35. Advanced Laparoscopic Colorectal Surgery

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Introduction

- All laparoscopic colorectal procedures are considered advanced procedures.

Learning Curve

- There continues to be relatively slow adoption of laparoscopic colectomy into practice. Laparoscopic colorectal surgery faces challenges due to the need to work in multiple quadrants of the abdomen, a greater need for understanding of depth perception and proprioception, a coordinated team, and a long learning curve.
- The estimated learning curve for laparoscopic colectomy is 20 or more cases.
- In the UK "CLASICC" trial, despite the surgeon's prior experience, the rate of conversion dropped from 38 to 16 % over the course of the study, suggesting an ongoing "learning curve."
- In the European COLOR trial, the median operative time for high-volume (>10 cases/year) hospitals was 188 min compared to 241 min for low-volume (<5 cases/year) hospitals, and likewise conversion rates were 9 % vs. 24 % for the two groups. High-volume groups also had more lymph nodes in the resected specimens, fewer complications, and shortened hospital stay.

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- Laparoscopic training has been incorporated into most, if not all, of the accredited colorectal training programs, providing graduates with laparoscopic skills.

Conversion

- Conversion rates vary widely in the literature, from 0 % to as high as 48 %, depending on multiple factors such as date of publication, disease process, patient factors, and of course, surgeon experience and ability.
- Patient- and disease-related factors such as obesity (defined as a body mass index greater than 30 kg/m^2), prior abdominal surgery (a marker for adhesions), acuity of inflammation (i.e., abscess and fistula formation), tumor bulk or contiguous involvement, and disease location may also affect the rate of conversion.
- For inflammatory conditions such as Crohn's disease and diverticulitis, the presence of an abscess or fistula may result in the need for conversion in up to 50 % of cases, with reports from experienced centers suggesting a conversion rate of 25–35 % for enteric fistulae.
- The presence of a fistula or small abscess is not a contraindication to a minimally invasive approach but should alert the surgeon to consider a variation in operative approach if obstacles cannot be overcome.
- Conversion from a laparoscopic to open resection should *not* be viewed as a failure of the surgeon but as a sign of mature surgical judgment.
- Delayed conversion, occurring only after a complication has occurred, may in some cases reflect poor judgment or little experience.
- The goal is to perform a preemptive conversion; once it is determined the case cannot be completed laparoscopically, rather than a reactive conversion to a complication, which occurred due to adverse conditions and that could have been avoided.

Outcomes

- In comparison with conventional colectomy, laparoscopic colectomy benefits may include shorter duration of postoperative ileus, less postoperative pain and concomitant reduction in the need for analgesics, earlier tolerance of diet, shortened hospital stay, earlier resumption of normal activities, improved cosmetic results, and possibly preservation of immune function.
- This is offset by a prolongation in operative time, the cost of laparoscopic equipment, and the learning curve of these technically challenging procedures.
- Conclusions regarding outcomes, therefore, often come from the repetitiveness of the results rather than the superiority of study design. For any one study, the evidence is weak, but collectively, due to the reproducibility of results by a large number of institutions, even with different operative techniques and postoperative management parameters, the preponderance of evidence favors a minimally invasive

approach with respect to postoperative outcomes. Also, the prospective randomized studies, which are available, corroborate the findings demonstrated in nonrandomized studies.

Operative Time

- Most studies demonstrate a longer operative time associated with a laparoscopic procedure. In prospective randomized trials, the procedure was roughly 40–60 min longer in the laparoscopic groups. As the surgeon and team gain experience with laparoscopic colectomy, operating times do reliably fall, but rarely does it return to the comparable time for a conventional approach.

Return of Bowel Activity and Resumption of Diet

- Most studies comparing open and laparoscopic colectomy have shown a statistically significant reduction (1–2 days) in the time to passage of flatus and stool.
- Psychological conditioning of the patient preoperatively may interfere with an objective assessment of bowel activity postoperatively.
- Both canine and porcine models have confirmed an earlier return of intestinal myoelectric activity following laparoscopic resection.
- A dog study demonstrated an earlier return to preoperative motility, utilizing radionucleotide techniques in animals subjected to laparoscopic resection.
- With shorter postoperative ileus, tolerance of both liquids and solid food is1–2 days sooner following laparoscopic resection.

Postoperative Pain and Recovery of Pulmonary Function

- Analog pain scales and narcotic requirements have demonstrated a significant reduction in pain following minimally invasive surgery.
- Adequate pain management allows the patient to inspire more deeply. A randomized trial from Cleveland Clinic showed an 80 % recovery of baseline forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV_1). The median recovery for the laparoscopic group was half the recovery (6 days) seen in the conventional group.

Length of Stay

- More rapid resolution of ileus, earlier resumption of diet, and reduced postoperative pain result in a shortened length of stay.
- Recovery after open operation has also been shortened by fast-track practices, but this is not consistent throughout the literature.

- In most studies, the length of hospitalization is 1–6 days less for the laparoscopic group.

Quality of Life and Return to Work

- Psaila et al. found that hand-grip strength, as a measure of protein loss, recovered more rapidly after laparoscopic surgery, and in six of eight areas, the SF-36 questionnaire showed less impairment of health following laparoscopic colectomy. By 4 months postoperatively, this trend persisted but to a lesser degree.
- Quality of life measurements in the COST study found that patients who had a laparoscopically completed procedure were improved compared with open procedures and with laparoscopic patients who required a conversion to open surgery, although this did not achieve significance.
- In a nonrandomized study, patients undergoing laparoscopy returned to full activities and work sooner than matched patients undergoing conventional resection (mean – 4.2 weeks vs. 10.5 weeks, 3.8 weeks vs. 7.5 weeks, respectively ($P < 0.01$ for all)).

