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INSTITUTIONAL STUDY OF CT BASED PLANNING FOR INTRACAVITARY RADIOTHERAPY IN CARCINOMA CERVIX: COMPARATIVE ANALYSIS OF VOLUMETRIC PLANS AND POINT BASED PLANS

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ABSTRACT

Aim of the study: To compare adequate coverage of target and doses to the organs at risk by both conventional (2D) and CT-scan (3D) based volumetric plans in Intracavitary brachytherapy in patients of carcinoma cervix. Volume based (3D) plans and point based (2D) plans were evaluated for intracavitary radiotherapy in 60 patients of carcinoma cervix. The D100, D90, V100, V90 for both IRCTV and HRCTV were evaluated. Volumetric and point doses to rectum and bladder were compared. percentage of tumor volumes encompassed within 7.5 Gyisodose. Mean ± SD = 92.13±2.28. Mean dose to 100% of HR-CTV. Mean±SD= 4.55±0.8.Dose to 90% of HR- CTV. Mean ±SD= 7.8±0.69Gy. % of IR-CTV coverage in 100% (7.5 Gy) isodose line. Mean ±SD= 79.29±8.23. D2cc bladder Mean±SD=8.8±1.73Gy. Dose to ICRU bladder point is Mean±SD=5.1±2.43Gy.Mean dose to 2cc rectum and point dose to rectum are Mean±SD=5.43±1.58Gy and 3.59(Gy)±0.97Gyrespectively. So, there is significant difference ($p<0.001$) between D2cc bladder and rectum and doses to ICRU bladder and rectal points. The CT based volumetric planning of Intracavitary brachytherapy is superior in context to proper target and organs at risk delineation. The tumor coverage by CT based Intracavitary planning according to GEC-ESTRO guidelines is better than the conventional planning.

Key words: Intracavitary brachytherapy, Carcinoma cervix, Gynecological malignancy.

INTRODUCTION

World-wide carcinoma of cervix is the most common gynecological malignancy and third most common malignancy in women, with over 5,00,000 women globally developing this tumor and 2,33,000 dying of the disease every year [1].

Treatment of carcinoma cervix is according to the FIGO staging 2010, which constitutes surgery in early stages and concurrent radiotherapy and chemotherapy in later stages(stage IIB to stage IV A) [2]. Radiotherapy constitutes external beam radiotherapy and brachytherapy. Brachytherapy can be planned by conventional X-ray planning and conformal CT-based planning. Before the advent of 3D imaging (CT-scan or MRI) and CT/MR compatible ICR applicators, point A based conventional planning was done. In 1977, Chassagne and Horiot proposed the bladder and rectal reference points and their use were later recommended by the ICRU [3-5].

With the advent of CT-scan and MRI-scan as the diagnostic modalities radiation oncologists started using these modalities as the treatment planning of intracavitary brachy therapy. CT/MRI based planning of intracavitary brachytherapy is according to the GEC-ESTRO guidelines[3,6]:GEC-ESTRO decided in 2000 to support and promote 3D imaging based 3D treatment planning

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approach in cervix cancer brachytherapy. A Working Group (WG) was founded (Gynaecological (GYN) GEC-ESTRO WG), which was based on contribution of physicians and physicists from different centres actively involved in this field at that time.The task was to describe basic concepts and terms for this approach and to work out a terminology which would enable various groups working in this field to use a common language for appropriately communicating their results. GEC-ESTRO working group have come out with recommendations on prescribing and reporting for image guided brachytherapy.

METHODS AND MATERIALS

This study was carried out in our department where volumebased (3D) plans and point based(2D) plans were evaluated for intracavitary radiotherapy in 60 patients of carcinoma cervix. The D100,D90,V100,V90 for both IRCTV and HRCTV were evaluated. Volumetric and point doses to rectum and bladder were compared.

RESULTS AND ANALYSIS

A total of 60 applications of intracavitary radiotherapy were studied in 26 patients of carcinoma cervix.

According to GEC-ESTRO consensus guidelines, all patients underwent CT-scan/MRI Abdomen-pelvis. According to FIGO staging, patients were given concurrent CT+RT, 50Gy/25# or 40Gy/20# with either cisplatin or carboplatin. 16 patients were given Carboplatin and 10 patients were given cisplatin as concurrent chemotherapy.

All the parameters given by GEC-ESTRO consensus guidelines and ICRU 38 were analysed for each application.

