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Variations in Laparoscopic Colectomy Utilization in the United States

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BACKGROUND: Recent published articles reported a wide geographic variation in the utilization of laparoscopic colectomy in the United States.

OBJECTIVES: This study aimed to report the current rates of laparoscopic colon resection in different types of hospitals in the United States.

DESIGN: The Nationwide Inpatients Sample database was used to examine the clinical data of patients undergoing elective colon resection for the diagnosis of colon cancer or diverticular disease from 2009 to 2012.

SETTING: Multivariate regression analysis was performed to compare different hospital types and regions regarding the utilization of laparoscopy.

PATIENTS: Patients undergoing elective colon resection for the diagnosis of colon cancer or diverticular disease from 2009 to 2012 were selected.

MAIN OUTCOME MEASURES: The primary outcome measured was the rates of laparoscopic colon resection in different types of hospitals.

RESULTS: We sampled a total of 309,816 patients who underwent elective colon resection. Of these, 171,666 (55.4%) had a laparoscopic operation. The utilization of a laparoscopic approach increased from 51.3% in 2009 to 59.3% in 2012. The increased utilization of a laparoscopic approach was seen in both urban (53.6% vs 61.6%) and rural hospitals (33.4% vs 42.3%), for colon cancer (45% vs 53.5%), and diverticular disease (61.9% vs 68.2%). The conversion rate to open surgery for diverticular disease was significantly higher than for colon cancer (adjusted odds ratio (AOR), 1.23; $p < 0.01$). After adjustment, urban hospitals (AOR, 2.13; $p < 0.01$), teaching hospitals (AOR, 1.13; $p < 0.01$), and large hospitals (AOR, 1.33; $p < 0.01$) had a greater utilization of laparoscopic surgery.

LIMITATIONS: This study was limited by its retrospective nature.

CONCLUSIONS: Although we have finally reached the point where a majority of patients undergoing an elective colectomy for diverticular disease and colon cancer receive a laparoscopic operation, there is wide variation in the implementation of laparoscopic surgery in colon resection in the United States. The utilization of

a laparoscopic approach has associations with hospital factors such as size, teaching status of the hospital, and geographic location (urban vs rural).

Laparoscopic-assisted colectomy was first introduced in 1991.[1,2] It was first accepted as a safe approach for benign conditions such as diverticular disease and not until 2004 for colon cancer.3–5 Since then, the feasibility, safety, and advantages of a laparoscopic approach compared with a traditional open colectomy have been cited in multiple studies.6–9 It is generally accepted that the utilization of laparoscopic surgery in colon resections can improve outcomes.

Although the availability of laparoscopic equipment is nearly universal in the United States,10 a recent published article reported on a wide geographic variation in the utilization of laparoscopic colectomy in the United States in a database study of the elderly Medicare population being treated for colon cancer.11 Another recently published article reported that the application of a laparoscopic technique is more likely for patients with a higher socioeconomic status and those able to be treated at urban academic centers.12 Factors such as the teaching status of the hospital, admission volume of the hospital, and the treatment location influence the patient's available options for laparoscopic surgery.11,12 Further efforts are needed to reduce the variation of the implementation of laparoscopic colectomy in the United States. Previous studies primarily investigated laparoscopic colectomy within specific populations such as the elderly population and patients with colon cancer, and they did not include some procedures such as total colectomy. Also, they did not provide full information on the geographic variation of laparoscopic colectomy. The investigation of factors associated with the utilization of laparoscopic colon surgery in a broader population and for a variety of disease states will assist in understanding the barriers to laparoscopic colectomy utilization in different locations. This study aimed to report contemporary utilization and trends in applying laparoscopic surgery in elective surgical treatment of diverticular disease and colon cancer in all adult patients and to investigate factors associated with the utilization of laparoscopic surgery in elective colon resections. In addition, we aim to report on geographic variation of laparoscopic colectomy in the United States.

