

Outcomes of Conversion of Laparoscopic Colorectal Surgery to Open Surgery

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ABSTRACT

Objectives: There is limited data regarding the outcomes of patients who undergo conversion to open surgery during a laparoscopic operation in colorectal resection. We sought to identify the outcomes of such patients.

Methods: The NIS (National Inpatient Sample) database was used to identify patients who had conversion from laparoscopic to open colorectal surgery during the 2009 to 2012 period. Multivariate regression analysis was performed to identify risk-adjusted outcomes of conversion to open surgery.

Results: We sampled 776 007 patients who underwent colorectal resection. 337 732 (43.5%) of the patients had laparoscopic resection. Of these, 48 265 procedures (14.3%) were converted to open surgery. The mortality of converted patients was increased, when compared with successfully completed laparoscopic operations, but was still lower than that of open procedures (0.6% vs. 1.4% vs. 3.9%, respectively; adjusted odds ratio [AOR], 1.61 and 0.58, respectively; $P < .01$). The most common laparoscopic colorectal procedure was right colectomy (41.2%). The lowest rate of conversion is seen with right colectomy while proctectomy had the highest rate of conversion (31.2% vs. 12.9%, AOR, 2.81, $P < .01$). Postsurgical complications including intra-abdominal abscess (AOR, 2.64), prolonged ileus (AOR, 1.50), and wound infection (AOR, 2.38) were higher in procedures requiring conversion ($P < .01$).

Conclusions: Conversion of laparoscopic to open colorectal resection occurs in 14.3% of cases. Compared with patients who had laparoscopic operations, patients who had conversion to open surgery had a higher mortality,

higher overall morbidity, longer length of hospitalization, and increased hospital charges. The lowest conversion rate was in right colectomy and the highest was in proctectomy procedures. Wound infection in converted procedures is higher than in laparoscopic and open procedures.

Key Words: Conversion, Laparoscopic surgery, Colorectal resection.

INTRODUCTION

Conversion from laparoscopic to open surgery is common in colorectal surgery with an incidence of 10% to 23%.^{1,2} Many studies have examined risk factors for conversion in laparoscopic colorectal surgery in an effort to identify high-risk patients. Some of the reported risk factors include high body mass index, Americans Society of Anesthesiology score > 2 , and the surgeon's operative experience.² There is limited data regarding outcomes of patients who had conversion from laparoscopic to open colorectal surgery. Also, the best surgical approach (laparoscopic vs. open) for high-risk patients is unclear.

There is controversy regarding the outcomes of patients who required conversion during laparoscopic colorectal operations. Some previously published data demonstrates poor outcomes with up to 50% morbidity rate in patients requiring conversion.^{3,4} Longer operative time for colorectal laparoscopic surgery and a high rate of conversion to open surgery in high-risk patients has raised concerns about benefits of laparoscopic surgery in this subset of patients. Also, higher local recurrence and reduced cancer-free survival have been reported in colorectal cancer patients who had conversion from laparoscopic to open procedures.^{3,5,6} Careful patient selection is recommended by such studies.^{5,6} However, some studies report only a small difference in outcomes of patients who underwent conversion and justify implementation of laparoscopic surgery into daily practice.⁷⁻⁹ Deciding on surgical technique in high-risk patients while considering the risk of conversion of laparoscopic surgery is difficult. Most previous studies had limited numbers of patients; therefore, a

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large nationwide study analyzing the contemporary rate of conversion and the impact of conversion on outcomes of colorectal patients is needed. Using a large database, we aim to report contemporary rates of conversion and outcomes of converted procedures compared with planned open and successfully completed laparoscopic operations.