Table 1. Age wise distribution of patients

Age in years	Number of patients	%
20-30	2	7.7
31-40	1	3.84
41-50	12	46.15
51-60	9	34.62
61-70	2	7.692
Total	26	100

Table 2. FIGO Staging of the patients- 8 patients (30.77%) were having stage IIB carcinoma cervix and 18 patinets (69.23%) were having stage IIIB

Stage	No. of patients	%
II B	8	30.77
III B	18	69.23
Total	26	100.00

Table 3. Table showing minimum, maximum, mean and SD values of tumor dosages (%)

	V100% HRCTV	D100% HRCTV	D90% HRCTV	D95% HRCTV	V100% IRCTV
Minimum	86.94	42.0	97.98	76.2	56.20
Maximum	98.78	81.3	127.1	117.0	89.89
Mean	92.13	61.32	105.52	91.98	75.29
± Std. Deviation	2.28	10.42	6.29	7.29	8.23

Table 4. Table showing dosages to Point A in ICRU point A based planning

Dose to point A(Gy)	No. of applications
<6	3
6-8	13
8-10	15
10-12	20
12-14	4
14-16	3
>16	2

Table 5. Previous studies compared to present study

Our study	5.10(±2.41)	8.8(±1.73)	9.66(±2.17)	12.88(±3.2)	7.1(±1.38)
Madan *et al* (2014)[10]	2.62	5.56	6.1	7.14	5.01
Hashim *et al* (2014)[11]	5.1(±2.03)	6(±1.9)	-	-	-
Tyagi *et al* (2012)[12]	3.08	6.91	-	-	-
Gao *et al* (2010)[13]	3.8(±0.4)	5.4(±0.9)	6(±1)	7.4(±1.2)	-
Pelloski *et al* (2004)[14]	12(±3.58)	18.93(±6.4)	-	-	15.84(±4.8)

Table 6. Previous studies compared to present study

Our study	3.6(±0.97)	5.34(±1.58)	6.07(±1.74)	7.39(±2.32)	4.4(±1.26)
Madan *et al* (2014)[10]	3.53	4.68	5.13	6.25	3.96
Hashim *et al* (2014)[11]	3.75(±0.65)	4.58(±1.22)	-	4.75(±1.01)	-
Tyagi *et al* (2012)[12]	3.8	4.2	-	-	-
Gao *et al* (2010)[13]	3(±0.5)	4(±1)	4.4(±1.1)	5.6(±1.5)	-
Pelloski *et al* (2004)[14]	11.85(±2.72)	12.06(±3.61)	-	-	10.34(±2.9)

Study	**Pair**	**Bladder**	**Rectum**	**P value**
Madan *et al* (2014)[11]	D_{2cc} and D_{ICRU}	3.06	1.11	0.001
	D_{1cc} and D_{ICRU}	3.76	1.58	0.001
	$D_{0.1cc}$ and D_{ICRU}	4.76	2.69	0.001

Fig 1. Graph showing age wise distribution of patients. The maximum no. of patients were in the age group of 41-50 years. Mean age was 49.69 years.

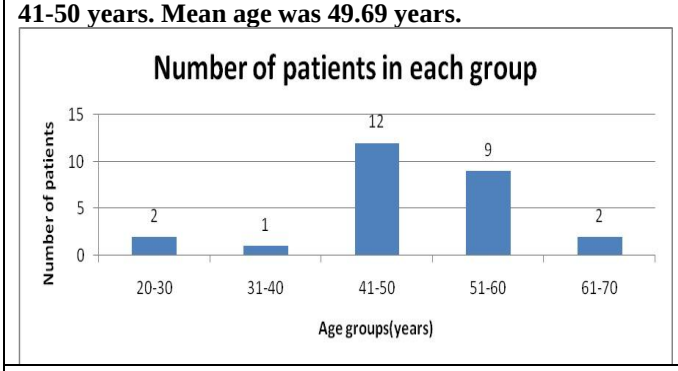


Fig 2. Bar diagram showing distribution of Point A doses among 60 applications by conventional planning. Point A dose was between 10-12 Gy for maximum applications.

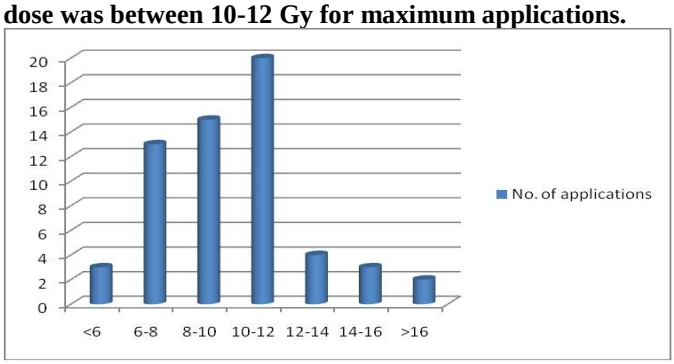


Fig 3. Scatter diagram showing correlation between $_{D2cc}$ bladder and ICRU bladder point dose. Person correlation coefficient [r]= 0.489, p value <0.001, Significant positive correlation.