Hospital Costs

- A case–control study from the Mayo Clinic looked at total costs following laparoscopic and open ileocolic resection for Crohn's disease. Sixty-six patients underwent laparoscopic ($n = 33$) or conventional ($n = 33$) ileocolic resection during the same time period (10/95 to 7/99) and were well matched. Patients in the laparoscopic group had less postoperative pain, tolerated a regular diet sooner by 1–2 days, and had a shorter length of stay (4.0 days vs. 7.0 days). In their cost analysis, despite higher operative cost, the overall mean costs were $3,273 less in the laparoscopic group.
- Other studies by Dupree et al. and Shore et al. have confirmed these findings with a mean reduction of $438 in costs and $7,465 in hospital charges, respectively, in patients undergoing laparoscopic compared to conventional ileocolic resection.
- The results are similar for elective sigmoid diverticular resection with a mean cost savings of $700–$800 (and there are additional examples in the disease-specific section).

Disease-Specific Outcomes

Crohn's Disease

- In Crohn's disease, there may be inflammatory changes, difficulty in assessing bowel involvement, and associated abscess and fistulous disease.
- Table 35.1 demonstrates an increasing laparoscopic experience with Crohn's disease.

Table 35.1 Studies of laparoscopic resection for Crohn's disease: ileocolic resection

		No. of patients		OP time (min)		LOS (day)		Morbidity (%)		
Author	Year	LAP	Open	LAP	Open	LAP	Open	LAP	Open	Comment
Bauer et al.	1996	25	14	–	–	6.5	8.5	–	–	High conversion if mass and fistula
Wu et al.	1997	46	70	144	202	4.5	7.9	10	21	52 % complex or redo cases
Dunker et al.	1998	11	11	–	–	5.5	9.9	9	9	Improved cosmesis
Wong et al.	1999	55		150		6.0		5		46 % complex cases
Canin-Endres et al.	1999	70		183		4.2		14		41 with fistulae, 1 conversion
Alabaz et al.	2000	26	48	150	90	7.0	9.6	–	–	Favorable results
Bemelman et al.	2000	30	48	138	104	5.7	10.2	15	10	Different hospitals for each group
Young-Fadok et al.	2001	33	33	147	124	4.0	7.0	–	–	Laparoscopy less expensive
Schmidt et al.	2001	46		207		5.7				Safe and effective, high conversion rate
Milsom et al.	2001	31	29	140	85	5.0	6.0	16	28	Prospective, randomized trial
Evans et al.	2002	84		145		5.6		11		Results improve with experience
Dupree et al.	2002	21	24	75	98	3.0	5.0	14	16	Laparoscopy less expensive
Shore et al.	2003	20	20	145	133	4.3	8.2	–	–	Laparoscopy less expensive
Benoist et al.	2003	24	32	179	198	7.7	8.0	20	10	Similar operative times, 17 % converted
Bergamaschi et al.	2003	39	53	185	105	5.6	11.2	9	10	Long-term obstruction less, 11 % vs. 35 %
Huilgol et al.	2004	21	19	136	120	6.4	8.2	19	16	
Rosman et al.	2005			26.8 min longer		2.62 days less		OR 0.62		Meta-analysis, SBO reduced in LAP cases
Tilney et al.	2006	338	445	29.6 min longer						Meta-analysis, conversion 6.8 %
Tan et al.	2007			26 min longer		1.82 days less		12.8	20.2	Meta-analysis, conversion 11.2 %
Lesperance et al.	2009	2,826 (6 %)	46,783			6.0	9.0	8	16	Nationwide Inpatient Sample
Soop et al.	2009	109		150		4.0		11		Conversion 6 %
Nguyen et al.	2009	335		177		5.0		13		Largest series, conversion rate 2 %

Table 35.2 Early descriptive studies of laparoscopic colectomy for ulcerative colitis

Author	Year	No. of patients	Comment
Meijerink et al.	1999	10	Feasible, 7 for acute colitis
Marcello et al.	2000	13	Restorative proctocolectomy, favorable results
Seshadri et al.	2001	37	25 % morbidity
Hamel et al.	2001	21	Compared with ileocolic resection, similar morbidity, and LOS
Marcello et al.	2001	16	For acute colitis, comparative study, favorable results
Brown et al.	2001	25	Longer OP time in LAP group
Dunker et al.	2001	35	Better cosmesis
Ky et al.	2002	32	Single-stage procedure, good results
Bell and Seymour	2002	18	Total colectomy for acute colitis, seems safe
Rivadeneira et al.	2004	23	Hand-assisted procedure, reduced operative time
Kienle et al.	2003	59	Large study, laparoscopic colon mobilization only
Nakajima et al.	2004	16	Hand-assisted technique, favorable results

IPAA ileal pouch-anal anastomosis, *EBL* estimated blood loss, *LOS* length of stay

- The majority of studies are retrospective case–control series and report conversion rates from 10 to 20 %, which increases to 40–50 % with complex cases (abscess, fistula, or reoperative surgery).
- Without tactile sensation, one of the concerns of laparoscopic surgery in the patient with Crohn's is missing an isolated proximal ileal lesion, but this has not been reported.
- Crohn's recurrence rates after laparoscopy are similar to conventional procedures.
- Laparoscopic resection for Crohn's disease appears to be safe.

Ulcerative Colitis

- Studies of laparoscopic proctocolectomy for ulcerative are summarized in Tables 35.2 and 35.3.
- Recent reports demonstrate that laparoscopic total colectomy and proctocolectomy with and without ileal pouch-anal anastomosis is technically feasible and shares the same advantages as seen with segmental colonic resection.
- Indar et al. showed that adhesions are reduced with laparoscopic pouch procedures, in a series of 34 patients (21 females).

Diverticulitis

- There are now a large number of studies evaluating laparoscopic surgery for diverticulitis (Tables 35.4 and 35.5).
- Most series report an operative time of 2–3 h with a conversion rate of 10–20 % for larger series.