MATERIALS AND METHODS

Data were derived from the Nationwide Inpatient Sample (NIS) database from 2009 to 2012. The NIS is the largest inpatient health care database in the United States and is maintained by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project.13 It contains deidentified data on nearly 8 million hospital stays each year across the United States with an approximately 20% stratified sample of the American community, nonmilitary, and nonfederal hospitals, representing over 97% of the US population.13 This study evaluated patients who underwent colon resection for diverticular disease and colon cancer. Patients with International Classification of Diseases, 9th Revision, Clinical Modifications (ICD-9-CM) diagnosis codes of colon cancer (153, 153.0–153.9, and 154.0) and diverticular disease (562.10–562.13 and 562.1) were included only if they had procedure codes for colon resection according to ICD-9-

CM procedure codes of 4571 to 4583 and 1731 to 1739. Patients younger than 18 years and nonelectively admitted patients were excluded from this study.

Variables that were considered include demographic specific data on age, sex, race, comorbidities, hospital teaching status, bed size of hospital (small, medium, and large) (Table 1), hospital location (rural vs urban) (Table 1), hospital region (Northeast, Midwest, South, and West), type of the resection, surgical approach, conversion rate to open surgery, and patient diagnosis, which were abstracted from the database when available. Primary end points were the contemporary rate of laparoscopic surgery and factors associated with the utilization of laparoscopic surgery in colon surgery. Risk-adjusted analysis was performed to investigate independent factors associated with the utilization of laparoscopic surgery.

Statistical Analysis

Data analyses were performed by using the SPSS software, Version 22 (SPSS Inc, Chicago, IL). Multivariable logistic regression was used to assess associations between hospital factors and surgical approaches. Adjustments were made for all variables of the study. The AO R with a 95% CI was calculated for each correlation. The level of significance used for retention was 0.05.

RESULTS

The study population consisted of 309,816 patients who underwent elective colectomy for the diagnosis of diverticular disease and colon cancer from 2009 to 2012. The median age of patients was 65 years; the majority of patients were white (80.9%) and female (52.6%). The most common comorbidities included hypertension (53.2%) and weight loss (18.3%). The summary of patient characteristics by patients' disease is shown in Table 2.

TABLE 1. Definition of some variables of the study

Variable	*Definition*
Small-size hospitals	Hospitals with 1–49 beds in rural hospitals, 1–99 beds in urban nonteaching hospitals, and 1–299 beds in urban teaching hospitals.
Medium-size hospitals	Hospitals with 50–99 beds in rural hospitals, 100–199 beds in urban nonteaching hospitals, and 300–499 beds in urban teaching hospitals.
Large-size hospitals	Hospitals with more than 100 beds in rural hospitals, more than 200 beds in urban nonteaching hospitals, and more than 500 beds in urban teaching hospitals.
Urban hospitals	A metropolitan statistical area is considered urban.
Teaching hospitals	Hospitals with a ratio of .25 or higher of full-time equivalent interns and residents to nonnursing home beds.

TABLE 2. Demographics of patients undergoing elective colon resection by patients' diagnosis

