Reducing Radiation Dose to Pelvic Small Bowel in Cervical Cancer Patients Treated with Ir-192 Intracavitary Brachytherapy by Using Urinary Bladder Distension

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Objectives: *Several techniques and devices have been used in an attempt to minimize radiation dose to gastrointestinal tract while giving pelvic radiation. We evaluated the effect of urinary bladder distension to displace pelvic small bowel out of intracavitary brachytherapy field to minimize radiation dose to small bowel in cervical cancer patients.*

Material and Method: *Eleven cervical cancer patients who received Ir-192 intracavitary brachytherapy with tandem and transverse ovoids were included in this study. Oral contrast material was used to visualize pelvic small bowel. Urinary bladder was distended by injection 125-200 ml. normal saline solution. Pelvic radiograph, anteroposterior and lateral view, was performed before and after bladder distention for brachytherapy treatment planning and comparing radiation dose at small bowel.*

Results: *The average maximum radiation dose at small bowel before and after bladder distension were 3,123cGy and 1,998cGy respectively. The summation of small bowel dose was reduced 54.17% (p = 0.002).*

Conclusion: *Urinary bladder distension could effectively displace pelvic small bowel and reduce the radiation dose to small bowel from Ir-192 intracavitary brachytherapy in cervical cancer patients.*

Keywords: *Urinary bladder distension, Small bowel, Brachytherapy, Cervical cancer*

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Cervical cancer has been a major problem in Thailand. According to statistic report of cancer from Division of Radiation Oncology, Department of Radiology, King Chulalongkorn Memorial Hospital, the number of cancer patients has been increasing every year, mostly with cervical cancer[1].

The preferred treatment for most cancer patients is multimodality approach consisting of radiation, surgery, chemotherapy etc. The main treatment of locally advanced cervical cancer is external beam radiation therapy and brachytherapy. The aim of radiation therapy is to maximize radiation dose to tumor while minimize radiation dose to normal tissue in order to enhance tumor control and reduce normal tissue complication.

The small intestine has potential risk for radiation injury due to lower radiation tolerance than either the urinary bladder or the rectum. We hypothesized that urinary bladder distension will displace the small intestine from pelvis during high dose rate brachytherapy.

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Material and Method

Patients

This study had been taken at Division of Radiation Oncology, Department of Radiology, King Chulalongkorn Memorial Hospital from June 2003 to December 2004.

Patients were eligible if they had biopsy-proven and previously untreated carcinoma of the uterine cervix. Eastern Cooperative Oncology Group performance status 0 to 2, normal mental health and age younger than 70 years were required. Other inclusion criteria was treatment with high dose-rate (Ir-192) intracavitary brachytherapy using the standard application, uterine tandem and transverse vaginal ovoids.

All patients gave written informed consent.

Patient with previous history of intra abdominal surgery, urinary incontinence or KUB system disease were excluded from study. The patient who can not tolerate urinary bladder distension by normal saline injection and computer treatment planning not performed will not be included in this the study.

Study procedures

To visualize the small bowel, the patient had taken oral contrast media (barium sulfate) before applying the intracavitary applicator. The patient was maintained upright position about 45-60 minutes allowing time for barium sulfate coating small bowel. After aseptic perineum preparation, foley's catheter was retained and contrast-filled in foley catheter balloon, then empty urinary bladder. Uterine tandem and transverse vaginal ovoids were inserted into the uterine cavity and upper vagina. Barium-soaked vaginal gauze packing were used to increase distance from brachytherapy source and define rectal point, (0.5 cm from posterlor vaginal wall). Radiography of the pelvis, antero-posterior view and lateral view was done for brachytherapy treatment planning and evaluation position of the small bowel before bladder distension. Normal saline solution, 200 ml was injected into urinary bladder via foley's catheter to distend urinary bladder. Radiography of the pelvis, antero-posterior view and lateral view was performed again to evaluate position of the small bowel after bladder distension. Standard brachytherapy treatment planning was then performed. Radiation dose to small bowel before and after bladder distension was calculated. The difference of the small bowel dose before and after bladder distension were compared by using Paired t-test statistical analysis.

