Iran. J. Radiat. Res., 2008; 5 (4): 175-180

Innovation of a method to decrease interruption time during treatment of pelvic area carcinomas

F. Mohagheghi[1*] and M. Mohammadi[2]

[1] Faculty of Medicine, Arak University of Medical Sciences, Arak, Iran

[2] Department of Medical Physics, Faculty of Medicine, Hamadan University of Medical Sciences, Hamadan, Iran

Background: *The presence of small intestine in the radiation field during pelvic cancers treatment causes an interruption in radiotherapy. A non-invasive method was developed to exclude small intestine during conventional radiotherapy.* ***Materials and Methods:*** The incidence of the radiation therapy interruption is highly dependent upon the area of the small intestine included in the portals and its absorbed dose. In order to investigate the radiation therapy interruption and the resulting elongation of the total treatment time, 35 patients suffering from pelvic cancers were selected and randomly assigned to control and study groups. All the patients were treated in prone position. In the 18 patients in the study group, a commercially available water bag was inserted between patient abdomen and treatment couch. Other 17 patients in the control group underwent similar therapy without water bag. ***Results:*** The total treatment time was shown to be 1.52 days shorter in the study group with a statistically significant difference ($p<0.003$). ***Conclusion:*** Due to the lack of the early morbidities during radiotherapy, it is concluded that the current method helps to optimize total treatment time by preventing interruption of radiation therapy. **Iran. J. Radiat. Res., 2008; 5 (4): 175-180**

Keywords: *Pelvic cancers, small intestine, acute morbidity, chronic morbidity, treatment delay.*

INTRODUCTION

Abundance of pelvic carcinomas including cervical, prostatic, uterus and rectal cancers is reported to be within 20-25% of all cancers referred to radiotherapy centers. Radiotherapy is known as the standard treatment of most pelvic cancers [1], as adjuvant, concurrent to chemotherapy, neodjuvant and an independent method according to stage, type and site of cancers [1, 2].

Regarding the small intestine location, a considerable volume of small intestinal volume is generally irradiated using ionizing radiation beams during pelvic cancers treatment [3]. Compared to other pelvic components, the high sensitivity of small intestine to radiation causes acute and late morbidities [3]. Either the use of concurrent chemotherapy or having a history of abdominal/ pelvic surgery and background disease; such as inflammatory bowel disease (IBD), and systemic disease such as diabetes mellitus, increases the small intestinal sensitivity to ionizing radiation. These consequently lead to treatment complication. Regarding the endurance of small intestine, the maximum permissible dose delivered to the small intestine for a fractionated as well as for a total dose is reported to be 180-200 and 4600-5000 cGy, respectively [2].

Early acute small intestinal morbidities caused by radiation therapy, like diarrhea and abdominal pain deranges the period of time for regular radiotherapy. This causes an interruption during the treatment process temporarily and rarely permanently. In order to prevent undesired damages to the small intestine, applying an interruption of radiotherapy is mandatory. However, the radiation therapy pause destroys the qualitative effects of treatment as well as increases the treatment duration time [2, 3].

Acute morbidities of small intestine occurred during pelvic cancer treatments, can also be controlled using a range of tools and techniques. For instance, the use of Belly Board, Small Intestinal Replacement Device

**Corresponding author:*
Dr. Fathollah Mohagheghi, Vali-Asr Hospital, Arak University of Medical Sciences, Arak, Iran.
Fax: *+98 861 2231283*
E-mail: *mohagheghfrt@yahoo.com*

(SIRD) and absorbable meshes are reported to be helpful devices to shift small intestine out of the radiation field. In addition, the application of high energy photons produced using medical linear accelerators (linacs), and the treatment either in the prone or Telendelenburg positions [3, 4] with a full bladder are reported to be effective techniques to decrease small intestinal absorbed dose. The Silicon Abdominal Prothesis (SAP) containing 750-1000 ml normal saline is also suggested as a useful tool to shift the bowel volume out of the radiation field. However, pre- and post-radiotherapy operations are required [5].

In addition, the total and fractionated doses [6] and the techniques used to deliver the prescribed dose, such as Conformal Radiation Therapy (CRT) and Intensity Modulated Radiation Therapy (IMRT) affect the small intestinal dose significantly [7]. Evaluation of iso-dose curves, obtained from a Treatment Planning System (TPS) indicates that the use of developed techniques such as IMRT with Belly Board exits 32-37% of small intestinal volumes from radiation fields [8]. The bowel volume spared in prone position is also reported to be larger than those positioned in supine situations [4, 9-12].

Due to the lack of modern facilities in our institution and many radiotherapy centers located at developing countries, as well as the use of invasive methods for the application of additive tools, this study focuses on a development of an innovative and non-invasive method to reduce the small intestinal dose during radiotherapy for pelvic cancers based on current availabilities. It is believed that this method can easily be utilized with high quality of treatment, no extra-charge and ignorable interruption during treatment.

