The study of a rectal dose in cervical carcinoma: High dose rate brachytherapy calculated based on the ICRU Report 38 Recommendation and Multiple Points Calculation in Lampang Cancer Hospital

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Abstract

Objective: To compare the rectal dose of high dose rate brachytherapy treatment planning based on ICRU 38 recommendation and multiple points calculation for evaluating the rectal dose and maximum point in rectum from brachytherapy treatment planning in Lampang Cancer Hospital.
Method: The high dose rate comparison of rectal dose from two methods was performed in 30 cervical cancer patients with brachytherapy treatment. The statistic analysis was paired t-test.
Results: A rectal dose relative to point A was calculated using reference point defined by multiple points. The result showed that mean of average maximum value of rectal dose from multiple reference six points was 60.87±16.97% while average maximum value of rectal dose calculated from the ICRU 38 was 59.0±15.89%. Position of the maximum rectal dose was 1 cm upward the reference point of ICRU 38 calculation (43.3%). Comparison of doses calculated by marking the reference points from two methods showed that maximum dose of multiple point calculation was higher than that of ICRU 38 calculation significantly *($p< 0.009$)*.
Conclusion: A rectal dose calculation using the reference point according to ICRU 38 recommendation suggested only a single point. It may not be the maximum rectal dose point. Therefore, a multiple point calculation along the length of rectum should be suggested for informing radiologists to be applied to patients. ***Bull Chiang Mai Assoc Med Sci 2013; 46(1): 33-39***

Keywords: *cervical cancer, brachytherapy, treatment planning, rectum*

การศึกษาปริมาณรังสีที่ลำไส้ตรงได้รับจากการใส่แร่ อัตราการแผ่ปริมาณรังสีสูง จากการคำนวณโดยกำหนดจุดอ้างอิงลำไส้ตรงแบบหลายจุด และการกำหนดตามมาตรฐาน ICRU ฉบับที่ 38 ในกลุ่มผู้ป่วยมะเร็งปากมดลูก ที่เข้ารับการรักษา ณ โรงพยาบาลมะเร็งลำปาง

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บทคัดย่อ

วัตถุประสงค์: เพื่อเปรียบเทียบผลการคำนวณปริมาณรังสีที่ลำไส้ตรงได้รับจากการใส่แร่อัตราการแผ่ปริมาณรังสีสูงจากการคำนวณโดยกำหนดจุดอ้างอิงลำไส้ตรงแบบหลายจุด และการกำหนดจุดอ้างอิงตามมาตรฐาน ICRU ฉบับที่ 38 รวมทั้งหาตำแหน่งที่ลำไส้ตรงได้รับปริมาณรังสีสูงสุด และพิจารณาปริมาณรังสีที่ลำไส้ตรงได้รับจากการใส่แร่ของโรงพยาบาลมะเร็งลำปาง

วิธีการวิจัย: ทำการศึกษาในกลุ่มผู้ป่วยมะเร็งปากมดลูกที่ได้รับการรักษาโดยการฉายรังสีจากภายนอก และใส่แร่ด้วยอัตราการแผ่ปริมาณรังสีสูงจำนวน 30 ราย เปรียบเทียบปริมาณรังสีของลำไส้ตรงที่คำนวณได้ โดยใช้สถิติ paired t-test

ผลการวิจัย : ปริมาณรังสีที่ลำไส้ตรงได้รับเมื่อเทียบกับจุด A จากการคำนวณโดยการกำหนดจุดอ้างอิงลำไส้ตรงแบบหลายจุด มีค่าเฉลี่ยของปริมาณรังสีที่สูงสุดเท่ากับ 60.87±16.97% ส่วนปริมาณรังสีที่คำนวณได้จากการกำหนดจุดอ้างอิงตามมาตรฐาน ICRU 38 มีค่าเฉลี่ยเท่ากับ 59.0±15.89% และตำแหน่งของลำไส้ตรงที่คำนวณได้ปริมาณรังสีสูงสุด ส่วนใหญ่อยู่เหนือขึ้นไปจากจุดอ้างอิงตามมาตรฐาน ICRU 38 ขึ้นไป 1 เซนติเมตร คิดเป็น 43.3% เมื่อเปรียบเทียบปริมาณรังสีที่คำนวณโดยการกำหนดจุดอ้างอิงทั้ง 2 วิธี พบว่าปริมาณรังสีสูงสุดที่ลำไส้ตรงได้รับจากการคำนวณโดยกำหนดจุดอ้างอิงแบบหลายจุดมีค่าสูงกว่าการกำหนดจุดอ้างอิงตามมาตรฐาน ICRU 38 อย่างมีนัยสำคัญทางสถิติ *($p<0.009$)*

