

One noteworthy finding of the present study was that a short interval between the initial operation and the diagnosis of LR was a predictor of worse prognosis. This may indicate that there are specific biological features controlling the aggressive nature of a rapidly growing tumor.

Wanebo et al.¹⁰ found that neither the stage of the primary tumor nor the disease-free interval correlated with survival after the resection of recurrent rectal cancer. Hahnloser et al.¹¹ also reported that the demography of the patients and the factors related to the initial rectal cancer did not affect the outcome of patients with locally recurrent rectal cancer. In contrast, our univariate analysis indicated that lymph node status and tumor differentiation of the primary tumor were associated with patient survival. Cox regression analyses confirmed that lymph node status and the histological type of the primary tumor contributed to improved prognosis after resection of LR.

The pattern of recurrence was also a predictor of survival, with the perianastomotic site being the most common (30.9%) in the present study. Previous reports define anastomotic recurrence as recurrence within 2 cm of the suture line and with no extramural spread.^{3,16} The incidence of this type of recurrence ranges from 6% to 21%.^{2,17,22,23} The higher rate of this pattern of recurrence recorded in our series is related to the fact that our definition of perianastomotic recurrence was more inclusive than that of previous reports.

An additional factor that may influence the outcome is distant metastasis. In our institute, the selection criteria for surgery for metastatic lesions were the possibility of an oncologically radical operation while preserving at least 40% of the normal hepatic parenchyma. The total number of hepatic metastases, their unilateral or bilateral presentation, and the existence of extrahepatic metastases were not considered to be exclusion criteria. Concurrent distant metastases were found in 21% of our patients with LR. According to previous reports, the presence of metastatic disease is a contraindication for surgery,^{24,25} although Gagliardi et al.⁵ reported that patients with small liver and peritoneal metastasis amenable to resection had an outcome similar to those with no metastasis. It is interesting that the presence of synchronous distant metastasis at the time of diagnosis of LR did not affect patient survival. Accordingly, we found that evidence of distant metastasis did not affect the survival rate. Therefore, patients with concurrent distant metastasis may also be candidates for surgical resection.

On the basis of these findings, salvage surgery is strongly recommended for patients with negative lymph node metastasis at their initial operation, well or moderate tumor differentiation of the primary tumor, and perianastomotic recurrence, even in the presence of

distant metastasis. The decision to operate on patients who fall outside these criteria requires careful consideration to minimize unnecessary surgery.

In conclusion, salvage surgery for locally recurrent rectosigmoid colon and rectal cancer may be beneficial depending on the following pathological characteristics: tumor differentiation and nodal status of the primary tumor, the interval between the initial operation and the diagnosis of recurrence, and the pattern of recurrence.

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Bladder-Sparing Extended Resection of Locally Advanced Rectal Cancer Involving the Prostate and Seminal Vesicles

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Abstract

Purpose. Total pelvic exenteration (TPE) is the standard procedure for locally advanced rectal cancer involving the prostate and seminal vesicles. We evaluated the feasibility of bladder-sparing surgery as an alternative to TPE.

Methods. Eleven patients with advanced primary or recurrent rectal cancer involving the prostate or seminal vesicles, or both, underwent bladder-sparing extended colorectal resection with radical prostatectomy. The procedures performed were abdominoperineal resection (APR) with prostatectomy ($n = 6$), colorectal resection using intersphincteric resection combined with prostatectomy ($n = 4$), and abdominoperineal tumor resection with prostatectomy ($n = 1$). Local control and urinary and anal function were evaluated postoperatively.

Results. Cysto-urethral anastomosis (CUA) was performed in seven patients and catheter-cystostomy was performed in four patients. Coloanal or colo-anal canal anastomosis was also performed in four patients. There was no mortality, and the morbidity rate was 38%. All patients underwent complete resection with negative surgical margins. After a median follow-up period of 26 months there was no sign of local recurrence, and ten patients were alive without disease, although distant metastases were found in three patients. Five patients had satisfactory voiding function after CUA, and three had satisfactory evacuation after intersphincteric resection (ISR).

Conclusion. These bladder-sparing procedures allow conservative surgery to be performed in selected patients with advanced rectal cancer involving the prostate or seminal vesicles, without compromising local control.

Key words Locally advanced rectal cancer · Total pelvic exenteration · Bladder-sparing surgery · Local control

Introduction

Locally advanced rectal cancer sometimes invades the prostate, seminal vesicles, and trigone of the urinary bladder. Total pelvic exenteration (TPE) is the standard procedure performed for patients with this type of rectal cancer.¹⁻⁷ Total pelvic exenteration involving en bloc removal of the rectum, urinary bladder, distal ureters, and reproductive organs may be performed with curative intent, with negative surgical margins.⁴ However, these patients often require one stoma for urinary diversion, such as an ileal conduit or a uretero-cutaneousomy,⁸⁻¹⁰ and an additional stoma for fecal diversion. This procedure results in double stomas and compromises quality of life severely, despite achieving acceptable locoregional control. Recent advances in sphincter-saving surgery for lower rectal cancer have allowed colo-anal canal and colo-anal anastomoses to be performed without adversely affecting outcome.¹¹⁻¹⁷ Orthotopic neobladder construction has also become standard following cystoprostatectomy for invasive bladder cancer.¹⁸⁻²⁰ This procedure represents a feasible alternative for patients undergoing radical cystectomy-prostatectomy, allowing them to void via the urethra with urinary continence. Moreover, it is a well-accepted technique with excellent results on long-term follow-up.¹⁸ Together, these advances may improve postoperative quality of life for patients with advanced rectal cancer requiring TPE,²¹ by enabling an operation to be performed without a stoma or with only a single stoma. Until recently, bladder-sparing surgery was thought to be possible only for patients without invasion over a wide range of the bladder and the membranous urethra. However, extended colorectal resection with partial

preservation of the bladder or anal sphincter, or both, may be possible if cancer-free surgical margins can be achieved. Campbell et al. recommended combined radical retropubic prostatectomy and proctosigmoidectomy as an alternative to TPE for patients with carcinoma of the rectum with isolated extension to the prostate gland or seminal vesicles.²² They also described two patients who underwent radical retropubic prostatectomy in conjunction with restorative proctosigmoidectomy for en bloc excision. These approaches have been explored as alternatives to TPE in patients with locally advanced primary rectal cancer at our institute since 2000. These procedures also have been performed recently in selected patients with local recurrence after rectal cancer surgery. This study examines the oncological findings of 11 patients who underwent bladder-sparing surgery as an alternative to TPE. We evaluated the feasibility of, and rationale for bladder-sparing surgery in patients with advanced rectal cancer involving the prostate or seminal vesicles, or both.

Patients and Methods

Patients

The subjects were 11 men with advanced primary or recurrent rectal cancer involving the prostate or seminal vesicles, or both, who underwent extended bladder-sparing colorectal resection between January 2001 and October 2005. The mean patient age at the time of surgery was 58.6 years (range, 26–72 years). Eight patients underwent surgery for primary tumors, and three underwent surgery for local recurrence after abdominoperineal resection (APR; $n = 1$), low anterior resection (LAR; $n = 1$), or anterior resection (AR; $n = 1$) of advanced rectal cancer. In all cases, the preoperative diagnosis was primary or recurrent rectal cancer invading the prostate or seminal vesicles. Preoperative staging was conducted using computed tomography (CT), magnetic resonance imaging (MRI), colonoscopy, and barium enema. Positron emission tomography (PET) was also done preoperatively to exclude multiple metastatic disease. All patients had localized tumors involving the prostate or seminal vesicles without distant metastases or marked pelvic lymph node metastasis. There was no evidence of urinary bladder involvement in any of the patients. All resected specimens were examined macroscopically and microscopically to determine the radial and distal surgical margins and lymph node metastases. Involvement of the adjacent organs and margins of surgical resection, perioperative morbidity and mortality, and locoregional control were investigated in all patients. Urinary and anal functions were also evaluated postoperatively by careful monitor-

ing of continence and voiding habits. Locoregional failure was defined as recurrence of rectal cancer within the pelvic cavity. Other recurrences were considered distant disease.