MATERIALS AND METHODS

This study was performed using a cobalt-60 machine (Theratron T-730, Ottawa, Canada) installed at the institute of cancer in Tehran, Iran. All dose deliveries were carried out at a Source to Surface Distance (SSD) of 80 cm with an approximated dose rate of 175 cGy per minute.

The treatment pause, occurred during radiotherapy course, was selected as the mostly dependant factor on small intestine absorbed dose. The work plan was originally presented in the ethical and approval committee for research at Tehran University of Medical Sciences. Among the patients suffering from pelvic cancers including prostatic, cervical, rectal, and uterus body referred to the radiotherapy and oncology ward during 2002-2003, 35 patients were selected randomly. The whole pelvic radiation exposure and a minimum total prescribed dose within 4500-5000 cGy were put as an extra-condition to verify samples required. The selected patients were divided into two 17- and 18- person groups as blank and target groups, respectively. The target group was then informed about the work procedure and also ensured that the results of the study would be presented according the rules signed.

In all radiotherapy sessions, target and control groups were positioned in prone situation and two lateral and a posterior-anterior radiation fields were applied for 5 days per week. The average posterior radiation field was around 15×15 cm². For slim pelvises a 14×15 cm² field and for normal size pelvises a 15×15 cm² field was used. The average lateral field sizes for normal and slim pelvises were 12×15 and 10×15 cm², respectively.

As figure 1 illustrates, an ordinary water bag available in market, holding 1500 cc room temperature water was incorporated between patient's abdomen region and treatment couch for all patients categorized in the target group for all radiotherapy sessions. The upper and the lower line of water bag were matched with patient's umbilical area and pubic bone, respectively. The area of the water bag was 17×28 cm², and its thickness was within 4.5±0.5 cm during several measurement procedures. The control group treatment was performed in the same condition, with no water bag


Figure 1. Water bag and its positioning during treatment of pelvic cancers.

application.

In order to evaluate the impact of the use of water bag, expected and real treatment days and days of treatment gap, occurred during radiotherapy sessions, as variants were analyzed using statistical student *t-test*. The main reasons of the treatment pause were defined to be abdominal pain and diarrhea in grades greater than 3. For lower grade diarrheas, the radiotherapy process was continued in the companion of the conservative treatments. It should also be pointed out that no other significant treatment side effect such as severe cystitis or severe rectorrhagia was observed during the study.

RESULTS

From 35 cases studied in the current work, 24 (68%) and 11 (32%) were female and male, respectively. The average age and the relevant standard deviations of patients entered in this study for target and control group were found to be 51.2 (±13.14) and 52.0 (±11.54) years, respectively. The average age and its standard deviation for male and female in the target and control group were also found to be 51.26 (±12.18), 51.21 (±13.84), 53.0 (±9.56) and 51.3 (±13.22), respectively. The original location of tumor for 11 patients (31.5%) was recognized to be rectum, while for 12 (34%) of them was cervix, for 8 patients (23%) it was uterus body and for 4 patients (11.5%) was in prostate area.

The total treatment time for the target and control groups was originally expected to be 36.9 and 37.2 days, respectively. However, the average period of achieved treatment time, was found to be 39.45 days for the target and 41.35 days for the control group. The standard deviation for case and control group was determined to be 2.73 and 2.80, respectively. In the other words, the treatment interruption for the target group was 2.56 days and it was 4.15 days for the control group. Therefore, the interruption of treatment for the target group was found to be 1.52 days shorter than that for the control group ($p<0.003$). Age, sex, demographic aspects and original location of tumor were also considered in this study and the achieved p-values were not found to be significant.

DISCUSSION

Results of the present study indicate that the application of the water bag, used for target group during radiotherapy sessions, has lesser pause in radiation therapy in comparison with the control group, treated with the same procedure without the use of the water bag. The physical pressure from water bag on pelvic components and lower abdominal area pushes small intestinal volume out of the radiation field, significantly. This could be addressed as the main reason of lesser interruption for target group. The situation of small intestine in a supine position with empty bladder, as well as its position for a prone position with the full bladder, with and without the application of water bag between patient and treatment couch is illustrated in figure 2. A typical rectangular radiation field is also added to radiographic images. The supine position and empty bladder, and the prone position and full bladder are shown in figures 2-a and 2-b, respectively. As these images show, the small intestine is located in the radiation field. The application of water bag in a prone situation and full bladder is also shown in figure 2-c. The use of water bag, due to aforementioned

