J. J. Mahany, Jr. *Mt. McKinley*, 2002. Photograph. Reflecting Pond, Denali National Park, Alaska.

Sphincter-preserving surgery is possible for the majority of patients who present with rectal cancer.

Methods and Results of Sphincter-Preserving Surgery for Rectal Cancer

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Background: Sphincter preservation is the goal in the treatment of rectal cancer and should be considered in all patients with an intact sphincter. Sphincter preservation for tumors of the upper rectum is easily achieved, but surgical management of cancer of the mid and lower third of the rectum continues to evolve. Several recent advances may influence future treatment strategies.

Methods: We reviewed the literature to identify the current methods of sphincter-preserving surgery and their oncologic and functional results.

Results: Proctectomy with total mesorectal excision reduces the incidence of local recurrence to less than 10% while preserving genitourinary function. The use of preoperative radiotherapy may further diminish the risk of local recurrence. In selected patients, partial resection of the anal sphincter may avoid definitive colostomy without compromising oncologic outcome. In contrast, the role of local resection of rectal cancer remains controversial. Restoration of continuity by means of a colonic reservoir reduces stool frequency and urgency and improves continence when compared to a straight coloanal anastomosis. The transverse coloplasty pouch may allow pouch construction in patients in whom it is currently impossible, but long-term follow-up is not yet available.

Conclusions: Sphincter-preserving surgery is possible for the majority of patients with rectal cancer. Optimal functional results may be obtained by a nerve-sparing operative technique and by use of a colonic reservoir for reconstruction following resection of mid or low rectal cancers.

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Introduction

Anterior resection, popularized by Dixon[1] in the 1940s, was the first operation to allow patients with rectal cancer to avoid a definitive stoma. While initially performed only in patients with tumors of the upper third of the rectum, the transanal coloanal anastomosis[2] extended the possibility of sphincter preservation even to patients with very low rectal cancers. Despite this advance, the oncologic results of surgery remained

variable, and the functional outcome, especially following low colorectal or coloanal anastomosis, could be debilitating.

The oncologic and functional outcomes of sphincter-preserving curative surgery for middle and low rectal cancer were revolutionized by two developments: recognition of the importance of the mesorectum in the spread of rectal cancer[3] and appreciation of the necessity to replace the reservoir function of the resected rectum.[4,5] As a result, the majority of patients with rectal cancer can now anticipate a sphincter-preserving operation with good functional results, a local recurrence rate of less than 10%, and preservation of genitourinary function. A number of possible advances in the treatment of low rectal cancer are currently under evaluation, including partial resection of the internal sphincter, novel techniques of reservoir construction,[6,7] the use of neoadjuvant radiotherapy, and the role of local resection in early rectal cancer. In this paper, methods of sphincter-preserving surgery that are established or currently under evaluation are discussed, with an emphasis on oncologic and functional results. The techniques described are most relevant for tumors of the middle and lower thirds of the rectum, as sphincter preservation with negative resection margins is usually easily achieved in the upper third of the rectum.

Patient Selection

Two predominant factors determine the suitability of a patient with rectal cancer for a sphincter-preserving resection.

The first requirement is the presence of a functioning, disease-free sphincter mechanism. A history of preoperative incontinence should be specifically noted, with a high level of suspicion for sphincter injury in patients who have had previous anal surgery or a complicated or prolonged vaginal delivery. Clinical examination is essential, but endoanal ultrasound or magnetic resonance imaging (MRI) should be performed if sphincter integrity is in doubt. Direct invasion of the sphincter mechanism by tumor is a contraindication to sphincter preservation if a curative resection is proposed. Sphincter preservation may be considered if sphincter function is imperfect without evidence of tumor invasion, but patients should be warned of the possibility of poor continence following surgery. Colonic pouch construction should always be undertaken in such patients to optimize function.