MATERIALS AND METHODS

This study was performed using the NIS (National Inpatient Sample) database from January 1, 2009, to December 31, 2012. The NIS database is the largest publically available all-payer inpatient care database in the United States and contains data on >7 million hospital stays each year.¹⁰ Approval for use of the NIS data in this study was obtained from the Human Research Protection of the University of California, Irvine Medical Center and the NIS. We analyzed discharge data on patients who had undergone colorectal resections for the diagnoses of benign or malignant colorectal tumors, diverticular diseases, Crohn disease, and ulcerative colitis using the procedural and diagnosis codes as specified by the *International Classification of Diseases, Ninth Revision, Clinical Modifications* (ICD-9-CM). To identify patients who underwent colorectal resection the ICD-9 procedure codes of 17.31 to 17.39, 45.71 to 45.76, 45.81, 45.82, 48.52, and 48.51 were used. Patients' diagnoses were defined based on the following ICD-9 codes: malignant neoplasm of colon and rectum (153.0–153.9, 154.0, 154.1, 230.3, and 230.4), benign neoplasm of colon and rectum (211.3, 211.4), diverticulosis (562.10 and 562.12), diverticulitis (562.11 and 562.13), Crohn disease (555.0, 555.9), and ulcerative colitis (556.0–556.9). Conversion of laparoscopic surgery to open surgery was defined as the ICD-9 diagnostic code of V64.41. Patients were excluded if they were younger than 18 years old or did not undergo colon or rectal resection.

Preoperative factors analyzed, as conveyed in Table 1, included patient characteristics (age, sex, and race) and 12 comorbid conditions including chronic pulmonary disease, chronic renal failure, fluid and electrolyte disorders, obesity (body mass index ≥ 30 kg/m²), hypertension, diabetes mellitus, metastatic cancer, liver disease, coagulopathy, alcohol abuse, history of previous abdominal surgery, and weight loss >10% in the preceding 6 months. Other factors analyzed included pathologic conditions (Crohn disease, ulcerative colitis, colorectal cancer, diverticulosis or diverticulitis, and benign colorectal tumor), procedure type (cecectomy, right colectomy, left colectomy, transverse colectomy, sigmoidectomy, and proctec-

tomy), surgical techniques (laparoscopic, open, and converted procedures), and postsurgical complications (intra-abdominal infection, acute renal failure, acute respiratory failure, deep vein thrombosis, urinary tract infection, pulmonary embolism, wound infection, wound disruption, bowel obstruction, postoperative prolonged ileus, and hospitalization for >7 days from admission date). Patients were divided into 3 groups: successful laparoscopic surgery, open surgery, and conversion from laparoscopic to open surgery. The overall rates of postoperative complications by each group of patients were analyzed. Risk-adjusted analysis was performed to compare postoperative complications of the 3 groups of patients. Female sex, age <70 years, and benign colorectal tumor were used as reference data points for comparison in line with the literature.¹¹

Statistical Analysis

Statistical analysis was performed with SPSS software (version 22; SPSS Inc., Chicago, Illinois). Multivariate analysis using logistic regression was used to compare outcomes of the 3 groups of surgical techniques (open, laparoscopic, and laparoscopic procedures that required conversion). *P* values <.05 were considered statistically significant. For each outcome, the adjusted odds ratio (AOR) with a 95% confidence interval (95% CI) was calculated and reported to estimate the relative risk associated with each surgical technique. Adjustments were made for age, sex, race, chronic pulmonary disease, chronic renal failure, history of abdominal surgery, obesity, hypertension, diabetes mellitus, metastatic cancer, liver disease, coagulopathy, alcohol abuse, weight loss, type of admission, type of the procedure, type of surgical technique, and pathology type. Discharge weight was used for national estimates.

RESULTS

We sampled 776 007 adult patients who underwent colorectal resection from 2009 through 2012. The mean age was 64 ± 15 years. Most patients were Caucasian (78.8%) and female (52.6%). The most prevalent comorbidities included hypertension (52.5%) and diabetes mellitus (18.5%). Demographic data of patients are described in Table 1.

Overall, 43.5% of patients had laparoscopic resection. The most common laparoscopic colorectal procedure was right colectomy (41.2% of all laparoscopic procedures) followed by sigmoidectomy (40.3%). Among patients who

Table 1.
Demographics of Patients Who Have Undergone Colon and Rectal Surgery in the United States, NIS 2009–2012