Surgical Technique for Primary Tumors

The left colon was mobilized and the inferior mesenteric artery was transected. The posterior and bilateral sides of the rectum were mobilized by total mesorectal excision (TME) with lateral lymph node dissection. The superior vesical arteries were preserved bi- or unilaterally. The pelvic nerve plexus and almost all of the internal iliac vessels, except for the bi- or unilateral superior vesical arteries, were sacrificed during lymph node dissection. The ureters were visualized and carefully protected throughout the procedure. At this time, the plane between the rectum and the base of the bladder was investigated. After confirming that these were no severe adhesions or obvious tumor involvement cephalad to the prostate, bladder-sparing surgery was deemed possible. We dissected the prostate and seminal vesicles using the usual method for radical prostatectomy, to preserve the urinary bladder. After the puboprostatic ligaments were incised sharply at the pubis and the dorsal vein complex was ligated using the bunching technique, the apex of the prostate was divided from the urethra. The prostatic vesical junction was also transected, and the entire prostate and seminal vesicles were separated from the bladder. Using the peranal approach for intersphincteric resection (ISR) or the perineal approach for APR, we performed en bloc removal of the rectum with the prostate and seminal vesicles. The membranous urethra and bladder were preserved and the bladder neck was reconstructed. An anastomosis between the urethra and bladder was done after confirmation of cancer-free margins in the resected specimen. When the membranous urethra was sacrificed for probable tumor involvement, a cystostomy was created for voiding with a catheter. Finally, a colo-anal anastomosis (CAA) with a diverting stoma or permanent colostomy was established. The diverting stoma was closed 3 months after radical surgery. The line of resection and final appearance of the reconstruction are shown in Fig. 1. Intraoperative histological examination was done using frozen sections if tumor invasion was suspected in the surgical margins, and the operative procedure was converted to TPE if cancer-free margins were not confirmed.

Adjuvant Therapy

Although preoperative radiochemotherapy for resectable rectal cancer is not standard protocol in Japan, four patients agreed to undergo preoperative radiochemo-

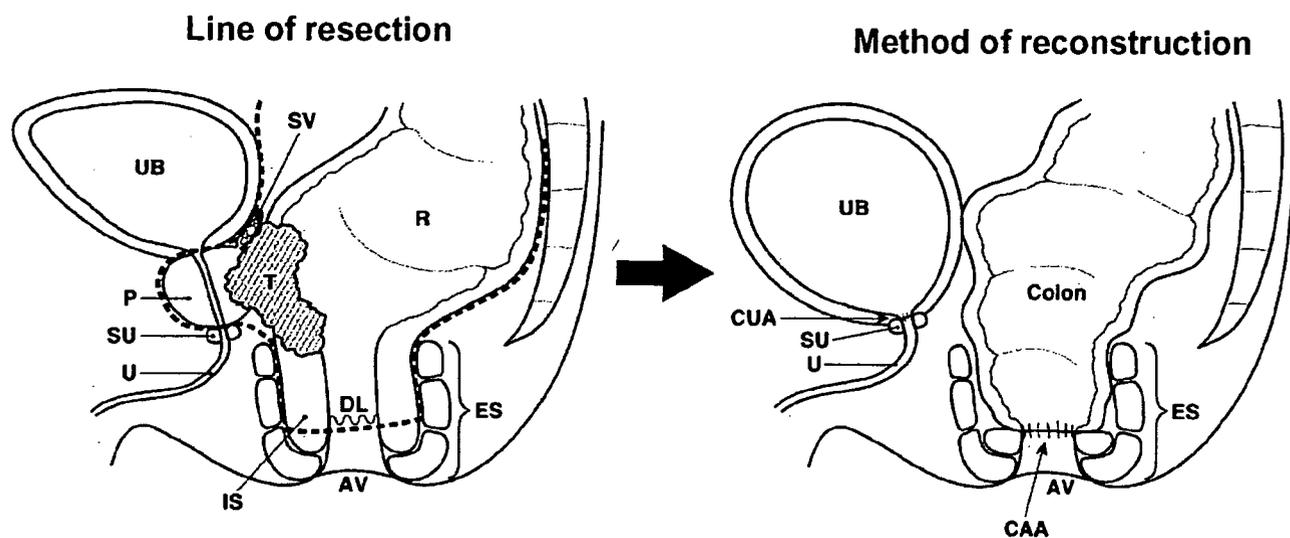


Fig. 1. Line of resection and method of reconstruction in the bladder-sparing surgery described in Materials and Methods. SV, seminal vesicle; UB, urinary bladder; P, prostate; SU, sphincter urethrae; U, urethra; R, rectum; T, tumor; DL,

dentate line; AV, anal verge; IS, internal sphincter; ES, external sphincter; CUA, cyst-urethral anastomosis; CAA, colo-anal anastomosis

therapy according to our previous protocol.¹⁶ These patients received 45 Gy over a 5-week period, followed by resection 2 weeks or more later. These four patients were also given 5-fluorouracil (5-Fu; 250 mg/m²/day) as a continuous infusion during radiotherapy to enhance the radiotherapeutic efficacy. Postoperative chemotherapy (5-Fu/Leucovorin (LV) therapy) was offered to patients if the final pathological specimen was node-positive. If the margins were cancer-free without lymph node metastasis, chemotherapy was not given.

Follow-Up

Follow-up examinations were done every 3 months for 2 years postoperatively, then every 6 months thereafter. Patients underwent clinical examination, laboratory tests, including measurement of tumor markers, radiological investigations, including liver and pelvic CT, and chest radiography, and evaluation of continence status for urinary and anal function. These functional results were investigated using a questionnaire on the degree of satisfaction with voiding and bowel functions based on continence, frequency, soiling, and urgency, determined by the ability to defer evacuation for 15 min. These functions were evaluated 3, 6, 12 and 24 months postoperatively. Physiological assessment was also done using anal manometry and uroflowmetry. The median follow-up period was 26 months (range, 4–60 months). No patient was lost to follow-up.

In this series, statistical analyses were not performed because of the small number of patients.

Results

We performed bladder-sparing surgery for locally advanced rectal carcinoma in 11 men with a mean age of 58.6 years (range 26–72 years). Only one patient ultimately required TPE for a huge tumor invading the wide area of the urinary bladder, the prostate, and the anal sphincter. All 11 patients were originally considered candidates for TPE, and their clinical characteristics are shown in Table 1. They all had preoperative findings of primary or recurrent rectal cancer with extension into the prostate or seminal vesicles, or both. No extrapelvic metastases were found on pre- or intraoperative examination. Three patients underwent surgery only, five received preoperative radiochemotherapy, and three received postoperative chemotherapy. The types of bladder-sparing surgery performed were APR combined with radical prostatectomy in six patients, anal sphincter-preserving surgery (ISR: 3, ultraLAR: 1) combined with radical prostatectomy in four, and abdominoperineal tumor resection with radical prostatectomy in one. A diverting stoma was established in all of the patients who underwent anal sphincter-preserving surgery. CUA was performed in seven patients, and catheter-cystostomy was performed in four patients in whom the urethral sphincter muscle could not be preserved. Thus, these four patients had colo-anal anastomoses and CUAs instead of stomas (Table 1). Although the operative procedures were not converted to TPE, a cystostomy was performed for four patients with intraoperative histo-

Table 1. Patients and surgical procedures

Patient no.	Age (years)	Invaded organs	Surgical procedure	Reconstruction	
				Urinary	Fecal
Primary					
1	60	P · SV	ISR + RP	CUA	CAA
2	60	P · SV	APR + RP	CUA	Stoma
3	72	P	APR + RP	CUA	Stoma
4	66	P	ISR + RP	CUA	CAA
5	57	P	APR + RP	CS	Stoma
6	43	P	APR + RP	CS	Stoma
7	52	P	APR + RP	CS	Stoma
8	68	P	ISR + RP	CUA	CAA
Recurrent					
9 (Post LAR)	52	P	APR + RP	CS	Stoma
10 (Post APR)	54	P · SV	APTR + RP	CUA	Stoma
11 (Post AR)	26	P · SV	Ultra LAR + RP	CUA	Ultra LAR (DST)

P, prostate; SV, seminal vesicle; ISR, internal sphincteric resection; APR, abdominoperineal resection; LAR, low anterior resection; AR, anterior resection; RP, radical prostatectomy; APTR, abdominoperineal tumor resection; CUA, cysto-urethral anastomosis; CS, cystostomy; CAA, colanal anastomosis; DST, double stapling technique

Table 2. Histopathology and prognosis

Patient no.	Tumor stage	Invaded organs	Surgical margins	Site of recurrence	Survival
1	T3 N0 M0	—	Negative	Liver → resection	60mo ANED
2	T3 N0 M0	—	Negative		41mo ANED
3	T4 N0 M0	P	Negative		31mo ANED
4	T3 N2 M0	—	Negative	Liver → resection	30mo ANED
5	T4 N0 M0	P	Negative	Lung (multiple)	27mo AWD
6	T4 N0 M0	P	Negative		25mo ANED
7	T4 N2 M0	P	Negative		22mo ANED
8	T4 N0 M0	P	Negative		13mo ANED
9	Recurrence	P	Negative		22mo ANED
10	Recurrence	SV	Negative		12mo ANED
11	Recurrence	P · SV	Negative		4mo ANED

P, prostate; ANED, alive with no evidence of disease; AWD, alive with disease; mo, months

logical evidence of cancerous invasion of the membranous urethra.

