Intraluminal High-Dose-Rate Brachytherapy for the Tumors of Gastrointestinal Tract

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= Abstract =

Purpose : Intraluminal high dose rate brachytherapy is an accepted treatment for the tumors of GI tract. However, there is only some limited clinical data for intraluminal high dose rate brachytherapy for the tumors of GI tract.

Materials and Methods : Between February 1991 and July 1993, 18 patients who have the tumors of GI tract (esophageal cancer-8 cases, rectal cancer-10 cases) were treated with high dose rate Iridium-192 afterloading system (Microselectron-HDR, Nucletron CO, Netherland) at the department of therapeutic radiology, St. Mary's hospital, Catholic university medical college. Age range was 47-87 years with a mean age 71 years. All patients were treated with intraluminal high dose rate brachytherapy within two weeks after conventional external radiation therapy and received 3-5 Gy/fraction 3-4 times per week to a total dose 12-20 Gy (mean 17 Gy). Standard fractionation and conventional dose were delivered for external radiation therapy. Total dose of external radiation therapy ranged 41.4-59.4 Gy (mean 49.6 Gy). Median follow up was 19 months.

Results : The analysis was based on 18 patients. The complete response and partial response in esophageal cancer was similar (38 %). Two year rates for survival and median survival were 13 % and 10 months, respectively. Among 10 patients of rectal cancers, partial response was obtained in 6 patients (60 %). There was no complete response in the patients with rectal cancer, but good palliative results were achieved in all patients.

Conclusion : Although the number of patients was not large and the follow-up period was relatively short, these findings suggested that intraluminal high dose rate brachytherapy could be useful in the treatment of the patients with advanced tumors of GI tract.

Key Words : High dose rate brachytherapy, Intraluminal radiation, Esophageal cancer, Rectal cancer

INTRODUCTION

Brachytherapy represents one of the best methods to maximize tumor dose while minimizing normal tissue dose, which will always be one of the main goals of radiation therapy. Organ preservation is an important area of oncological practice, and brachytherapy can allow for high tumorcidal doses of radiation to be delivered while preserving form and function. A major technological advance in this field has been high dose rate (HDR) remote afterloading[1].

HDR-technique has been used for more than 10 years in a few centers. Remote Afterloading High Dose Rate Brachytherapy(HDRB) has several advantages as compared with Conventional Low Dose Rate Brachytherapy(LDRB) which include the patient comfort, elimination of the personal exposure, and shorter duration of hospitalization. Also, HDR-remote afterloading systems allows a further incremental improvement in the physical placement of the implants, in the ability of the treating physician to maximize displacement of normal tissues for short periods of time, and to optimize dosimetry, all of which contribute to an improved dose delivery to the tumor or target volume relative to normal surrounding tissues. HDRB was performed on an outpatient basis and often in fractionated schedule, too. The other important factor is that it gives treatment results at least not worse than LDRB in several reports[2]. Furthermore, the acute complications were acceptable and the late complications were perhaps more than LDRB. But, the late complications must be avoided by optimal technique & proper fractionation schedule.

Endocavitary radiation therapy produces high rates of local control and long-term survival in appropriated selected patients with rectal cancer. Sischy[3] reported local control in 95 % of a highly selected group of patients. Two advantages of this treatment are increased preservation of the surrounding tissues and less bleeding than after excision. Endocavitary radiation has been used as the palliation in poor risk patients with more advanced cancers.

Wei-bo Yin from China[4, 5] used high dose rate intraluminal brachytherapy as sole therapy of advanced esophageal cancers. Sur et al[6] used high dose rate intraluminal brachytherapy as an adjuvant therapy of external radiation therapy. Local control and survival were significant superior than the conventional external radiation therapy alone group. These reports suggest that there may be a valuable role for the routine use of a boost with high dose rate intraluminal brachytherapy after external radiation therapy of esophageal cancers.

In general, intraluminal high dose rate brachytherapy is an accepted treatment for the tumors of GI tract. However, there is only some limited clinical data for intraluminal high dose rate brachytherapy for the tumors of GI tract.

We review preliminary intraluminal HDRB-experiences with an attempt to analyse for the effectiveness of therapy and complication.

MATERIALS AND METHODS

1. Patients Characteristics

From February 1991 to July 1993, 18 patients were treated with Iridium-192 (micro-Selectron-HDR afterloading system, Nucletron CO, Netherland) at the department of therapeutic radiology, St' Marys hospital. There were all intraluminal radiation procedures in eight patients of esophageal cancer and ten patients of rectal cancer received the intraluminal HDRB. They had been treated with external radiation therapy, for curative or palliative aims. All patients had not been received any radical surgery before intraluminal HDRB because of surgically unresectable tumors.

