Abdominal pillow for the sparing of small bowel in four-field conventional pelvic radiotherapy

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Summary

From 2003 through 2004, 88 patients with gynecological cancer were referred to Istanbul University Oncology Institute for pelvic radiation therapy. All patients underwent small bowel evaluation within the pelvic radiotherapy field in both the supine and prone positions with and without an abdominal pillow. The small bowel area included in radiation fields and intestinal movement were compared on PA films. All patients were treated by using the abdominal pillow. The median external beam pelvic radiation dose of 5040cGy (range, 3220-5400cGy) was administered. The mean distance of upward displacement of small bowel in the prone position on abdominal pillow compared with in the prone position alone and in the supine position was 3.6 cm (range, 0-14 cm) and 4.7 cm (range, 0-14 cm). Using the abdominal pillow, the mean small bowel area was reduced by 45% and 55% compared to the prone position alone and the supine position, respectively (p = 0.0001). In patients who had pelvic surgery intestinal movement was significantly reduced. The incidence of G1, G2 and G3 acute radiation toxicity was 18%, 36% and 3%, respectively. This study demonstrates that the small intestines can be displaced out of the radiation field by an abdominal pillow in the prone position. Also, this noninvasive technique provides for reduction of acute gastrointestinal morbidity.

Key words: Gynecologic tumors; Pelvic radiotherapy; Radiotherapy techniques; Patient positioning; Small bowel toxicity.

Introduction

Radiation therapy is a critical component in the treatment of gynecologic tumors; however, it has clinical limitations due to the complications, mainly damage to adjacent normal tissues. Radiation therapy regimens are formulated to maximize the chances for cure while incurring the smallest amount of damage to normal tissues. In gynecologic cancers, the most serious complications are those involving the gastrointestinal or genitourinary systems.

Intestinal complications of radiation therapy are classified as either acute or chronic. The acute effects of radiotherapy are caused by ionizing radiation on the epithelium of the intestine. The chronic effects of radiotherapy result from the induction of vasculitis and fibrosis, and they are more serious than the acute effects.

Small bowel tolerance is a highly significant dose-limiting factor, because of early and late adverse effects. The incidence and severity of problems are related to the total dose and dose per fraction, volume of intestine irradiated, the daily use of single-field treatment, use of concomitant chemotherapy, comorbidities, previous abdominal surgery and observation time [1].

Particularly, treatment of late toxicity on the small bowel is difficult after clinical symptoms have developed. Therefore, preventing intestinal toxicity must be of maximum importance. Advances in the techniques of delivery of radiotherapy to pelvic organs may decrease the incidence of intestinal complications.

Several methods may be used to prevent intestinal toxicity. For example, use of computerized radiation dosimetry to design the best treatment plan and to use high-energy treatment machines, such as linear accelerators, that deliver a high dose to tumor volume while sparing the normal structures [2]. Other methods are to move out of the pelvis with surgical methods, to change radiation techniques, and to use radioprotectants during the radiotherapy.

The small bowel is a mobile structure and segments of the small bowel can move in and out of the irradiated volume. Numerous surgical techniques have been used to reduce small bowel volume. Repositioning of normal tissues can be accomplished by mechanical rather than invasive surgical techniques. For this reason, the position techniques such as the use of a belly board, an open table top and an up-down table have been described [3-5].

The main aim of this study was to try to reduce the small intestine within the pelvic treatment field, and in this way to reduce acute and chronic complications of pelvic radiotherapy by using the abdominal pillow.

Methods

Eighty-eight patients with gynecological malignancies (cervical cancer in 48, endometrial cancer in 35, vaginal cancer in 3, and endometrial sarcoma in 2) were selected for this study. All 37 patients with endometrial tumor and six patients with cervical carcinoma underwent total hysterectomy and bilateral salpingo-oophorectomy. Pelvic lymph node sampling or dissection was performed in 31 patients (35%). Patient characteristics are summarized in Table 1.

Information about the treatment and complications of the treatment were explained to the patients, and they accepted the