Patients Characteristics	Patients Who Underwent Planned Open Surgery (n = 438 275)	Patients Who Underwent Successfully Completed Laparoscopic Surgery (n = 289 468)	Patients Who Had Conversion of Laparoscopic Surgery (n = 48 264)	Total Cohort (n = 776 007)
Age				
Mean, y	65	62	62	64
Median, y	66	63	63	65
Sex				
Female	232 293 (53)	151 999 (52.5)	23 581 (48.9)	407 873 (52.6)
Admission type				
Elective	211 691 (48.3)	235 971 (81.6)	33 724 (69.9)	481 386 (62)
Urgent/emergent	225 694 (51.5)	53 109 (18.4)	14 487 (30)	293 290 (37.8)
Race				
White	305 799 (78.3)	212 175 (79.7)	34 392 (77.5)	552 366 (78.8)
Black	40 958 (10.5)	22 635 (8.5)	4475 (10.1)	68 068 (9.7)
Hispanic	26 379 (6.8)	18 613 (7)	3229 (7.3)	48 221 (6.9)
Asian or Pacific Islander	6316 (1.6)	4861 (1.8)	779 (1.8)	11 956 (1.7)
Other	11 332 (2.9)	7921 (2.8)	1491 (3.4)	20 744 (3)
Comorbidity				
Hypertension	235 493 (53.7)	146 918 (50.8)	25 145 (52.1)	407 556 (52.5)
Diabetes	85 849 (19.6)	48 714 (16.8)	9218 (19.1)	143 781 (18.5)
Chronic lung disease	76 246 (17.4)	39 532 (13.7)	7167 (14.8)	122 945 (15.8)
Metastatic cancer	74 460 (17)	25 449 (8.8)	6806 (14.1)	106 715 (13.8)
Previous abdominal surgery	61 594 (14.1)	26 550 (9.2)	12 399 (25.7)	100 543 (13)
Weight loss	61 257 (14)	11 453 (4)	3511 (7.3)	76 221 (9.8)
Obesity	49 766 (11.4)	31 292 (10.8)	7802 (16.2)	88 860 (11.5)
Renal failure	32 935 (7.5)	11 909 (4.1)	2453 (5.1)	47 297 (6.1)
Coagulopathy	19 929 (4.5)	5234 (1.8)	1221 (2.5)	26 384 (3.4)
Alcohol abuse	11 481 (2.6)	4000 (1.4)	924 (1.9)	16 405 (2.1)
Liver disease	9609 (2.2)	4692 (1.6)	1109 (2.3)	15 410 (2)
Procedure				
Right hemicolectomy	154 813 (35.3)	121 188 (41.9)	17 966 (37.2)	293 967 (37.9)
Sigmoidectomy	179 181 (40.9)	116 505 (40.2)	19 620 (40.7)	315 306 (40.6)
Left hemicolectomy	61 660 (14.1)	24 516 (8.5)	6693 (13.9)	92 869 (12)
Transverse colectomy	21 819 (5)	8705 (3)	2273 (4.7)	32 797 (4.2)
Total colectomy	20 389 (4.7)	8770 (3)	1498 (3.1)	30 657 (4)
Cececctomy	15 280 (3.5)	11 942 (4.1)	2520 (5.2)	29 742 (3.8)
Multiple resection of colon	2936 (0.7)	953 (0.3)	258 (0.5)	4147 (0.5)
Proctectomy	2885 (0.7)	684 (0.2)	310 (0.6)	3879 (0.5)

Table 1.
Continued

Patients Characteristics	Patients Who Underwent Planned Open Surgery (n = 438 275)	Patients Who Underwent Successfully Completed Laparoscopic Surgery (n = 289 468)	Patients Who Had Conversion of Laparoscopic Surgery (n = 48 264)	Total Cohort (n = 776 007)
Pathology				
Benign colorectal tumor	55 705 (12.7)	72 941 (25.2)	8041 (16.7)	136 687 (17.6 %)
Colorectal cancer	192 405 (43.9)	113 676 (39.3)	19 919 (41.3)	326 000 (42)
Diverticulitis of colon	146 541(33.4)	88 641 (30.6)	16 435 (34.1)	251 617 (32.4)
Diverticulosis of colon	61 584 (14.1)	28 353 (9.8)	5139 (10.6)	95 076 (12.3)
Crohn disease	24 816 (5.7)	11 314 (3.9)	3417 (7.1)	39 547 (5.1)
Ulcerative colitis	13 287 (3)	5941 (2.1)	779 (1.6)	20 007 (2.6)

Values are n (%) unless otherwise indicated.

NIS, National Inpatient Sample database.

underwent planned laparoscopic colorectal resection, 48,265 patients (14.3%) had conversion to open surgery.

The mean length of total hospital stay was 9 days in patients with conversion, while patients who had successfully laparoscopic surgery had mean hospitalization of 6 days. The mean risk-adjusted difference in hospitalization length was statistically significant (mean difference = 2 days; 95% CI, 1.60–1.70; $P < .01$).