สรุปผลการวิจัย: การคำนวณปริมาณรังสีที่ลำไส้ตรงได้รับจากการกำหนดจุดอ้างอิงลำไส้ตรงตามมาตรฐานที่ ICRU 38 แนะนำเพียงจุดเดียว อาจไม่ใช่จุดที่ลำไส้ตรงได้รับปริมาณรังสีสูงสุด ดังนั้นจึงควรกำหนดจุดอ้างอิงแบบหลาย ๆ จุดตามแนวความยาวของลำไส้ตรง เพื่อเป็นข้อมูลสำหรับรังสีแพทย์ในการนำมาใช้ประกอบการรักษาผู้ป่วยต่อไป ***วารสารเทคนิคการแพทย์เชียงใหม่ 2556; 46(1) : 33-39***

คำหัส: *มะเร็งปากมดลูก การใส่แร่ การวางแผนรักษา ลำไส้ตรง*

Introduction

A Cancer registration of the National Cancer Institute reported that cervical cancer is the second order among Thai women cancer follows breast cancer1. Patients diagnosed with cervical cancer will be planned for each course of treatment which depends on a stage of disease. There are three approaches which are surgery, radiotherapy and chemotherapy. Radiotherapy is an important one for cancer treatment, especially in the case with a spreading of cancer which cannot be treated by surgery. Radiotherapy aims to deliver the maximum dose of radiation to a local tumor, but protecting a normal tissue from ray. This will expand the quality of life of patients who undergo radiation.

For cervical cancer treatment, external beam radiotherapy is given to a whole pelvis for inducing primary tumor shrinkage and sterilization of microscopic disease within pelvic lymph-node. Therefore, the major organs (bladder and rectum) are affected and must be taken into account. They must not be received exceed dose limit in order to prevent the side effects. An accuracy of bladder and rectal radiation dose has been introduced as an important component of medical treatment.

In addition, an intracavitary application of cervical carcinoma also need an accuracy of the bladder and rectal doses which are associated with several factors, such as a variation of position, a reference point of bladder and rectum. Recently, it is admired to use a reference point as recommended by ICRU (International Commission on Radiation Units and Measurements) report 38. However, in practical, the reference point (the location calculated follows the rectal ICRU 38) which is believed to be the maximum rectal dose location may be discrepant from the recommendation because of several reasons. First, the differences of patient's rectal shape which leads to an in-corrected applicator positioning. Second, types of an applicator used. Therefore, the dose calculated by standard point of reference may not be the maximum rectal dose.

Materials and methods

This prospective study was performed in 30 cases/applications using BEBIG Multi-Source high dose rate brachytherapy treatment unit and its standard applicator set. The 3rd time of brachytherapy of each case was selected for the study. The prescribed dose was 6-7.5Gy to point A for each application. Each patient was treated with radical irradiation (external beam irradiation and HDR brachytherapy) without hysterectomy. Patients received external beam irradiation using 6MV or 10MV photons