Table 1. Patient Characteristics

	Rectal cancer	Esophageal cancer
patient	10(male-6/female-4)	8(male-4/female-4)
Age(mean)	47 - 77 (70)	63 - 87 (72)
KPS	60 - 80	60 - 80
Pathology	Adenocarcinoma	Squamous cell ca.

KPS = Karnofsky performance scale

Table 2. Method of Intraluminal High Dose Rate Brachytherapy

		Rectal cancer	Esophageal cancer
Ext. RT	Total dose(mean)	50.4 - 55.8 Gy (51.6)	41.4 - 59.4 Gy (49.6)
HDRB	Total dose(mean)	12 - 20 Gy (16)	15 - 20 Gy (17.5)
	Fraction size	3 - 5 Gy	3 - 4 Gy
	Fraction number	4 - 5	5 - 6
	Fraction interval	3 - 4 times / wk	3 - 4 times / wk

Only 2 patients of rectal cancers underwent palliative loop-colostomy due to severe obstruction.

Age range was 47-87 years with a mean age 71 years. All patients were treated with intraluminal high dose rate brachytherapy within two weeks after conventional external radiation therapy and received 3-5 Gy/fraction 3-4 times per week to a total dose 12-20 Gy (mean 17 Gy). Standard fractionation and conventional dose were delivered for external radiation therapy. Total dose of external radiation therapy ranged 41.4-59.4 Gy (mean 49.6 Gy). Performance status of HDRB-patients ranged from 60 to 80 in Karnofsky scale. Median follow-up periods was 19 months with range 3-31 months.

The characteristics of these patients including pathology, age, performance scale are shown in Table 1.

2. HDRB-Techniques

In the HDRB for esophageal cancer, nasogastric tube was inserted to tumor bed. The position of catheter-tip was determined under fluoroscopic control. Dummy sources were inserted into the catheter and pushed to its distal end. The dummy is a wire with radioopaque beads located at 1cm-interval which can be potentially occupied by the radiation source. Orthogonal simulation films were taken and define the treatment volume. Treatment volume encompass the primary tumor site with a margin of 2 cm both proximally and distally. This can be verified either by endoscopic examination or by correlating localization films with pretherapy imaging studies, provided the imaging studies accurately determined the proximal and distal tumor extent. Computerized planning could optimize the dwell position and dwell time of the sources (Iridium-192) to fit the isodose curve in the target volume. Typically, the treatment time is calculated to give the prescription dose at a distance of 1.0 cm from the source. 3-4 Gy at 1.0 cm from the source was prescribed. When the planning is complete, the afterloading device (nasogastric tube) is connected to the afterloading machine and the dose is administered over several minutes. Total doses of HDRB ranged 15-20 Gy.

In the HDRB for rectal cancer, rectal applicator (Sängstaken-Blackmore tube with ballooning) with catheter was inserted to tumor bed. Also, the position of catheter-tip was determined under fluoroscopic control. Dummy sources were inserted into the catheter and orthogonal simulation films were taken. Treatment planning performed in a manner similar to that described for esophageal cancers. 3-5 Gy at 1.0 cm from the source was prescribed. Total doses of HDRB ranged 12-20 Gy (Table 2).

3. Evaluation

In the esophageal cancers, all patients, prior to radiotherapy, underwent barium esophagography, esophagoscopy, computed tomography, and chest X-ray, and follow up evaluation of response after treatment by barium esophagography, endoscopy, and computed tomography. In the rectal cancers, barium enema or colonoscopic examinations were performed before treatment. Also, patients were evaluated for extent of disease in the pelvis and for distant metastatic disease by chest X-ray, carcinoembryonic antigen level, and computed tomography of abdomen and pelvis. Follow up studies for response evaluation were barium enema, sigmoidoscopy, colonoscopy, and computed tomography.

Response evaluations were defined as followings.

(1) CR(complete response) -- complete disappearance of tumor mass

(2) PR(partial response) -- over 50% reduction in tumor bulk

(3) SD(stable disease) -- minimal or no response

(4) Prog(progression) -- disease progression after treatment

We analysed the response rate and survival with respect to external radiation dose, HDRB-fraction size, and HDRB-total dose. Survival was calculated from the completion of treatment to the time of death by Kaplan-Meier method.