Calculation radiation dose to the small bowel in brachytherapy treatment planning was by creating points for making volume of interest . Reference point (0,0,0) was defined at cervical os. Then, three axis X,Y and Z was determined from the reference point (X axis was the axis in direction of left to right, Y axis was the axis in direction of caudal to cephalad, Z axis was the axis in direction of posterior to anterior). Defined points in X axis was every 1 cm from -5 cm to +5 cm of the reference point. Defined points in Y axis was every 1 cm from the reference point to +5 cm (Fig. 1). Defined points in Z axis was every 1 cm from reference point. The points in Z axis was defined along the anterior curvature of the uterine tandem (Fig. 2). There were total 462 points of X, Y and Z for studying the small bowel dose in each patients.

We studied the total radiation dose from every point of small bowel in volume that created from three axis. The total radiation does was called "Summation of radiation dose". The mean radiation dose to small bowel was also calculated by the following formula.

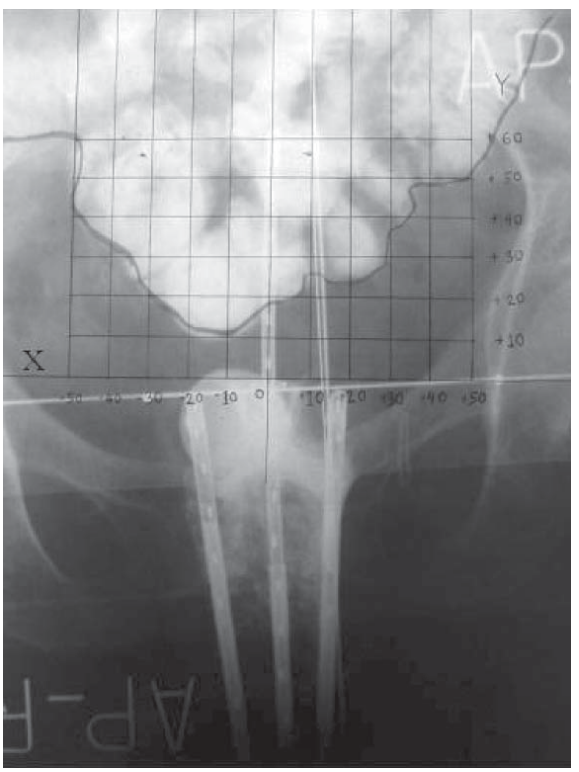

Fig. 1 Show radiograph in antero-posterior view with calculated points in X and Y axis (before bladder distension)

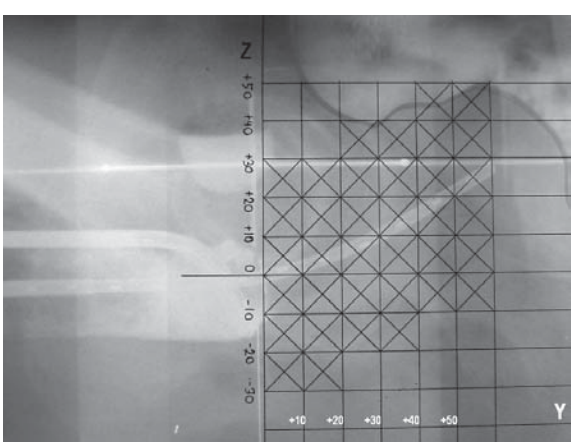

Fig. 2 Show radiograph in lateral view with calculated points in Y and Z axis (before bladder distension)

$$\text{Mean radiation dose} = \frac{\text{Summation of Radiation dose}}{\text{Number of calculated point in that study}}$$

Statistic data analysis

The Paired t-test was used to test the difference between radiation dose before and after bladder distension. This study used program SPSS 11.5 for window for statistical data analysis.

Results

Eleven patients with invasive carcinoma of the uterine cervix were entered into the study between June 2003 and December 2004. There were 20 experimental studies. The median age of the patients was 44 years (range from 34 to 69 years). Urinary bladder was distended by injection normal saline solution, 125-200 ml. The characteristics of the patients are shown in Table 1.

