Distribution of doses to organs at risk in Cervical Cancer High Dose Rate Brachytherapy using Tandem and Ovoids or Vaginal Cylinder

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Abstract: Brachytherapy is an integral part of the treatment of cervical cancer. In brachytherapy, the dose delivered to the tissue is determined primarily by the inverse square law thus the dose decreases rapidly as the distance from the source increases. Therefore, an important role in dose distribution is the geometry of the applicator. A patient's anatomy as well as the fact that the patient may have been operated on must also be taken into account when selecting the applicator. The aim of this study was to assess the influence of the type of cervical cancer brachytherapy applicators (tandem and ovoids or vaginal cylinder) on the dose delivered to adjacent organs, urinary bladder, and rectum. The treatment plans of 10 patients with cervical cancer treated by intracavitary brachytherapy were reviewed, and dose distribution data was collected. Prescribed doses were 7 Gy (or 8 Gy)/fractions, and the number of fractions was from 3 to 5, thus cumulative target EQD2 was between 85-90 Gy. Deliveries of doses to the rectum and bladder were controlled within the tolerance ranges. It was found that the selection of the applicator and the doses administered to the bladder and rectum were correlated. Tandem and ovoid applicators produced lower doses in the bladder and rectum by approximately 20% than the vaginal cylinder. The results of this analysis may potentially enable the optimization of dose distribution for organs at risk in each individual clinical situation.

Keywords: brachytherapy, cervical cancer, applicators, tandem and ovoids, vaginal cylinder

1. Introduction

The fourth most common malignant tumor in women is uterine cervix cancer, with 604.127 new cases identified in 2020 [1]. According to the clinical stage and pathology type of cervical cancer, treatment may include surgery, radiotherapy, and chemotherapy

[2]. Brachytherapy (BT) is a method of treatment developed in the early 1950s and is used to give the majority of the dose to the central tumor of the cervix cancer with a reduction of the dose to organs at risk due to rapid dose decreasing. Iridium-192, which has a half-life of 73.8 days, is the radionuclide most frequently used for HDR BT [3, 4]. Due to this, this radionuclide can be applied to radiotherapy systems relatively affordably because it requires replacing the source approximately four times a year, and this is enough to maintain a high dose rate of at least 12 Gy/h [5]. With this technique, in order to avoid insufficient underdosing, proper selection of the applicator is necessary. Many vaginal applicators are available, some of them are suitable for low-dose-rate brachytherapy [6], whereas the tandem and cylinder applicator effectively delivers 100% isodose of brachytherapy to the tumor without raising the danger of toxicity for high-dose-rate brachytherapy (HDR B) [7, 8]. Thus, the aim of this study was to evaluate organs at risk (OAR) doses estimated in patients with cervical cancer treated with HDR BT in the case when two types of applicators (tandem and ovoids or vaginal cylinder) are used.

2. Methods and results

A sample of 10 cervical cancer patients treated at the Centre of Radiation Oncology, the University Clinical Center Kragujevac was observed. At the time of diagnosis, the patient's average age was 65.6 (range 56-79). Patients with locally advanced cervical cancer are treated with definitive radiotherapy (transcutaneous (External Beam Radiotherapy (EBRT)) and brachytherapy) with or without chemopotentiation. The total dose prescribed during EBRT and brachytherapy to the tumor volume (Gross Tumor Volume (GTV)) ranged from 85-90 Gy, calculated based on the application of the EQD2 model for dose calculation where α/β for the tumor is 7, and for organs at risk 3 [9]. EBRT was performed with 3D-conformal radiotherapy (3D-CRT), intensity modulated therapy (IMRT) or volumetric modulated arc radiotherapy (VMAT).

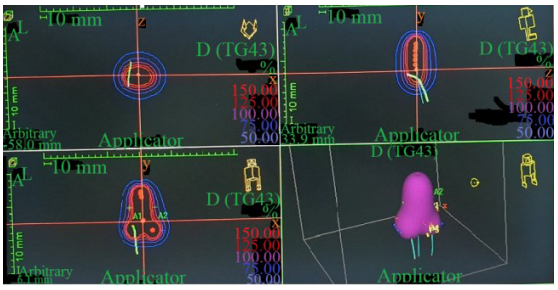

Figure 1. Dose distribution calculated by Oncentra brachytherapy treatment planning software for carcinoma cervix with tandem and ovoids applicator.