RESULTS

1. Disease Control

Eighteen patients completed therapy, and no patients were lost to follow up. Among 8 patients of esophageal cancers, CR was achieved in 3 patients (38 %), and PR was obtained in 3 patients (38 %). Of the remaining 2 patients, 1 patient showed no response and 1 patient showed disease progression. And among 10 patients of rectal cancers, PR was achieved in 6 patients (60 %). Of the remaining 4 patients, 3 patients showed no response(SD, 30 %) and 1 patient showed disease progression(Table 3). Most of esophageal and rectal cancer achieved the palliation effect of pain in rectal cancer and odynophagia in esophageal cancer. A number of potential prognostic factors of effect on survival and local treatment response were investigated using multivariate analysis. In the esophageal cancers, the response rate in total dose of external radiation therapy $\leq$ 50.4 Gy was 50% and in total dose of external radiation therapy above 50.4 Gy was 50%, respectively.($p>.05$, N.S.) The median survival duration and 2-year survival rate in total dose of external radiation therapy $\leq$ 50.4 Gy were 16 months and 25%, and in total dose of external radiation therapy above 50.4 Gy were 9.8 months and 0%, respectively.($p>.05$, N.S.) And, the response rate in 3 Gy of HDRB-fraction size was 16.7% and in 4 Gy of HDRB-fraction size was 83.3%, respectively.($p=0.06$) The median survival duration and 2-year survival rate in 3 Gy of HDRB-fraction size were 7.5 months and 0%, and in 4 Gy of HDRB-fraction size were 14.7 months and 17%, respectively.($p=0.06$) Also, the response rate in HDRB-total dose below 20 Gy was 16.7% and in HDRB-total dose $\geq$ 20 Gy was 83.3%($p=0.06$). The median survival duration and 2-year survival rate in HDRB-total dose below 20 Gy were 7.5 months and 0%, and in HDRB-total dose > 20 Gy were 14.7 months and 17%, respectively.($p=0.06$) In the rectal cancers, the response rate in total dose of external radiation therapy < 50.4 Gy was 80% and in total dose of external radiation therapy above 50.4 Gy was 20%, respectively.($p>.05$, N.S.) And, the response rates in 3 Gy, 4 Gy, and 5 Gy of HDRB-fraction size were 0%, 40%, and 60%, respectively ($p=0.016$). Also, the response rate in HDRB-total dose below 20 Gy was 0% and in HDRB-total dose $\geq$ 20 Gy was 100%($p=0.003$).

Table 3. Local Control Rate in Rectal and Esophageal Cancer after External RT and High Dose Rate Brachytherapy

	Rectal(10)	Esophageal(8)	Total(18)
CR	0	3 (38%)	3 (17%)
PR	6 (60%)	3 (38%)	9 (50%)
SD	3 (30%)	1 (12%)	4 (22%)
Prog	1 (10%)	1 (12%)	2 (11%)
RR(CR+PR)	6 (60%)	6 (76%)	12 (67%)

CR - complete response
PR - partial response
SD - minimal or no response
Prog - disease progression
RR - response rate (CR+PR)

Total dose of external radiation therapy had no significant influence on survival and local response in esophageal cancers. Also, it had no affect on the local response in rectal cancers. There was a trend toward better local response and survival in esophageal cancers with higher HDRB-total dose and fraction size. And, high total dose and large fraction size of HDRB had a significant affect on the local response of the rectal cancer (Table 4).

Follow-up periods were too short to estimate

Table 4. Prognostic Factors on Survival and Local Response Rate of Esophageal Ca. and Rectal Ca. by External Radiation Therapy plus High Dose Rate Brachytherapy

Types of ca. / factors	Esophageal ca.				Rectal ca	
	RR	P value	MS/2YSR	P value	RR	P value
Ext. RT-dose						
≤50.4 Gy	50%	N. S.	16mo/25%	N. S.	80%	N. S.
>50.4 Gy	50%		9.8mo/0%		20%	
HDRB-fraction size						
3 Gy	16.7%	0.06	7.5mo/0%	0.06	0%	0.016
4 Gy	83.3%		14.7mo/17%		40%	
5 Gy					60%	
HDRB-total dose						
<20 Gy	16.7%	0.06	7.5mo/0%	0.06	0%	0.016
≥20 Gy	83.3%		14.7mo/17%		100%	