The mortality rate in patients who underwent laparoscopic colorectal resection with and without conversion was 1.4% and 0.6%, respectively, while the adjusted risk of mortality in patients who underwent conversion was higher than in patients without conversion (AOR, 1.61; 95% CI, 1.45–1.78; $P < .01$). Also, the risk-adjusted mortality of patients who underwent planned open surgery was higher than for converted patients (3.9% vs. 1.4%; AOR, 1.70; 95% CI, 1.57–1.85; $P < .01$).

The mean hospital charge was \$77 186 in patients with conversion, while patients who underwent successfully completed laparoscopic surgery had a mean hospital charge of \$56 032. The mean difference in hospital charge was statistically significant (mean difference = \$12 215; 95% CI, \$11 648–\$12 782; $P < .01$).

The risk-adjusted analysis for postsurgical complications associated with conversion of laparoscopic surgery to open surgery is reported in Table 2. Specific postsurgical complications linked with conversion of laparoscopic surgery include intra-abdominal abscesses (AOR, 2.64; $P < .01$), and postoperative wound infection (AOR, 2.38; $P < .01$). Hemorrhagic complications and wound infection in

converted procedures were more than in both laparoscopic and planned open procedures (Table 2).

The risk of conversion of laparoscopic surgery to open surgery is reported by perioperative factors and type of colorectal resection in Tables 3 and 4. The lowest rate of conversion exists in right colectomy (12.9%). Factors such as history of previous abdominal surgery (AOR, 3.50; $P < .01$) and presence of metastatic cancer (AOR, 1.73; $P < .01$) have strong associations with conversion. Also, compared with right colectomy procedure, the highest risk of conversion exists in proctectomy procedure (AOR, 2.81; $P < .01$) followed by transverse colectomy (AOR, 1.88; $P < .01$).

Table 5 estimates the increased risk of conversion associated with the presence of multiple risk factors in colorectal surgery. For example, patients with history of previous abdominal surgery who were admitted emergently with one of the comorbidities of liver disease, obesity, or metastatic cancer had at least 7 times increased risk of conversion.

Finally, Table 6 describes the associations between preoperative variables and mortality of patients who underwent converted procedures. Factors such as age >70 years and coagulopathy have strong associations with mortality.

DISCUSSION

Conversion of laparoscopic to open colorectal surgery is associated with increased mortality and morbidity rates, as well as an increase in length of hospitalization. However, the outcomes of patients who required conversion are still

Table 2.
Risk-Adjusted Analysis for Postoperative Complications of Open and Converted Procedures Compared With Laparoscopic Procedures

Complications	Laparoscopic Procedures (n = 289 468)	Converted Procedures (n = 48 264)			Open Procedures (n = 438 275)		
		Rate	P Value	AOR and 95% CI	Rate	P Value	AOR and 95% CI
Mortality	1735 (0.6)	660 (1.4)	<0.01	1.61 (1.45–1.78)	16 891 (3.9)	<0.01	2.81 (2.67–2.97)
Wound disruption	960 (0.3)	693 (1.4)	<0.01	2.93 (2.63–3.26)	8246 (1.9)	<0.01	3.58 (3.33–3.84)
Wound infection	6782 (2.3)	3372 (7)	<0.01	2.38 (2.28–2.50)	25 707 (5.9)	<0.01	1.84 (1.79–1.90)
Hospitalization >7 days	57 472 (19.9)	19 289 (40)	<0.01	2.11 (2.06–2.16)	239 758 (54.7)	<0.01	2.52 (2.49–2.55)
Intra-abdominal abscess	940 (0.3)	644 (1.3)	<0.01	2.64 (2.36–2.95)	4380 (1)	<0.01	1.94 (1.80–2.10)
Hemorrhagic events	3641 (1.3)	1071 (2.2)	<0.01	1.65 (1.53–1.77)	5635 (1.3)	<0.01	0.89 (0.85–0.93)
Prolonged ileus	40 202 (13.9)	10 546 (21.9)	<0.01	1.50 (1.46–1.54)	87 429 (19.9)	<0.01	1.29 (1.27–1.31)
Bowel obstruction	1843 (0.6)	1200 (2.5)	<0.01	1.47 (1.36–1.59)	8983 (2)	<0.01	1.60 (1.51–1.69)
Pneumonia	5029 (1.7)	1593 (3.3)	<0.01	1.40 (1.32–1.50)	24 574 (5.6)	<0.01	1.86 (1.80–1.92)
Respiratory failure	3537 (1.2)	1205 (2.5)	<0.01	1.52 (1.42–1.64)	26 568 (6.1)	<0.01	2.43 (2.34–2.52)
Acute renal failure	10 086 (3.5)	3162 (6.6)	<0.01	1.43 (1.36–1.50)	50 299 (11.5)	<0.01	1.79 (1.74–1.83)
Urinary tract infection	8885 (3.1)	2324 (4.8)	<0.01	1.22 (1.16–1.28)	34 261 (7.8)	<0.01	1.48 (1.44–1.52)
Deep vein thrombosis	1014 (0.4)	244 (0.5)	0.62	0.96 (0.82–1.12)	5049 (1.2)	<0.01	1.62 (1.51–1.74)
Pulmonary embolism	1011 (0.3)	295 (0.6)	<0.01	1.21 (1.05–1.39)	4534 (1)	<0.01	1.72 (1.60–1.85)
Myocardial infarction	1597 (0.6)	389 (0.8)	<0.01	1.13 (1.01–1.28)	6972 (1.6)	<0.01	1.66 (1.57–1.76)