There were no perioperative deaths, but five patients suffered perioperative complications. A cysto-urethral anastomotic leak developed in four patients, requiring catheterization through the site of the anastomosis for 3–24 weeks postoperatively; however, no urethral stricture developed. A wound infection developed in three patients, but resolved with local wound care.

All resected margins were examined pathologically and reported to be tumor-free; however, final pathological examination revealed involvement of the prostate or seminal vesicles in eight patients. According to pathological staging by TNM classification in the eight primary rectal cancers, four tumors were T4N0, one was T4N2, and three were T3N0. The three patients with recurrent tumors also underwent surgery with curative intent. Complete resection with negative surgical

margins was achieved in all patients with a primary or recurrent tumor.

After follow-up ranging from 4–60 months (median, 26 months), ten patients were alive without evidence of disease, and one was alive with disease. Recurrence developed in three patients, as a solitary liver metastasis in two and as multiple lung metastases in one. The two patients with solitary liver metastasis underwent curative partial hepatic resection, and the patient with multiple lung metastasis refused chemotherapy. None of the patients had local recurrence (Table 2).

Functional outcomes were evaluated in nine patients who were followed up for at least 12 months postoperatively (Table 3, 4). Five of the patients who underwent CUA were able to void via the urethra, with little or no residual urine (0–20 ml) and without the need for intermittent self-catheterization. All five patients had complete daytime urinary continence. Overflow incontinence

Table 3. Postoperative urinary functions (more than 12 months after surgery)

Patient no.	Reconstruction	Voiding	VV (ml)	RV (ml)
1	CUA	Spontaneous, continence	350	0
2	CUA	Spontaneous, continence	250	0
3	CUA	Spontaneous, continence	300	20
4	CUA	Spontaneous, continence	150	15
5	CS	Incontinence		Catheterization
6	CS	Incontinence		Catheterization
7	CS	Incontinence		Catheterization
8	CUA	Spontaneous, continence	250	10
9	CS	Incontinence		Catheterization

CUA, cysto-urethral anastomosis; VV, voided urine volume; RV, residual urine volume; CS, cystostomy

Table 4. Postoperative fecal evacuation functions (more than 12 months after surgery)

Patient no.	Continence	Stool frequency	Feces-flatus discrimination	Urgency	Soiling
2	(+)	3/day	Good	(-)	Night-time (-) Day-time (-)
4	(+)	3-5/day	Good	(±)	Night-time (-) Day-time (-)
8	(+)	5/day	Good-Fair	(±)	Night-time (±) Day-time (-)

at night was occasionally experienced during the first year postoperatively, but this improved in the second year. Excretory urography demonstrated excellent urinary function bilaterally with no evidence of hydronephrosis. Retrograde cystography did not show reflux in any of the five patients (Fig. 2). The four patients who underwent catheter-cystostomy passed urine via an inserted catheter. This voiding style was similar to that of patients with an ileal conduit; however, no special outfits were needed after catheter-cystostomy. Unfortunately, erectile function was not able to be preserved in any of the patients.

Of the three patients who underwent ISR with radical prostatectomy, none experienced major soiling or incontinence, although one patient suffered occasional minor soiling for about 1 year after closure of the diverting stoma. These patients passed fewer than five bowel movements per day and could discriminate feces from flatus by 1 year after stoma closure (Table 4). Anal function tended to improve slowly during the second year after surgery. Stoma closure is planned for the remaining patient.

Discussion

Locally advanced rectal cancer with adherence to, or involvement of the adjacent organs is not uncommon. En bloc excision of locally invasive rectal cancer

without extrapelvic metastases can be curative, and TPE is still the conservative surgical option for locally advanced pelvic tumors, to achieve negative surgical margins in selected patients. This radical procedure was originally performed in the Ellis Fischel Cancer Center in the 1940s and was first reported by Brunschwig in 1948 as "a palliative operation for advanced cervical cancer"²³. This formidable intervention carried with it high morbidity and mortality rates^{5,6}. However, recent published series have reported mortality rates of lower than 10%, even with long-term follow-up^{4,6,24,25}. Unfortunately, morbidity rates are still relatively high. TPE involving en bloc removal of the rectum, urinary bladder, distal ureters, and reproductive organs frequently requires diversion of urinary and anal functions, such as combined sigmoid colostomy and ileal conduit placement. TPE resulting in double stomas severely compromises the quality of life of these patients. Thus, orthotopic neobladder surgery is often attempted as an alternative for patients undergoing radical cystectomy for bladder cancer, to enable voiding via the urethra with urinary continence^{7,21}. Sphincter-preserving operations with colo-anal anastomoses are also attempted for patients with distal rectal cancer.

We believe that even more limited excision is feasible and preferable if the tumor can be removed en bloc. In patients with locally advanced rectal cancer and invasion limited to the prostate or seminal vesicles, extended



Fig. 2. Postoperative urogram findings in patients who underwent cystourethral anastomosis showed no evidence of hydronephrosis or reflux. Left Patient 1, 40 months after surgery.

Excretory urography shows no hydronephrosis. Right Patient 4, 6 months after surgery. Retrograde cystogram demonstrates a relatively small capacity (about 280 ml) and no reflux

colorectal resection with partial preservation of the bladder and anal sphincter may be possible, provided cancer-free margins can be achieved. Balbay et al. wrote: "Bladder-sparing surgery to treat patients with locally invasive colorectal carcinoma provides good local control without sacrificing survival. Selected men in whom CT and intraoperative evaluation identifies only localized involvement of the prostate or seminal vesicle appear to be reasonable candidates for bladder-sparing procedures"²². These procedures without ISR were first reported by Campbell et al. in 1993. In their experience of two patients, en bloc excision yielded negative surgical margins with no evidence of local recurrence at 1-year follow-up examination, and the patients displayed satisfactory control of intestinal and voiding function^{22,27}. Although no long-term follow-up evaluation was reported, if adequate surgical margins can be achieved without total cystectomy, local and distant failure rates will not be diminished by cystectomy and urinary diversion.

In the present series, negative surgical margins were obtained in all patients by using en bloc resection combined with radical prostatectomy, even in the three patients with local pelvic recurrence of colorectal cancer. No standards for the treatment of locally recurrent rectal cancer have been established. Local recurrence close to or involving nearby pelvic organs after APR

often cannot be resected with negative margins unless TPE is performed. Fortunately, negative surgical margins were obtained by bladder-sparing surgery in these three patients with local recurrence involving the prostate or seminal vesicles, or both. Despite our concerns about the risk of local recurrence after limited excision to preserve the superior or inferior bladder vessels to supply the residual bladder, no local recurrence was seen during follow-up (median, 26 months). Moreover, the patients who underwent CUA reported satisfactory control of voiding function. Their voiding style was similar to that of patients with an ileal neobladder. Unfortunately, the remaining four patients required cystostomy after preservation of the membranous urethra was deemed impossible because of probable cancerous invasion. These patients voided via an inserted catheter without special outfits, much like patients with an ileal conduit. An obvious difference between neobladder surgery and bladder-sparing surgery is that the neobladder is made using intestine, which presents inevitable long-term complications such as mucinous production, nutritional abnormalities, metabolic acidosis, skeletal demineralization, and the risk of malignant transformation in the intestinal segment^{27,29}. No such problems are associated with the bladder-sparing surgery we described because the original bladder is preserved.

