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ORIGINAL ARTICLE

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Can elevated-hip position simulation reduce doses to small bowel in postoperative intensity-modulated pelvic radiotherapy for cervical or endometrial cancer?

Junfeng Li[1], Jin Xu[1], Hongchuan Zhang[1], Yan, Tan[1], Junjun Liao[1], Guangjin Yuan[1,*]

[1] Department of Oncology, the People's Hospital of Dianjiang Chongqing, China

OBJECTIVES: To evaluate the doses to small bowel with elevated-hip position simulation at different angles in patients with cervical or endometrial cancer for postoperative intensity-modulated pelvic radiotherapy.

METHODS: Ten patients with cervical or endometrial cancer underwent postoperative intensity-modulated pelvic radiotherapy. Patients were simulated with elevated-hip position at different angles (0, 20 and 30 degrees). Intensity-modulated pelvic radiotherapy plans were generated for the above three positions to a prescribed dose of 50.4 Gy in 1. 8 Gy daily fractions. Volumes or dose–volume parameters for small bowel, bladder and rectum were compared.

RESULTS: Volumes for small bowel were reduced in the elevated-hip position at 20 or 30 degrees (537.5 ± 142.9 or 495.9 ± 123.3 cm3) compared with the position at 0 degree (602.9 ±165.3 cm3), but not significantly (P=0.267). Small bowel V10Gy, V20Gy, V30Gy and V40Gy values were also reduced for the elevated-hip position at 20 or 30 degrees (524.2 ± 137.5, 397.8 ± 113.2, 202.4 ± 49.2, 93.8 ± 21.1 or 484.3 ± 122.6, 372.9 ± 93.9, 169.6 ± 42.0, 88.0 ± 19.8 cm3) as compared with the position at 0 degree (593.5 ± 164.0, 482.7± 134.7, 206.7 ± 66.2, 114.1 ± 29.0cm3), however, not significantly (P≧0.05). The parameters for bladder and rectum were not significant at different positions.

CONCLUSIONS: A slight decrease in small bowel volume or dose was seen in elevated-hip positions (at 20 or 30 degrees), which may reduce small intestine toxicity during postoperative intensity-modulated pelvic radiotherapy.

KEY WORDS: small bowel dose, elevated hip position, postoperative intensity-modulated pelvic radiotherapy, cervical or endometrial cancer

Correspondence: Guangjin Yuan,
Department of Oncology, the People's Hospital of Dianjiang Chongqing, China
E-mail: 273385519@qq.com
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INTRODUCTION

According to the recent cancer statistics, an increasing trend of the incidence of gynecologic cancers was observed in China over last 2 decades [1]. Among them, cervical cancer ranked fifth in female cancer incidence with 11.34 per 100,000, and endometrial cancer ranked eighth with 6.64 per 100,000 [1]. For high-risk cervical or endometrial cancer patients, postoperative adjuvant radiotherapy is needed, which may reduce local recurrence and improve overall survival [2].

Radiation-induced enteritis is a common side effect in patients who undergo radiotherapy for pelvic malignancies [3]. Radical pelvic surgery (hysterectomy and tumor resection) may cause anatomical displacement of organs, leading to part of the intestinal loop falling into the pelvic cavity. A recent study has shown that the dose-volume of the small intestine receiving 20-40 Gy in the postoperative adjuvant radiotherapy group was statistically increased compared with that in the radical radiotherapy group of cervical cancer [4]. Therefore, we conceive that simulation with elevated-hip position may help the intestinal loop slidding out of the pelvic cavity, and then may reduce the dose to small intestine during pelvic radiotherapy.

METHODS

Patients

Ten patients with cervical or endometrial cancer, who underwent radical hysterectomy and were shown to have high-risk prognostic factors, e.g. pelvic lymph node (LN) metastasis and/or parametrial invasion, were enrolled in this study. Adjuvant radiotherapy was performed using intensity-modulated radiotherapy (IMRT). The study was approved by the ethics committee of the People's Hospital of Dianjiang Chongqing.