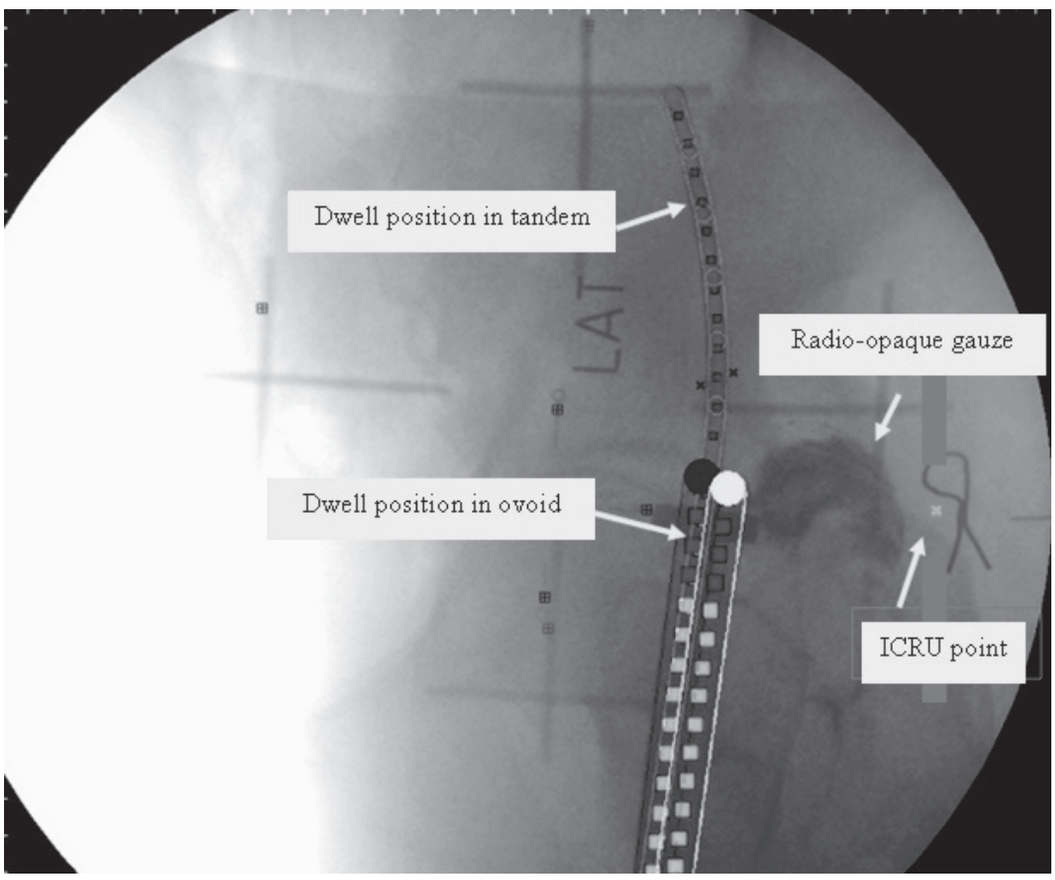


Figure 1 Rectal reference point recommended in ICRU reported 38

refer to a dose of 56Gy in 28 fractions over a 6 weeks period. Of these, the first 40Gy in 20 fractions were given with open fields and the remaining 16Gy in 8 fractions were given with a midline block and reduced field. Size of the field was determined individually according to the stage and patient anatomy. Brachytherapy part of the treatment consists of 3-4 HDR weekly fractions of 6–7.5Gy to point A. The treatment was carried out on MultiSource HDR which uses Co-60 as a radioactive source. Activity of the source, about 1.05Ci in all 30 applications was administered. Standard applicator set consists of a tandem 15° and two ovoid with 20 mm in diameter. Rectal mucosa was marked using back of the posterior vaginal wall for 0.5 cm. Posterior vaginal wall was marked by means of intra-vaginal radio-opaque gauze. Intracavitary treatment planning was performed on treatment planning unit MultiSource TPS for each insertion, based on AP and lateral orthogonal radiographs. Rectal doses were calculated using 2.2 version of Eckert & Ziegler BEBIG