Values are n (%) unless otherwise indicated.

AOR, adjusted odds ratio; CI, confidence interval.

better than those of patients who underwent planned open colorectal operations. This study reinforces implementation of laparoscopic surgery into daily practice in colorectal surgery. Also, considering the prognosis of patients who underwent converted laparoscopic procedures compared with patients who underwent open colorectal procedures, laparoscopic surgery in high-risk patients (even accepting higher chance for conversion) may still have benefits.

Our results show that laparoscopic colorectal resectional surgery has a contemporary rate of 43.5% in the United States. This is in line with the previous report of 41.6% rate of laparoscopic colorectal surgery by the Surgical Care and Outcomes Assessment Program Collaborative in 2010.¹² Kwon et al. reported the use of laparoscopic procedures in colorectal surgery increased from 23.3% in 2005 to 41.6% in 2010.¹² Our results confirm the increase in rate of laparoscopic colorectal surgery over time.

Laparoscopic colorectal resectional surgery has a contemporary conversion rate of 14.3%. The conversion rate of laparoscopic surgery has been previously reported be-

tween 5% and 29% in colorectal surgery.^{6,13,14} The wide variance of conversion rate is related to the patient selection, surgeon's experience, and procedure-related factors that affect the need for conversion in different studies.^{6,13,14} However, the conversion rate in colorectal surgery remains higher than for most other abdominal laparoscopic procedures such as cholecystectomy (4.9%)¹⁵ or splenectomy (5%).¹⁶ Proctectomy had the highest rate of conversion in colorectal surgery (31.2%). Our results show proctectomy and right colectomy have the highest and the lowest rates of conversion, respectively. High conversion rates of proctectomy in colorectal surgery have been previously reported.^{6,14,17} Also, patients suffering from Crohn disease have the highest conversion rate for any pathologic condition. The incidence of conversion in patients suffering from Crohn disease in this study was 23.2%. Also, risk adjustment shows that Crohn disease increases the risk of conversion >2 times than do benign colorectal tumors. This is in line with the previous report by Schmidt et al¹⁸ of significant increase in conversion rate of laparoscopic colectomy for patients suffering from Crohn disease.

Table 3.
Risk-Adjusted Analysis of Factors Associated With Conversion of Laparoscopic Colorectal Surgery to Open Surgery

Variables	P Value	AOR	95% CI
Age, y			
≤70	Reference	Reference	Reference
>70	<0.01	1.07	1.04–1.09
Sex			
Female	Reference	Reference	Reference
Male	<0.01	1.29	1.27–1.32
Admission type			
Elective admission	Reference	Reference	Reference
Urgent/emergent admission	<0.01	1.71	1.67–1.75
Comorbidity			
No comorbidity	Reference	Reference	Reference
Previous abdominal surgery	<0.01	3.50	3.41–3.59
Metastatic cancer	<0.01	1.73	1.67–1.79
Obesity	<0.01	1.57	1.52–1.61
Liver disease	<0.01	1.27	1.18–1.36
Alcohol abuse	<0.01	1.19	1.11–1.29
Weight loss	<0.01	1.30	1.24–1.35
Diabetes mellitus	<0.01	1.07	1.04–1.10
Chronic pulmonary disease	0.04	1.02	1.001–1.06
Renal failure	0.01	1.06	1.01–1.11
Coagulopathy	0.01	1.09	1.02–1.16
Hypertension	0.37	1.01	0.98–1.03
Pathology			
Benign colorectal tumor	Reference	Reference	Reference
Crohn disease	<0.01	2.89	2.74–3.06
Diverticulitis of colon	<0.01	1.92	1.82–2.02
Colorectal cancer	<0.01	1.41	1.36–1.46
Diverticulosis of colon	<0.01	1.35	1.28–1.41
Ulcerative colitis	0.24	0.92	0.82–1.05