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Fig. 1

Fig. 2

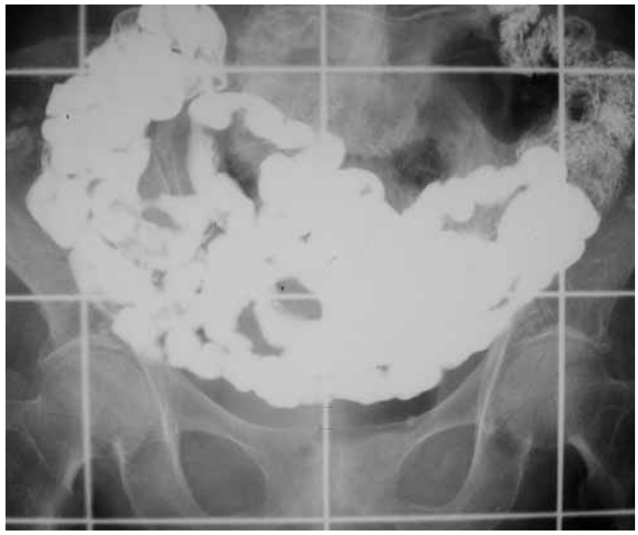

Fig. 3

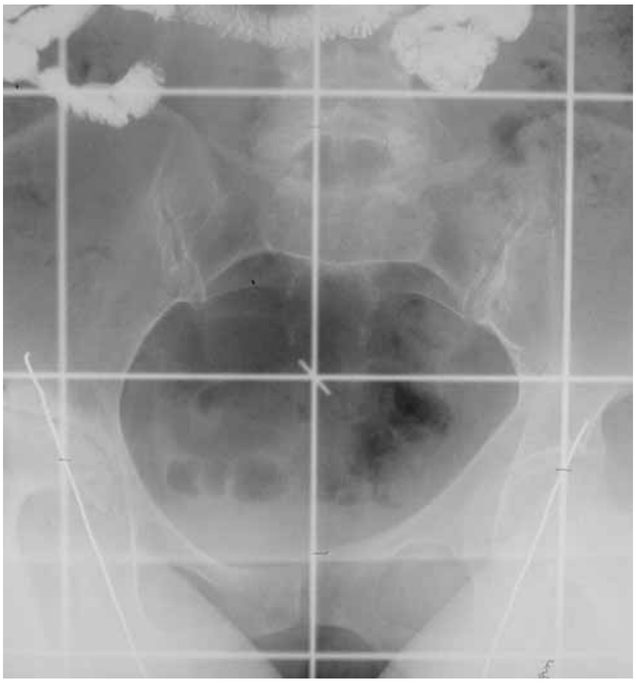

Fig. 4

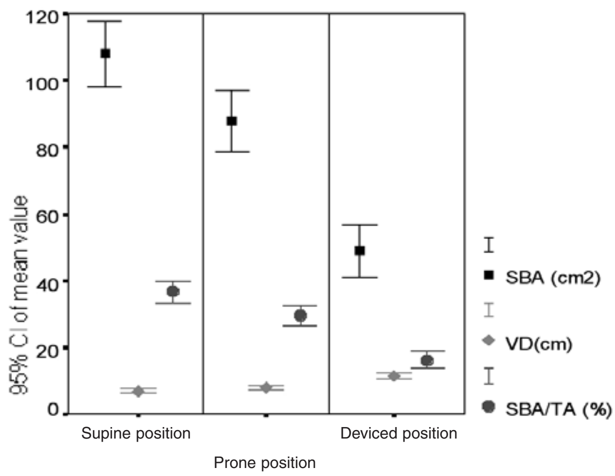

Figure 1. — Patient position on the abdominal pillow during simulation procedure.
Figure 2. — Posterio-anterior simulation film. Patient is in the prone position on the table.
Figure 3. — Nearly all opacified small bowels were displaced with the abdominal pillow.
Figure 4. — Mean values of small bowel area, vertical distance, small bowel area/treatment area mean values in supine, prone and prone with the pillow positions.

treatment in question. After the procedure, in all patients simulations were done in supine and prone positions with or without an abdominal pillow. The footplate and the prone pillow were used for patient stabilization. The treatment position is represented in Figure 1. We made the abdominal pillow using air equivalent foam material. We had three devices made. One was placed within the simulation room and the other two were placed within the treatment rooms. They measured 50 cm (bottom length), 29 cm (width), and 12 cm (thickness).

During the simulation procedure, the small bowel was visualized using barium contrast. The patients were given about 500 ml of barium sulfate and then one to three hours elapsed to allow the contrast to fill in the small bowel. The patients were placed in the supine position and next in the prone position on the simulator table; pelvic field borders were set according to bone structure and posterior anterior simulation films were taken. Then the abdominal pillow was placed under the lower abdomen of the patient and a pause of a few minutes was sustained because the small bowel had to be moved out of the pelvis. In this position, the posterior-anterior and lateral orthogonal simulation films were obtained (Figures 2 and 3).

The films were then visually analyzed. The target volume was drawn from each set of simulation films. The fields with the least amount of small bowel overlying the target volume were chosen. The small bowel inside the treatment fields was shielded with cerrobend blocks. The treatment fields were checked with portal films once a week and the faults were corrected.