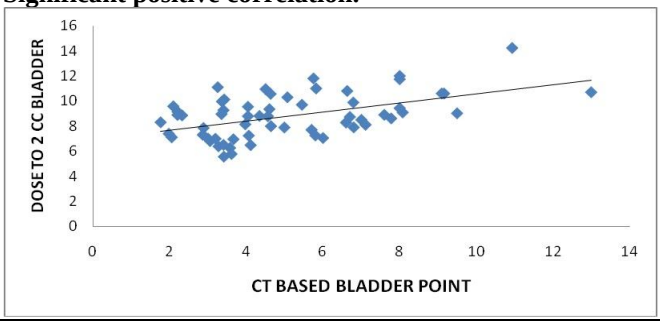


Fig 4. Scatter diagram showing correlation between D_{2cc} rectum and ICRU rectum point dose. Pearson correlation coefficient [r]= 0.590 p value <0.001, Significant positive correlation.

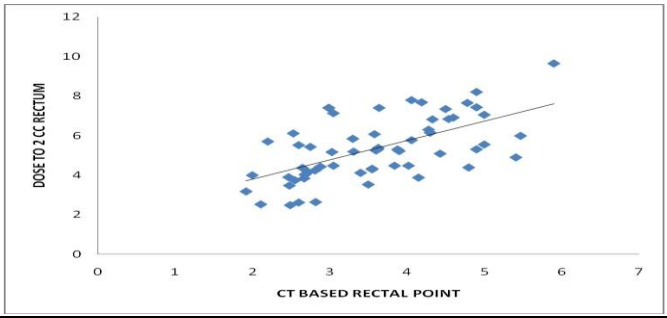
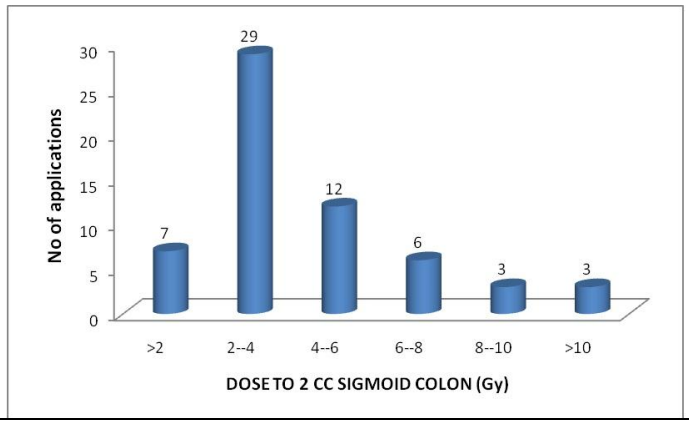


Fig 5. Figure showing dose distribution of 2 cc sigmoid colon Minimum-0.91 Gy, Maximum-12.8 Gy, Mean± SD 4.4 ± 2.58.



DISCUSSION

Traditional method of dose calculation for Intracavitary brachytherapy has been based on orthogonal radiograph, which provided the position of the applicator relative to the bony structure. It shows the doses at fixed points relative to the applicator, such as Point A and Point B of the Manchester system and the organs at risk. However, this system does not show the dose to the tumor volume and the organs at risk. Here we have compared the doses to the organs at risk by Volume based (CT scan) and conventional method of planning. We have studied 60 applications of Intracavitary brachytherapy in 26 patients of carcinoma cervix. All patients are within 20-65 years of age. 8 patients were of FIGO stage IIb and 18 patients were of FIGO stage IIIB cancer cervix. The median karnofsky performance score is 80. All patients received EBRT and ICR. All the parameters were analyzed and compared. Many previous studies have shown some inconsistencies between the dose to the target and bladder and rectal doses by 2 methods of Intracavitary radiotherapy planning (volumetric and conventional). For this comparison we have used Dose to the ICRU reference points in conventional planning and the dose to 2 cc volume of bladder and rectum.

Tumor dose

Minimum, maximum and mean ±Std. deviation (SD) values of volume covered within 100% isodose line/7.5 Gyisodose line (V100%) for HR-CTV are 86.94%, 98.78% and 92.13%±2.28 respectively. The D90% (Dose to 90% of volume) for HR-CTV ranges from 97.98% to 127.14% with mean value is 105.52%±6.29. D90% dose ranges from 9.53 Gy to 4.81 Gy with mean of 7.8 Gy (SD=0.69). Minimum, maximum and mean values of the volume covered within 100% isodose line/7.5 Gy for IR-CTV are 88.89%,56.20%and 75.29% (±8.23 SD).