Variables	*Colon cancer (192,063)*	*Diverticular disease (117,753)*	*p*
Age			
Mean ±SD, y	68±13	57±13	<0.01
Median, y	69	57	–
Sex, n (%)			
Male	98,912 (51.6)	63,820 (54.3)	<0.01
Race, n (%)			
White	135,462 (78.7)	89,266 (84.4)	<0.01
Black	17,584 (10.2)	5186 (4.9)	<0.01
Hispanic	10,041 (5.8)	7999 (7.6)	<0.01
Asian or Pacific Islander	4207 (2.4)	585 (0.6)	<0.01
Others	4801 (2.8)	2720 (2.6)	<0.01
Comorbidity, n (%)			
Fluid and electrolyte disorders	31,527 (16.4)	12,389 (10.5)	<0.01
Obesity	21,149 (11)	15,053 (12.8)	<0.01
Hypertension	112,747 (58.7)	52,167 (44.3)	<0.01
Weight loss	10,088 (5.3)	2987 (2.5)	<0.01
Chronic pulmonary disease	28,115 (14.6)	16,289 (13.8)	<0.01
Diabetes mellitus	43,010 (22.4)	13,764 (11.7)	<0.01
Coagulopathy	3999 (2.1)	1409 (1.2)	<0.01
Congestive heart failure	11,699 (6.1)	2153 (1.8)	<0.01
Renal failure	11,006 (5.7)	2456 (2.1)	<0.01
Metastatic cancer	50,278 (26.2)	319 (0.3)	<0.01
Liver disease	3922 (2)	1459 (1.2)	<0.01
Surgical approach, n (%)			
Open	96,760 (50.4)	41,390 (35.1)	<0.01
Laparoscopic	95,302 (49.6)	76,364 (64.9)	<0.01
Converted procedures to open	12,229 (12.8)	9100 (11.9)	<0.01
Procedure, n (%)			
Cecectomy	3416 (1.8)	261 (0.2)	<0.01
Right colectomy	106,494 (55.4)	1311 (1.1)	<0.01
Multiple segmental resection	906 (0.5)	355 (0.3)	<0.01
Transverse colectomy	10,286 (5.4)	281 (0.2)	<0.01
Left colectomy	21,290 (11.1)	12,969 (11)	0.53
Total colectomy	4378 (2.3)	525 (0.4)	<0.01
Other resections	3223 (1.7)	1399 (1.2)	<0.01
Sigmoidectomy	42,069 (21.9)	100,653 (85.5)	<0.01
Hospital bed size, n (%)			
Small	23,366 (12.2)	14,850 (12.6)	<0.01
Medium	46,735 (24.3)	30,242 (25.7)	<0.01
Large	121,962 (63.5)	72,661 (61.7)	<0.01
Teaching status, n (%)			
Nonteaching	99,626 (51.9)	63,927 (54.3)	<0.01
Teaching	92,437 (48.1)	53,826 (45.7)	<0.01
Location, n (%)			
Rural	23,918 (12.5)	11,826 (10)	<0.01
Urban	168,145 (87.5)	105,928 (90)	<0.01
Region, n (%)			
Northeast	37,350 (19.4)	26,295 (22.3)	<0.01
Midwest	47,615 (24.8)	29,420 (25)	0.22
South	72,418 (37.7)	43,739 (37.1)	<0.01
West	34,680 (18.1)	18,300 (15.5)	<0.01

Overall, 55.4% of operations were attempted with a laparoscopic approach. Of these, 12.4% were converted to open procedures. The rates of laparoscopic surgery for diverticulitis and colon cancer were 64.9% and 49.6%. Although patients with diverticular disease had a higher rate of laparoscopic surgery, the risk of conversion to open surgery was significantly higher in diverticular disease than in colon cancer (AO R, 1.23; $p < 0.01$).

Utilization of a laparoscopic approach increased from 51.3% in 2009 to 59.3% in 2012. The increased utilization of laparoscopic surgery was seen in both colon cancer (45% vs 53.5%) and diverticular disease (61.9% vs 68.2%) (Fig. 1). However, there was no decrease in the risk of conversion to open surgery during the study period (12.7% vs 12.3%).