RR=response rate, MS=median survival, 2YSR=two year survival rate, N.S.=non specific

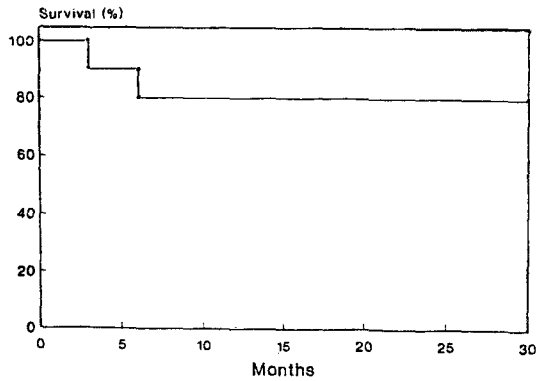

Fig. 1. Overall survival of patients with rectal cancer treated with external radiation therapy plus high dose rate brachytherapy.

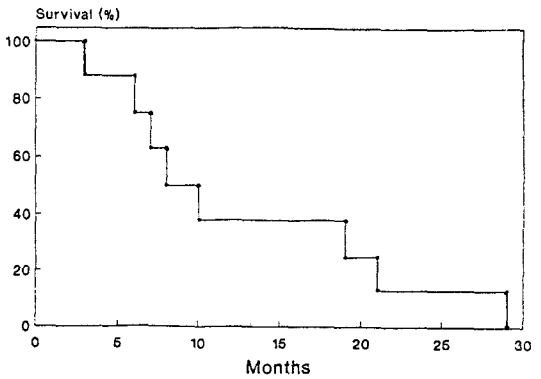

Fig. 2. Overall survival of patients with Esophageal cancer treated with external radiation therapy plus high dose rate brachytherapy.

the mean survival time of the rectal cancers. Of all rectal cancers, 8 patients are still alive with follow-up period between 16 and 31 months (Fig. 1). In the esophageal cancers, median survival and 2-year survival rate were 10 months and 13% (Fig. 2).

2. Complication

Most patients of esophageal cancer was developed radiation induced esophagitis, which was transient. There was one case of tracheo-esophageal fistula in the intraluminal HDRB of esophageal cancer. And the other complications as stricture and ulceration were not seen. In the rectal cancers, three patients experienced the anal pain during the HDRB because of the irritation of the lesions by the HDRB device. Minor bleeding from the treatment site occured in one patient, and required one or more sessions of superficial electrocoagulation to eliminate the nuisance bleeding. And two patients were left with reduced compliance of the rectum and urinary bladder from the external radiation therapy and suffered temporary fecal and urinary urgency and frequency.

None were incapacitated by this problem. Two patients had mucous discharge that required wearing a pad occasionally. But, it was well tolerable and disappeared within a few days. And, the other complications were acceptable.

DISCUSSION

Brachytherapy, derived from the Greek words brachys and therapia, has come to describe short distance radiation treatment. The earliest forms of implantation used active source placed directly by the physician into the tumor volume. With the introduction of megavoltage equipment, there was a pronounced decrease in brachytherapy. However, with the introduction of afterloading procedures, brachytherapy experienced a renaissance. It was not long before remote afterloading equipment was developed. Remote afterloading leads to better dose localization and improved sparing of surrounding normal tissues. Also, it provides for unsurpassed radiation protection for personnel. The current generation of HDR afterloading equipment allows the radiation therapist to combine CT-guided volumetric pre-planning with both dose volume analysis made at the time of the implant and a variety of differentially shielded rectal applicators. Using these methods an infinite variety of customised implants can be accomplished and tailored to the extent of the disease and the therapeutic aims. Also, newer systems, by allowing a single small source to 'dwell' at a site for a calculated point and time when combined with dose optimization software programs, provide a significant further improvement in dose distribution[1, 2]. Nori[7] reported on 287-rectal cancer-patients treated 1981-1986 using HDR brachytherapy methods. In 15 patients with persistent disease, he reported 70% local control and of 13 patients with recurrent tumors, he achieved 40% local control. Nori[7] recommended doses of 5-7 Gy at 0.5 cm from the surface of the rectal applicator and conventional external irradiation or 5 Gy/fx at 1 cm from the rectal mucosa. Freund et al[8] safely treated seven rectal cancer-patients in 1986 using schedules of either 8 Gy (specified at 1 cm from the applicator surface) weekly for three weeks or 5 Gy (specified at 0.5 cm) weekly for three weeks. Freund et al8) were also the first to recommend and to use pre-treatment planning of volume dosage from CT-scans.