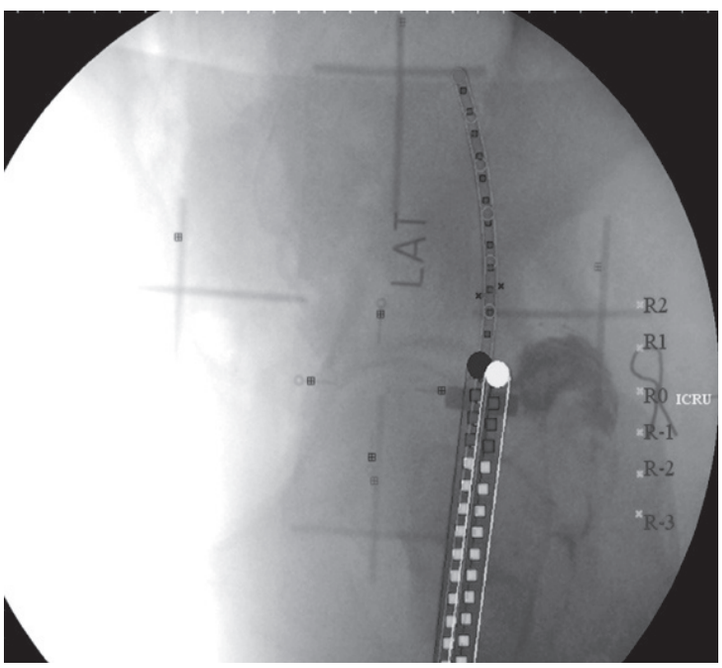


Figure 2 Rectal reference points in multiple points

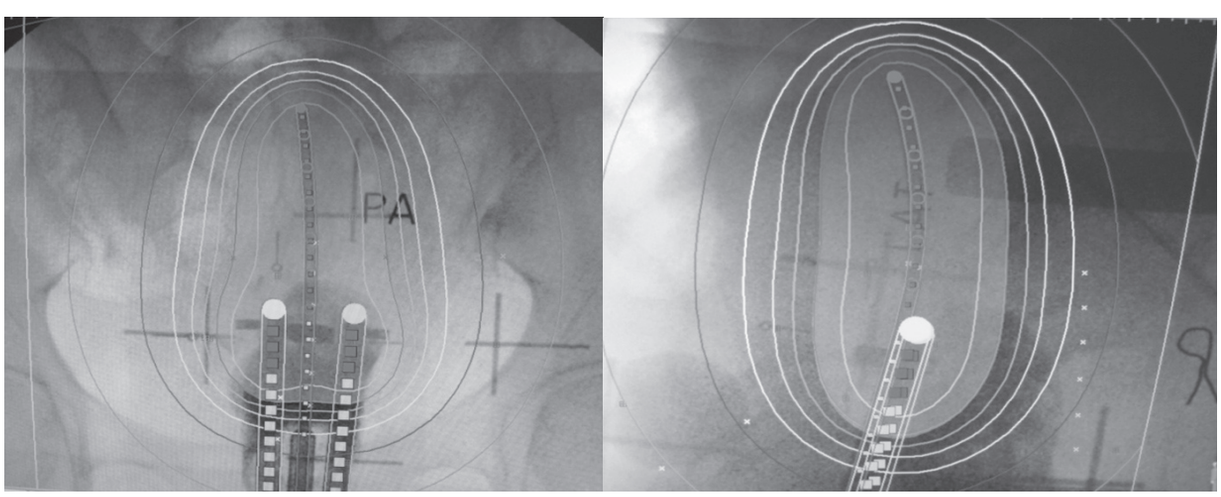


Figure 3 Intra-cavitary brachytherapy dose distribution

Gmbh treatment planning software. Rectal reference point recommended in ICRU 38 is shown in Figure 1.

This study investigated the rectal reference point as multiple points by adding reference points which are higher than a recommended point of ICRU 38 for 2 points (R1, R2) and positions which are lower than recommended in ICRU 38 for 3 points (R-1, R-2 and R-3) respectively. A gap between each point is 1cm as shown in Figure 2. Therefore, there are totally six reference points including the reference point of ICRU 38 recommendation (R0).

In treatment planning, an assign dwell position in tandem was activated from the tip to the level of tandem flange depending on the length of tandem used step size 0.5cm. Four dwells were activated within each ovoid. Out of 30 executed applications, in just one, length of the tandem was 40-60mm as shown in Figure 3.

Statistical comparison between rectal doses on an ICRU 38 rectal reference point and a maximum dose from the reference point of multiple points was done using paired t-test. Statistical significance was considered at the level of $p<0.05$.

Results

The rectal dose shown in percentage normalized to prescribed dose to point A was calculated by