Table 35.3 Comparative studies of laparoscopic resection for ulcerative colitis

		No. of patients		OP time (min)		LOS (day)		Morbidity (%)		
Author	Year	LAP	Open	LAP	Open	LAP	Open	LAP	Open	Comment
Maartense et al.	2004	30	30	210	133	10	11	20	17	SF-36 and GIQLI scores similar
Larson et al.	2006	100	200	333	230	4	7	33	37	LAP faster than hand assisted (320 min vs. 372 min)
Zhang et al.	2007	21	25	325	220	9	11	25	28	
Benavente-Chenhalls	2008	16	16	500	382	25	44	5.3	9.9	UC and primary sclerosing cholangitis
Ahmed Ali et al.	2009	253	354	91 min longer		2.7 days less		38–47	42–53	Cochrane review
Fichera et al.	2009	73	106	335	322	8.3	7.4			Incisional hernia repair 7.8 % open vs. 0 % LAP
Chung et al.	2009	37	44	223	140	4.9	8.5	9/37	21/44	1st of 3 stage procedure, 2nd stage earlier in LAP

Table 35.4 Descriptive series of laparoscopic resection for diverticulitis

Study	Year	*N*	Mortality (%)	Morbidity (%)	Conversion (%)	OR time (min) [a]	Resume diet (day)[a]	Flatus/BM (day)[a]	LOS (day)[a]
Eijsbouts et al.	1997	41	0	18	15	195	NA	NA	6.5
Stevenson et al.	1998	100	0	21	8	180	2	2	4
Tuech et al.	2000	77	0	17	14	NA	NA	NA	NA
Trebuchet et al.	2002	170	0	8.2	4.1	141	3.4	NA	8.5
Bouillot et al.	2002	179	0	15	14	223	3.3	2.5	9.3
Pugliese et al.	2004	103	0	8	3	190	NA	4	9.7
Schneidbach et al.	2004	1,545	0.4	17	6.1	169	NA	NA	NA
Pessaux et al.	2004	582	1.2	25	NA	NA	NA	NA	NA
Schwandner et al.	2005	363	0.6	22	6.6	192	2.8	4.0	11.8
Jones et al.	2008	500	0.2	11	8–1.5	120	NA	NA	4

OR operating room, *BM* bowel movement, *LOS* length of stay, *NA* not available
[a]Median or mean values listed

Table 35.5 Case–control studies of laparoscopic resection for diverticulitis

Study	Year	No. of patients		Mortality (%)		Morbidity (%)		Convert (%)	OR time (min)[a]		Resume diet (day)		Flatus/BM (day)		LOS (day)		Total costs[a]	
		CON	LAP	CON	LAP	CON	LAP		CON	LAP	CON	LAP	CON	LAP	CON	LAP	CON	LAP
Diverticulitis																		
Liberman et al.	1996	14	14	0	0	14	14	0	182	192	6.1	2.9[b]	NA		9.2	6.3[b]	P 13,400	11,500
Bruce et al.	1996	17	25	0	0	23	16	12	115	397[b]	5.7	3.2[b]	NA		6.8	4.2[b]	$7,068	10,230[b]
Kohler et al.	1998	34	27	0	0	61	15	7	121	165[b]	5.8	4.1[b]	5.3	3.7[b]	14.3	7.9[b]	DM 8,975	7,185[b]
Senagore et al.	2002	71	61	0	1.6	30	8[b]	7	101	107	NA		NA	6.8		3.1[b]	$4,321	3,458[b]
Dwivedi et al.	2002	88	66	0	0	24	18	20	143	212[b]	4.9	2.9[b]	NA		8.8	4.8[b]	$14,863	13,953[b]
Lawrence et a1.	2003	215	56	1.6	1	27	9[b]	7	140	170[b]	NA		NA		9.1	4.1[b]	$25,700	17,414[b]
Gonzalez et al.	2004	80	95	4	1	31	19[b]	NA	156	170	NA		3.7	2.8	12	7[b]	NA	
Alves et al.	2005	169	163			31.4	16.0	15.3										
Lee et al.	2006	21	21						171	197					18	10		
Shapiro et al.	2008	166	80	0	0	7.8	6.3	12.5	153	185					4	8		

OR operating room, *BM* bowel movement, *LOS* length of stay, *CON* conventional surgery, *LAP* laparoscopic surgery, *NA* not available, *P* pounds, *DM* Deutsche marks

[a]Median or mean values listed

[b]Statistically significant difference

[c]Results of nonconverted laparoscopic cases given

[d]Minilaparotomy

- The largest series of diverticular resection comes from a German multi-institutional study of 1,545 patients accumulated over 7 years at 52 institutions. The study demonstrated a low morbidity and mortality with an overall conversion rate of 6.1 %.
- Nearly all of the comparative studies related to laparoscopic vs. open sigmoid resection demonstrate a benefit for the laparoscopic approach including a shorter duration of ileus and shortened length of stay, but as in other studies, with a longer operative time.
- Recent studies have demonstrated a cost saving with the laparoscopic approach.
- Less experienced surgeons should consider an early conversion of complicated diverticular resection or potentially an alteration in the approach to a hybrid approach where the difficult pelvic dissection can be guided by the hand laparoscopically or by conventional means through the open wound.
- Laparoscopic lavage and placement of drains for purulent peritonitis secondary to perforated diverticulitis has been reported.
- Myers et al. concluded that laparoscopic management of perforated diverticulitis with generalized (purulent) peritonitis is feasible, with a low recurrence risk in the short term.
- Alamili et al. performed a review of the literature, which included eight studies, none randomized, reporting 213 patients with acute complicated diverticulitis managed by laparoscopic lavage. Mean age was 59 years and most patients had Hinchey stage III disease. Conversion to laparotomy occurred on 6 patients (3 %) and the complication rate was 10 %. Mean hospital stay was 9 days. After mean follow-up of 38 months, 38 % underwent elective sigmoid resection. Potential benefits were acknowledged, but larger studies were recommended.

Rectal Prolapse

- Laparoscopic fixation and sigmoid resection and rectopexy have been used to treat rectal prolapse (Table 35.6).
- Laparoscopic studies have shown a longer operative time (45–60 min) and shortened length of stay (2–3 days). Functional results following surgery were similar and the majority of patients reporting an improvement in incontinence and constipation.
- The majority of reports on laparoscopic surgery for rectal prolapse have limited follow-up (less than 3 years), and the reported recurrence rates ranges from 0 to 6 % (Table 35.6).
- Recently, however, there have been two studies with a mean follow-up of 5 years.
- In a study of 42 patients by D'Hoore et al., with a mean follow-up of 61 months, the rate of recurrent prolapse was 4.8 %.