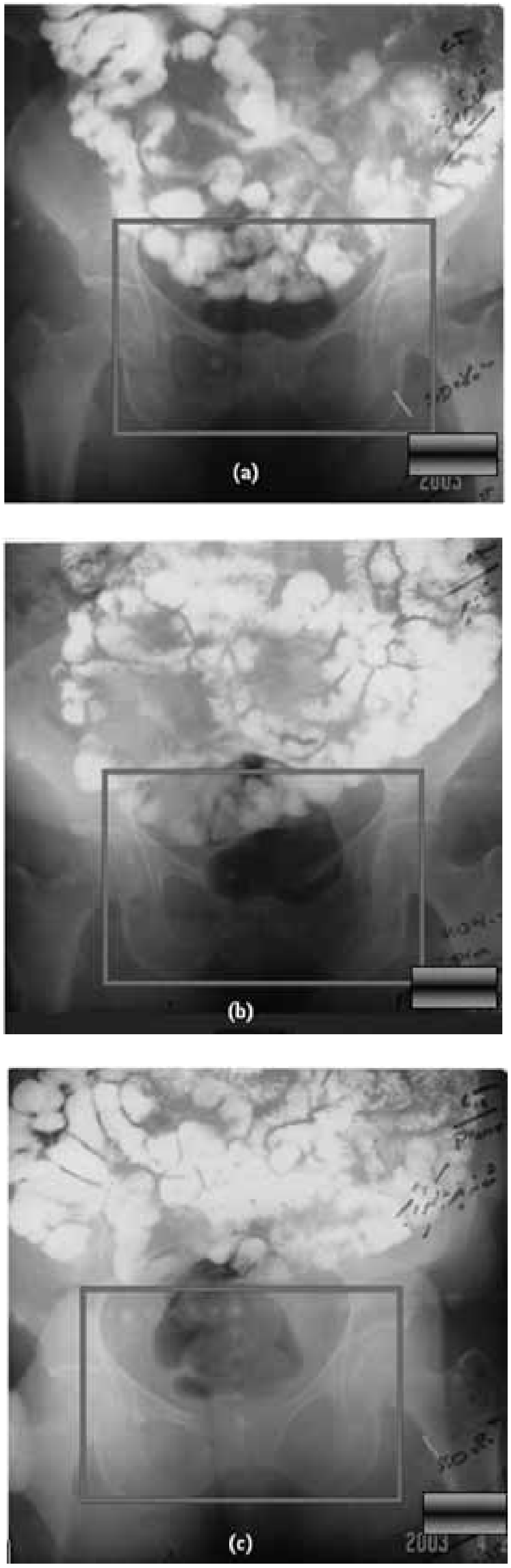

Figure 2. Pelvic radiography in a) a supine position and empty bladder, b) a prone position and full bladder, c) a prone position and full bladder with water bag.

reasons, decreases the small intestinal volume in the radiation field significantly. Therefore, not only the patient's thickness has been decreased in anterior posterior (AP) direction, but the majority of small intestinal volume has also been shifted outside the radiation field. Consequently, this reduces the early small intestinal complication rates, caused by ionizing radiation dose delivery during treatment. Due to late appearance of morbidities for small intestine during radiotherapy courses, this technique is also able to reduce the late complications such as perforation, obstruction and adhesion of small intestine.

Regarding small intestinal tolerance threshold during radiotherapy (around 4500 cGy), removing the small intestine from radiation field, not only decreases the probability of early and late morbidities, but also it decreases the total radiotherapy treatment time, as well as the probability of treatment pause significantly. The use of water bag caused dose difference, due to the dose deposition in water bag. This routinely occurs for the anterior radiation beam. In this study, in order to control the dose difference at the region of interest, especially where water bag was used, all patients selected for the target group were positioned in prone situation. They were then treated using two lateral fields plus one posterior radiation field. Due to the lack of the use of anterior field, there was no concern for radiation skin sparing as well as for different dose deposition for patients who were enrolled as the target group.

Compared to other relevant studies this investigation sounds to be similar to the method in which, Belly Board and SIRD have been used. In other words, regarding all patients' endurance and the lack of a considerable pause during radiotherapy, the outcome of the current study matches the former studies applying Small Bowel Devices (SBDs) to shift up the small intestine from radiation field within 56% to 57% [13, 14]. Due to the reduction of undesired interruptions during treatment, this study is also comparable with a study in which Belly

Board and a four-field dose delivery per session and prone situation is applied [15, 16].

The proposed method enables to exclude small intestine during conventional radiotherapy session similar to the method in which the SAP device is used [5]. However, the current technique is a non-invasive method and due to low cost, it can generally be used in all radiotherapy centers especially in developing countries where there is no suitable equipment like aforementioned devices. The use of proposed method optimizes total treatment time and prevents treatment pause during radiotherapy sessions. In addition, due to the lack of the early morbidities during radiotherapy sessions, makes patient feel more comfortable. This leads the quality of radiation therapy as well as helps to un-occupied patients' bed during gaps.