We did not take lateral simulation films at each position, since it costs too much and we had limited time for each patient

Table 1. — *Characteristics of 88 patients treated for gynecological tumors.*

Patients characteristics	n	%
Habits and Comorbidities		
Smoking	21	24
Diabetes mellitus	9	10
Hypertension	23	26
Diagnosis		
Uterine cervical cancer	48	54
Endometrial cancer	35	40
Vaginal cancer	3	4
Corpus sarcoma	2	2
Treatment		
Postoperative radiotherapy	43	49
Postoperative chemoradiotherapy	6	7
Curative chemoradiotherapy	34	39
Radiotherapy alone	5	5

simulation. We took lateral simulation films only at the treatment positions. The intestinal movement was evaluated according to the distance between the bottom of the small bowel and inferior border of the radiation field. Later, small bowel areas on the simulation films were separated into squares so that we could calculate the amount of bowel out of the field. Finally we calculated the intestinal area and the total irradiation area and compared these statistically.

In the X-ray simulation, limits were L4-L5 or L5-S1 vertebral interspaced superiorly and ischial tuberosity or below the foramina obturatoria inferiorly according to diagnosis and stage of disease.

The standardized irradiation protocol consisted of whole-pelvis external irradiation 45-50.4 Gy with a daily dose 1.8-2.0 Gy, which is specified at the isocenter for four-field techniques with 15 MV linear accelerator.

Initial studies with MR imaging were done six months or more after completion of radiation therapy.

Enteric toxicity was evaluated in accordance with the Radiation Therapy Oncology Group (RTOG) criteria [6].

All data were analyzed with the SPSS for Windows program package (Version 7.5, SPSS Inc.). The differences between the two groups were evaluated with the chi-square test and the coupled data were paired with the Student's t-test.

Results

The patients' median age was 56 years (range, 27-77). Body weight of the patients ranged between 48-132 kg and median weight was 70 kg. Forty patients who had cervical cancer were administered concomitant chemotherapy with pelvic radiotherapy. During the post-radiotherapy period, the median follow-up was 24 months (range, 10-55 months). Forty-three of 88 patients (49%) were treated with postoperative radiotherapy, 34 patients (39%) were treated with curative chemoradiotherapy, five patients (5%) were treated with curative radiotherapy alone, and six patients (7%) were treated with postoperative chemoradiotherapy (Table 1).

While in the prone position using an abdominal pillow the median intestinal area within the fields was 41.2 cm^2 (range, 0-161 m^2), in the prone position and in the supine position these median areas were 85.7 cm^2 (range, 9-220 cm^2) and 105.3 cm^2 (12-257 cm^2), respectively. Mean small-bowel area ratio to whole pelvic radiation field with the abdominal pillow, in the prone position and in the supine position were 13.5% (range, 0-50%), 29% (range, 3-72%) and 39% (range, 5-83%), respectively ($p = 0.0001$). In other words, using the abdominal pillow, average reductions of small bowel area in the pelvic radiation field were 54% (range, 0-100%) and 45% (range, 0-100%) on PA films compared to the supine position and the prone position alone, respectively ($p = 0.0001$) (Table 2).

The mean distance of upward displacement of small bowel in the prone position with an abdominal pillow compared to the prone position alone and supine position were 3.6 cm (range, 0-14 cm) and 4.7 cm (range, 0-14 cm). Both of these are statistically significant ($p = 0.0001$). In prone position, this distance was 1.5 cm (range, 1-2 cm) compared to the supine position ($p = 0.0001$). Mean values of vertical distance, small bowel area, small bowel area/treatment area in the supine, prone and prone with the pillow positions are shown in Figure 4.

In six out of 88 patients (7%), there was no small bowel present in the treatment field after using an abdominal pillow. On the contrary in four patients the small bowel

Table 2. — *Mean and median values of small bowel area, vertical distance and small bowel area rate in the pelvic radiation field in the supine, prone and prone position with device.*

	Mean ± SD - Median (minimum - maximum)				p value
	Supine position (SP)	Prone position (PP)	Position with device (DP)		
SBA (cm^2)	107.9± 46.2	87.8 ± 43.9	49.0 ± 36.6	DP-PP	.000
	105.3 (12.1-257.0)	85.7 (8.8-220.0)	41.2 (0-161.2)	DP-SP	.000
				PP-SP	.000
VD (cm)	6.9 ± 2.8	8.0± 3.0	11.5 ± 3.8	DP-PP	.000
	6.6 (1.9-15.8)	7.2 (3.1-17.0)	12.0 (3.7-20.5)	DP-SP	.000
				PP-SP	.000
SBA/TA (%)	36.6 ± 15.6	29.6 ± 14.5	16.2 ± 12.0	DP-PP	.000
	35.9 (5.3-82.9)	29.1 (3.3-72.2)	13.8 (0-50.2)	DP-SP	.000
				PP-SP	.000

SBA: Small bowel area in treatment field; VD: Vertical distance between lower part of the small bowel and inferior border of the treatment field; TA: Treatment area. Student's t-test.