Anal sphincter-preserving surgery using ISR or ultra LAR was performed in 4 of these 11 patients, 3 of whom reported satisfactory control of anal function, while the others reported occasional minor soiling and other functional disturbances such as urgency, fragmentation, and frequent bowel movements. In our experience, and that of other authors, curability and acceptable anal function can be achieved with ISR in patients with very low rectal tumors¹²⁻¹⁷. Attempts should be made to preserve the anal sphincter, partially or completely, whenever possible.

In this series, the bladder was preserved successfully in eight men, by performing prostatectomy without compromising local control, even though these patients had been considered candidates for standard TPE. Bladder-sparing surgery seems to be an appropriate procedure for patients with locally advanced colorectal cancer involving the prostate or seminal vesicles, or both, without urinary bladder invasion, extensive pelvic nodal metastasis, or distant metastasis. Exploration was necessary to determine if limited en bloc resection of invasive rectal cancer was feasible, since discrimination between cancerous involvement and inflammatory adhesions is very difficult intraoperatively, although preoperative imaging examinations such as CT, MRI and PET can be helpful. We recommend careful intraoperative examination using frozen sections to evaluate the extent of pelvic invasion, and to determine whether limited resection is possible. However, intraoperative decisions based on frozen sections may carry some risk, since tumor exposure can occur and convert a potentially curative resection into a non-curative resection. However, if the bladder and anal sphincter are spared, the procedures described offer several advantages over TPE. We think that these procedures may yield improved functional results without compromising local control. More experience and longer follow-up evaluations are necessary to define the operative morbidity, risk of recurrence, and functional results associated with these surgical procedures.

Acknowledgments. This study was supported in part by Third-Term Comprehensive Control Research for Cancer grant #031 from the Ministry of Health, Labor, and Welfare of Japan. We also thank the staff of the Department of Pathology at our institute for the pathological investigations in this study.

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Laser Doppler assessment of the influence of division at the root of the inferior mesenteric artery on anastomotic blood flow in rectosigmoid cancer surgery

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Accepted: 30 August 2006 / Published online: 3 November 2006
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Abstract

Aims The aim of this study is to evaluate the influence of dividing the inferior mesenteric artery (IMA) and preserving the left colic artery (LCA) on rectosigmoid cancer surgery. **Patients and methods** Colonic blood flow at the proximal site of the anastomosis was measured by laser Doppler flowmetry in 96 patients with cancer of the rectum and sigmoid colon while clamping IMA or LCA. Results were analyzed with patient characteristics and postoperative complications. **Results** Blood flow was significantly decreased by either IMA or LCA clamping, and its reduction rate was $38.5 \pm 1.8\%$, ranged from 0 to 82.8%, or $16.4 \pm 1.8\%$, ranged from 0 to 66.2%, respectively. For multivariate analyses, aging and male gender were predictive factors of high blood flow reduction by IMA clamping. The reduction rate was significantly correlated with aging in male patients, while no such correlation was observed in women. Aging correlation in men was more significant in ultralow anterior resection cases. Three elderly male patients received IMA high ligation among 19 patients who demonstrated more than 50% blood flow reduction by IMA clamping. Among these, two patients, those who underwent ultralow anterior resection, suffered severe anastomotic ischemia.

Conclusions Colonic blood flow at the proximal site of the anastomosis was significantly decreased by either IMA or LCA clamping. Patients with high reduction by IMA clamping need intraoperative efforts to prevent anastomotic ischemia, particularly in elderly male patients who undergo ultralow anterior resection.

Keywords Laser Doppler flowmetry · Inferior mesenteric artery · Colorectal surgery · Anastomosis · Ischemia

Introduction

The most considerable complication in sphincter-saving operation for cancer of the rectum is anastomotic dehiscence, which has been reported with an incidence of 6–11% [1, 2], despite the fact that more than 20 years have passed since double stapling technique was employed. Meanwhile, the incidence of anastomotic leakage in colon cancer surgery is approximately 1% [3, 4]. One of the most important factors that influence the healing of the anastomosis is the intestinal microcirculation. The discrepancy in this incidence of anastomotic failure might be associated with difference in surgical anatomy. In colon cancer surgery, both sides of the bowel that are used for the anastomosis are mobile and bowel resection line is determined by the level of vessel division; therefore, adequate anastomotic blood flow is relatively easy to obtain. On the contrary, in rectal cancer surgery, the distal side of the bowel used for the anastomosis is frequently fixed in the pelvis. Therefore, the preservation of a long colonic segment proximal to the anastomosis is mandatory to ease anastomotic tension. Ultralow anterior resection (uLAR), which has recently been widely adopted in cancer surgery of the anorectal junction, has expanded the

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indications for sphincter-preserving surgery [5]. Especially in this operation, blood flow in the colon proximal to the anastomosis may occasionally decrease.

From a practical point of view, main root or branches of the inferior mesenteric artery (IMA), which are the main feeding vessels to the sigmoid or descending colon used for the anastomosis, are sacrificed during lymph node dissection. When the root of the IMA is divided, blood supply to the proximal colon used for the anastomosis is completely dependent on the marginal artery from the superior mesenteric artery (SMA). In case of insufficient blood supply from the marginal artery, the proximal colon used for the anastomosis becomes ischemic, which may lead to leakage. In these types of cases, the left colic artery (LCA) is occasionally preserved to obtain adequate blood supply in Japanese colorectal cancer divisions. To the best of our knowledge, no previous study has assessed the influence of LCA preservation on anastomotic blood flow.

Several intraoperative methods may be used to diminish the likelihood of colonic ischemia. Laser Doppler flowmetry (LDF) is a convenient method to measure intestinal blood flow during routine surgeries because of its ease of application [6, 7]. The aims of the present study are to use LDF measurements to assess the influence of IMA ligation and LCA preservation on blood flow in the colon proximal to the anastomosis and to elucidate predictive factors for anastomotic ischemia in cancer surgery of the rectum and sigmoid colon.

Patients and methods

Patients

Ninety-six Japanese patients (54 men and 42 women) with a mean age of 63.4 years old (range 40–85 years) and histologically documented cancer of the rectum and sigmoid colon were eligible for the study. Patients were candidates for curative surgery in Department of General Surgery, Graduate School of Medicine, Chiba University, Japan, between April 1999 and March 2004. Table 1 shows patient characteristics, and none of the patients displayed a history of severe concomitant diseases, intestinal obstruction, or any other abdominal operations besides appendectomy. None of our patients were malnourished preoperatively, as defined by the presence of anemia (hemoglobin < 11 g/dL), hypoalbuminemia (serum albumin < 3 g/dL) or weight loss (> 10% of preillness body weight). Among 21 patients with cardiac or vascular disease, 19 patients needed medication for hypertension and two had previous history of angina pectoris. Four patients had diabetes mellitus and one patient was insulin-dependent. Twenty-one patients had a smoking habit. No patients had steroid medication. All patients underwent preoperative

Table 1 Patients' characteristics

IMA ligation	High group (n=47)	Low-A group (n=29)	Low-B group (n=20)	Total (n=96)
Gender (M/F)	27/20	19/10	8/12	54/42
Age (mean, range)	64.0, 48–84	62.3, 40–80	63.9, 44–85	63.4, 40–85
Location				
Sigmoid colon	10	6	4	20
Upper rectum	10	9	3	22
Middle rectum	8	8	6	22
Lower rectum	19	6	7	32
Operation method				
SR	5	3	2	10
HAR	10	6	4	20
LAR	14	17	7	38
uLAR (DST/TAA)	8/3	2/0	4/1	14/4
APR	7	1	2	10
Anastomosis (straight/side-to-end/J pouch)	29/7/4	25/2/1	12/5/1	66/14/6
Covering stoma (%)	4 (10.0)	2 (7.1)	1 (5.6)	7 (8.1)
Preoperative irradiation (%)	5 (10.6)	1 (3.4)	0 (0)	6 (6.3)
Cardiac or vascular disease (%)	13 (27.6)	5 (17.2)	3 (15.0)	21 (21.9)
Diabetes mellitus (%)	3 (6.4)	1 (3.4)	0 (0)	4 (4.2)
Insulin dependent (%)	1 (2.1)	0 (0)	0 (0)	0 (0)
Smoking (%)	11 (23.4)	6 (20.6)	5 (25.0)	21 (21.9)

DST double stapling technique, TAA transanal anastomosis

mechanical preparation with polyethylene glycol and received intraoperative catheter placement for epidural anesthesia. Preoperative radiation administered in this study consisted of 42.6 Gy over a period of 4–5 weeks, as previously reported [8]. The present study was approved by the institutional review boards, and full written consent was obtained from all patients.