Half of the studied patients were treated with HDR brachytherapy using tandem and ovoids, and the other half with vaginal cylinders. CT scanning and delineation of the target and organs at risk (bladder and rectum) were done as a standard procedure. Optimization was then performed in order to deliver the prescribed dose to the target

while maintaining the dose at the organs at risk within tolerance limits all in order to obtain the best treatment plan that satisfies all input criteria (Figures 1 and 2).

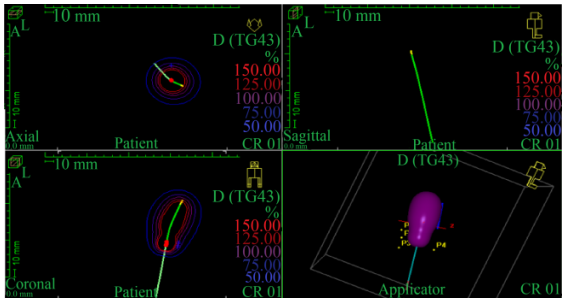

Figure 2. Dose distribution calculated by Oncentra brachytherapy treatment planning software for carcinoma cervix with vaginal cylinder applicator.

In comparing dose distributions for organs at risk, it can be concluded that tandem and ovoid applicators deliver lower doses. It can be observed from Table 1 and Figure 3 that these doses are approximately 20 % lower.

Table 1. The dosimetry results of the two types of applicators used in the study.

Patient	Type of the brachytherapy applicator	Age (year)	Prescribed dose [cGy] and No. of fraction	Number of rectal reference points	Number of bladder reference points	Dose to rectal point [cGy]	Dose to bladder point [cGy]
1	vaginal cylinder	77	800 (3)	7	1	552.16	567.07
2	vaginal cylinder	59	700 (5)	10	3	502.18	527.89
3	vaginal cylinder	79	800 (4)	12	3	605.17	575.41
4	vaginal cylinder	71	700 (5)	7	1	515.66	497.48
5	vaginal cylinder	67	700 (5)	3	1	398.46	243.05
6	tandem and ovoids	74	700 (5)	4	1	293.72	372.97
7	tandem and ovoids	56	700 (5)	5	2	328.58	232.42
8	tandem and ovoids	56	700 (5)	4	2	487.88	366.64
9	tandem and ovoids	60	700 (5)	5	2	448.40	493.10
10	tandem and ovoids	57	700 (5)	4	2	422.09	548.55

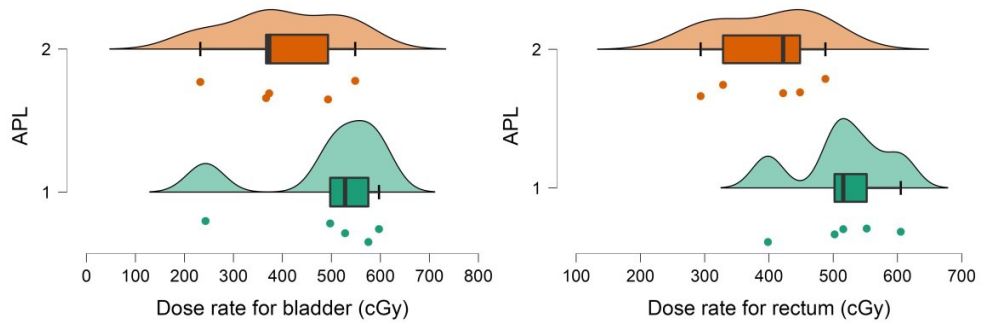

Figure 3. Distribution of high dose rate values for organs at risk (bladder and rectum) according to the type of applicator (APL: 1- vaginal cylinder, 2- tandem and ovoids applicators).

Independent samples T test showed a significance of p=0.045 for HDR for the rectum and choice of the applicator. The analysis was performed using JASP computer software (Version 0.16) [10].

3. Conclusions

According to this study, tandem and ovoid applicators provide a lower dose distribution to the bladder and rectum than vaginal cylinder applicators. The differences in dosimetric characteristics as well as the advantages and disadvantages of the applicators themselves may account for these obtained results. In order to improve clinical outcomes, it is necessary to analyze all of these aspects in more detail.

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