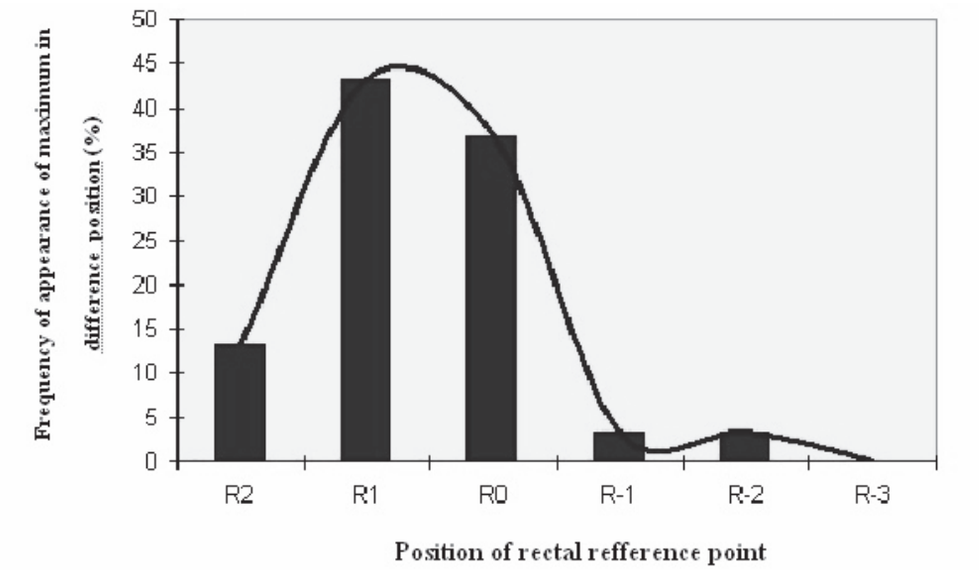


Figure 4 Distribution of maximum dose along rectal position expressed in percentage

Table 1 Rectal dose on multiple reference points and recommended in ICRU 38 calculated by treatment planning system (shown in percentage normalized to prescribed dose to point A)

Method define reference point		% Normalized to prescribed to point A			Standard Deviation
	Position	Minimum	Maximum	Average	
Multiple Point	R2	30.3	97.7	57.75	16.46
	R1	31.3	91.3	59.48	16.35
	R0	30.4	88.6	59.00	15.89
	R-1	27.5	80.6	55.27	15.06
	R-2	24.1	66.3	47.96	13.16
	R-3	21.4	54.0	38.28	10.08
	average 6 points	28.1	77.2	52.97	13.99
	Maximum 6 points	31.4	97.7	**60.87**	**16.97**
ICRU reported 38		30.4	88.6	**59.00**	**15.89**

treatment planning. The mean of the average maximum value of rectal dose from multiple reference six points was 60.87± 16.97% whereas the mean of the average maximum value of rectal dose calculated from the ICRU 38 was 59.0±15.89 as shown in Table 1.

The location of a maximum rectal dose calculated by treatment planning using multiple reference points was not as same as a location that ICRU 38 recommended for 19 cases (63.3%). The location of a maximum rectal dose of multiple reference point method was higher than that of ICRU 38 for 2 cm (R2) in 4 cases (13.3%) and for 1cm (R1) in 13 cases (43.3%), was lower than that of ICRU 38 for 1cm (R1) and 2cm (R2) in 1 case each (3.3%). No maximum rectal dose was found lower than 3cm of ICRU 38 recommended point. However, the rectal maximum dose location of multiple reference points was identical to ICRU 38 for 11 cases (36%).

These results showed the location of maximum rectal dose is usually higher than the reference point of ICRU 38 approximately 1 cm as shown in Figure 4.

An absolute rectal dose received in the Gray (Gy) and percent normalized to prescribed dose to point A calculated from treatment planning by defining reference point recommended in ICRU 38 (which is believed to be the location where the maximum rectal dose was found) and by multiple points showed the maximum rectal dose of the multiple points was tended to be higher than that of ICRU 38 recommendation. The rectal maximum dose position of multiple reference points was higher and lower than that of ICRU38 recommendation point 17 out of 30 cases (56.7%) and 2 out of 30 cases (6.6%), respectively. The statistic comparison found that the reference point specify by multiple points was significantly higher than that set by ICRU 38 *(p<0.009)*. Each of the total 30 cases was compared and data not shown.

Discussion

A rectal dose obtained from intracavitary brachytherapy is important for considering and predicting the side effects of the treatment. It should not exceed the dose limit which rectum can be accepted. In this study, we determined the rectal dose calculated from treatment planning by defining a reference point of rectum. The rectum as a posterior vaginal wall was defined by intravaginal radio-opaque gauze. The marked point was at the shadow behind the gauze moistened modalities for 0.5 cm. Then, we calculated percentage normalized a prescribed dose to point A of two methods. The multiple point method showed the maximum dose in the range from 31.4-97.7% and the reference point calculated by ICRU 38 was in the range from 30.4-88.6%. It was higher and wider than the study of Deshpande et al.[1] They reported that about 70% of applications, a rectal dose using rectal marker and calculated by orthogonal radiographs was in range from 40-70% of prescribed dose to point A.