The second criterion by which patients are selected for sphincter-preserving surgery is distance of the tumor from the anal margin. Tumors of the rectum dis-

seminate proximally and radially, but rarely distally. Williams[8] reported no distal intramural spread in 76% of rectal tumors, with a further 14% spreading less than 1 cm distally. Distal intramural spread exceeded 1 cm in only 10% of tumors, all of which were poorly differentiated. As a result, patients with tumors as low as 2 cm above the dentate line may be suitable for a sphincter-preserving operation without compromising oncologic security. The recommended distal margin for an oncologically safe resection is 1 cm for T1-2 lesions and 2 cm for T3-4 tumors.[9]

Resection of the upper third of the anal sphincter may allow even lower tumors to be safely resected without abdominoperineal resection. Initial results suggest that there are minimal adverse effects on postoperative continence.[10] Continence is reported to be unchanged from that found in patients undergoing standard anterior resection if less than 1 cm of sphincter is excised, provided that a colonic reservoir is fashioned.[11] Resection of a larger amount of sphincter results in a degree of incontinence in 50% of patients at 4 years of follow-up.[11] Currently, there is no evidence of an oncologic disadvantage in patients treated with partial sphincter resection instead of abdominoperineal resection, but longer-term oncologic and functional results are awaited.

Preoperative Radiotherapy

Recent evidence supports a role for preoperative radiotherapy in rectal cancer. In a recent report, long-course radiotherapy (usually 40-45 Gy over 5 weeks) resulted in tumor downstaging in 40% and allowed sphincter-preserving surgery in 80% of patients with low rectal cancer.[12] Combined radiotherapy and chemotherapy increases the possibility of R0 resection and improves local control.[13] A multicenter trial showed that short-course radiotherapy (25 Gy over 5 days) did not result in downstaging but was associated with a decreased rate of local recurrence when compared to total mesorectal excision alone.[14] Improved local control did not result in increased survival at 2 years in this series.

The use of preoperative high-dose radiotherapy (60 Gy) has been proposed to allow sphincter-sparing surgery for very low rectal cancers that would normally require abdominoperineal resection.[15] Two weeks after standard long-course (40 Gy) preoperative radiotherapy is completed, radiologic staging is repeated and compared to pretreatment images. Patients with tumor reduction of 30% or more receive a further tumor boost to a total biological dose of 60 Gy followed by sphincter-preserving surgery; nonresponders go on to

Table 1. — Results of Total Mesorectal Excision Without Adjuvant Therapy for Rectal Cancer

Study	Number of Patients	Local Recurrence (%)	Survival (%) 2-Yr	5-Yr	Leak (%)
Kapiteijn[14] (2001)	908	8.2	81.8		–
Leong[21] (2000)	117	9.3		81.4	7.3
Bolgnese[22] (2000)	71	12.6		70.5	–
Enker[23] (1999)	342	7.0		83.0	–
MacFarlane[24] (1993)	278	4.0		82.0	–
Dixon[25] (1991)	218	6.4		64.0	1.0

abdominoperineal resection without further radiotherapy. Using this approach, a sphincter preservation rate of 70% and a local recurrence rate of 13% may be achieved, but 20% of patients report poor long-term functional results. This technique is currently under evaluation in a randomized trial.

Preoperative radiotherapy increases overall postoperative morbidity, particularly septic complications, but does not increase postoperative mortality.[16] There is some evidence that the adverse effects of radiotherapy are more common in patients receiving a biological dose in excess of 30 Gy.[16] Radiotherapy may also result in impaired postoperative continence and increased frequency of defecation. This has been attributed to radiation injury to the sphincter and distal rectum. Exclusion of the anal sphincter from the field of radiation plus total proctectomy with mucosectomy followed by reconstruction using a colonic pouch-anal anastomosis has been shown to minimize postoperative anorectal dysfunction.[17]

