

Original article

Comparison of 2 ml (D2cc) and ICRU in image-guided brachytherapy for cervical cancer

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Objectives The use of image-guided brachytherapy (IGBT) for treatment of cervical cancer changes evaluation from point to volume with point and with volume evaluation. The purpose of IGBT is to enable a high dosage to be delivered to the tumor but to spare the surrounding tissues. This retrospective study investigated the dosages in the bladder and rectum following IGBT for cervical cancer.

Methods Fourteen patients who received CT-guided brachytherapy for cervical cancer were enrolled. Whole pelvic radiotherapy (WPRT) with 45 Gy in 25 fractions plus 24-28 Gy in 4 fractions of IGBT was used. A dose of 2cc in the bladder and rectum bladder and rectum was evaluated and compared to the ICRU points in terms of EQD2.

Results In the bladder, the mean dose in EQD2 of D2cc was 86.1 Gy while the mean dose to ICRU-B was 77.2 Gy. In the rectum, the mean dose in EQD2 of D2cc was 67.7 Gy while the mean dose to ICRU-R was 95 Gy.

Conclusion ICRU and D2cc showed differing tendencies show different effects. In the bladder, D2cc was higher than D-ICRU but in the rectum the opposite was found. **Chiang Mai Medical Journal 2020;59(1):11-5.**

Keywords: image-guided brachytherapy, cervical cancer, rectum, bladder

Introduction

Cervical cancer is one of the most common cancers in the female population of Thailand. Data from the institute cancer registry at Chiang Mai University Hospital show the incidence of cervical cancer in the year 2011 was 205 cases (1). Radiotherapy is the standard treatment in non-metastatic, inoperable cases, and the combination of whole pelvic radiotherapy (WPRT) and brachytherapy (BT) has been used for many years to treat cervical cancer with a very high local control rate. Historical data shows that if brachytherapy is used there is a much higher rate of successful outcome than treatment without brachytherapy (2).

In modern medicine the increased use of image-guided brachytherapy using Magnetic Resonance Imaging (MRI) or Computed Tomography (CT) has changed the practice of brachytherapy from point to volume concepts, a practice supported by clinical studies (3-6).

In the case of volume concepts, adaptive brachytherapy enables dose adjustment to the high-risk clinical target volume (HR-CTV) followed by dose adjustment to the organs at risk (OARs) such as the bladder and rectum. Analysis of OARs in comparative studies has enabled the evaluation of the volume dose (D2cc) and point dose (International Commission on Radiological

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Radiation Units and Measurements or ICRU) and shown them in different ways to have different effects (7-9).

In this study, we conducted a dose comparison of the concepts of volume versus point in the bladder and rectum to determine the correlation between the two concepts.

Methods

We retrospectively evaluated 14 cervical cancer patients who were treated in 2009 at Faculty of Medicine, Chiang Mai University using CT-guided brachytherapy with the study code of RAD-08-07-03A-09. Whole pelvic radiotherapy (45 Gy in 25 fractions) plus 24-28 Gy in 4 fractions to 90% of the high-risk clinical target volume (HR-CTV) were used in the treatments. At that time, a PLATO workstation was used in our division for brachytherapy contouring and planning. The bladder (B) and rectum (R) were contoured in accordance with the Groupe Européen de Curiethérapie and the European Society for Radiotherapy & Oncology (GEC-ESTRO) and CT-based guidelines (10-13). The points of ICRU in the bladder and rectum were placed on the plan. The cumulative dose to ICRU-B and ICRU-R were evaluated

in comparison to D2cc of the bladder (D2cc-B) and rectum (D2cc-R) in terms of EQD2 (14). The positions of D2cc and ICRU points of the bladder and rectum are shown in Figure 1.

Statistical analysis was performed using a paired t-test of the cumulative dose in EQD2 to D2cc and ICRU point at each OAR. The dose differentiations of D2cc and ICRU point at each OAR were also calculated and evaluated. SPSS version 22.0 (IBM Inc.) was used for the statistical analysis.