Abbreviations as in Table 2.

Converted laparoscopic procedures have higher mortality and overall morbidity than do successfully completed laparoscopic procedures. Our results show that mortality and postoperative complications increase with conversion. We reinforce previous reports of an increased risk of wound infection, prolonged hospitalization, and postoperative ileus with conversion compared with successful laparoscopic surgery.^{3,17} Other postoperative complications we found that have associations with conversion included intra-abdominal abscess, acute renal failure, re-

spiratory failure, myocardial infarction, pulmonary embolism, hemorrhagic complications, pneumonia, wound disruption, postoperative bowel obstruction, and urinary tract infection. Our result reinforces the importance of controlling the correctable risk factors for conversion including surgeon-related factors (learning curve, experience, technical ability) by adequate training.¹³

Converted laparoscopic procedures, compared with planned open colorectal procedures, have lower rates of

Table 4.
Risk-Adjusted Analysis of Conversion of Laparoscopic Colorectal Surgery to Open by Procedure Type

Procedures	Conversion Rate, %	<i>P Value</i>	AOR	95% CI
Right colectomy	12.9	Reference	Reference	Reference
Proctectomy	31.2	<0.01	2.81	2.37–3.32
Transverse colectomy	20.7	<0.01	1.88	1.79–1.98
Left colectomy	21.4	<0.01	1.44	1.39–1.50
Multiple resection of colon	21.3	<0.01	1.43	1.23–1.66
Cecectomy	17.4	<0.01	1.23	1.16–1.29
Total colectomy	14.6	<0.01	1.16	1.08–1.26
Sigmoidectomy	14.4	<0.01	1.10	1.06–1.14

Abbreviations as in Table 2.

Table 5.
Multivariate Risk Estimating of Conversion in Colon and Rectal Surgery Patients (Increased Risk Calculated Compared With Female Patients Admitted Nonemergently Without Any Comorbidity)

Previous Abdominal Surgery	Admission Status	Sex	Additional Risk Factors	Estimated Increased Risk of Conversion
Yes	Emergent/urgent	Male	Obesity	12.12 times
			Metastatic cancer	13.35 times
			Liver disease	9.80 times
		Female	Obesity	9.39 times
			Metastatic cancer	10.34 times
			Liver disease	7.59 times
	Elective	Male	Obesity	7.08 times
			Metastatic cancer	7.80 times
			Liver disease	5.72 times
		Female	Obesity	5.49 times
			Metastatic cancer	6.05 times
			Liver disease	4.44 times
No	Emergent/urgent	Male	Obesity	3.46 times
			Metastatic cancer	3.80 times
			Liver disease	2.79 times
		Female	Obesity	2.68 times
			Metastatic cancer	2.95times
			Liver disease	2.17 times
	Elective	Male	Obesity	2.02 times
			Metastatic cancer	2.23 times
			Liver disease	1.63 times
		Female	Obesity	1.57 times
			Metastatic cancer	1.73 times
			Liver disease	1.27 times

Table 6.
Preoperative Variables Associated With Mortality of Patients Who Underwent Converted Colorectal Procedures