Low Anterior Resection and Total Mesorectal Excision

The key to an oncologically sound resection of mid or low rectal cancer is the en bloc resection of the rectum and its enveloping mesentery to the level of the pelvic floor with a negative distal and radial resection margin. This technique, total mesorectal excision (TME),[3] consists of sharp dissection of the predominantly avascular plane between the parietal and visceral pelvic fascia. Anteriorly, the specimen contains the intact Denonvilliers' fascia and the peritoneal reflection. Autonomic nerve preservation requires identification and sparing of the preaortic superior hypogastric plexus as well as the bilateral hypogastric nerves that join the sacral parasympathetic nerves to form the inferior hypogastric plexus anterolaterally on both sides.[18,19] Standardized application of this technique has been demonstrated to improve oncologic outcome,

reducing the incidence of local recurrence to less than 10% without the use of adjuvant treatment.[20] The incidence of local recurrence may be further reduced by the use of preoperative radiotherapy.[14] There is some controversy about the role of TME for tumors of the upper rectum, as many surgeons advocate a lesser resection with division of the mesorectum 5 cm below the tumor followed by direct colorectal anastomosis. However, for cancer of the mid or low rectum, proctectomy with TME is the cornerstone of oncologic treatment, irrespective of the reconstructive technique chosen for restoration of continuity (Table 1).[14,21-25]

A high standard of pathological reporting, especially of nodal status and radial margins, is important to the success of this technique because it permits more accurate assessment of prognosis and improves the selection of patients for adjuvant therapy. A positive radial margin is a negative prognostic indicator with sensitivity, specificity, and positive predictive values of 92%, 95%, and 85%, respectively.[26] Tumor-free radial margins of less than 1 mm increase the risk of distant metastases threefold to 38% when compared to a margin greater than 1 mm.[27] A tumor-free radial margin in excess of 2 mm is preferable to minimize local recurrence as such patients have an incidence of local recurrence of 5.8% vs 16% for patients with a lesser margin.[27] Preoperative MRI allows accurate prediction of tumor invasion of the circumferential resection margin[28] and may help to identify patients likely to benefit from neoadjuvant radiotherapy.

Total mesorectal excision followed by immediate restoration of continuity is associated with a higher incidence of anastomotic leakage than previous techniques of resection for rectal cancer have obtained. An incidence of clinically detected anastomotic leakage of 12.6% has been reported following low anterior resection, even in patients considered low risk for anastomotic dehiscence. This was reduced to 3.3% if a diverting stoma was created.[29] In this randomized study, construction of a straight anastomosis following total proctectomy resulted in a significantly higher rate

of symptomatic anastomotic leakage (15%) when compared to colonic pouch-anal anastomosis (2%). This is partly attributable to the use of a temporary stoma in 71% of patients in whom a reservoir was constructed vs only 59% of those with a straight anastomosis. A further series reported an anastomotic leak rate of 17% for low colorectal anastomosis without a defunctioning stoma, 7% for low colorectal anastomosis with a stoma, and 4.9% for a colonic pouch-anal anastomosis with a defunctioning stoma.[30] Patients with a nondefunctioned low colorectal anastomosis are more likely to develop peritonitis than patients with either a colorectal or colonic pouch-anal anastomosis with a protective defunctioning stoma.[30] As a result, most colorectal surgeons perform routine defunctioning stomas in patients with a colonic pouch and have a policy of liberal use of stomas in straight low anastomoses. The preferred temporary stoma is a loop ileostomy, which is associated with significantly fewer stoma-related complications than a transverse colostomy.[31]

Local Resection of Low Rectal Tumors

Local resection of early rectal cancer using either a standard transanal approach or endoscopic microsurgery (TEMS) has been suggested but no randomized trial exists to support this approach. Transanal resection allows anal sphincter preservation while avoiding the risks of abdominal surgery, but its oncologic acceptability remains controversial. A recent meta-analysis indicates that local recurrence occurs in 9.7% of patients (range 0%–24%) of patients with T1 tumors, 25% (range 0%–67%) of those with T2 tumors, and 38% (range 0%–100%) of those with T3 tumors.[32] These results are improved by the addition of preoperative chemoradiotherapy.[33] Safe application of this technique requires accurate preoperative staging, careful transanal resection, and meticulous histological examination. Factors that increase the risk of recurrence following local resection include T stage, poor histological grade, lymphovascular invasion, and positive excision margins.[32] However, even in patients who were carefully selected according to these criteria, local recurrence rates of 18% for T1 tumors and 37% for T2 tumors have been reported.[34] At present, this technique should be restricted to patients unsuitable for abdominal surgery in whom local resection with adjuvant chemoradiation is possible.