Results

The mean dose to D2cc of the bladder and rectum were 86.1 Gy and 67.7 Gy, respectively, while the mean dose to ICRU of the bladder and rectum were 77.8 Gy and 95.4 Gy, respectively. The dose to D2cc of the rectum was significantly lower than the dose of ICRU point while the dose to D2cc of the bladder was higher than the dose to ICRU. All data are shown in Table 1.

Discussion

The comparison of the dose to point and volume was of interest when the brachytherapy treatment moved from point (ICRU 38) to volume

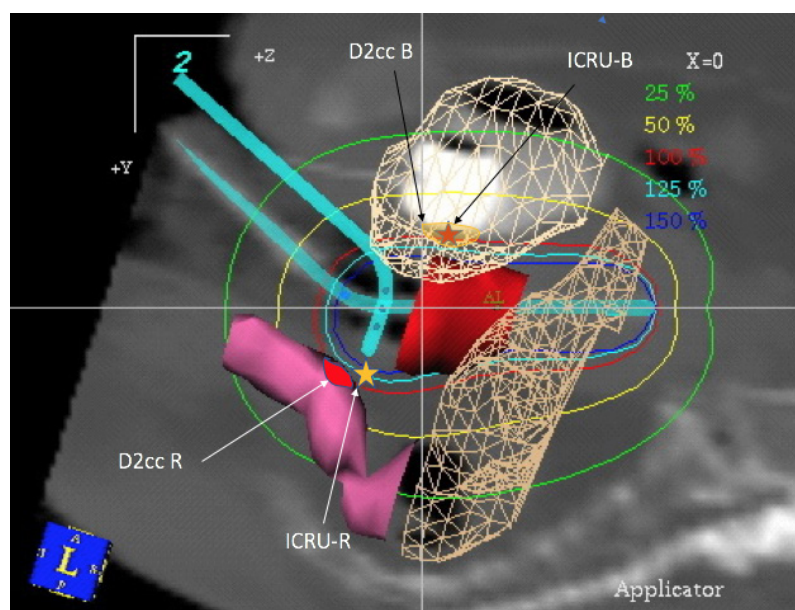


Figure 1. Areas of the dose at 2 milliliters (D2cc) and the International Commission on Radiation Units and Measurement (ICRU) points of the bladder and rectum

Table 1. Dose comparison of D2cc and ICRU in EQD2

Parameter	D2cc (Gy) mean±SD	ICRU (Gy) mean± SD	Difference (Gy/%)	p-value
Bladder	86.1±5	77.8±19	8.3 (17.8)	0.15
Rectum	67.7±4.8	95.0±8.8	27.3(28.4)	<0.0001

Note: ICRU; International Commission on Radiation Units and Measurements, B; bladder, R; rectum, EQD2; equivalent dose of 2Gy

Table 2. Selected studies of ICRU versus D2cc

Study	N	Evaluation	Results
Mazeron et al. ⁽⁷⁾	229	EQD2	The mean dose to ICRU-R 55.75 Gy versus D2cc 59.27 Gy ($p=0.0003$)
Vinod et al. ⁽⁸⁾	20	Fraction	The mean dose to ICRU-R 4.01 Gy versus D2cc 4.28 Gy
Kim et al. ⁽⁹⁾	22	Fraction	The mean dose at ICRU-B 4.01 Gy versus D2cc 4.84 Gy The mean dose at ICRU-R 4.12 Gy versus D2cc 3.73 Gy
Our study	14	EQD2	The mean dose at ICRU-B 77.8 Gy versus D2cc 86.1 Gy The mean dose at ICRU-R 95.0 Gy versus D2cc 67.7 Gy

Note: ICRU; International Commission on Radiation Units and Measurements, B; bladder, R; rectum, EQD2; equivalent dose of 2Gy

(ICRU89) (3,4). Our study showed that evaluation by D2cc is significantly lower than ICRU in the rectum with a mean difference of 27 Gy while no significant difference in dose to the bladder between D2cc and ICRU was observed with a mean difference of 8 Gy. This result does not correlate with the findings of studies by Mazeron et al. and Vinod et al. that reported the dose of D2cc in the rectum was higher than the dose at ICRU (7,8). Our study did show a correlation with the study by Kim et al. that point-based evaluation in comparison to volume-based evaluation was lower in the bladder and higher in the rectum (9). Possible explanations for our results include that 1) the position of the high dose in the bladder was mostly close to the bladder base in our cohort and 2) the rectum when we estimated as point was closer to the applicator than in the volume aspect (Figure 1). Summaries of selected studies are shown in Table 2.