Endocavitary radiation therapy produces high rates of local control and long-term survival in appropriately selected patients with rectal cancer. The indications for this technique have been described by Papillon[9], as follows, (1) Lesion accessible by treatment proctoscope (<10cm from anal verge) (2) No evidence of disease extension beyond the bowel wall on digital rectal examination (3) Maximum tumor size 3cm×5cm (4) No significant extension to anal canal. Papillon and Berard[10] described the use of endocavitary radiation, a low energy radiation applied directly to a tumor, for local therapy of rectal cancer and reported a 78% 5-year survival in groups of selected patients, and Sischy[3] reported local control in 95% of a highly selected group of patients. Endocavitary radiation has been used as palliation in poor risk patients with more advanced cancers. However, the use of only local destruction for favorable, yet invasive, rectal cancers is complicated by the warning by Morson et al.[11] that 10% of these patients will have metastatic cancer in the pararectal lymphatics. This may be an acceptable risk for the eldery patients in poor general health but not for the younger or low risk patients. This report shows the importance of using external radiation in conjuntion with endocavitary radiation, and defines the types of patients who might benefit from this nonresective means of managing rectal cancers. A similar approach was reported by Meyerson and coworkers[12]. Thirty patients received 45 Gy followed 6 weeks later by 30 to 90 Gy with endocavitary irradiation. Their tumors were defined as larger than 3 cm, nonmobile, well or moderately well differentiated, and clinical stage T2 or pathologic stage T3. Deeply ulcerated or infiltrating tumors were excluded. With a median follow-up of 2 years, the local failure rate was 30%, and the 2 year disease-free survival rate

was 42% (55% with salvage). Minor proctitis occured in 17%.

The development of high dose rate afterloading devices with small diameter Iridium-192 sources has reduced treatment time, and narrow diameter applicators can be passed via the nasal cavity without the need for sedation or anesthesia. Because of the high activity of the source it remains in place for only a matter of minutes, and fractionated treatments are feasible. This approach appears to have greater antitumor effect than numerically similar total doses of fractionated external beam treatment. This may be attributable to the large fraction size (5 Gy vs 1.8 to 2 Gy with external beam), which may exceed the repair potential of tumor cells. In addition, there are components of the tumor (closer to the source than the prescription depth) that receive much higher doses than the prescription dose. For esophageal cancer, the value of brachytherapy for palliation is not established. However, there are preliminary data to suggest that it can improve outcome when used routinely after radical treatment with external beam radiation tperapy[13]. Wei-bo Yin from China[4, 5] used total doses of approximately 15 to 30 Gy fractionated HDR-intraluminal brachytherapy as sole therapy of advanced esophageal cancer. No data on palliation were provided, but severe treatment-related pain occured in 66% of 203 patients. Strictures occured in 11% of patients (23 of 203) as a late reaction. Because the overall survival was very poor, the actuarial risk was probably considerably higher. In view of the high toxicity and poor survival of HDR-intraluminal brachytherapy alone, it is probably best to combine it with external radiation therapy when feasible. Also, Sur et al[6] prospectively assigned 50 patients to alternating treatment arms consisting of external radiation therapy with or without a HDR-intraluminal brachytherapy boost. Endoscopic response, freedom from dysphagia, and local control were superior ($p>.05$) in the HDRB-arm. Survival at 1 year was significantly superior in the HDRB-arm. These reports raise the possibility that there may be a valuable role for the routine use of a boost with HDR-intraluminal brachytherapy after external radiation therapy. Consequently, it is best to combine it with external radiation therapy when feasible. Typically, treatment begins with external radiation therapy to induce shrinkage and improve dose distribution with HDR-intraluminal brachytherapy in doses of 50 to 60 Gy, followed by HDR-intraluminal brachytherapy total doses of 10 to 20 Gy. The optimal radiation treatment parameters for HDR-intraluminal brachytherapy for esophageal cancer are not defined. The variables include the dose of external radiation treatment, number of brachytherapy procedures, dose per fraction and depth of prescription, interval between procedures, and total dose. Clearly, it is not possible to make conclusive recommendations about dose fractionation schemes. Hishikawa et al[14] treated 31 patients with 40 to 70 Gy external radiation therapy followed by HDR-intraluminal brachytherapy and reported that ulcers were present in 22 of 23 of patients who had no local recurrence. They described linear ulcers that were superficial and noncircumferential that healed spontaneously in approximately 3 months. Circumferential ulcers were more refractory and in some instances were associated with fistula. There were no association between dose of external radiation therapy and severity of ulceration. However, the total dose of HDR-intraluminal brachytherapy appeared to predict the risk of severe ulceration. Hishikawa et al[15] reported that fistulae are predominantly bronchial or vascular and occured in approximately equal frequency in patients treated with external radiation therapy only (5 of 30, 17%) or Ext. RT plus HDRB (10 of 53, 19%). Of the fistulae occurring after HDRB, half were associated with persistent cancer.