Laser Doppler measurements

The laser Doppler system (model ALF21, time constant 3 s, Advanced Laser Flowmeter, Tokyo, Japan), which was 2 kg in weight and convenient for mobile use, was employed using semiconductor laser light with a wavelength of 780 nm. The laser light was guided to the tissue, and backscattered light was detected with a master probe (type H, Advanced Laser Flowmeter). This method relies on the measurement of Doppler frequency shifts in laser light reflected from moving red blood cells. Results are displayed after conversion to units in milliliters per minute per 100 g. Each measurement was performed in a minimum period of 30 s until stable data were obtained. The procedure was repeated two times. The mean of the three values was used as the tissue blood flow. When these three values were significantly discrepant, additional measure-

ments were obtained until values became stable. Anesthesiologists were asked to avoid drug administration through epidural anesthesia before these measurements.

Operative procedures

uLAR was defined as an operation in which the anastomosis is within 2 cm from the dentate line. By surgeon's preference, the J pouch was constructed in patients with uLAR, and a side-to-end anastomosis was performed in patients with low anterior resection (LAR) and uLAR. The length of the J pouch was usually 7–8 cm, and the anastomotic site in the side-to-end anastomosis was 3–4 cm proximal from the transection line.

Tumor stagings were assessed by preoperative computed tomography, magnetic resonance imaging or endoscopic ultrasonography. High ligation of the IMA was defined as dividing the IMA above the origin of the LCA. In contrast, low ligation was defined as division below the origin of the LCA. High ligation of the IMA was indicated for patients with suspicion of regional lymph node metastasis (more than 10 mm in long axis) (high group) (Fig. 1). Patients diagnosed with TMN stage II tumors were candidates for lymph node dissection around the root of IMA with selective LCA preservation (low-A group). Patients diagnosed with TMN stage I tumors were candidates for IMA low ligation without lymph node dissection around the root of the IMA (low-B group). The LCA was not exposed in this group. Therefore, the sigmoid artery was occasionally preserved in addition to the LCA. A diverting ileostomy or colostomy was constructed in patients who underwent transanal suture anastomosis or received preoperative irradiation, or in those considered as high risk for leakage.

Blood flow recordings during clamping of the IMA

Blood flow recordings were taken after mobilization of the left colon. The IMA, the superior rectal artery (SRA) and LCA were exposed in the high and low-A groups, while these arteries were not exposed but identified by pulsation in the low-B group. The colon and mesocolon were clamped at approximately 2 cm anal side from the planned proximal transection line with a bowel clamp to shut the ascending blood flow along the intestinal wall and the marginal artery, which originated from the middle or lower rectal artery. A blood flow recording probe was then placed on the antimesentery close to the planned bowel proximal transection. The proximal transection line was usually determined approximately 10–15 cm orally from the proximal edge of the tumor according to the vasculature. In patients whose tumor was in the lower rectum, the planned resection line was usually determined at approximately 10–15 cm proximal from the level of peritoneal reflection, even if they underwent uLAR or abdominoperineal resection (APR). Recordings were performed during clamping of the IMA by a vessel clamp. The laser Doppler probe was held manually without pressure against the serosa to avoid motion artifacts.

Blood flow recordings during clamping of the LCA

After the IMA was unclamped, the SRA was clamped at a point within 1 cm distal to the LCA branching. When the LCA branched from the sigmoid artery or when the sigmoid artery branched from the LCA, the sigmoid artery was clamped by another vessel clamp without severing blood flow from the LCA. Blood flow at approximately the same site used in measurements with clamping of the IMA was recorded before and after clamping of the LCA. The

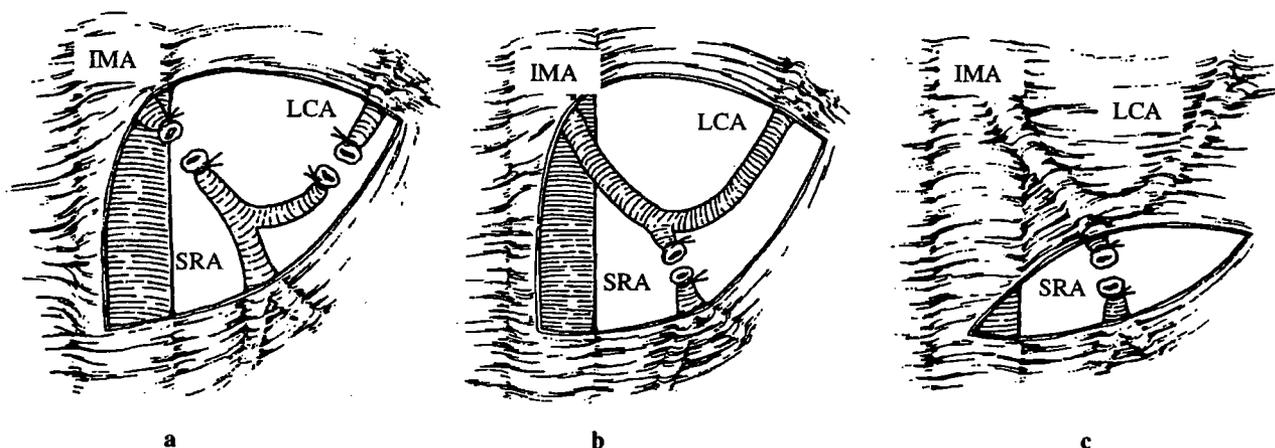


Fig. 1 Types of arterial ligation and lymph node dissection. **a** High group, IMA was ligated at the root with lymph node dissection; **b** low-A group, LCA was selectively preserved with lymph node dissection

around the root of IMA; **c** low-B group, LCA was preserved without lymph nodes dissection around the root of IMA

planned proximal transection line of the colon and mesocolon was clamped during all measurements.

Correlation between blood flow and postoperative complications

Postoperative anastomotic complications were assessed in a total of 86 patients, which excluded 10 patients who underwent APR. Postoperative radiological examination of the anastomosis was not routinely performed in our institution. Therefore, anastomotic leakage was recognized when it was clinically evident. Anastomotic stenosis was defined when intervention, such as endoscopic dilatation or reoperation, was needed. In addition, patients with more than 50% blood flow reduction by IMA clamping were assessed in detail.

Data analysis

According to the transection level of the proximal colon, patients were divided into three groups, which were the sigmoid colon resection (SR)/high anterior resection (HAR), LAR, and uLAR/APR groups. Blood flow before and after clamping of the IMA or LCA were compared by Wilcoxon signed rank test. Reduction rate was calculated with the following formula:

$$\text{Reduction rate(\%)} = (\text{Preclamp} - \text{Postclamp}/\text{Preclamp}) \times 100$$

Logistic regression was used to identify independent predictors of high blood flow reduction by clamping of the IMA or LCA. High blood flow reduction was defined as greater than 50 or 25% reduction rate by IMA or LCA clamping, respectively. In addition, univariate logistic regression analyses were performed to determine candidate variables, such as those found to be significant at the level of $p < 0.20$ for subsequent multivariate logistic regression analysis, which was conducted to identify variables with significant independent effects. Correlations between aging and either of the blood flow or reduction rates were analyzed by Spearman rank correlation coefficient. This method was adopted for the analysis of correlation between aging and reduction rate according to the operative methods as well. Statistical significance was designated as a probability value of less than 0.05.

Results

High ligation of the IMA was indicated for 45 patients, and 31 patients were candidates for lymph node dissection around the root of IMA with selective LCA preservation. However, two patients among the 31 eventually had the

IMA sacrificed to relieve anastomotic tension. Twenty patients were candidates for IMA low ligation without lymph node dissection around the root of the IMA. As a consequence, 47 patients belonged to high group, 29 to low-A group, and 20 to low-B group. No patients were injured or divided the descending branch of the middle colic artery to the proximal anastomotic segment of the bowel. No patients had macroscopic ischemic change in the anastomosed colon.