Restoration of Continuity After Sphincter-Preserving Resection

Reconstructive options following a sphincter-sparing resection for rectal cancer include straight col-

orectal anastomosis, straight coloanal anastomosis, and colonic pouch-anal anastomosis. Several factors must be considered in the selection of an appropriate technique for restoration of continuity if postoperative neorectal function is to be optimized. Proctectomy with a very low anastomosis can result in altered anorectal function, the so-called "anterior resection syndrome," which is characterized by frequency, urgency, and soiling[35] and is thought to be due to the loss of the reservoir function of the remaining rectum, as well as diminished compliance. The level of anastomosis may be a determinant factor[36] since, in general, the lower the level of anastomosis, the more adverse the functional outcome. This is supported by reports that patients undergoing very low anterior resection have poorer quality of life scores than those undergoing high anterior resection[37] or even abdominoperineal resection.[38] Postoperative function is also impaired in patients who have a straight colorectal anastomosis and receive postoperative radiotherapy or in those who have preoperative radiotherapy followed by anastomosis of colon to an irradiated rectal remnant.[17] Direct coloanal anastomosis is associated with particularly poor functional results, with patients experiencing increased frequency of defecation, increased nocturnal defecation, fecal urgency, and incontinence. Although potentially debilitating, these functional problems may be considered acceptable by a patient for whom straight coloanal anastomosis is the sole option if colostomy is to be avoided.

The poor functional results and the high rate of anastomotic leakage reported after both low colorectal and straight coloanal anastomoses led to the development of the colonic pouch.[4,5] This J-shaped reservoir of 6 to 7 cm in length is anastomosed to the anal margin in a modification of Parks technique of sutured transanal anastomosis,[2] although some surgeons prefer a stapled anastomosis. Successful reconstruction using a J pouch requires well-vascularized colon and a tension-free anastomosis, facilitated by high ligation of the inferior mesenteric vein, preservation of the paracolic arcade of Riolan, and complete mobilization of the splenic flexure. Rarely, transmesenteric passage of the colonic pouch is necessary to minimize tension. Our experience with this technique of colonic pouch-anal anastomosis[4] has been favorable,[39,40] and use of the technique has been associated with low morbidity and mortality.

Use of a colonic reservoir results in significant improvement in both the maximal tolerable volume and the threshold volume prior to sensing the urge to defecate when compared to straight coloanal anastomosis. Improved function has been demonstrated as early as 6 weeks after surgery,[6] confirming that construction of a reservoir is beneficial even in patients who may have

limited survival.[41] This improved function includes reduced urgency and frequency of defecation (Table 2), improved continence, and reduced nocturnal defecation when compared to a straight anastomosis.[44]

Some evacuation problems are reported following coloanal anastomosis; up to 20% of patients require the use of enemas or suppositories to evacuate the pouch. This has been attributed to the use of excessively large reservoirs with pouches as large as 12 cm reported in some early series.[5] Even with smaller pouches, a degree of difficulty in evacuation occurs. ==Although evacuatory difficulties are inconvenient, they are easily addressed by the use of enemas, and patients generally remain asymptomatic in the intervals between evacuation.[4] In== contrast, patients who have a low anterior resection or straight coloanal anastomosis may be troubled by excessive frequency resulting in anal excoriation with constant discomfort.

A modified reservoir, the transverse colpoplasty pouch, is currently being evaluated as a possible alternative to the colonic J pouch.[7] It is a smaller volume reservoir that may be useful in patients in whom it is not possible to use a J pouch due to a small pelvis, a thickened mesentery, or a short mesocolon. Its smaller volume and the absence of an antiperistaltic limb may result in a reduced incidence of difficulty in pouch evacuation.[7] Initial reports indicate that functional results are similar to those achieved following colonic J pouch-anal anastomosis, although postoperative morbidity is greater.[45] Our current policy is to restrict the use of this technique to patients taking part in a randomized trial.