There are some limitations to our study, the main one being that the sample size is small. The numbers recruited are lower than other comparable studies, e.g., our study included only 14 patients in terms of EQD2 whereas Mazeron et al. reported on 229 patients (7). However, although

the results differ from some studies, (7,8) our study adds weight to the important finding reported by Kim et al. that the dose in OARs differs when evaluating volume versus point (9).

Conclusions

Comparative dosimetry of ICRU and D2cc in the bladder and rectum shows that point-based evaluation is higher in the bladder and lower in the rectum results in higher values in the bladder than in the rectum.

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Conflict of interests

No conflicts of interest.

References

1. Chitapanarux I, Srisukho S. Cancer incidence and mortality in Chiang Mai. Chiang Mai Cancer registry, 2014.
2. Gill BS, Lin JF, Krivak TC, Sukumvanich P, Laskey RA, Ross MS, et al. National Cancer Data Base analysis of radiation therapy consolidation modality for cervical cancer: the impact of new technological advancements. *Int J Radiat Oncol Biol Phys.* 2014;90:1083-90.
3. ICRU report no.38. Dose and volume specification for reporting intracavitary therapy in gynecology. *J ICRU.* 1985;20.
4. ICRU report no.89. Prescribing, recording, and reporting brachytherapy for cancer of the cervix. *J ICRU.* 2016;13(1-2).
5. Pötter R, Dimopoulos J, Georg P, Lang S, Waldhäusl C, Wachter-Gerstner N, et al. Clinical impact of MRI assisted dose volume adaptation and dose escalation in brachytherapy of locally advanced cervix cancer. *Radiother Oncol.* 2007;83:148-55.
6. Pötter R, Georg P, Dimopoulos JC, Berger D, Nesvacil N, Georg D, et al. Clinical outcome of protocol-based image (MRI) guided adaptive brachytherapy combined with 3D conformal radiotherapy with or without chemotherapy in patients with locally advanced cervical cancer. *Radiother Oncol.* 2011;100:116-23.
7. Mazon R, Fokdal LU, Kirchheiner K, Georg P, Jastaniyah N, Šegedin B, et al. Dose-volume effect relationships for late rectal morbidity in patients treated with chemoradiation and MRI-guided adaptive brachytherapy for locally advanced cervical cancer: Results from the prospective multicenter EMBRACE study. *Radiother Oncol.* 2016;120:412-19.
8. Vinod SK, Caldwell K, Lau A, Fowler AR. A comparison of ICRU point doses and volumetric doses of organs at risk (OARs) in brachytherapy for cervical cancer. *J Med Imaging Radiat Oncol.* 2011;55:304-10.
9. Kim RY, Shen S, Duan J. Image-based three-dimensional treatment planning of intracavitary brachytherapy for cancer of the cervix: dose-volume histograms of the bladder, rectum, sigmoid colon, and small bowel. *Brachytherapy.* 2007;6:18-94.
10. Haie-Meder C, Pötter R, Van Limbergen E, Briot E, De Brabandere M, Dimopoulos J, et al. Recommendations from Gynaecological (GYN) GEC-ESTRO Working Group (I): concepts and terms in 3D image based 3D treatment planning in cervix cancer brachytherapy with emphasis on MRI assessment of GTV and CTV. *Radiother Oncol.* 2005;74:235-45.
11. Pötter R, Haie-Meder C, Van Limbergen E, De Brabandere M, Dimopoulos J, Dumas I, et al. Recommendations from gynaecological (GYN) GEC ESTRO working group (II): concepts and terms in 3D image-based treatment planning in cervix cancer brachytherapy-3D dose volume parameters and aspects of 3D image-based anatomy, radiation physics, radiobiology. *Radiother Oncol.* 2006;78:67-77.
12. Viswanathan AN, Dimopoulos J, Kirisits C, Berger D, Pötter R. Computed tomography versus magnetic resonance imaging-based contouring in cervical cancer brachytherapy: results of a prospective trial and preliminary guidelines for standardized contours. *Int J Radiat Oncol Biol Phys.* 2007;68:491-8.
13. Viswanathan AN, Erickson B, Gaffney DK, Beriwal S, Bhatia SK, Lee Burnett O 3rd, et al. Comparison and consensus guidelines for delineation of clinical target volume for CT- and MR-based brachytherapy in locally advanced cervical cancer. *Int J Radiat Oncol Biol Phys.* 2014;90:320-8.
14. Joiner MC, Van Der Kogel A. Basic clinical radiobiology. 4th ed. Raton: CRC press, 2009.