The summation of radiation dose the small bowel received are listed in table. The average summation of radiation dose of small bowel before and after urinary bladder distension were 50,881.75 cGy and 23,317.3 cGy, respectively. The average of the reduced radiation dose of small bowel was 27,564.45 cGy (p=0.00194). The reduced radiation dose was 54.17% (95% CI, 22.62%to 85.72%).

The comparison of the summation of radiation dose to small bowel before and after urinary bladder distension demonstrated statistically significant difference. The average of the summation does after normal saline solution injection was also significantly reduced. (50,881.75 cGy and 23,317.3 cGy, p=0.00194; Table 1).

The comparison of mean radiation dose to small bowel before and after urinary bladder distension demonstrated statistically significant differences. The average mean radiation dose after normal saline solution injection was significantly reduced (407.31 cGy and 325.22 cGy, p=0.005; Table 1).

The average maximum radiation dose after bladder distension was statistically significant diminished (1,996.45 cGy and 3,123 cGy; p=0.01619; Table 1).

The average minimum radiation dose after normal saline solution injection was also decrease but no statistical significant difference. (95.16 cGy and 108.9 cGy; p=0.95).

An example of films is demonstrated before and after bladder distension in Fig. 3.

Discussion

Cervical carcinoma is the most common cancer in Thai female. It is the second rank in patients who were diagnosed cancer in King Chulalongkorn Memorial Hospital in 2001[1]. Radiation therapy has been considered a standard treatment in locally advanced cervical cancer[11]. Recently, survival was shown to be improved from concurrent chemoradiation[12-16]. However, normal tissue complication is the area of concern when we treat with concurrent chemoradiation. Small bowel is one of the dose limiting normal tissue structure (TD 5/5=4500cGy)[17]. Increased stool frequency is commonly seen during pelvic irradiation. Chronic complications include small bowel obstruction, malabsorption and perforation. There are several factors predisposing to late small bowel complications, including total radiation dose, dose per fraction, irradiated small bowel volume, previous surgery and combined chemoradiation. The severity of acute small bowel complications was associated with irradiated small bowel volume whereas late complication was related to small bowel volume receiving more than 45 Gy. Many researches were conducted, regarding the incidence of small bowel complication in pelvic irradiation patient[2-10].

Several surgical and non-surgical techniques have been employed to reduce pelvic small bowel volume[5-10]. Surgical options include omental sling, absorbable synthetic mesh sling, temporary intrapelvic tissue expander, intrapelvic prosthesis and reperitonizing pelvic floor. Such methods, however, are not often feasible.

Due to their safety, simplicity, practicability and applicability to Thai patients, we chose urinary bladder distension to displace pelvic small bowel out of the irradiated area. The statistical significant reduction of the small bowel radiation dose in the pelvic brachytherapy field should be resulted in decreasing the complications. Clinical significance of these procedures in reducing acute and late small bowel complications remains to be verified.

From this study we discovered that the radiation dose to small bowel from Ir-192 intracavitary brachytherapy in cervical cancer patients was significantly reduced by urinary bladder distension. However, this study utilized two dimensional treatment planning, the accuracy for evaluation dose at small bowel may have some error.

In the future research, three-dimensional treatment planning with dose volume histograms calculation may be used to obtain more accurate information of the small bowel dose and other region of inter-

Table 1. Patient characteristics and radiation doses at small bowel before and after bladder distension