CT simulation

One hour before positioning, patients emptied their bladder and drank 800 ml of water to fill the bladder. Then the patients were immobilized in the supine position (hip not elevated) with thermoplastic abdominal fixation device. Enhanced computed tomography (CT) scanning was performed with a slice thickness of 5 mm using a Philips large aperture CT machine. The scanning range was from the upper edge of T12 vertebral body to 3 cm below the ischial tuberosity, and The CT images were transferred to the treatment planning system (Elekta, Monaco).

Simulation with elevated-hip position could be completed with styrofoam plus thermoplastic mask. However, the angle of elevated -hip position is hard to determined. Therefore, we used triangular foam pad with 20 or 30 degrees. After the patient lay on the carbon plate with triangular foam pad, low abdominal massage was performed downwards to help the intestinal loop slidding out of the pelvic cavity. CT scanning and images tranferring were taken as the above.

Contour and treatment planning

The clinical target volume (CTV) was contoured according to the consensus guideline for postoperative pelvic radiotherapy of cervical or endometrial cancer, which comprises vaginal cuff tissue, pertinent surgical clips, lymphoceles, and regional nodes, including common iliac, external and internal iliac, and presacral lymph nodes [5]. The planning target volume (PTV) was generated by using 0.5 cm uniform expansion of the CTV. Organs at risk (OARs), were contoured using RTOG guideline, including bladder, rectum, small bowel, femoral heads, and other normal tissues.

The prescription dose was 50.4 Gy for PTV at 1.8 Gy per fraction. The planning goal for IMRT was to obtain the prescribed dose to cover 95% of the PTV and not to exceed 110% as maximum dose. The dose constraints for OARs were V50Gy (the volume receiving 50Gy of radiation) < 50% for the bladder, V50Gy < 50% for the rectum, V50Gy < 5% for the femoral heads and Dmax (the maximal dose) < 52 Gy for the small bowel.

The IMRT plans were generated using Monaco treatment planning system. Plans were optimized until they met the dose specifications for target volumes and critical structures as stated above. The plans with the elevated-hip position at 0 degree were delivered by a dynamic multileaf collimator technique with the Elekta linear accelerator, but the other plans with the elevated-hip position at 20 and 30 degrees were only used for research purpose.

Dosimetric evaluation and comparison

Quantitative evaluation of plans was performed by means of dose–volume histogram (DVH). The volumes below the superior plane of PTV, and V10Gy, V20Gy, V30Gy, V40Gy and V50Gy for small bowel, and V40Gy for bladder and rectum, were compared in the three plans with the elevated-hip position at 0, 20 and 30 degrees.

Statistical analysis

Comparisons of dosimetric indices in the three plans with the elevated-hip position at 0, 20 and 30 degrees were analyzed with one-way analysis of variance. All statistical analysis was conducted with SPSS 20.0 software, and the differences were considered statistically significant if $P < 0.05$.

RESULTS

Patient characteristics

Ten patients who underwent postoperative adjuvant pelvic radiotherapy, were enrolled in the study, among which 8 patients had cervical cancer, 2 patients had endometrial cancer. The median age of these patients was 58.7 years (range 44–74 years). Table 1 showed the patient characteristics.

Dosimetric comparisons

Mean volumes for small bowel below the superior plane of PTV were reduced in the plans with the elevated-hip position at 20 and 30 degrees (537.5 ± 142.9 and 495.9 ± 123.3 cm3) than that in the plan with the position at 0 degree (602.9 ±165.3 cm3), but not significantly (P=0.267). Mean dose volumes for small bowel in plans with the elevated-hip position at 0, 20 and 30 degrees were presented in Table 2. Small bowel V10Gy, V20Gy, V30Gy and V40Gy values were decreased in the plans with the elevated-hip position at 20 and 30 degrees compared with the plan with the position at 0 degree, but there were no statistically significant differences, although marginally statistical difference for V40Gy.