Table 35.6 Laparoscopy for rectal prolapse

Study	Year	No. of patients	Follow-up (month)	Procedure	Operative time (min) LR/LRR	LOS (day)	Recurrence (%)	Comment
Poen et al.	1996	12	19	LR	195	10	0	Improved continence
Himpens et al.	1999	37	6–48	LR	130	7	0	3 % conversion
Stevenson et al.	1998	34	18	LR/LRR	185	5	0	7 % mucosal prolapse, no recurrence
Bruch et al.	1999	57	30	LR/LRR	227/257	15	0	Constipation improved in 76 %
Boccasanta et al.	1999	10						Compared with open – longer OP time, lower cost, shorter LOS
Xynos et al.	1999	10	NS	LRR	130	4.7	NS	Compared with open – longer OP time, shorter LOS
Kessler et al.	1999	32	33	LR/LRR	150	5	FT 6.2	10 % developed bowel obstruction
Heah et al.	2000	25	26	LR	96	7	0	16 % conversion
Kellokumpu et al.	2000	34	24	LR/LRR	150/255	5	7	Constipation improved in 70 %
Benoist et al.	2001	48	20–47	LR/LRR	–	–	MP 8	Suture rectopexy preferred to mesh
Solomon et al.	2002	20	24	LR	153	3.9	0	Prospective, randomized study
Kairaluoma et a1.	2003	53	12	LR/LRR	127/210	5	6	Compared with open – longer OP time, shorter LOS
D'Hoore et al.	2004	42	61	LR	NS	NS	FT 4.8	Constipation improved in 84 %
Lechaux et al.	2005	48	36	LR/LRR	193	4–7	MP 4.2	Constipation worsened in 23 %
Ashari et al.	2005	117	62	LRR	110–180	5	FT 2.5; MP 18	Large study with long-term follow-up
Heemskerk et al.	2007	33		LR	39 min longer			OR time longer for robotic vs. LAP, more expensive

Adapted from: Heemskerk J, de Hoog DE, van Gemert WG, Baeten CG, Greve JW, Bouvy ND. Robot-assisted vs. conventional laparoscopic rectopexy for rectal prolapse: a comparative study on costs and time. Dis Colon Rectum 2007;50:1825–30

RR resection rectopexy, *PFR* pelvic floor repair, *AR* anterior resection, *FRM* full rectal mobilization without fixation, *LRR* laparoscopic resection rectopexy, *LR* laparoscopic rectopexy, *FT* full thickness, *MP* mucosal prolapse, *NS* not specified

- In the largest study of laparoscopic surgery for rectal prolapse by Ashari et al., with 117 patients over a 10-year period and a mean follow-up of 62 months, the rate of recurrent full-thickness prolapse was only 2.5 %. They also noted an 18 % rate of mucosal prolapse, which is somewhat concerning.
- Further long-term follow-up of these patients is needed to ensure that the rate of recurrence remains acceptable.

Colorectal Cancer

- Prior to 2004, fewer than 5 % of resections for colon and rectal cancer were being performed laparoscopically.
- There are no good sources for estimating current figures although approximately 30 % of candidates for recertification for the American Board of Colon and Rectal Surgery (ABCRS) denote that they perform "some" laparoscopy.
- Data from randomized controlled trials, however, have laid to rest these controversial aspects of the minimally invasive approach for colon cancer, especially with respect to early concerns.
- Lacy and colleagues published the first large single-center randomized controlled trial in 2002. With median follow-up of 39 months, he and his colleagues reported higher cancer-related survival for the laparoscopic arm. Specifically, he showed no difference between arms for stage II cancers, but an improved survival for the laparoscopic approach in stage III cancers where the outcome was similar to that of stage II patients.
- This was followed in 2004 by the results of the large multicenter COST study group. With almost 900 patients randomized either to the open or the laparoscopic arm of the study, no differences were found in overall survival nor disease-free survival. Further reassurance was provided in finding that there were only two wound recurrences in the laparoscopic group and one in the open arm.
- The "CLASICC" trial from the UK included both colon and rectal cancers. The findings were similar, except for a rather spectacularly high rate of conversion, at 29 %. Those results were updated more recently in 2007.
- Concerning issues from that trial were the very high conversion rate, the rate of positive radial margins in patients undergoing resection for rectal cancer (in both the laparoscopic *and* the open arms), and the 20 % reduction in survival in patients undergoing abdominoperineal resection compared with low anterior resection. This raises very realistic concerns regarding technical issues.
- The COLOR (colon cancer laparoscopic or open resection) trial was performed as a multicenter randomized trial at 37 centers throughout Europe. The study accrued patients from 1997 to 2003, and there were several interim reports regarding accrual and outcomes compared with operative volumes, but the long-term oncologic outcomes were not reported until 2009, and even then only 3-year outcomes were reported.
- The results of these four trials are summarized in Table 35.7.

Table 35.7 Prospective, randomized trials comparing laparoscopic and conventional surgery for colorectal cancer

	Lacy et al. 2002	COST 2004	CLASICC 2005	COLOR 2009
Baseline characteristics	LAP vs. open	LAP vs. open	LAP vs. open	LAP vs. open
No. assigned	111:108	435:437	526:268	627:621
No. completed (dead or no data)	105:101	435:428	452:231 (74:37)	534:542 (83:70)
Age	68:71	70:69	69:69	71:71
Gender (F)	55:58	49 %:51 %	44 %:46 %	48 %:47 %
Previous surgery	40:47	43 %:46 %		38 %:38 %
BMI				24.5:24.9
Operative findings				
Procedure				
Right	49:49	54 %:54 %	24 %:24 %	48 %:47 %
Left	4:1	7 %:7 %	7 %:9 %	11 %:11 %
Sigmoid	52:46	38 %:38 %	13 %:12 %	38 %:39 %
AR/LAR	3:9		37 %:36 %	
			12 %:13 %	
Other	3:3		4 %:3 %	4 %:4 %
TNM stage				
0		5 %:8 %	Not given	
I	27:18	35 %:26 %		24 %:25 %
II	42:48	31 %:34 %		43 %:41 %
III	37:36	26 %:28 %		33 %:34 %
IV	5:6	4 %:2 %		
No. lymph nodes	11.1:11.1	12:12	12:13.5	
Conversion	12 (11 %):N/A	21 %:N/A	29 %:N/A	19 %:N/A
OR time (min)	142:118[a]	150:95[a]	180:135 (anesthesia time)	
Incision length (cm)		6:18[a]	10:22	