No. of study	Patient name	Age	Stage	Volume NSS (ml)	Sum of dose (cGy)			Mean of dose (cGy)			Maximum of dose (cGy)		
					Before	After	Difference	Before	After	Difference	Before	After	Difference
1	A	44	IIB	200	29454	6750	22704	545	482	63	3538	1334	2204
2	B	43	IIIB	200	43425	15937	27488	517	613	-96	3640	2828	812
3	C	40	IIB	200	93814	45667	48147	830	716	114	3927	3927	0
4	C	40	IIB	200	85637	66733	18904	468	624	-156	5657	5657	0
5	D	69	IB	200	23125	4149	18976	463	160	303	1605	284	1321
6	D	69	IB	200	32100	49241	-17141	553	424	129	2948	4074	-1126
7	D	69	IB	200	90214	8766	81448	547	231	316	4464	449	4015
8	E	39	IB	200	56126	32179	23947	460	339	121	3115	1060	2055
9	E	39	IB	175	75526	61904	13622	455	495	-40	9650	9650	0
10	E	39	IB	200	18988	10610	8378	316	287	30	1167	755	412
11	F	46	IIB	200	42156	14055	28101	413	319	94	1525	648	877
12	G	38	IIIB	150	105162	34470	70692	433	311	122	5764	2389	3375
13	H	53	IIB	200	1665	0	1665	151	0	151	193	0	193
14	H	53	IIB	200	4470	0	4470	186	0	186	304	0	304
15	H	53	IIB	125	102570	55620	46950	570	520	50	4581	4581	0
16	I	34	IIB	200	233	0	233	117	0	117	126	0	126
17	J	63	IIB	200	159310	27838	131472	456	290	167	8358	1105	7253
18	J	63	IIB	200	25298	17418	7880	256	249	7	1105	514	591
19	J	63	IIB	200	22505	11441	11064	232	238	-6	496	496	0
20	K	69	IIB	200	5857	3568	2289	177	162	15	297	218	79
					50882	23317	27564	407	325	82	3123	1998	1348
				Average		p-value	0.0019		p-value	0.005		p-value	0.01619