Changes in blood flow during clamping of the IMA

Blood flow values (mean \pm SE) at the anastomosis before and after IMA clamping in all patients were 23.7 \pm 0.9 and 14.6 \pm 0.8 mL/min/100 g, respectively. The reduction rate was 38.5 \pm 1.8%, ranging from 0 to 82.8%. No decrease in blood flow was observed in three patients (3.1%) who underwent SR, HAR, or APR (Fig. 2).

Changes in blood flow during clamping of the LCA

The LCA could not be recognized in four patients (5.3%) in the high group and low-A group. Fourteen patients in the low-B group were excluded from analysis because LCA was not recognized due to the thick mesentery. Blood flow changes by clamping of the LCA were measured in a total of 78 patients (8 SRs, 17 HARs, 29 LARs, 14 uLARs, and 10 APRs). The LCA directly branched from the IMA in approximately two thirds of all patients. Blood flow values (Mean \pm SE) at the anastomosis before and after LCA clamping in all patients were 17.5 \pm 1.0 and 14.8 \pm 1.0 mL/min/100 g, respectively. The reduction rate was 16.4 \pm 1.8%, ranging from 0 to 66.2%. No blood flow decrease was observed in 22 patients (22.9%) including three patients with no decrease by IMA clamping as well. The other 19 patients (9 men and 10 women) underwent 2 SRs, 3 HARs, 11 LARs, 1 uLAR, and 2 APRs (Fig. 3).

Assessment of predictive factors of high blood flow reduction by IMA or LCA clamping

Nineteen patients experienced greater than 50% blood flow reduction by IMA clamping. For univariate analyses, aging, coexisting cardiovascular disease, and nonsmoking habits were considered to be potential predictive factors of the high blood flow reduction by IMA clamping. For multivariate analyses, aging was a significant independent factor and male gender was the second predictive factor of the high blood flow reduction by IMA clamping (Table 2). Twenty-two patients experienced greater than 25% blood flow reduction by LCA clamping. No predictive factor of high blood flow reduction by LCA clamping was identified for univariate analyses.

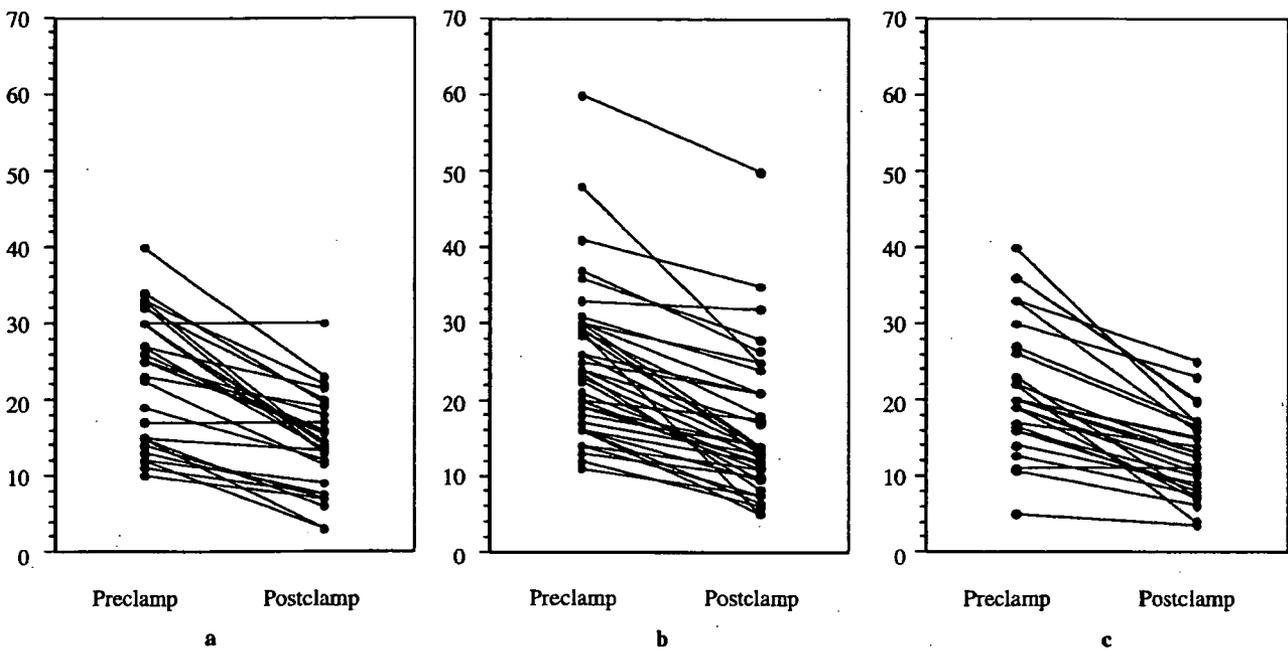


Fig. 2 Blood flow changes during IMA clamping (a SR/HAR, b LAR, c uLAR/APR). Blood flow values before vs after IMA clamping in SR/HAR, LAR, and uLAR/APR are 23.6 ± 1.5 vs 14.0 ± 1.1 , 24.6 ± 1.7 vs 15.9 ± 1.5 , and 22.5 ± 1.7 vs 13.3 ± 1.1 mL/min/100 g, respectively. Blood flow reduction rates by IMA clamping in SR/HAR, LAR, and uLAR/APR are $40.2 \pm 3.5\%$, $36.6 \pm 2.8\%$, and $39.5 \pm 3.2\%$, respectively

Correlation between blood flow and aging

In male patients, the blood flow after IMA or LCA clamping was negatively correlated with aging, although no correlation

was observed between aging and blood flow before clamping of these arteries. In addition, the blood flow reduction rate was positively correlated with aging. Contrarily, these three values in female patients were not

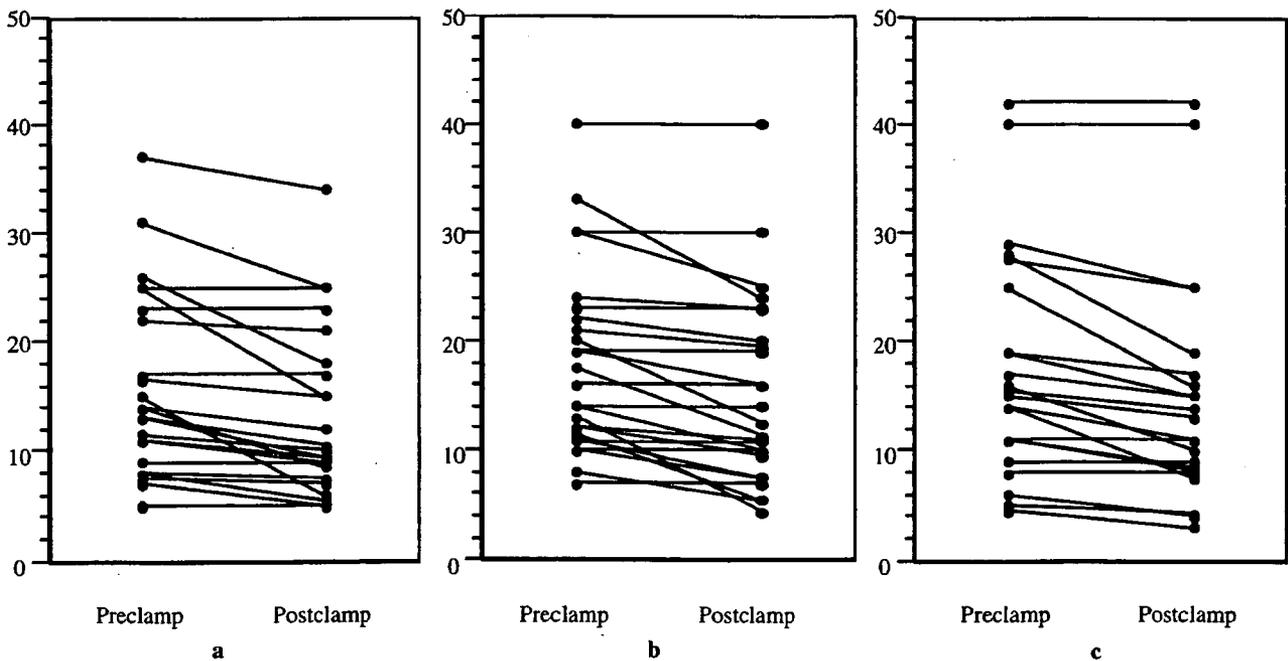


Fig. 3 Blood flow changes during LCA clamping (a SR/HAR, b LAR, c uLAR/APR). Blood flow values before vs after LCA clamping in SR/HAR, LAR, and uLAR/APR are 16.0 ± 1.8 vs 13.3 ± 1.6 , 18.8 ± 1.8 vs 16.2 ± 1.9 , and 17.8 ± 2.8 vs 15.2 ± 2.9 mL/min/100 g, respectively. Blood flow reduction rates by LCA clamping in SR/HAR, LAR, and uLAR/APR are $16.9 \pm 3.3\%$, $16.0 \pm 3.6\%$, and $17.9 \pm 3.6\%$, respectively