(continued)

Table 35.7 (continued)

	Lacy et al. 2002	COST 2004	CLASICC 2005		COLOR 2009
Short-term outcomes					
Oral intake (h)	54:85[a]				
(day)			6:6		
Hospital stay (day)	5.2:7.9[a]	5:6[a]	9:11		
30-day mortality		<1 %:1 %	4 %:5 %		
Postoperative complications	12:31[a]	19 %:19 %	33 %:32 %		21 %:20 %
			Colon	Rectum	
Wound infection	8:18		5 %:5 %	13 %:12 %	4 %:3 %
Pneumonia	0:0		7 %:4 %	10 %:4 %	1 %:2 %
Ileus	3:9				
Leak	0:2		2 %:0 %	10 %:7 %	3 %:2 %
Duration of oral analgesics (day)		1:2[a]			
Duration of parenteral analgesics (day)		3:4[a]			
Cancer outcomes					
Tumor recurrence	18:28	76:84			
Distant	7:9				56:54
Locoregional	7:14				26:26
Peritoneal seedling	3:5				
Port site	1:0	2:1	9 (2.5 %):1 (0.6 %)		7 (1.3 %):2 (0.4 %)
5-year overall survival[b]	82 %:74 %	79 %:78 %	3-year reported 68.4 %:66.7 %		3-year reported 81.8 %:84.2 %
I	85 %:94 %	84 %:94 %	No graphs by TNM stage		84 %:82 %
II	75 %:77 %	78 %:81 %	No graphs by TNM stage		78 %:82 %
III	72 %:45 %	60 %:63 %	No graphs by TNM stage		62 %:57 %

5-year disease-free survival[b]		78 %:80 %	3-year reported 66.3 %:67.7 %	3-year reported 74.2 %:76.2 %
I	90 %:88 %	92 %:96 %	No graphs by TNM stage	80 %:77 %
II	80 %:76 %	82 %:88 %	No graphs by TNM stage	70 %:75 %
III	70 %:45 %	62 %:60 %	No graphs by TNM stage	58 %:55 %
Cancer-related survival[b]	91 %:79%[a]			
I	100 %:99 %			
II	88 %:85 %			
III	84 %:50%[a]			

[a]Statistically significant difference
[b]Extrapolated from graphs in manuscript

- The results of these trials (Table 35.7) have demonstrated that similar oncologic resections can be achieved by experienced surgeons performing laparoscopic colon resections. After publication of the COST study results, ASCRS and SAGES copublished an approved statement that laparoscopic colectomy for cancer appeared to produce similar oncologic outcomes but emphasized that these procedures should only be attempted by surgeons experienced with laparoscopic techniques.

Outcomes for Rectal Cancer

- Surgical resection of rectal cancer has the potential to achieve a curative result. Total mesorectal excision (TME) is currently the standard of care, minimizing the risk of local recurrence and providing accurate information regarding staging, that affects prognosis and subsequent therapy.
- Early prospective studies, from experienced surgeons, suggested that laparoscopic resection did not worsen survival or disease control in patients with rectal cancer compared with open resection.
- An early study by Leung et al. evaluated laparoscopic vs. open resection for rectosigmoid cancer, so this was not a trial of TME. A total of 403 patients were accrued between 1993 and 2002, 203 in the laparoscopic arm and 200 open. The probability of survival at 5 years for the laparoscopic and open resection groups were 76.1 and 72.9 %, respectively. Five-year disease-free survival rates were 75.3 and 78.3 %, respectively. The operative time for the laparoscopic group was significantly longer, whereas postoperative recovery was significantly better than for the open resection group. These benefits, however, were at the expense of higher direct cost. Reassuringly, the distal margin, the number of lymph nodes found in the resected specimen, overall morbidity, and operative mortality did not differ between groups.
- The CLASICC randomized controlled trial in the UK differed from its contemporaneous trials (COST, COLOR) in that patients with both colon cancer and rectal cancer were included. The study enrolled 268 patients to the open arm, of whom 128 (48 %) had rectal cancer, and 526 patients to the laparoscopic arm, of whom 253 (48 %) had rectal cancer. The conversion rate for the study overall was 29 %, with a 25 % conversion rate for colon cancer and 34 % for rectal cancer. The conversion rate dropped by year of the study, from 38 % in year 1 to 16 % in year 6 of the study. Operative time was longer for the laparoscopic rectal resections (180 min vs. 135 min), time to bowel movement shorter (5 days vs. 6 days), time to regular diet the same (6 days), and hospital stay shorter (11 days vs. 13 days). It was noted that the rate of positive circumferential resection margins (CRM) was the same between the two groups, but a closer look at the data is very disturbing. The CRM was positive in 14 % of open patients and 16 % of laparoscopic patients ($P = 0.8$). Admittedly, these are not significantly different, but the fact they are not different is not reassuring as

the rate in the open group is hardly acceptable! In the low anterior resection group, it was noted that there was a nonsignificant trend toward a higher positive CRM rate in the laparoscopic group (12 % vs. 6 %, $P=0.19$). It was noted that no difference was seen in CRM positivity in the abdominoperineal group, but again the actual figures are far from reassuring with a 20 % (10/49) positive rate in the open group vs. 26 % (7/27) in the laparoscopic group.