The reproducibility of the water bag positioning during radiotherapy session, can be addressed as one of the main challenges in this study. However, it was an effort to reproduce the exact positioning of the tool during the study, but we believe that more consideration should be taken into account.

During the application of water bag for a three-field technique used in this investigation, the skin absorbed dose increases up to 80% of maximum dose delivered at d_{max}, due to its position in the post build-up region when treatment was performed using a cobalt-60 machine. The absorbed dose values can also be increased for the same sites using high energy photon beams [17]. In order to cope with this problem the use of air bags, either similar to the water bags used in the current study or pneumatic attles can be suggested for further studies.

Regarding the limitations of this study, the application of the current method for more patients in the target and control categories is recommended. This leads the more accurate and reliable results. The accurate size of small intestine shifted outside the radiation field before and after the use of water bag can also be compared using CT images prepared during treatment process.

In addition, the comparison of patient's dose delivery calculated using a three-dimensional TPS and the investigation of dose volume histograms (DVHs) for two scenarios, applied for target and control groups in the proposed study, are also recommended. These will be able to estimate the reduction of radiation dose values absorbed by small intestine for a range of techniques applied to spare it during pelvic cancers treatment.

REFERENCES

1. Janjan NA, *Declos ME, Crane CH.* (2002) The colon and rectum, In: *Radiation Oncology*, Cox JD, Ang KK (eds). Mosby: St. Louis. pp. 513-17.
2. Constine LS, Moris M, Rubin P, Okuniess P. (2004) Late effects of cancer treatment on normal tissues, In: *Principle and practice of radiation oncology*, Perez CA (ed). Lippincott Williams & Wilkins: Philadelphia. pp. 357-390.
3. Skibber J, Tuff PM, Nimsky BD (2005) Cancer of rectum, In: *Principle and practice of oncology*, Devita T (ed). Lippincott Williams & Wilkins: Philadelphia. pp.1299-1303.
4. Capirci C and Polico C (2001) Dislocation of small bowel volume within box pelvic treatment fields using "Up down table" device. *Int J Radiat Oncol Biol Phys, **51**: 465-473.*
5. Burnett AF and Coe FL (2000) The use of a pelvic displacement prosthesis to exclude the small intestine from the radiation field following radical hysterectomy. *Gynecol Oncol, **79**: 438-43.*
6. Hall EJ (2000) Radiobiology for the radiologist. 4th ed., Philadelphia. *Lippincott*, 314-339.
7. Yamazaki A and Shirato H (2000) Reduction of late complications after irregularly shaped four-field whole pelvic radiotherapy using computed tomography simulation compared with parallel-opposed whole pelvic radiotherapy. *Jpn J Clin Oncol, **30**: 180-184.*
8. Kim JY and Kim DY (2007) Intensity-modulated radiotherapy with a belly board for rectal cancer. *Int J Colorectal Dis, **22**: 373-79.*
9. Huh SJ and Park W (2004) Small-bowel displacement system for the sparing of Small bowel in three-dimensional conformal radiotherapy for cervical cancer. *Clin Oncol, **16**: 467-73.*
10. Mayer NA and Adli M (2003) Prone position reduces small bowel dose in pelvic radiation with intensity-modulated radiotherapy for gynecologic cancer. *Acta Oncol, **57**: 230-38.*
11. Portelance L and Chao KS (2001) Intensity modulated radiation therapy (IMRT) reduces small bowel, rectum, and bladder doses in patients with cervical cancer. *Int J Radiat Oncol Biol Phys, **51**: 261-266.*
12. Roesk JC and Felming G (2002) intensity modulating whole pelvic radiotherapy in women with gynecologic malignancies. *Int J Radiat Oncol Biol Phys, **52**: 1330-37.*

13. Holst R, La Couture T, Koprowski C, Goldschmidt E. (1995) A simple manual method of repositioning small bowel during pelvic irradiation. *Med Dosim, **20**: 123-9.*
14. Sezeur A, Martella L, Abbou C (1999) Small intestine protection from radiation by means of a removable adapted prosthesis. *Am J Surg, **178**: 22-25.*
15. Ghosh K and Padilla LA (2001) using a belly board device to reduce the small bowel volume within pelvic radiation fields in women with postoperatively treated cervical. *Gynecol Oncol, **83**: 271-75.*
16. Kim TH, Chie EK, Kim DY (2005) Comparison of the belly board device method and the distended bladder method for reducing irradiated small bowel volumes in preoperative radiotherapy for rectal cancer patients. *Int J Radiat Oncol Biol Phys, **62**: 769-75.*
17. Khan FM (1993) The physics of radiation therapy. 3rd ed., Philadelphia: *Lippincott*, Williams & Wilkins.