A position of the maximum rectal dose obtaining (about 43.3%) was above the reference point recommended by ICRU 38 for 1cm. However, about 11% of maximum rectal dose position was identically to the ICRU 38 recommended position. This is consistent to the study of ÇetingÖz *et al*.[2] They reported that the most exposed region of a rectum is located along the point of a rectal marker which covers the length from 1.5 to 3 cm. Mostly, the maximum dose point is higher than that of ICRU 38 point and it is rarely lower than ICRU 38 recommended [3] A comparison of rectal doses obtained from brachytherapy calculated by the standard reference point recommended in ICRU 38 and by multiple points was significantly different. A rectal dose calculated by the multiple points showed a mean of 4.12Gy (60.68% of the dose point A), whereas the dose measured by ICRU 38 showed a mean of 3.95Gy (59% of the dose point A). These results were tally with the study of Baucal M who found that the maximum dose obtained using rectal marker dose calculation was at 74.3% compared to point A). It was higher than the dose calculated by the reference point according to ICRU 38, which was 66.2%.

Currently, they are many ways to specify the exact position of the rectum. There are also advantages and disadvantages for each method. For example, the exact location of the rectum assigning by inserting marker directly into rectum mostly leads to a lower dose than the standard ICRU 38 determining method. The reasons

were, first, inserting marker into the rectum was not close to the front wall of the rectum and second, a rectum is a hollow structure.[4] In 2002, Baucal M and his colleagues designed equipment which looks like a balloon. They inserted it into rectum followed by air spraying into an inflatable air bag for fitting the size of rectum. They found that the rectal dose was higher than that of ICRU 38 point determination. Another method, which injecting a contrast medium into rectum, made patients felt uncomfortable and it is complicated for implanter. Moreover, a rectal dose measured by placing rectal probe directly to rectum was lower than that of ICRU 38 recommended for 1.5 times. This error may occur because of a shifting of rectal probe and the probe position is not close to a rectal wall.[5] In 1993, Schoeppel SL examined that a maximum rectal dose of dose – volume histogram (5cc) obtained by CT planning was 1.6 times higher than that predicted by ICRU method.[6]

From all of results, a rectal dose calculation is important for evaluating patient complication. The radiation dose is associated with the complications in patients. Therefore, it should be evaluated and followed up to provide information for radiologist decision and treatment. Moreover, this study showed that the rectal reference point according to ICRU 38 recommendation (single point) may not reflect the maximum rectal dose received. Thus, the defining of the maximum rectal dose by multiple points must be determined along the length of the rectum. To specify a rectal location by this method, radiograph has to be clear in defining the extent of the vagina back wall. Thick body of patient can make unclear boundaries. Recently, there are approaches to determine the rectal dose, such as marker insertion directly into the rectum and 3D dose calculation using computerized tomography images. Each method has both advantages and disadvantages. However, our method is a simple one, saving time and easy to use in a daily clinical practice.

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References

1. Attasara P, Buasom R. Hospital Base Cancer Registry.1st ed. Bangkok : Rumthaiplace Ltd,2010.
2. Deshpande DD, Shrivastav SK, Pradhan AS, Viswanathan PS, Dinshaw KA. Dosimetry of intracavitary applications in carcinoma of the cervix: rectal dose analysis. Radiother Oncol. 1997; 42(2): 163-6.
3. ÇetingÖz R, Ataman ÖU, TunÇel N, et al. Rectum dose analysis of intracavitary ap plications in gynecologic cancers. Journal of BUON. 1998; 4: 307-13.
4. Baucal M, Babic J, Kuzmanovic Z. Rectal dosimetry in intracavitary applications of cervix carcinoma: Comparison of two methods. Archive of Oncology. 2002; 10(4): 253-59.
5. Serkies K, Badzio A, Jereczek-Fossa B, Tarnawska Z, Nowak R, Szewczyk P, *et al.* Rectal doses in intracavitary brachytherapy of gynecological malignancies: comparison of two dosimetric methods. Radiother Oncol. 2001; 58(1): 37-41.
6. Eich HT, Haverkamp U, Micke O, Prott FJ, Muller RP. Dosimetric analysis at ICRU reference points in HDR-brachytherapy of cervical carcinoma. Rontgenpraxis. 2000; 53(2): 62-6.