- Thus although the reports of the randomized controlled trials for colon cancer were reassuring, the CLASICC trial raised concerns regarding the application of laparoscopic techniques for rectal cancer. The fact that there were also high rates of CRM positivity in the open cases raised the issue of technical competence in the CLASICC trial and deflected some of the attention away from the laparoscopic technique itself. Fortunately, overall, there were no differences in the long-term outcomes in the follow-up report of oncologic outcomes. There was no statistically significant difference in 3-year overall survival for patients undergoing anterior resection (AR) or abdominoperineal resection (APR) in either technique group (AR, open 66.7 %, laparoscopic 74.6 %; APR, open 57.7 %, laparoscopic 65.2 %). The higher positivity of the circumferential resection margin reported after laparoscopic anterior resection did not translate into an increased incidence of local recurrence. There was no difference in 3-year local recurrence rates after anterior resection of rectal cancer (7 % open, 7.8 % laparoscopic) or abdominoperineal resection of rectal cancer (21 % open, 15 % laparoscopic).
- Numerous single-institution prospective case series have since supported the safety and efficacy of laparoscopic resection of rectal cancer in experienced centers and experienced hands.
- Ng et al. reported short-term outcomes and long-term survival in a large single-institution series of 579 patients undergoing laparoscopic resection for rectosigmoid and rectal cancer. Rectosigmoid and upper rectal cancers (12–18 cm from the anal verge), both undergoing low anterior resection, were grouped together for the subsequent analysis. Patients with tumors in the mid-rectum (7–12 cm from the anal verge) underwent sphincter-preserving TME. Patients with low-rectal tumors (<7 cm from the anal verge) underwent either TME or APR. Over a 15-year period, there were 316 laparoscopic anterior resections, 152 sphincter-preserving TME, and 92 laparoscopic APRs. Median follow-up was 56 months. Overall, early and late operative morbidity rates were 18.8 and 9.7 %, respectively. The anastomotic leak rate was 3.5 % ($n=20$). Conversion occurred in 31 patients (5.4 %). Port site recurrence was seen in 0.4 % of patients (1 laparoscopic anterior resection, 1 laparoscopic TME) and locoregional recurrence in 7.4 % of patients. Microscopic resection margin involvement was identified in 6 laparoscopic TME and in 2 laparoscopic APR. Overall 5- and 10-year survival rates were 70 and 45.5 %, and cancer-specific 5- and 10-year survival rates were 75 and 56 %, respectively. Of note, patients in

the anterior resection group were not stratified by tumor location, so the number of patients with rectosigmoid vs. upper rectal cancer is unclear. The authors concluded that laparoscopic resection for rectal cancer is safe and offers long-term oncologic outcomes equivalent to those of open resection.

- In a retrospective study of 421 patients comparing outcome between open (310 patients) and laparoscopic (111) resection for stage II and stage III rectal cancer, Law et al. reported 5-year actuarial survival rates of 71.1 % vs. 59.3 % in the laparoscopic vs. open arms, respectively ($P=0.029$), after a median follow-up of 34 months. There was no difference in local recurrence. Laparoscopic resection was associated with decreased blood loss (200 ml vs. 350 ml, $P<0.001$) and shorter hospital stay (7 days vs. 9 days, $P<0.001$). The conversion rate was 12.5 %. On multivariate analysis, laparoscopic resection was an independent factor associated with improved survival ($P=0.03$, hazards ratio 0.558 [95 % confidence interval, 0.339–0.969]). There was, however, no breakdown of the number of stage II vs. stage III rectal cancer patients. The study concluded that compared to open resection, laparoscopic resection for locally advanced rectal cancer is associated with more favorable overall survival.
- Thus in these large retrospective and prospective single-institution studies, the data consistently demonstrate improved early postoperative outcomes with no negative impact on oncologic outcomes and even improved oncologic outcomes in some series.
- Interestingly, the potential for improved TME specimens has been demonstrated in an elegant study by Gouvas et al., in 39 open and 33 laparoscopic proctectomies.
- A more recent single-institution randomized controlled trial was reported by Lujan et al. After neoadjuvant chemoradiation, 204 patients with mid- and low-rectal cancer were randomized to open (103) or laparoscopic resection (101). Sphincter preservation rates were not different, 78.6 and 76.2 % in the open and laparoscopic group, respectively. Complication rates and involvement of CRM rates were similar, but the lymph node retrieval rates were greater in the laparoscopic group (mean 13.6 vs. 11.6). There were no differences in oncologic outcomes in terms of local recurrence, disease-free, or overall survival.
- Concerns still remained regarding the applicability of laparoscopic techniques for rectal cancer outside highly specialized, high-volume institutions. For this reason, there are several multicenter randomized trials in various stages of accrual.
- In the USA, a prospective, multicenter randomized trial was established to determine the feasibility, reproducibility, and oncologic applicability of minimally invasive techniques in the resection of rectal cancer. This study is currently accruing patients under the auspices of the ACOSOG Study AZ6051. The primary objective of the trial is to test the hypothesis that laparoscopic resection of rectal cancer is not inferior to open resection.

Outcomes being measured are based on a composite primary endpoint of oncologic factors, which are considered to indicate a safe and feasible operation. These parameters are circumferential margin >1 mm, distal resected margin >2 cm (or >1 cm with clear frozen section in the low rectum), and completeness of TME, defined by careful evaluation by an experienced pathologist. Secondary objectives are to assess patient-related benefit of laparoscopic-assisted vs. open rectal resection (blood loss, length of stay, pain medicine utilization), to assess disease-free survival and local pelvic recurrence at 2 years, and to assess quality of life, sexual function, bowel, and stoma function.