Death or serious long-term morbidity due to esophageal irradiation is uncommon. Occasionally, patients have been reported with radiation pneumonitis, pericarditis, myocarditis, or spinal cord damage. The most frequent complication from esophageal irradiation is stricture. In a recent study by O'Rourke[16], 40% of patients developed a postradiation stricture. The previous report from

the Princess Margaret Hospital[17] suggested that most postradiation strictures that did not quickly resolve with dilation were malignant. In O'Rourke [16]experience, half of the strictures were benign and the survival rate of patients with benign stricture actually exceeded that of patients who experienced no stricture. Not all postradiation stricture heralds the development of recurrent disease; many of these patients can be managed successfully by conservative means[18]. Occasionally, patients present with nonmalignant ulceration in the esophagus, and such events may increase in frequency as high dose rate intraluminal irradiation is used and more concurrent chemotherapy is undertaken. Occasionally, fistula formation, with or without hemorrhage, is seen; these complications usually result from rapid resolution of tumor that has invaded from the esophagus into neighboring trachea, bronchus, or aorta[19]. In our study, all patients were well tolerated. Some patients had only mild acute complications, as the 'radiation esophagitis', except for one case of tracheo-esophageal fistula. Because of shorter follow-up periods, we cannot observe any late complication. There is a tendency of high complication rate with higher dose per fraction and decrease by increasing the number of fraction with similar total dose. Therefore, to evaluate biologic effects of HDRB, we need new clinical trials to test the treatment schedule.

In the rectal cancers, patients selected for our HDRB are usually medically inoperable or have such advanced local disease that resection is not feasible for cure. The Princess Margaret Hospital [20] reported a 2% 5-year acturial survival rate and 91% local failure rate for 67 patients with primary unresectable cancer. More favorable results for 37 patients were reported from Kaiser Permanente[21]. With 24 to 84 months of follow-up, 14% had no evidence of disease, and the local failure rate was 51%. Because of relative small numbers of patients and shorter follow-up periods, we cannot explain the comparison with these classical datas in our study. But, in our study, most complications were acceptable and recovered within a few days. Response rate was 60% with a median follow up period of 19 months, and all patients achieved the palliation effect of pain. Furthermore, HDRB-fraction size and HDRB-total dose had a significant influence on the local. response rate. In these aspects, we will try the efforts of study of total radiation dose and fraction size of HDRB. We need more appropriate selection of group of patients with large numbers of patients and longer follow-up periods, in the future.

In the esophageal cancers, a number of series amounting to more than 450 patients with preoperative irradiation showed local eradication of tumor(or the appearance of nonviable tumor) in about 15% of patients whose tumors were resected after a course of radiation[22-23]. Because about 30% of esophageal cancer-patients present with nonmetastatic disease, one might theorize that the cure rate of esophageal cancer treated with radiation therapy alone could be as high as 5%. This turns out to be the case in the many reported series including a large review of 8500 cases[24]. In several series of patients treated in the 1970s and 1980s, median survival was typically 8 to 10 months, with a 1-year survival rate of about 35%, a 2-year survival rate of about 10% to 15%, and a 5-year survival rate of about 5%[25-29]. Earlam and Cunha-Melo24)reviewed 49 series with over 8400 patients treated primarily with irradiation. They found overall 1-, 2-, and 5-year survival rates of 18%, 8%, and 6%, respectively. They stated that in three series that were comparable to surgical series, the 1-, 2-, and 5-year survival rates ranged from 42% to 46%, 8% to 27%, and 6% to 20%, respectively. These figures are as good as those in most surgical series without the operative mortality rate. In our study, the 2-year survival rate and median survival were 13% and 10 months. These results are comparable to most surgical series and classical datas treated primarily irradiation. Also, there was a trend toward better local response and survival with higher HDRB-total dose and fraction size. It is encouraging results that all patients achieved the palliation effect of odynophagia.