Table 3. — *Correlation of pelvic surgery and vertical movement.*

Pelvic Surgery	< 5 cm Vertical movement n (%)	> 5 Vertical movement n (%)	p (chi-square test)
Patients who had pelvic surgery	31 (63)	18 (37)	0.05
Patients who did not undergo pelvic surgery	17 (44)	22 (56)	

Table 4. — *Comparison of acute enteric toxicity according to vertical intestinal movement.*

Vertical movement distance	Grade 0-1 Acute enteric toxicity n (%)	Grade 2-3 Acute enteric toxicity n (%)	p (chi-square test)
< 5 cm	22 (46)	26 (54)	0.002
> 5 cm	31 (77)	9 (23)	

Table 5. — *Comparison of acute enteric toxicity according to intestinal area ratio in the radiotherapy field.*

Intestinal area ratio (SBA/TA)	Grade 0-1 Acute enteric toxicity n (%)	Grade 2-3 Acute enteric toxicity n (%)	p (chi-square test)
< 20%	41 (69)	18 (31)	0.001
> 20%	12 (41)	17 (69)	

area did not get narrower compared to the prone position alone and supine position. In patients who had had previous pelvic surgery and in other patients, percentages of more than 5 cm vertical movement were 37% and 56%, respectively (p = 0.05) (Table 3).

Pelvic RT was generally well tolerated. Except for one, all patients completed their pelvic radiotherapy without requiring a break in treatment. The incidences of grade 1, grade 2 and grade 3 acute enteric toxicity were 18% (16 patients), 36% (32 patients) and 3% (3 patients), respectively.

In patients who had more than 5 cm intestinal vertical movement, grade 2-3 acute intestinal toxicity incidence was lower than in other patients (23% and 54%, respectively, p = 0.002). Similarly in patients who had more than 20% intestinal area in the pelvic radiation field grade 2-3 acute intestinal toxicity incidence was higher than for other patients (69% and 31%, respectively, p = 0.01) (Tables 4 and 5). The incidence of chronic intestinal toxicity was very low. Of 88 patients, two (2%) and one (1%), had grade 1 and grade 3 toxicity, respectively.

Discussion

Pelvic radiation therapy is often indicated in the treatment of patients with gynecological cancer. Although the goal of the radiotherapy is tumor control, this must be done with the minimum amount of toxicity to prevent worsening of the quality of life.

The small intestine is particularly sensitive to radiotherapy, because the intestinal epithelium has a rapid turnover. The diverse manifest of intestinal complications of radiation therapy may develop insidiously, are often progressive, and may be lethal. The incidence of late small bowel damage is one of the most important dose-limiting factors in radiation treatment of the pelvis. Most chronic injuries occur between 12 and 24 months after radiation [7]. Late small bowel complications that are generally irreversible are an indirect result of progressive scarring and blood vessel injury. It is complex and involves changes in most compartments of the intestinal wall. Prominent structural features include mucosal atrophy, intestinal fibrosis and vascular sclerosis. Following pelvic radiotherapy for gynecologic malignancy, incidence of severe late chronic radiation injury of the small intestine varies between 0.5 and 15% [8]. The incidence of small bowel damage is related to total radiation dose, dose per fraction, short treatment times and volume of irradiated tissue [9, 10].

The volume of the irradiated small bowel in the radiation portals for gynecologic carcinoma is considered to be an important factor with regard to the severity of acute and chronic morbidity [11, 12]. Prevention of these complications can be achieved by limiting the volume of small bowel treated.

One of the methods used to decrease the effects of radiation on normal tissues is to use a multiple field technique. Four-field radiotherapy has been utilized to reduce the complications resulting from two-field pelvic irradiation [13, 14]. This way the maximal effect is in the area where the beams cross which is targeted on the tumor, and the normal tissues get less radiation.

In 1986, Gallagher and associates described the "grid method" for the measurement of the irradiated small bowel volume for standardization. This method allowed a quantitative comparison of the efficacy of the different technical innovations. They used barium contrasted bowel loops on simulation radiographs and divided the bowel region into a grid of 1 cm x 1 cm squares. Consequently, they reported that a compression pillow with bladder distention in the prone position provided maximum sparing of small bowel radiation field and found a profound effect of the volume of irradiated small bowel on late toxicity [15].