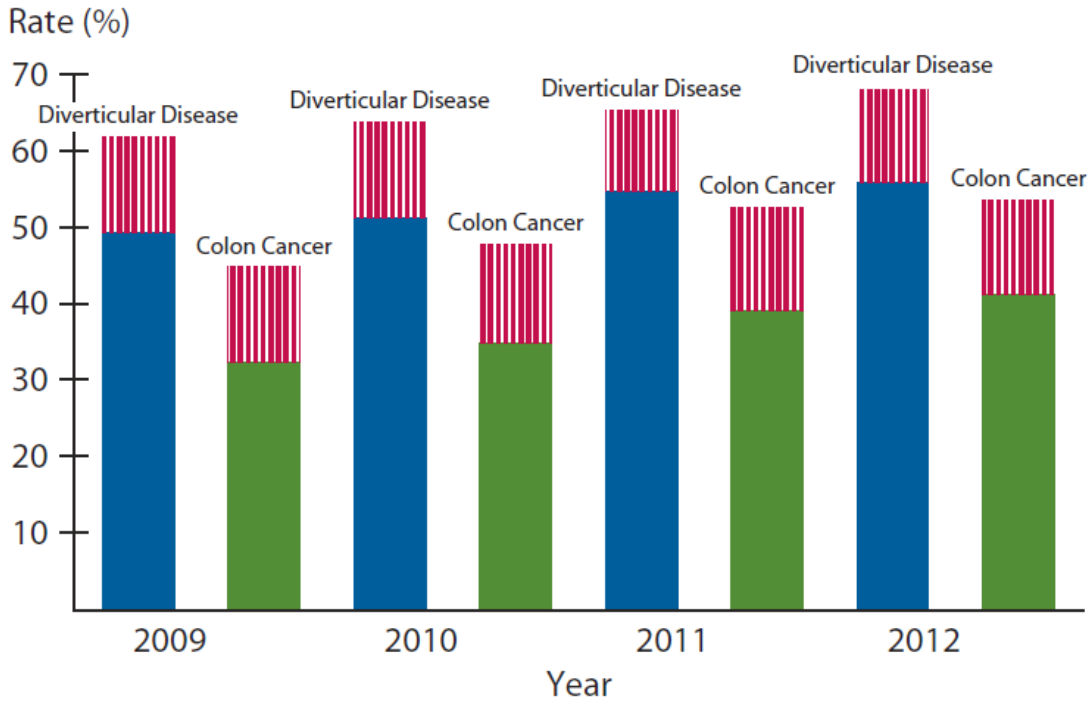

FIGURE 1. Rate of elective laparoscopic surgery in colon resections for colon cancer and diverticular disease, 2009 to 2012. Solid colors show the rates of successfully completed laparoscopic colectomy for colon cancer and diverticular disease. The striped sections show the rates of conversion to open procedures.

Table 3 reports the rates of laparoscopic colectomy in different hospitals by hospital factors. Patients who underwent surgery in Northeast teaching hospitals and patients who underwent colon resection in small-size rural hospitals had the highest and lowest rates of laparoscopic colectomy. Overall, Northeast hospitals had the highest rate of utilization of laparoscopic colectomy, and Midwest hospitals had the lowest rate of utilization of laparoscopic surgery (Figure 2). Table 4 reported the rates of laparoscopic colectomy by the type of procedure. The highest and the lowest rates of laparoscopic colectomy exist in sigmoidectomy (62.7%) and total colectomy (36.1%). The risk-adjusted analyses for factors associated with utilization of laparoscopic colectomy were reported in Table 5. Factors such as teaching status of hospital, location of hospital (rural vs urban), region of hospital, and bed size of the hospital were significantly associated with the utilization of laparoscopic surgery for colectomy. Also, comorbid conditions such as metastatic cancer, coagulopathy, obesity, and chronic lung disease were significantly lower in patients who underwent laparoscopic surgery.

DISCUSSION

Our study results show that there is a wide variation in the utilization of laparoscopic surgery in elective colectomy (62.5% vs 27.4%). Considering that the availability of laparoscopic equipment in the United States is universal, and given the acceptance of laparoscopic surgery as the preferred choice in surgical treatment for benign and

malignant colon operations,3,4,10,11 the wide variation in the utilization of laparoscopic surgery may be best explained by the nonhomogeneous laparoscopic skills of surgeons in the United States. The wide variation in utilization of laparoscopic techniques in colon resections speaks to the need for a nationwide or regional training program to prepare practicing surgeons to perform more laparoscopic colon procedures. Further efforts are needed to improve surgeons' abilities in advanced laparoscopic surgery and to provide opportunities for learning, especially in rural nonteaching hospitals. A decrease in the broad variation of utilization of laparoscopic colectomy can be achieved by reviewing/explaining the advantages of laparoscopic surgery in educational meetings to increase the adoption of laparoscopic surgery. National organizations such as the American College of Surgeons and American Society of Colon and Rectal Surgeons (ASCRS) should provide easy accessibility of laparoscopic colectomy training programs for surgeons in the United States through a nationwide training program with a focus on rural areas.

TABLE 3. Rates in utilization of laparoscopic elective colectomy by hospital factors

Hospital factor	*Small bed size hospitals*	*Medium bed size hospitals*	*Large bed size hospitals*	*Rural hospitals*	*Urban hospitals*	*Teaching hospitals*	*Nonteaching hospitals*	*Northeast region*	*Midwest region*	*South region*	*West region*
Small bed size hospitals	50.6	–	–	27.4	53.2	55.8	44.7	50.6	44.3	53	59.7
Medium bed size hospitals	–	56.1	–	33.9	58.2	56.8	55.6	60	54.3	55	56.3
Large bed size hospitals	–	–	56.1	39	58.6	60	52.7	60.7	50.9	56.6	57.1
Rural hospitals	27.4	33.9	39	36.8	–	–	36.8	36.4	38.7	36.6	32.9
Urban hospitals	53.2	58.2	58.6	–	57.8	58.6	56.9	60.8	52.9	58.5	59.4
Teaching hospitals	55.8	56.8	60	–	58.6	58.6	–	62.5	54.6	58.1	60.2
Nonteaching hospitals	44.7	55.6	52.7	36.8	56.9	–	52.5	53	46.9	54.1	55.6
Northeast region	50.6	60	60.7	36.4	60.8	62.5	53	58.8	–	–	–
Midwest region	44.3	54.3	50.9	38.7	52.9	54.6	46.9	–	50.7	–	–
South region	53	55	56.6	36.6	58.5	58.1	54.1	–	–	55.9	–
West region	59.7	56.3	57.1	32.9	59.4	60.2	55.6	–	–	–	57.1