Table 2 Assessment of predictive factors of high blood flow reduction by IMA clamping

Variables	Patients (n)	High reduction (>50%)	Univariate P value	Multivariate P value
Age				
<63 years	48	5	0.006	0.020
≥63 years	48	17		
Sex				
Male	54	17	0.058	0.053
Female	42	5		
Location				
Sigmoid colon	20	5	NS	
Upper rectum	22	7		
Middle rectum	22	3		
Lower rectum	32	7		
Operation method				
SR/HAR	30	8	NS	
LAR	38	8		
uLAR/APR	28	6		
Preoperative irradiation				
Yes	6	0	NS	
No	90	22		
Cardiac or vascular disease				
Yes	21	8	0.067	NS
No	75	14		
Diabetes mellitus				
Yes	4	1	NS	
No	92	21		
Smoking				
Yes	21	1	0.136	NS
No	75	21		

statistically correlated with aging. For subset analyses with operative methods in male patients, the correlation between reduction rate and aging was more significant in the uLAR/APR group, not in the SR/HAR and LAR groups (Fig. 4).

Correlation between blood flow and postoperative complications

Among the total of 86 patients who underwent sphincter-saving operations, six patients suffered anastomotic complications, with five anastomotic leakages and one severe stenosis. Among these, complications caused by colonic ischemia were pathologically confirmed in two patients with leakage or stenosis. The other four patients with anastomotic leakage displayed no definite ischemic changes on macroscopic and histological examination with the postoperative fiberoptic. Among these, three patients underwent colostomy without resection of the anastomosis and one healed conservatively.

Nineteen patients experienced greater than 50% blood flow reduction by IMA clamping. Eight patients of those received IMA high ligation and three were elderly men.

Among them, two patients who underwent uLAR suffered ischemic complications as mentioned above. One patient, who had complications of anastomotic leakage demonstrating panperitonitis, displayed necrosis in 15 cm of the colon orally from the anastomosis on emergency operation and consequently underwent permanent colostomy with resection of the segment. Another patient, who had already reconstructed loop colostomy during the initial operation, suffered severe stenosis in the proximal colon within 30 cm from the anastomosis. The patient consequently underwent resection of the ischemic colon with a redo of the anastomosis. Initially, an attempt was made to preserve the LCA because of the tumor stage; however, IMA was eventually ligated to reduce anastomotic tension. Both of them presented with coexisting atherosclerosis, received no preoperative irradiation, and displayed no macroscopic ischemic changes in the colon proximal to the anastomosis on initial operation. In the patients that displayed less than 50% blood flow reduction rate by IMA clamping, six male patients underwent uLAR. Among them, only one patient had complications with an anastomotic leak, but demonstrated no evidence of anastomotic ischemia.

Discussion

LDF measurement is simple and noninvasive. It has been used intraoperatively to assess the anastomotic blood flow not only in the colon and rectum [9–11], but also in the stomach [12, 13] and the bronchus [14]. However, LDF data are affected by motion artifacts in recording sites or changes in the patient's cardiovascular status caused by intraoperative bleeding loss or drug administration through epidural anesthesia [15, 16]. These issues remain as major disadvantages of this method. Therefore, continuous recordings might be mandatory for reliable data. In the present study, these data fluctuations were minimized by continuous measurements in a relatively short duration during the clamping of arteries with a recording probe securely held.

Absolute values of blood flow are thought to be the important predictive factors for intestinal ischemia, and most previous reports analyzed absolute values. However, as mentioned above, absolute values are affected by several factors such as patient blood pressure or motion artifacts. Moreover, measuring units were variable between each device. Although 11 patients showed less than 10 mL/min/100 g of absolute value after clamping of the IMA with less than 50% of the reduction rate, none of them suffered anastomotic complications. The reduction rate might be supposed to be higher as the preclamp data are higher; however, no correlation was observed between preclamp data and reduction rate by either IMA or LCA clamping (data not shown). Therefore, reduction rate was analyzed in

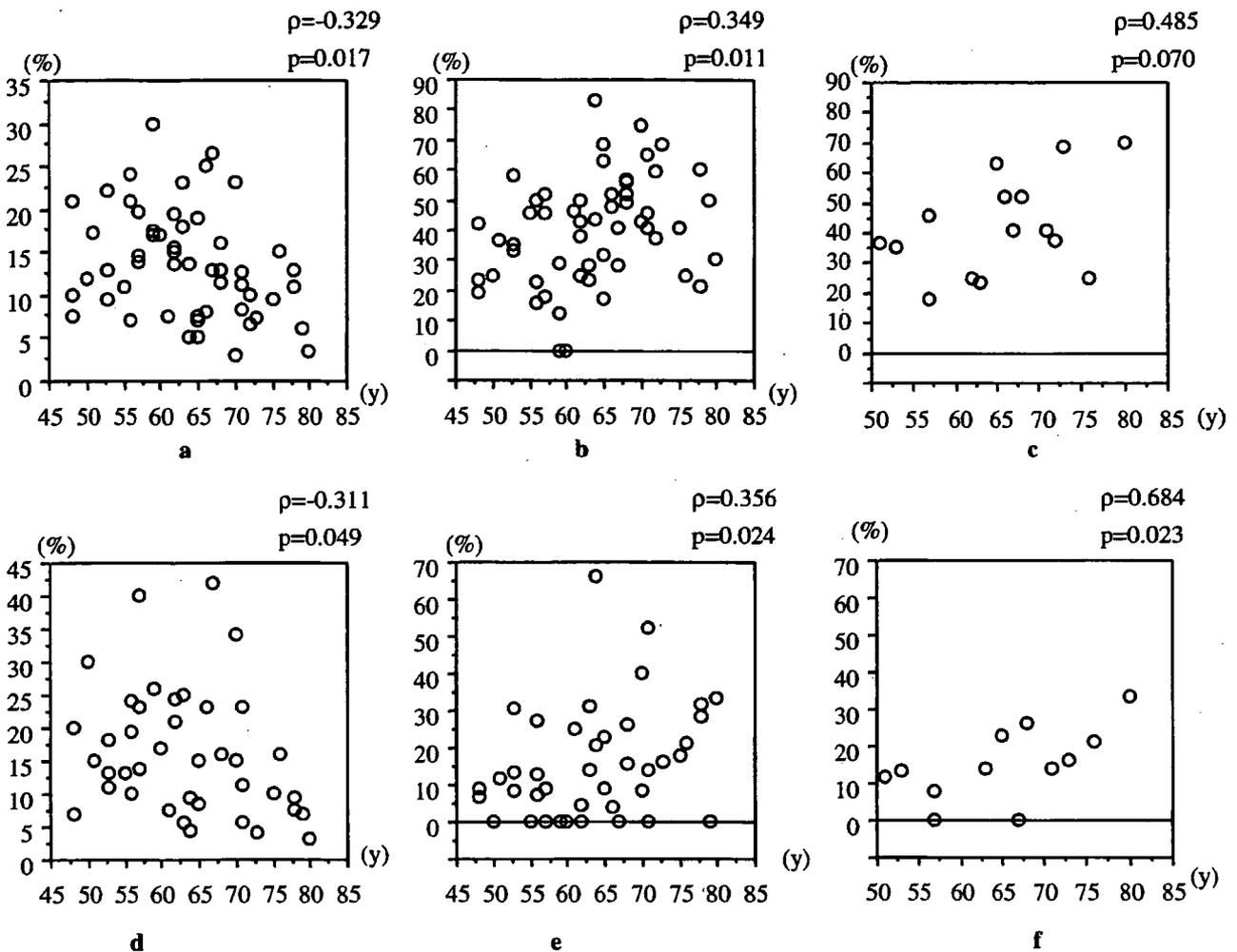


Fig. 4 Correlation between age and blood flow results in men (*above*, IMA clamping; *below*, LCA clamping; *a, d* postclamp; *b, e* reduction rate; *c, f* reduction rate of the patients those who underwent uLAR/APR).