The mean dose to point A in our study is 9.8 Gy ±2.80. The mean dose to point is compared with the mean D90% (Gy). The difference is 2 Gy and the difference is significant (p=0.0001). The point A dose by conventional ICRU point A based planning overestimates the tumour dose [7-9]. The tumor (HR-CTV) coverage within 100% prescribed dose inversely varies with the target volume. In some cases where the lateral extent of the tumor is within the parametrium, the coverage will be less even if the tumor volume is small if the dose prescription is based on Point A based planning system [10]. Reflected lack of any direct correlation between dose delivered to point A and loco regional control [11, 12].

Mean tumor dose 8.6 Gy(±1.78 SD), and the mean tumor coverage in 100% isodose (V100%) 88.8% (± 9.2 SD) [13]

Mean V100% 79.9±13.2,D_{90} 5.4±0.4 Gy and dose to point H 5.8±0.2 Gy [14]. Average V150% is 66.3% and SD is 8.427% and V200% is 44.33% and SD is 9.714%.

Doses to Organs at risk

In the planning of Intracavitary brachytherapy radiation induced morbidity, particularly to the bladder and rectum has been of considerable concern.

Deore SM *et al* tried to correlate the maximum reference doses to bladder and rectum from orthogonal films and the late morbidity to these organs, but the same could not be demonstrated.

According to Christopher Pelloski $D_{2cc}$for bladder and rectum appear to be reproducible, and their use reduces the effect of very small errors or irregularities in contouring that, because of the steep dose gradient, can cause significant inaccuracies in the maximal dose, and also because the D_{2cc} of bladder and rectum are based on absolute volume of tissue, rather than a fraction of the total volume, they are relatively independent of the bladder and rectal volume which may vary between applications. So, dose to 2cc volume is more meaningful for evaluating dose to organs at risk [14]

Here, tables are showing comparative results of different study.

In our study the differences between Dose to 2 cc, 1 cc, 0.1cc bladder and rectum and ICRU bladder and rectal point dose were analyzed using paired t test which showed significant results.

Madan *et al* concluded that doses to ICRU bladder and ICRU rectal point underestimate the dose to bladder and rectum so, they cannot be the surrogate for the D_{2cc} Bladder or D_{2cc} rectum.

Whereas, Hashim *et al* showed that ICRU bladder point dose does not differ signifiacantly from the D_{2cc} Bladder but for ICRU rectal dose and $D_{2\ cc}$ rectum the difference is significant. According to Hashim *et al* dose to ICRU bladder point can be a surrogate for the D_{2cc} bladder. However the dose to the ICRU rectal point does not appear to be a surrogate for the D_{2cc} rectum.

Tyagi *et al* showed significant difference between the mean D_{ICRU} bladder and D_{2cc} bladder (p=0.00), but not for D_{ICRU} rectum and D_{2cc} rectum (p=0.08). It was found that the bladder doses were underestimated by the film method. The result with non isocentric film based planning was similar to the orthogonal planning.

Gao *et al* showed that dose to 2 cc rectum weakly correlated with the ICRU rectal point dose, and the bladder dose based on ICRU point is also significantly underestimated.

N.R. Dutta *et al* showed that $B_{max\ ICRU}$ underestimates the $B_{max\ CECT}$ and the difference ranges from -212 to -1059 cGy. The paired differences were significant between $B_{max\ ICRU}$ and $B_{max\ CECT.}$ The mean difference between $R_{max\ ICRU}$ and $R_{max\ CECT}$ is -883 to 185cGy. The paired difference was significant (p= 0.005)

Pelloski *et al* showed that dose to ICRU rectal point may be a reasonable surrogate to dose to 2 cc rectum. Our study shows the dose to 2cc sigmoid colon mean± 4.4 Gy±2.58. In case of ICRU point based planning the dose to sigmoid colon cannot be assessed whereas in the 3D volumetric planning we can assess and also restrict the dose to sigmoid colon.

CONCLUSION

- The CT based volumetric planning of Intracavitary brachytherapy is superior in context to proper target and organs at risk delineation.
- The tumor coverage by CT based Intracavitary planning according to GEC-ESTRO guidelines is better than the conventional planning.
- We have concluded that the 3D- Volumetric planning for Intracavitary radiotherapy based on the GEC-ESTRO guidelines can be done at each application of Intracavitary brachytherapy in carcinoma cervix.
- The CT based (3D) volumetric planning also shows the dose to 2cc of sigmoid colon and we can also restrict the dose to sigmoid colon.

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CONFLICT OF INTEREST:
The authors declare that they have no conflict of interest.

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