cancer.

However, the location of this point A varies with the geometry of application. The latest ICRU-89 guidelines have recommended to use the ABS-defined point A for dose reporting.

Our findings suggest that mean point A doses of Manchester and ABS plans didn’t differ significantly.

The mean difference of point A with respect to prescription dose was 1.8% for A (MAN) and 1.2% for A (ABS). Similar results have been reported by Maurya et. al. and Anderson et. al whose values were 1.7% and 1.5% for Manchester and ABS definition respectively [15].

As shown in Table 1&2, average D2cc doses for rectum and bladder is 530cGy and 780.5cGy of prescribed dose respectively for A (MAN) and 551.25 cGy and 826.6cGy of prescribed dose respectively for A (ABS). The dose to bladder and rectum was much higher in ABS system as compared to Manchester system. The dose to bladder was found to be statistically different in both systems (p value=0.03), whereas in case of dose to rectum, differences observed was not significant in both system recommendations. (p value =.557) Similar results were derived from the study done by Howll.et.al. [16] who showed that prescribing dose to point A (ABS) leads to higher bladder and rectum dose over the prescribing dose to A (MAN), could be due to the reason that ABS point A lies superior to the above Manchester point A.

V_{100} was higher for ABS plans which is similar to the observation of Anderson et.al [15] and Chang.et.al. They concluded that using ABS point A as prescription point increased the total delivered dose. The mean percentage difference in our study was 5% which was higher than finding of Anderson et. al who repored the mean percentage change of 3%.

For HR-CTV mean percentage difference between D_{90} and prescribed dose was lower in ABS plans, and thus dose received by 90% volume of tumour was higher in plans using ABS point A definition for prescribing dose. There was significant difference in D_{90} values of A (ABS) and A (MAN) plans. This finding is different from Anderson et. al whose mean percentage difference between D_{90} parameter of two definitions was not more than 2% 90 [15].

TRAK was higher in A(ABS) by an average of 3% as compared to A(MAN) plans. This matches with Kim et. al. who showed that plans normalized to ABS point A had higher TRAK and thus prescribing to this point increased the total dose up to 2%.

The mean distance of A (ABS) point from A (MAN) point was found to be 0.6cm in our study. Zhang et.al [17] and Anderson et. al [15] calculated this shift to be 0.9cm and 0.6cm respectively.

In conclusion, the present study attempts to analyze the differences in rectum and bladder dose, as well as the size of the volume enclosed for prescribed isodose curve following ICRU 38 and ABS-ICRU 89 recommendations for brachytherapy tretment of cervical cancer. For the prescription of the treatment plans, the Manchester points (A points) were used according to ICRU 38 and the points recommended by ABS and ICRU 89. The study revealed that doses to both the points may be recorded during the transition period. However, the Manchester point Acan be preferred over the ABS point A as it conforms better with the desired outcome, is less susceptible to dose variations with geometrical changes and found to be more static.

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