Genitourinary Function After Sphincter-Sparing Surgery for Rectal Cancer

Sexual Function

Surgery for rectal cancer may decrease male sexual function, but the introduction of TME with autonomic nerve preservation has significantly increased the number of men with preserved postoperative sexual function.[19,47] In a prospective study of sexual function before and after rectal cancer surgery, TME significantly preserved the ability to achieve orgasm and to ejaculate when compared to standard rectal cancer surgery.[19] In a retrospective evaluation of sexual function following TME, 86% of patients less than 60 years of age and 67% of patients older than 60 years maintained their ability to engage in sexual intercourse, while 87% of all men maintained their ability to have an erection following TME. Retrograde ejaculation occurs rarely but does not diminish the patient's capacity for normal sexual activity.[48] The effects of TME for rectal cancer on female sexual function are less clear. One study reports main-

Table 2. — Number of Bowel Movements per 24 Hours in Patients Following Anterior Resection According to Technique of Reconstruction and Duration of Follow-Up

	Follow-Up	Median # Bowel Movements per 24 Hours		P Value
		Coloanal Anastomosis	Colonic J Pouch	
Lazorthes[5] (1986)	<1 yr	3.6	2.4	<.01
	>1 yr	3.0	1.7	<.01
Nicholls[42] (1988)	47 mos (coloanal anastomosis)* 7 mos (colonic J pouch)*	2.3	1.4	NS
Seow-Choen[43] (1995)	1 mo	4 (range 2–20)	2.5 (range 0.5–10)	<.03
	6 mos	4 (range 0.5–6)	2 (range 0.5–6)	<.007
	1 yr	2 (range 0.5–10)	2 (range 0.5–4)	<.05
Ho[45] (1996)	1 yr	6 (range 3–7)	3 (range 2–7)	.02
Hallbook[44] (1996)	2 mos	6.4	2.0	<.001
	1 yr	3.5	2.0	<.001
Lazorthes[41] (1997)	3 mos	5.0	2.5	<.01
	1 yr	4.5	2.0	<.01
	2 yrs	3.0	2.0	<.01
Mantyh[6] (2001)	6 wks	4.5	3.1	<.05
Harris[46] (2001)	47 mos (median)	2.0	2.0	NS

* Mean duration of follow-up.
NS = not significant.

tained female sexual function, with 85% experiencing vaginal lubrication and 91% achieving orgasm.[49] A higher proportion of women patients report sexual inactivity or indifference prior to surgery, resulting in greater difficulty in accurate evaluation of their postoperative status.[19,48,50]

Urinary Function

Changes in bladder function following sphincter-sparing surgery for rectal cancer are rare.[30,40] A prospective study comparing TME with blunt dissection reported increased difficulty in bladder emptying following TME, especially in patients with imperfect preoperative function.[19] There was no difference between groups in sensation of incomplete emptying, urgency, leakage, dysuria, or postmicturition dribbling. A larger retrospective series identified no cases of serious urinary dysfunction following TME,[49] and most reported cases are transitory in nature.[48]

Conclusions

Sphincter preservation should be considered in all patients with a functioning sphincter mechanism and a rectal cancer more than 2 cm above the dentate line. This limit continues to descend as initial experience with partial sphincter resection proves satisfactory. Tumors of the middle and lower third of the rectum should be treated by anterior resection with TME, although this may not be necessary for all tumors of the upper rectum. Routine application of this technique reliably results in rates of local recurrence below 10% without the use of adjuvant therapy and with good preservation of postoperative genitourinary function. Neorectal function following anterior resection varies according to the level of anastomosis but may improve with the routine use of a colonic reservoir in patients with tumors of the mid or lower rectum. Early postoperative complications are minimized by a policy of liberal use of a temporary diverting loop ileostomy.

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