Variables	P Value	AOR	95% CI
Age, y			
≤70	Reference	Reference	Reference
>70	<0.01	4.35	3.57–5.30
Sex			
Female	Reference	Reference	Reference
Male	<0.01	1.31	1.10–1.55
Admission type			
Elective	Reference	Reference	Reference
Emergent/urgent	<0.01	2.78	2.33–3.32
Comorbidity			
No comorbidity	Reference	Reference	Reference
Coagulopathy	<0.01	4.06	3.17–5.21
Renal failure	<0.01	2.95	2.36–3.69
Liver disease	0.01	1.63	1.09–2.44
Chronic pulmonary disease	<0.01	2.03	1.68–2.45
Metastatic cancer	<0.01	1.93	1.55–2.39
Weight loss	<0.01	2.44	2.01–2.97
Obesity	0.09	1.22	0.96–1.55
Diabetes mellitus	0.36	0.91	0.74–1.11
Hypertension	0.06	0.63	0.53–1.06
Previous abdominal surgery	0.15	1.14	0.94–1.38
Alcohol abuse	0.61	0.86	0.49–1.51

mortality and overall morbidity. Although converted laparoscopic procedures are performed with open surgical techniques and outcomes of such patients should not be better than planned open procedures, our results show mortality and postoperative complications were lower in converted procedures versus open procedures. Similar results were reported by Simorov et al.¹⁹ This can be partly explained with the difference in case selection between laparoscopic and open surgery, and partly by the progress made (eg, mobilization) prior to conversion. Further studies are indicated to compare outcomes of converted colorectal operations with planned open operations in 2 complete homogeneous groups of patients.

After risk adjustment with a multivariate analysis, wound infection, postoperative ileus, and postoperative hemorrhagic complications in patients who underwent converted procedures are higher than both open and completed laparoscopic procedures. Further studies are indicated to confirm the significant increase of these 3

complications in patients undergoing converted procedures.

Our study, which represents the largest to date on this topic, shows that 13 preoperative factors have associations with conversion of laparoscopic surgery to open surgery. The strongest association exists with a previous history of abdominal operation. Also, we confirm the previous reports of older age, male sex, and obesity as risk factors of conversion of laparoscopic surgery.^{2,13,20,21} Surprisingly, male sex has been cited as a predictive factor of conversion multiple times.^{13,20} It can be best explained by the differences in pelvic anatomy between male and female sexes and the higher amount of visceral obesity.

Patients suffering from metastatic cancer and liver disease have increased risk of conversion of laparoscopic surgery. Our results show metastatic cancer and liver disease increase the risk of conversion of operation 73% and 27%,

respectively. The higher rate of conversion in patients with advanced cancer has been reported previously.^{13,20}

Emergently admitted patients with a history of previous abdominal surgery and comorbidities including liver disease, obesity, or metastatic cancer have at least a 7 times higher risk of conversion than do patients admitted non-emergently without any comorbidities. Because comorbidities of liver disease, obesity, and metastatic cancer are not acutely correctable risk factors, open planned surgery for such high-risk patients with multiple risk factors may have benefits. Although none of the identified risk factors is a contraindication to laparoscopic surgery, using this information may help surgeons in estimating the risk of conversion and expected outcomes for high-risk patients.

Finally, age >70 years and coagulopathy have strong associations with mortality of patients who underwent converted procedures. Careful control of coagulation disorders may decrease postoperative mortality of such patients.

Study Limitations

This study is a retrospective study of an immense database and is subject to selection bias and coding errors.²² Also, a wide variety of hospital settings and surgeons' expertise can affect the study results. The 3 groups of patients compared in the study were not 3 homogeneous groups of patients and their demographic data, comorbidities, and disease stage varied. Also, some conversions may have been reported as open procedures. Due to the restrictions of the database, some of the potentially important factors, such as the reason for the conversion and surgeon-related factors (eg, surgeon's experience), were not included in this study.² Despite these limitations, this study is one of the most comprehensive and largest studies investigating outcomes of conversion of laparoscopic colorectal surgery to open surgery.

CONCLUSIONS

Colorectal resectional laparoscopic surgery has a contemporary conversion rate of 14.3%. Although patients with converted procedures have higher rates of morbidity and compared with successfully completed laparoscopic procedures, morbidity and mortality of converted patients are still lower than those of planned open colorectal procedures. Wound infection, postoperative ileus, and postoperative hemorrhagic complications in patients who underwent converted procedures are higher than for both open and successfully completed laparoscopic procedures. In colorectal resectional operations, Crohn disease patients

have the highest risk of conversion of any pathology. A history of previous abdominal surgery is the most important predictor of conversion in colorectal surgery. Among procedures, proctectomy has the highest risk of conversion. The most important mortality predictor of patients who underwent converted operations are age >70 years and coagulopathy. Improved control of coagulation disorders may decrease postoperative mortality of such patients.

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