- The UK MRC CLASICC trial is close to reporting its mature 5-year data. The Japan Clinical Oncology Group (JCOG) Study 0404, which has been evaluating laparoscopic surgery for colorectal cancer, was activated in October 2004 and is also close to reporting its long-term data.
- At present, the European Colon Cancer Laparoscopic or Open Resection (COLOR) II trial is a randomized, international, multicenter study comparing the outcomes of laparoscopic and conventional resection of rectal carcinoma with curative intent. Prior to its start, a feasibility study is to be performed with the objective of controlling for quality of laparoscopic TME. The primary endpoint is locoregional recurrence at 3 years. Secondary endpoints are recurrence-free and overall survival at 3, 5, and 7 years, rate of distant metastases, port site and wound site recurrences, microscopic evaluation of the resected specimen, 8-week morbidity and mortality, quality of life, and cost.
- Given limited prospective data, laparoscopic resection for rectal cancer remains investigational in the USA. Although it is performed in some specialist centers by experienced surgeons, open surgical resection is still the standard of care in most hands, and the role of laparoscopy is yet to be confirmed. Studies consistently show improved short-term outcomes, such as quicker recovery times, shorter hospital stays, and reduced analgesic requirements, but these are at the price of longer operative times and higher overall costs. Careful patient and tumor selection are essential. Mature 5-year data are pending from the MRC CLASICC and the JCOG 0404 trials. The European COLOR II trial and the ACOSOG-Z6051 trial, specifically comparing outcomes of laparoscopic-assisted and open resection for rectal cancer, are under way but far from reporting results.

Laparoscopic Resection of Colon and Rectal Cancer

- The following description regarding the safe performance of laparoscopic resection for curable colon and rectal cancer is based on current literature, experience, and an understanding that patients are treated by experienced surgeons whose minimally invasive skills fulfill the Credentialing Recommendations endorsed jointly by ASCRS and SAGES.

General Considerations

- Following detection of a colon or rectal cancer, routine evaluation incorporates preoperative staging, assessment of resectability, and determination of the patient's operative risk.
- There are several factors to consider when a laparoscopic approach is considered: (1) site of the tumor is important, as right and sigmoid colectomy are generally less technically demanding than, for example, low anterior resection; (2) extensive adhesions; (3) obesity, and particularly the distribution of abdominal fat, may preclude laparoscopic resection, especially in the case of a rectal cancer in an obese male patient with a narrow pelvis; (4) the patient should be informed of both laparoscopic and open alternatives and the possible need for conversion; and (5) the surgeon must have adequate experience prior to embarking on resection for a potentially curable malignancy.

Tumor Localization

- A laparoscopic approach requires accurate localization of the tumor to a specific segment of the colon, as even a known cancer may not be visualized from the serosal aspect of the bowel during laparoscopy. The wrong segment of colon may be removed if accurate localization has not been performed.
- A variety of other options are available to localize a lesion including, preoperative colonoscopic marking with ink tattoo or metallic clips, barium enema, or intraoperative endoscopy. The area adjacent to a cancer or polyp may be marked either by endoscopic clips or by submucosal India ink injection. If clips are placed, immediate abdominal X-ray films should be taken; otherwise, intraoperative imaging with laparoscopic ultrasound or fluoroscopy is necessary to localize the clip's location. This procedure is not commonly employed since it requires an experienced radiologist and/or endoscopist.
- Preoperative endoscopic tattooing is a common method of tumor localization. India ink is a nonabsorbable marker, which has been reported in more than 600 cases for tumor localization since 1975. The ink is injected into the submucosa in three or four quadrants around the lesion, or 2 cm distal to the lesion if the tumor is in the distal colon and distal margins are potentially an issue (typically, 0.5 cm^3 per site). During diagnostic laparoscopy the ink marking can be identified even at the flexures or transverse colon. India ink injection appears to be safe with few reported complications.
- Intraoperative endoscopy is hampered by persistent bowel distention, prolongation of operative times, and need for equipment and endoscopist intraoperatively. More recent studies have evaluated CO2 colonoscopy, which allows for more rapid absorption of the intracolonic gas which may facilitate its use during laparoscopic procedures.

- Preoperative staging and perioperative preparation are similar to open resections.

Operative Issues

- Oncologic principles must not be compromised by a laparoscopic resection. For colon cancer surgery: proximal and distal resection margins (based upon the area supplied by the named feeding arterial vessel), mesenteric lymphadenectomy containing a minimum of 12 lymph nodes, and ligation of the primary feeding vessel at its base.
- Inability to achieve these aims laparoscopically should prompt conversion to an open procedure.
- For rectal cancer surgery: a distal margin of 1–2 cm, removal of the blood supply and lymphatics up to the origin of the superior rectal artery (or inferior mesenteric artery if indicated), and appropriate mesorectal excision with radial clearance.

Contiguous Organ Attachment

- En bloc resection is recommended for locally advanced adherent colorectal tumors. A bulky tumor invasive into an adjacent organ may be detected by preoperative imaging, such as CT scan, and guide the recommendation for an open resection.
- A known T4 colonic cancer will prompt an open approach in the vast majority of cases, although some experienced surgeons may complete en bloc resection of involved small bowel or abdominal wall laparoscopically.

Prevention of Wound Implants

- Port site recurrences, or wound implants, have been reported at both extraction site and trocar site incisions, which prompted extensive investigation. Current consensus is that wound implants should be kept at a rate less than 1 % by correct oncologic technique and experience.
- In vitro and in vivo animal models have generated most recommendations for avoidance of wound implants.
- Gasless laparoscopy has shown mixed results.
- Tumor growth may be proportional to insufflation pressure. Carbon dioxide is associated with increased tumor implantation and growth but is clinically the safest and most widely used gas.
- Helium decreases tumor implants but is not easily adapted to the clinical setting.
- Wound excision may either decrease or increase the rate of tumor implants.
- Gas leakage along loosely fixed trocars (the “chimney effect”) may be associated with increased cancer wound implantation.
- An expert panel convened by the European Association of Endoscopic Surgery (EAES) reported that half the members irrigated the port sites and

all members protected the extraction site and/or extracted the specimen in a bag.

- The most important development in the issue of wound implants is experience and the refinement of laparoscopic techniques and equipment that permit a true oncologic resection to be performed.
- Early reports of implant rates of 2–21 % have not been reproduced in large retrospective series by experienced surgeons, who reported rates of 1 % or less (similar to the incisional recurrence rate for open colorectal cancer resection).