The small bowel is a mobile structure and segments of small bowel can move in and out of the irradiated volume. Therefore, repositioning of normal tissues can be accomplished by mechanical rather than invasive surgical techniques. Some investigators have treated patients in the prone position to displace small bowel loops out of the pelvic fields. Caspars and Hop used small bowel contrast studies to evaluate prospectively the impact of positioning in small-bowel displacement from the pelvis. The volumes were calculated for the supine and the prone position. In comparison, they showed the prone position to be superior to the supine position in 78% of patients [16].

Treating a patient with a full bladder may push the small bowel up and out of the pelvis when pelvic radiotherapy is given. Green noted that in many patients distention of the bladder may be eased by displacing the small bowel from the pelvis [17].

Holst *et al.* described a small bowel displacement system (SBDS) that is fixed to the treatment table [18].

SBDS allowed a mean reduction of the small bowel within the field up to 57% compared to the quantity of small bowel visualized in the treatment field with prone positioning alone. Similarly, some investigators have reported that the small-bowel volume can be significantly reduced by a mean of 50-66% with the belly board device [19-22].

Huh *et al.* showed that by using the SBDS the mean distance of upward displacement of small bowel was 4.8 cm and average reduction of the mean percentage of the small bowel area was 59% compared to the prone position alone on PA films [4]. Similarly, in our study, corresponding figures were 3.7 cm and 45%, respectively.

Most radiotherapists are seriously worried about enhanced small bowel complications with postsurgery radiotherapy. Thus, in the pelvic radiotherapy field too much intestine may be included. Green *et al.* observed small bowel fixation in over 60% of patients who had pelvic surgery [17]. In our study, in patients who had previous pelvic surgery vertical intestinal movement was significantly limited compared to the other patients. Moreover, all four patients who did not have intestinal movement received radiotherapy postoperatively.

Huh *et al.* used a customized SBDS in the 3-D CRT to displace the small bowel maximally out of the pelvic radiation fields. In their series, ten consecutive patients were referred for pelvic radiotherapy for uterine cervical cancer. They showed that the median small bowel volume with SBBS was reduced by 56.4% compared to small bowel volume in the prone position alone. At the prescription dose, the median volume of the irradiated small bowel was significantly reduced by use of the SBDS (9.8% vs 1.2%) [21].

Kim *et al.* showed that these techniques can be used without causing serious set up errors. They investigated the inter-fractional setup accuracy of the customized SBDS and reported that the mean inter-fractional deviation of the isocenter, along the right-left, craniocaudal, and posterior-anterior directions were 1.2 ± 1.6, 1.0 ± 3.0, and 0.9 ± 4.4 mm, respectively [23]. The aim of our trial was not to evaluate set-up errors. However we used immobilizing devices as the prone pillow and footplate and marked the top of the abdominal pillow and patients' skin to prevent set-up errors. On weekly portal films, we did not determine any serious problems.

Historically, women with locally advanced cervical cancer were treated with radiotherapy alone. However, concurrent chemoradiation is obligatory in the management of locally advanced cervical cancer at present. This current trend is a poorly understood biological variable. Thus, bowel-exclusion techniques must be considered especially important, also in our study, in which 40 of 88 patients (46%) received concurrent chemotherapy. Nevertheless, grade 2-3 enteric toxicity was not significantly increased in patients treated with chemotherapy.

Various agents that confer protection against radiation have been developed, of which the most promising is amifostine (WR 2721). The few clinical trial data available on the use of amifostine in pelvic cancer patients suggest benefit in reducing lower GI tract toxicities [24]. However, the role of amifostine is still unclear for enteric toxicity.

In our study, the severity of the acute radiation effects closely correlated with the area of small bowel in the pelvic radiotherapy field. The chronic intestinal toxicity rate was not enough for statistical analysis and follow-up period was short to evaluate long-term toxicity. However, after incurring late toxicity of the small bowel, treatment is very difficult. For this reason, preventing intestinal toxicity is very important for treatment of patients with gynecological cancer. We think that the small bowel within the irradiation field can be reduced by using the abdominal pillow in pelvic radiotherapy. Therefore, this technique may help to prevent both acute and chronic enteric toxicity.

Conclusion

Radiation-induced intestinal injury is a difficult problem in pelvic irradiation. Therefore clinicians must consider that prevention of enteric toxicity is a part of the treatment of pelvic tumors. This study demonstrates that the small intestines can be displaced out of the radiation field by an abdominal pillow in the prone position. Thus acute toxicity may be reduced compared to conventional methods.

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