Values displayed are percentages.

FIGURE 2. Utilization of elective laparoscopic colectomy by region in United States. The box next to each region in the map with the same color as the related region shows the rate of intention to laparoscopic colectomy and the conversion rate of laparoscopic colectomy.

Even including conversions, we have finally reached the point where a majority of patients undergoing an elective colectomy for diverticular diseases and cancer receive a successfully completed laparoscopic operation. We found a steady increase in the rate of laparoscopic surgery over the 5-year study period at the end of which the rate reached 59.3% in 2012. This is in line with the rate of 51% for elective laparoscopic colon or rectal resection in the United States in 2010 according to the National Comprehensive Cancer Network centers.14 However, further efforts are needed to reduce the wide variation in the utilization of laparoscopic colectomy in the United States.

TABLE 4. Rate of intention to elective laparoscopic colectomy according to procedure type (NIS 2009–2012)

Procedure	*Rate of intention to laparoscopic surgery, %*
Sigmoidectomy	62.7
Cecectomy	59.7
Right colectomy	52
Left colectomy	49.5
Multiple segmental resection	44.4
Transverse colectomy	40.6
Total colectomy	36.1

NIS = Nationwide Inpatient Sample.

The adoption of laparoscopic colectomy for colon cancer is increasing but is still lower than for diverticular disease. Although the rate of conversion to open surgery was significantly higher in diverticular disease than in colon cancer resections in our study, the adoption rate of laparoscopic surgery in colon cancer was significantly lower than in diverticular disease (64.9% vs 49.6%) (Fig. 1). Since 2004 when the safety of laparoscopic colectomy was confirmed according to the Clinical Outcomes of Surgical Therapy Study group trial in North America, the rate of laparoscopic colectomy has been increasing significantly. 4,15 Recent guidelines endorsed by ASCRS and the Society of American Gastrointestinal and Endoscopic Surgeons cite the feasibility of laparoscopic colon cancer resection.16 Further studies are indicated to investigate the reasons for relatively low rates of adoption of laparoscopic surgery in colon cancer surgery compared with diverticular disease in the United States. Geographic and hospital factors are significantly associated with the adoption of laparoscopic surgery in colon resections. Our study results show that hospital location, hospital bed size, teaching status, and the region of the hospital are significantly associated with the adoption of laparoscopic surgery in colon resection. The mentioned factors are associated with more than 2 times variation in the rates of laparoscopic colectomy in the United States. Considering the homogeneous accessibility of surgeons to laparoscopic equipment in the United States, further efforts in the dissemination of laparoscopic training techniques and enhanced educational resources for patients are needed.9

TABLE 5. Risk-adjusted analysis of factors associated with utilization of laparoscopic surgery in elective colon resections for diverticular disease and cancer