Although the number of patients was not very large and the follow-up period was relatively short, these findings suggested that intraluminal high dose rate brachytherapy, as a adjuvant therapy of external radiation therapy, could be useful in the treatment of the patients with advanced tumors of GI tract.

Therefore, we will study to optimize technique and fraction-schedule for the response and the complications of HDRB, with a large number of patients and the longer follow-up periods.

REFERENCES

1. **Fowler JF.** The Radiobiologic of Brachytherapy: Proc Brachytherapy Meeting Remote afterloading. State of the Art.Martinez AA, Orton CG, Mould RF(eds) 1989; May:121-137
2. **Speiser B.** Advantages of high dose rate remote afterloading system: Physics or Biology. Int J Radiat Oncol Biol Phys 1991; 20:1133-1135
3. **Sischy B.** The use of endocavitary irradiation for selected carcinomas of the rectum: Ten years experience. Radiother Oncol 1985; 4:97-101
4. **Wei-bo Y.** Brachytherapy of carcinoma of the esophagus in China, 1970-1974 and 1982-1984. 1989. Proceedings of the Brachytherapy Meeting Remote Afterloading: State of the Art. Dearborn, Michigan. May 4-6, 1989, Nucletron Corp, Columbia, MD 1992; 52-56
5. **Wei-bo Y.** Brachytherapy of carcinoma of the esophagus in China. Proceedings of the Brachytherapy Working Conference 5th International Selectron Users' Meeting. Hague, The Netherlands. Nucletron International BV Netherlands 1989; 439-441
6. **Sur RK, Singh DP, Sharma SC, et al.** Radiation therapy of esophageal cancer: Role of high dose rate brachytherapy. Int J Radiat Oncol Biol Phys 1992; 22:1043-1046
7. **Nori D.** Clinical applications of high dose rate brachytherapy: Memorial experience, in: Brachytherapy update VIII, 71-104, Memorial-Sloan Kettering: New York, 1988
8. **Freund U, Bruggmoser G, Wannenmacher M.** Indicators for high dose afterloading radiotherapy, in : Proceedings of 2nd.annual international high dose rate afterloading symposium, 55, May, 1987
9. **Papillon J.** Rectal and Anal Cancers: Conservative Treatment by Irradiation - An Alternative to Radical Surgery. Berlin. Springer-Verlag, 1982
10. **Papillon J, Berard P.** Endocavitary irradiation in the conservative treatment of adenocarcinoma of the low rectum. World J Surg 1992; 16:451-457
11. **Morson BC, Bussey HJ, Samoorian S.** Policy of local excision for early cancer of the colorectum. Gut 1977; 18:1045-1050
12. **Myerson RJ, Walz BJ, Kodner IJ, et al.** Endocavitary radiation therapy for rectal carcinoma: Results with and without external beam. Endocurietherapy/Hyperthermia Oncology 1989; 5:195-200
13. **Syed AMN, Feder BH.** Technique of afterloading interstitial implant. Radiological Clinics(Basel) 1977; 46:458-475
14. **Hishikawa Y, Tanaka S, Miura T.** Esophageal ulceration induced by intracavitary irradiation for esophageal carcinoma. Am J Radiol 1984; 143: 269-273
15. **Hishikawa Y, Tanaka S, Miura T.** Esophageal fistula associated with intracavitary irradiation for esophageal carcinoma. Radiology 1986; 159:549-551
16. **O'Rourke IC, Tiver K, Bull C, et al.** Swallowing performance after radiation therapy for carcinoma of the esophagus. Cancer 1988; 61:2022-2026
17. **Beatty JD, Rider WD.** Carcinoma of the esophagus: Pretreatment assessment, correlation of radiation treatment parameters with survival and identification and management of radiation treatment failure. Cancer 1979; 43:2254-2267
18. **Levine MS, Langer J, Laufer I, et al.** Radiation therapy of esophageal carcinoma: Correlation of clinical and radiographic findings. Gastrointest Radiol 1987; 12:99-105
19. **Yang ZY, Hu YH, Gu XZ.** Non-cancerous ulcer in the esophagus after radiotherapy for esophageal carcinoma - a report of 27 patients. Radiother Oncol 1990; 19:121-129
20. **Cummings BJ Jr, Rider WD, Harwood AR, et al.** Radical external beam radiation therapy for adenocarcinoma of the rectum. Dis Colon Rectum 1983; 26:30-36
21. **Rao AR, Kagan AR, Chan PYM, et al.** Effectiveness of local radiotherapy in colorectal carcinoma. Cancer 1978; 42:1082-1086
22. **Kelsen DP, Minsky B, Smith M, et al.** Preoperative therapy of esophageal cancer: A randomized comparison of chemotherapy versus radiation