Mean V40Gy for bladder and rectum in the plans with the elevated-hip position at 0, 20 or 30 degrees were 47.9% ± 10.1%, 49.1% ± 9.7%, 48.1% ± 10.0%, and 49.6% ± 8.2%, 50.8% ± 9.5%, 50.2% ± 9.6%, respectively; there was no significance in the three plans (P > 0.05).

Table 1.patient and tumor characteristics

Patient No.	Age (year)	Pathology	FIGO stage
1	69	cervical cancer	IB2
2	60	cervical cancer	IIA1
3	64	endometrial cancer	IB
4	44	cervical cancer	IIA2
5	52	cervical cancer	IB2
6	48	cervical cancer	IIA2
7	58	cervical cancer	IB1
8	56	endometrial cancer	IIA
9	74	cervical cancer	IIA2
10	62	cervical cancer	IB2

Table 2.mean dose volumes (cm3) for small bowel in plans with the elevated-hip position at 0, 20 and 30 degrees (mean ± SD)

Parameters	0 degree	20 degree	30 degree	P value
V10Gy	593.5 ± 164.0	524.2 ± 137.5	484.3 ± 122.6	0.239
V20Gy	482.7± 134.7	397.8 ± 113.2	372.9 ± 93.9	0.101
V30Gy	206.7 ± 66.2	202.4 ± 49.2	169.6 ± 42.0	0.223
V40Gy	114.1 ± 29.0	93.8 ± 21.1	88.0 ± 19.8	0.05

DISCUSSION

Pelvic radiotherapy is generally used as a standard treatment for gynecological cancers [6, 7]. Radiation enteritis (RE) is a common side effect of pelvic radiation, with nearly 80% of patients experiencing acute RE and 20% late RE [3]. The clinical manifestations of RE include nausea, vomiting, abdominal pain, diarrhea, bloody stool, et al., which may lead to radiotherapy intolerance, or affect the quality of life of patients. Many studies have shown that the occurrence of RE is related to radiation technology, total dose and volume, fraction dose, et al. [8]. Treatment of RE is essentially symptomatic, and its prevention may seem to be more important.

The intestinal loop is mobile in the abdominal-pelvic cavity. During pelvic radiotherapy, the dose to small bowel can be reduced through patient positioning (i.e. prone position with belly board) and with manipulation of bladder filling [9-11], in which the intestinal loop may be coerced superiorly and away from the direct paths of irradiation fields. Studies have shown that a prone position results in a lower irradiated small bowel volume than the supine position, and a more significant reduction with the additional use of a belly board, during pelvic radiotherapy [12, 13]. Radical pelvic surgery (hysterectomy and tumor resection) may cause anatomical displacement of organs, leading to part of the intestinal loop falling into the pelvic cavity; therefore, the dose-volume of small bowel receiving 20-40 Gy in the postoperative adjuvant radiotherapy group was statistically increased compared with that in the radical radiotherapy group of cervical cancer [4]. In the present study, we explored the effects of elevated-hip position on the dose-volume of small bowel during pelvic radiotherapy. Small bowel V10Gy, V20Gy, V30Gy and V40Gy values were decreased in the plans with the elevated-hip position at 20 and 30 degrees compared with the plan with the position at 0 degree, although there were no statistically significant differences. Of course, abdomino-pelvic adhesion following operation may offset the effect of elevated-hip position to decrease the volume of small bowel during pelvic radiotherapy. The dose-volume of bladder and rectum was not different among those plans.

In conclusion, the elevated-hip position appears to give superior small bowel dose-volume relative to that of nonelevated-hip position when utilising IMRT for postoperative gynecological cancers. It would be expected to reduce both acute and late toxicity of pelvic radiotherapy.

NOTES

Conflict of interest

The authors have no conflicts of interest to declare for this study.

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Ethics approval and consent to participate

The ethics approval was obtained from the the People's Hospital of Dianjiang Chongqing. The informed consent was provided before investigation.

Consent for publication

Not applicable for this study.

Competing interests

The authors declare no competing interests.

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