การศึกษาเปรียบเทียบระหว่างปริมาณรังสีที่ 2 มิลลิลิตร เปรียบเทียบกับจุด ICRU ในการให้รังสีรักษา ระยะใกล้โดยใช้ภาพนำในมะเร็งปากมดลูก

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หน่วยรังสีรักษาและมะเร็งวิทยา ภาควิชารังสีวิทยา คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

วัตถุประสงค์ การใช้รังสีรักษาระยะใกล้โดยใช้ภาพนำในการรักษามะเร็งปากมดลูกทำให้การประเมินปริมาณรังสีต่อเนื้อเยื่อปกติเปลี่ยนจากจุดเป็นการประเมินแบบปริมาตร โดยมีจุดประสงค์เพื่อให้รังสีปริมาณสูงต่อรอยโรค แต่ลดปริมาณรังสีต่อเนื้อเยื่อปกติ การศึกษานี้มีเป้าหมายเพื่อประเมินปริมาณรังสีต่อกระเพาะปัสสาวะและลำไส้ตรงในการให้รังสีรักษาระยะใกล้โดยใช้ภาพนำในมะเร็งปากมดลูก

วิธีการ ผู้ป่วยมะเร็งปากมดลูกจำนวน 14 ราย ได้รับรังสีรักษาระยะใกล้โดยใช้ภาพนำ ทุกรายได้รับการฉายรังสีบริเวณอุ้งเชิงกรานในปริมาณ 45 เกรย์ ใน 25 ครั้ง ร่วมกับ 24-28 เกรย์ ใน 4 ครั้ง ปริมาณรังสีที่ 2 มิลลิลิตรของกระเพาะปัสสาวะและลำไส้ตรงจะนำมาเปรียบเทียบกับปริมาณรังสีที่จุด ICRU ในรูปแบบปริมาณรังสีสมมูลที่ 2 เกรย์ (EQD2)

ผลการศึกษา ปริมาณรังสีเฉลี่ยที่กระเพาะปัสสาวะในรูปแบบของ EQD2 ที่ 2 มิลลิลิตรเท่ากับ 86.1 เกรย์ เปรียบเทียบกับ 77.2 เกรย์ ที่จุด ICRU ของกระเพาะปัสสาวะ ในขณะที่ปริมาณรังสีเฉลี่ยที่ลำไส้ตรงในรูปแบบของ EQD2 ที่ 2 มิลลิลิตร เท่ากับ 67.7 เกรย์ เปรียบเทียบกับ 95 เกรย์ที่จุด ICRU ของลำไส้ตรง

สรุป การเปรียบเทียบปริมาณรังสีที่เนื้อเยื่อปกติทั้งสองให้ผลการศึกษาที่แตกต่างกัน ปริมาณรังสีที่ 2 มิลลิลิตรของกระเพาะปัสสาวะให้ปริมาณรังสีที่สูงกว่าจุด ICRU ในขณะที่ปริมาณรังสีที่ 2 มิลลิลิตรของลำไส้ตรงให้ปริมาณรังสีที่ต่ำกว่าจุด ICRU
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คำสำคัญ: รังสีรักษาระยะใกล้โดยใช้ภาพนำ มะเร็งปากมดลูก ลำไส้ตรง กระเพาะปัสสาวะ