therapy. J Clin Oncol 1990; 8:1352-1361
23. **Marks R, Scruggs HJ, Wallace KM.** Preoperative radiation therapy for carcinoma of the esophagus. Cancer 1976; 38:84-89
24. **Earlam R, Cunha-Melo JR.** Oesophageal squamous cell carcinoma: II. A critical review of radiotherapy. Br J Surg 1980; 67:457-461
25. **Petrovich Z, Langholz B, Formenti S, et al.** Management of carcinoma of the esophagus : The role of radiotherapy. Am J Clin Oncol[CCT] 1991; 14:80-86
26. **Langer M, Choi NC, Orlow E, et al.** Radiation therapy alone or in combination with surgery in the treatment of carcinoma of the esophagus. Cancer 1986; 58:1208-1213
27. **Okawa T, Kita M, Tanaka M, et al.** Results of radiotherapy for inoperable locally advanced esophageal cancer. Int J Radiat Oncol Biol Phys 1989; 17:49-54
28. **Harrison LB, Fogel TD, Picone JR, et al.** Radiation therapy for squamous cell carcinoma of the esophagus. J Surg Oncol 1988; 37:40-43
29. **Caspers RJ, Welvaart K, Verkes RJ, et al.** The effect of radiotherapy on dysphagia and survival in patients with esophageal cancer. Radiother Oncol 1988; 12:15-23

= 국문 초록 =

위장관 종양의 고선량율 강내 방사선치료

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목 적 : 위장관종양에 대한 고선량율 강내 방사선치료의 결과를 분석하고자 하였다.

방 법 : 가톨릭의대 성모병원 치료방사선과에서는 1991년 2월부터 1993년 7월까지 18명의 수술을 할 수 없는 중증의 위장관종양 환자들(식도암-8, 직장암-10)을 대상으로 Iridium-192을 사용하여 원격조정 고선량율 강내 방사선치료에 대한 후향적 분석을 하였다. 연령 분포는 47-87세로, 평균 71세였다. 모든 환자들은 이전에 수술적 조작을 받은적이 없었고, 외부 방사선치료 이후 2주 이내에 고선량율 강내 방사선치료를 하였으며, 고선량율 강내 방사선치료의 일일 조사량은 3-5 Gy (3-4회/1주), 총 조사량은 12-20 Gy로 평균 17 Gy였다. 외부방사선 총 조사량은 41.4-59.4 Gy로 평균 49.6 Gy였다. 추적기간은 3개월에서 31개월이었고, 중앙추적기간은 19개월이었다.

결 과 : 식도암에서 완전관해와 부분관해는 각각 38%로 같은 결과를 보였으며, 중앙 생존기간과 2년 생존율은 10개월과 13%였다. 직장암 10명 중 60%의 환자에서 부분반응을 보였으며, 완전반응은 없었지만, 모든 환자에서 현저한 증상개선을 보였다. 저자는 고선량율 강내 방사선 일일 조사량 및 총 조사량, 외부방사선 조사량이 국소반응율과 생존율에 미치는 영향을 분석, 조사하였다. 이 중, 고선량율 강내 방사선 일일 조사량 및 총 조사량이 직장암의 국소반응율에 가장 큰 영향을 미쳤으며, 이는 통계적 유의성을 보였다 ($p<0.05$). 식도암에서는 고선량율 강내 방사선 총 조사량이 국소반응율과 생존율에 각각 영향을 미쳤으나, 이는 통계적 유의성은 없었다. 또한, 외부방사선 조사량은 모든 환자에게서 국소반응율과 생존율에 영향을 미치지 않는 것으로 나타났다. 모든 환자들에게서 치료 후 현저한 증상개선을 보였으며, 합병증은 대부분의 환자에서 발생하였는데, 대개의 경우 그 증상이 미비하였고, 수일 이내에 회복되었다.

결 론 : 이 논문에서는 상대적으로 짧은 추적기간과 적은 수의 환자들을 대상으로 분석을 하였으나, 고선량율 강내 방사선치료 조작은 위장관 종양의 치료에서 외부 방사선치료의 추가적 요법으로 사용할 수 있을 것으로 생각된다.