Variables	*Adjusted OR*	*95% CI*	*p*
Age	0.99	0.99–0.99	<0.01
Sex			
Male	[a]	[a]	[a]
Female	0.96	0.94–0.97	<0.01
Comorbidity			
Chronic pulmonary disease	0.86	0.84–0.88	<0.01
Hypertension	0.97	0.96–0.99	0.01
Coagulopathy	0.89	0.84–0.94	<0.01
Obesity	0.97	0.94–0.99	0.01
Liver disease	0.90	0.85–0.95	<0.01
Renal failure	0.87	0.84–0.91	<0.01
Diabetes mellitus	0.90	0.88–0.91	<0.01
Congestive heart failure	0.76	0.73–0.79	<0.01
Metastatic cancer	0.59	0.58–0.60	<0.01
Weight loss	0.57	0.54–0.59	<0.01
Fluid and electrolyte disorders	0.69	0.67–0.70	<0.01
Diagnosis			
Colon cancer	[a]	[a]	[a]
Diverticular disease	1.36	1.33–1.39	<0.01
Procedure			
Total colectomy	[a]	[a]	[a]
Right colectomy	2.27	2.13–2.42	<0.01
Transverse colectomy	1.46	1.35–1.58	<0.01
Left colectomy	1.69	1.58–1.81	<0.01
Cecectomy	2.76	2.50–3.05	<0.01
Other procedures	0.15	0.13–0.17	<0.01
Multiple segmental resection	1.32	1.15–1.52	<0.01
Sigmoidectomy	2.20	2.06–2.34	<0.01
Location			
Rural	[a]	[a]	[a]
Urban	2.13	2.07–2.18	<0.01
Teaching status			
Nonteaching	[a]	[a]	[a]
Teaching	1.13	1.11–1.14	<0.01
Hospital bed size			
Small	[a]	[a]	[a]
Medium	1.26	1.23–1.29	<0.01
Large	1.33	1.29–1.36	<0.01
Region			
Midwest region	[a]	[a]	[a]
South region	1.12	1.09–1.14	<0.01
West region	1.16	1.13–1.19	<0.01
Northeast region	1.13	1.10–1.16	<0.01

[a]References group in comparison

There is a variation in adoption of laparoscopic surgery in different colon procedures. We found sigmoidectomy has the highest rate of laparoscopic surgery (62.7%). Procedures such as total colectomy and transverse colectomy had significantly lower rates of laparoscopic surgery. The high rate of utilization of the laparoscopic approach for sigmoidectomy was cited previously and can be related to the higher utilization of laparoscopic surgery for diverticular disease than for colon cancer.9 Considering that the laparoscopic approach to different colon procedures requires different levels of laparoscopic skills, improvement in surgeons' skills in laparoscopic surgery can decrease the variation in adoption of laparoscopic surgery in different colon procedures. We found multiple factors associated with the utilization of laparoscopic surgery in colon resections. It is not surprising that patients with significant comorbid conditions and older patients had significantly lower rates of laparoscopic colectomy, although numerous studies have shown that these patient populations benefit perhaps even more than younger, healthier patients. Also, we found that Midwest region hospitals had significantly lower rates of laparoscopic colectomy in comparison with other US regions (Fig. 2). Further studies are indicated to explain this correlation.

Study Limitations

This study is a retrospective review and causality cannot be inferred based only on our data. Our study is subject to the typical biases for retrospective studies such as selection bias and coding inaccuracies. Also, residual confounding could apply for some of the observed associations. The NIS database does not provide any clinical information on the stage of the disease and history of previous operations, which may impact the utilization of the laparoscopic approach. We compared laparoscopic surgery in patients with colon cancer and diverticular disease in the elective setting. However, the utilization of laparoscopic surgery in emergent cases needs to be investigated. In addition, these 2 groups of patients were not homogeneous groups of patients regarding demographic data and comorbidities. Despite these limitations, the present analysis can be used as a baseline in future strategies and studies of the utilization of laparoscopy in colorectal surgery.

CONCLUSION

Overall, 55.4% of patients undergoing elective colectomy for diverticulitis or colon cancer underwent laparoscopic colectomy. Even including conversions, by 2012 we had finally reached the point where a majority of patients undergoing an elective colectomy for diverticulitis and cancer receive a laparoscopic operation. There is a wide variation in the utilization of laparoscopic surgery in colon resection in the United States. Geographic and hospital factors such as size, teaching status of the hospital, and the area of the hospital (urban vs rural, geographic region) are strongly associated with the utilization of laparoscopic surgery. Teaching hospitals in the Northeast and small-size rural hospitals have the highest and the lowest rates of utilization of laparoscopic colectomy. There is a variation in adoption of laparoscopic surgery in different colon procedures. Sigmoidectomy has the highest rate of laparoscopy (62.7%) in colon resections. Improvement in surgeons' skills in laparoscopic surgery can decrease the variation in the adoption of laparoscopic surgery in different colon procedures. Future efforts by national societies such as ASCRS and the Society of American Gastrointestinal and Endoscopic

Surgeons are needed to improve the abilities of surgeons in advanced laparoscopic surgery and to provide opportunities for learning, especially in rural nonteaching hospitals.

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Dr Moghadamyeghaneh had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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