Training and Credentialing in Laparoscopic Colorectal Surgery

- Early studies estimated the learning curve for laparoscopic colectomy to be 20–50 cases.
- The following is the approved statement from ASCRS and SAGES:

> Laparoscopic colectomy for curable cancer results in equivalent cancer related survival to open colectomy when performed by experienced surgeons. Adherence to standard cancer resection techniques including but not limited to complete exploration of the abdomen, adequate proximal and distal margins, ligation of the major vessels at their respective origins, containment and careful tissue handling, and en bloc resection with negative tumor margins using the laparoscopic approach will result in acceptable outcomes. Based upon the COST trial, prerequisite experience should include at least 20 laparoscopic colorectal resections with anastomosis for benign disease or metastatic colon cancer before using the technique to treat curable cancer. Hospitals may base credentialing for laparoscopic colectomy for cancer on experience gained by formal graduate medical educational training or advanced laparoscopic experience, participation in hands-on training courses and outcomes.

- The issue of defining numbers for credentialing purposes is a source of considerable controversy.
- For perspective, a resident completing a General Surgery Residency Program in 2003 and entering practice had performed a mean of 120 cases on the large intestine (mode 106, Residency Review Committee for Surgery, Reporting Period 2002–2003). Of these, an average of 50 cases required resection and anastomosis. Thus the guideline for 20 laparoscopic cases is not excessive or unreasonable in terms of attaining comparable experience prior to independent practice.

Alternative Approaches

Hand-Assisted Laparoscopy

- Hand-assisted laparoscopic colectomy is an alternative to straight laparoscopic techniques.

- A hand-assisted laparoscopic colectomy may be easier to adopt than a straight laparoscopic approach.
- Studies have demonstrated that hand-assisted colectomy provides similar functional results to straight laparoscopic resection with fewer conversions.
- Operative times appear shorter than traditional laparoscopy in the majority of studies but length of stay has been similar.

Robotic Colorectal Surgery

- The robotic device allows for precise control of movement, restoration of all the "degrees of freedom" provided by the human wrist, magnification, and three-dimensional images. The most convincing application to date has been in the field of urology, where the device has allowed for intracorporeal suturing of the bladder to urethra anastomosis. Even this has been challenged recently.
- In the field of colorectal surgery, the use of the device remains controversial. It is hard to justify its use in colectomies. Even those who have used it for right and left colectomy have demonstrated increased operative times and increased costs.
- It may potentially have a greater role in the resection of rectal cancer.
- However, consensus has not been reached. It is salutary to read the editorial of Cadeddu et al. on robotic prostatectomy. He reflects upon the issue that marketing of the robotic device has reached such heights that opinion has "reached the level of surgical dogma among patients and physicians at the expense of objective data." The robotic device fascinates surgeons and patients alike. It is a wonderful tool. But it remains just that – a tool. Many surgeons who are currently performing advanced laparoscopic colorectal procedures have skills such that they do not require a robot. The robot may facilitate dissection in the pelvis for rectal cancer, especially for surgeons who might not otherwise be able to complete a pelvic dissection laparoscopically, but it remains to be seen if the current economic climate will continue to support expensive technology to support lack of acquisition of operative skills.

Single-Incision Colectomy

- This development of single-incision colectomy is still in its seminal stages. Initial publications are primarily case reports or press releases. Reports have expanded from the original cholecystectomy to include appendectomy, sleeve gastrectomy, adrenalectomy, and colectomy.
- There is growing data about the safety of single port in skilled hands, but incremental benefits may be very difficult to confirm.

NOTES Colectomy

- Natural orifice transluminal endoscopic surgery (NOTES) became a focus of intellectual and surgical creativity after the pairing of a surgeon

and a gastroenterologist in India led to the release of a video of an appendectomy performed via a gastrotomy with flexible endoscopic instruments, with extraction of the specimen transorally. After 5 years and millions of dollars of research and development money later, yet the approach is still seeking what Jeff Ponsky has referred to as the "Killer App" or the application that transcends obstacles to its use (personal communication). Although surgeons see this approach as potentially being the same quantum leap in surgical technique that laparoscopy was compared with laparotomy, there are different barriers.

- The transvaginal approach has been used primarily, as the majority of patients requiring cholecystectomy are female, and this approach affords greater confidence in the quality of the preparation. The transrectal approach does have its merits, however, and transrectal endoscopic microsurgery (TEMS) has illustrated that this path of access can be adequately prepped.
- Second, and likely least pertinent, the rectum has been used as a means of obtaining access to the peritoneal cavity with a flexible instrument that is then used to perform dissection and resection of a segment of colon. Transgastric and bidirectional approaches with both transgastric and transrectal approaches have been described. These are tours de force of technique but not immediately relevant to clinical practice.
- The third area of research has focused on use of the TEMS device as a means of access. This makes sense that the planned anastomotic site becomes the means of access to the abdominal cavity and has implications for sigmoidorectal surgery (and also for bariatric surgery with upper endoscopy using the planned anastomotic site). Several groups have described using the TEMS device to make a circumferential incision in the rectum at the planned level of anastomosis and then continuing the dissection in the presacral space and the left retroperitoneum. The technique does not reliably allow for mobilization of the splenic flexure, so again, applications are limited at this point with current instrumentation.

Future Considerations

- It is actually quite fascinating to see how slowly laparoscopic techniques for colorectal surgery have been adopted. The procedures are likely similar in terms of technical difficulty to bariatric procedures, yet the vast majority of bariatric procedures are performed laparoscopically as opposed to less than 30 % of colorectal procedures. One wonders if market forces are implicated, as many bariatric procedures are not covered by insurance and the patient pays out of pocket. Over the next few years, the field of colorectal surgery may become quite divergent, especially within the subspecialist field of minimally invasive procedures. Surgeons who have adopted hand-assisted techniques may not be able to adopt single-incision

techniques, if the latter prove to have benefits. The realm of NOTES is still undetermined, but there will likely be considerable cross-fertilization with the techniques and instrumentation used for single-incision procedures.

- Bemelman phrased this upcoming period best: when fast-track protocols make it difficult to differentiate laparoscopic from open approaches, then the long-term implications of a laparoscopic approach carry far more weight than such short-term benefits as time to bowel function and time in the hospital. More important are long-term outcomes such as rates of bowel obstruction and preservation of fertility. This is an exciting time for this field, not least for our patients who will hopefully continue to benefit from the extensive efforts being expended in making these major procedures less invasive.