Blood flow values after clamping and reduction rates were significantly correlated with aging. Reduction rates by LCA clamping with uLAR/APR were significantly correlated with aging.

are recommended to undergo LCA preservation as long as curability is not compromised, or to change the proximal transection line to a more oral site. Hartmann procedure may be one of the options to avoid severe anastomotic complications. In contrast, three patients demonstrated no blood flow reduction by IMA clamping, and low ligation of the IMA offered no benefit to increase anastomotic blood flow to these patients. Similarly, preserving the LCA was unable to provide additional blood supply in 22 patients who demonstrated no blood flow reduction by LCA clamping.

In the present study, blood flow in women was not influenced by age. On the other hand, reduction rates by IMA or LCA clamping were significantly higher in elderly men. Fourteen of 19 patients (73.7%) who presented with more than 50% reduction by IMA clamping were men. These findings may be attributable to several factors, which include gender difference in arterial anatomy or in atherosclerosis. Numerous studies have assessed the influ-

are recommended to undergo LCA preservation as long as curability is not compromised, or to change the proximal transection line to a more oral site. Hartmann procedure may be one of the options to avoid severe anastomotic complications. In contrast, three patients demonstrated no blood flow reduction by IMA clamping, and low ligation of the IMA offered no benefit to increase anastomotic blood flow to these patients. Similarly, preserving the LCA was unable to provide additional blood supply in 22 patients who demonstrated no blood flow reduction by LCA clamping.

In the present study, blood flow in women was not influenced by age. On the other hand, reduction rates by IMA or LCA clamping were significantly higher in elderly men. Fourteen of 19 patients (73.7%) who presented with more than 50% reduction by IMA clamping were men. These findings may be attributable to several factors, which include gender difference in arterial anatomy or in atherosclerosis. Numerous studies have assessed the influ-

ence of gender and age on atherosclerosis. Most previous studies demonstrated that men have more atherosclerotic lesions than women do in the coronary arteries, abdominal aorta, and carotid arteries. Furthermore, aging has a significant influence on progression in atherosclerosis [20–22]. Celermajer and associates reported that atherosclerosis appeared to occur earlier in men than in women and that a steep progression in women commenced at around the time of the menopause [23]. In the present study, the influence of menopause on colonic blood flow could not be assessed due to the insufficient number of premenopausal female patients.

In further analysis by operative methods, correlation between aging and blood flow reduction rate by IMA and LCA clamping was demonstrated in the uLAR/APR group. This might be due to the fact that the colon proximal to the anastomosis was left long enough to perform a very low anastomosis in uLAR and that distal edge of the proximal segment would be reduced in blood supply from the marginal artery, particularly in elderly male patients who may have atherosclerosis in the marginal artery as mentioned above. The present study suggests that anastomotic blood flow in elderly male patients is highly dependent on the IMA and that preservation of the LCA, if possible, may have the benefit of providing adequate anastomotic blood supply, especially in the uLAR cases.

Adequate intestinal blood supply is essential not only in the bowel proximal to the anastomosis, but also in that distal to it. The middle rectal artery is sacrificed occasionally in LAR and frequently in uLAR, which may lead to decreases in blood flow in the rectum used for the distal side of the anastomosis [11]. In SRs, the bowel distal to the anastomosis is at risk for ischemia when the SRA is divided below Sudeck's critical point, which is well known to surgeons [24, 25]. However, none of the patients in the present series experienced ischemic changes in the bowel distal to the anastomosis.

It is generally believed that radiotherapy may compromise anastomotic healing [26]. Contrary to these reports, other studies demonstrated that preoperative radiation did not increase the risk of anastomotic leakage [27, 28]. In this study, a covering stoma was fashioned in all patients who received preoperative radiation. None of them demonstrated more than 50% blood flow reduction by IMA clamping and suffered anastomotic leakage or ischemia. Hallböök and associates have demonstrated that side-to-end anastomotic reconstruction is preferable to adequate anastomotic blood flow [10]. However, both patients who experienced ischemic morbidity in the present study underwent side-to-end anastomoses.

Prevention against anastomotic ischemia should be taken from multiple aspects. In preoperative assessment, angiography is beneficial to evaluate colonic mesenteric circulation. However, recently developed multidetector row

computed tomography with three-dimensional imaging is a less invasive and faster method to assess patency and branching of the IMA and marginal artery from the SMA. However, it is impossible to measure intestinal blood flow with these methodologies. In postoperative management, hypovolemia, hypoxia, anemia, and any significant cardiovascular changes should be avoided to maintain adequate colonic blood flow. Dworkin and Allen-Mersh measured anastomotic blood flow during the first five postoperative days and concluded that increased collateral circulation to the anastomosis was unlikely to develop [9]. Anastomotic blood flow is therefore probably determined at the time of surgery. Thereby, intraoperative assessment of the anastomotic blood supply is essential. The difficult decision of choosing an anastomotic site is generally based on a subjective evaluation, such as observing ischemic change on serosa surface, rather than objective data. Two patients who suffered severe anastomotic ischemia displayed no macroscopic ischemic changes on initial operation as mentioned above. Novell and Lewis transected the marginal artery at the level of the proximal resection margin of the colon, observed blood flow from the cut end, and concluded that an observed pulsatile flow was associated with a lower incidence of anastomotic dehiscence [29]. This kind of assessment was not performed in this study and therefore could not be compared to present results. In conclusion, LDF allowed continuous and real-time measurement of anastomotic blood flow and its results were correlated with postoperative outcome in this study. LDF assessment is useful to predict a high-risk group for postoperative anastomotic ischemia, particularly in elderly male patients who undergo uLAR.

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Multiple Resections for Hepatic and Pulmonary Metastases of Colorectal Carcinoma

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Received May 21, 2006; accepted November 8, 2006

Background: Resections are effective for some patients with both hepatic and pulmonary metastases of colorectal cancer, but the best selection criteria for the resections and effective treatment for recurrence after the resections have not been determined.

Methods: A retrospective analysis was performed for 30 consecutive patients who received aggressive multiple resections for both hepatic and pulmonary metastases of colorectal cancer. Recurrences after resections were surgically treated whenever resectable.

Results: For the 30 patients, 45 hepatectomies and 40 pulmonary resections were performed and 17 patients received three or more resections. No mortality was observed. Overall survival after the first metastasectomy for the second organ (liver or lung) was 58% and nine 5-year survivors were observed. Multivariate analyses revealed that primary colon cancer, stage IV in TNM classification and maximum size of hepatic tumor >3 cm at initial hepatectomy were poor prognostic factors, but several long-term survivors were observed even among patients with those factors.

Conclusions: Multiple resections for hepatic and pulmonary metastases of colorectal cancer are safe and effective. No single factor is considered to be a contraindication for the resections. For recurrence after the resections, surgical resection is also recommended if resectable.

Key words: colorectal cancer – hepatic metastasis – pulmonary metastasis – resection

INTRODUCTION

The liver and lung are the most common sites of distant metastases for colorectal carcinoma (1). Hepatic and pulmonary metastases may be detected sequentially or simultaneously in patients with colorectal carcinoma. Efficacy of resections for these two distant metastases has been reported in several studies (2–14). However, the criteria to select patients for those resections are still obscure.

In addition, although recurrence after those resections is one of the major problems of the strategy, further surgical approaches for recurrence after those resections are controversial.

The purpose of this study was to evaluate the efficacy of aggressive multiple resections for hepatic and pulmonary

metastases of colorectal carcinoma and to find prognostic factors that might elucidate who would benefit most from hepatic and pulmonary resections for colorectal metastases.

PATIENTS AND METHODS

Two hundred and sixty-seven patients who had undergone hepatic resection and 98 patients who had undergone pulmonary resection, as the first treatment for colorectal metastasis at the National Cancer Center Hospital East between September 1992 and June 2005 were examined retrospectively. Eight patients had undergone surgical resections for both hepatic and pulmonary metastases as the first treatment for colorectal metastases. Metastases were synchronous with primary colorectal carcinoma in one of the eight patients. In the remaining 259 patients who had undergone hepatic resection as the first treatment for colorectal

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