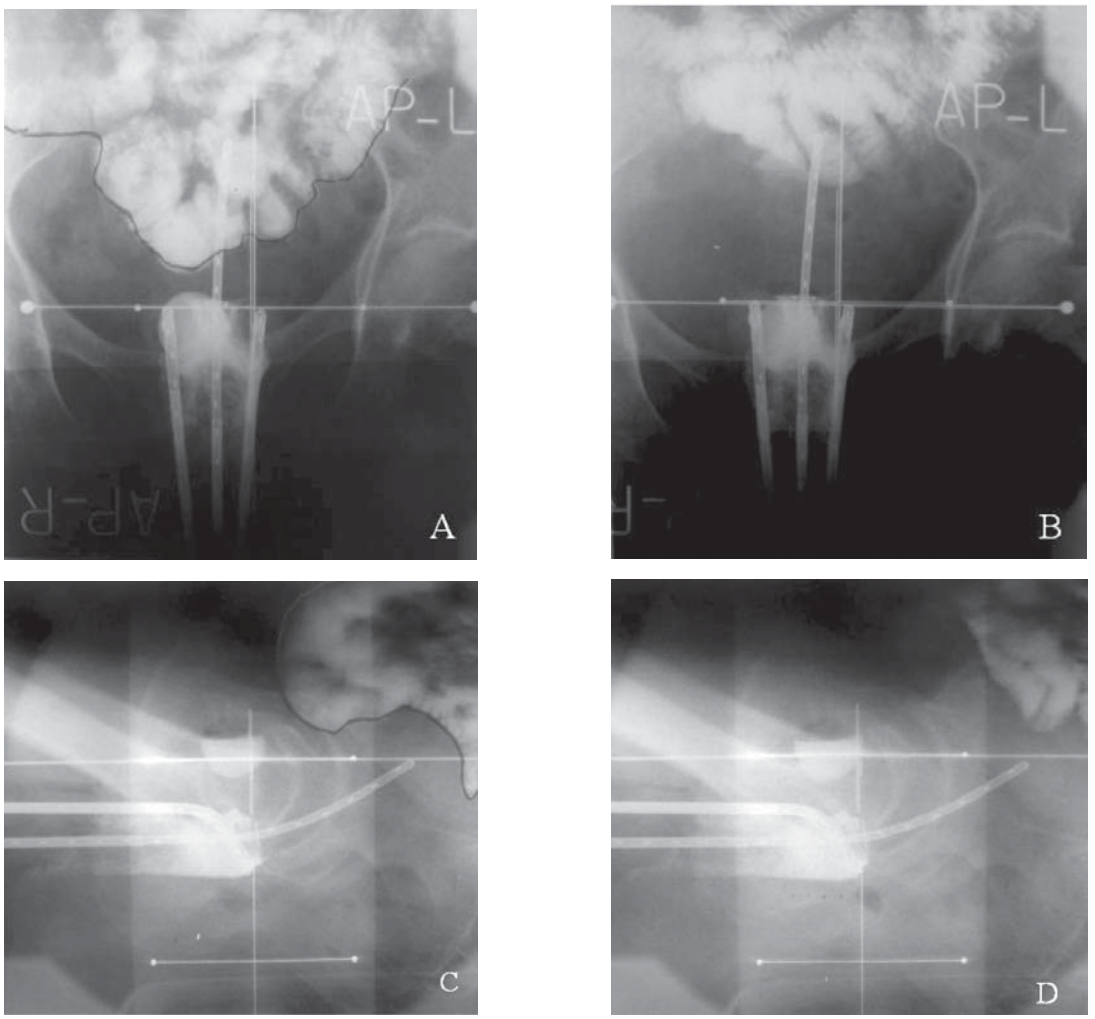

Fig. 3 Revealed upward displacement of pelvic small bowel after bladder distension
A: Radiograph in antero-posterior view before bladder distension demonstrated pelvic small bowel close to the brachytherapy applicator. B: Radiograph in antero-posterior view after bladder distension revealed upward displacement of pelvic small bowel. C: Radiograph in lateral view before bladder distension demonstrated pelvic small bowel close to the brachytherapy applicator. D: Radiograph in lateral view after bladder distension revealed upward displacement of pelvic small bowel

est. Furthermore, clinical aspect of acute and late small bowel complication should be explored in the randomized controlled trial.

Conclusion

Urinary bladder distension technique using normal saline solution injection is effective in reducing small bowel radiation dose in pelvic intracavitary brachytherapy. This simple, safe, and inexpensive technique may decrease complications from pelvic radiation.

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การใส่น้ำในกระเพาะปัสสาวะเพื่อลดปริมาณรังสีที่ลำไส้เล็ก จากการใส่แร่ อิริเดียม–192 ในผู้ป่วยมะเร็งปากมดลูก

จิรศักดิ์ สุขาบูรณ์, กาญจนา โชติเลอศักดิ์, ประเสริฐ เลิศสงวนสินชัย, ชลเกียรติ ขอประเสริฐ

วัตถุประสงค์: *มีการศึกษาถึงวิธีการต่าง ๆ ที่จะลดปริมาณรังสีที่บริเวณลำไส้ในผู้ป่วยที่ได้รับการรักษาด้วยรังสีบริเวณอุ้งเชิงกราน งานวิจัยนี้จึงได้ทำการศึกษาผู้ป่วยที่เป็นมะเร็งปากมดลูก ถึงการขยายขนาดกระเพาะปัสสาวะ เพื่อดันลำไส้เล็กให้ออกไปจากบริเวณที่ใส่แร่ ซึ่งทำให้ปริมาณรังสีที่ลำไส้เล็กได้รับลดลง*

วัสดุและวิธีการ: *ผู้ป่วยมะเร็งปากมดลูกที่ได้รับการใส่แร่ Ir-192และใช้อุปกรณ์ในการใส่แร่เป็น tandem และ transverse ovoids โดยให้ผู้ป่วยรับประทานทานสารทึบรังสี เพื่อให้เห็นตำแหน่ง ของลำไส้เล็กในอุ้งเชิงกราน แล้วทำให้กระเพาะปัสสาวะขยายตัวโดยการใส่น้ำเกลือในกระเพาะปัสสาวะ 125-200 cc จากนั้นเปรียบเทียบปริมาณรังสีที่วัดได้ก่อนและหลังใส่น้ำเกลือในกระเพาะปัสสาวะ*

ผลการศึกษา: *การใส่น้ำเกลือในกระเพาะปัสสาวะ สามารถลดปริมาณค่าเฉลี่ยของปริมาณรังสีสูงสุดที่ลำไส้เล็กลงได้จาก 3,123cGy เป็น 1,998cGy ลดลงอย่างมีนัยสำคัญทางสถิติ (p =0.01619)*

สรุป: *การขยายขนาดของกระเพาะปัสสาวะทำให้ ดันลำไส้เล็กออกไปนอกบริเวณที่รับรังสีจากการ สอดใส่แร่ อิริเดียม-192 ในผู้ป่วยมะเร็งปากมดลูกอย่างมีประสิทธิภาพ ทำให้ลดปริมาณรังสีที่ ลำไส้เล็กลงได้*