

## Retrospective Cohort Study

# Laparoscopic vs open partial colectomy in elderly patients: Insights from the American College of Surgeons - National Surgical Quality Improvement Program database

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## Abstract

**AIM:** To compare the outcomes between the laparoscopic and open approaches for partial colectomy in elderly patients aged 65 years and over using the American College of Surgeons - National Surgical Quality Improvement Program (ACS NSQIP) database.

**METHODS:** The ACS NSQIP database for the years 2005-2011 was queried for all patients 65 years and above who underwent partial colectomy. 1:1 propensity score matching using the nearest-neighbor method was performed to ensure both groups had similar pre-operative comorbidities. Outcomes including post-operative complications, length of stay and mortality were compared between the laparoscopic and open groups.  $\chi^2$  and Fisher's exact test were used for discrete variables and Student's *t*-test for continuous variables.  $P < 0.05$  was considered significant and odds ratios with 95%CI were reported when applicable.

**RESULTS:** The total number of patients in the ACS NSQIP database of the years 2005-2011 was 1777035. We identified 27604 elderly patients who underwent partial colectomy with complete data sets. 12009 (43%) of the cases were done laparoscopically and

15595 (57%) were done with open. After propensity score matching, there were 11008 patients each in the laparoscopic (LC) and open colectomy (OC) cohorts. The laparoscopic approach had lower post-operative complications (LC 15.2%, OC 23.8%,  $P < 0.001$ ), shorter length of stay (LC 6.61 d, OC 9.62 d,  $P < 0.001$ ) and lower mortality (LC 1.6%, OC 2.9%,  $P < 0.001$ ).

**CONCLUSION:** Even after propensity score matching, elderly patients in the ACS NSQIP database having a laparoscopic partial colectomy had better outcomes than those having open colectomies. In the absence of specific contraindications, elderly patients requiring a partial colectomy should be offered the laparoscopic approach.

**Key words:** Colectomy; Laparoscopic; Outcomes; Elderly; National Surgical Quality Improvement Program

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**Core tip:** Elderly patients having partial colectomies are at greater risk for complications due to a higher incidence of comorbidities. This study looked at patients aged 65 and above in a nationally validated database from the American College of Surgeons National Surgical Quality Improvement Program. Patients having a laparoscopic partial colectomy, when compared to an open partial colectomy, had fewer complications, shorter lengths of stay and decreased mortality.

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## INTRODUCTION

The role of laparoscopy has been well documented in the field of colorectal surgery<sup>[1,2]</sup>. The laparoscopic approach has been associated with reduced post-operative pain, less morbidity, shorter lengths of stay, lower costs, fewer adhesions and a lower incidence of hernias<sup>[3,4]</sup>. Despite these well-established advantages, the minimally invasive approach has been underutilized with a recent study showing adoption rates of up to 40%<sup>[5,6]</sup>. The elderly population, aged 65 years and above, is one of the higher risk groups due to the presence of comorbidities and as a result is at increased risk for post-operative events<sup>[7]</sup>. Consequently, caring for such patients can present unique challenges. Laparoscopic cholecystectomy has been shown to be safe in this age group<sup>[8,9]</sup>. A

laparoscopic colectomy requires a longer operating time than a laparoscopic cholecystectomy<sup>[10]</sup> and operative duration has been shown to be correlated with postoperative complications as well as length of stay<sup>[11,12]</sup>. On the other hand, open colorectal surgery in the elderly is itself associated with increased morbidity and mortality<sup>[13]</sup>. Hence it becomes important to look specifically in this elderly cohort and analyze if the laparoscopic approach is advantageous when compared with the conventional open approach.

The aim of this study is to compare the outcomes between elderly patients undergoing laparoscopic partial colectomy (LC) and open partial colectomy (OC). There are various studies showing improved outcomes with the laparoscopic approach but there are very few reports on its impact specifically in the elderly population<sup>[14,15]</sup>. The studies that are available are generally single institution studies based on small sample sizes<sup>[16-18]</sup>. The present work is based on a very large sample size from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database. ACS NSQIP is the first nationally validated, risk adjusted, outcome based program to measure and improve the quality of surgical care. The number of variables, cases and centers participating in the ACS NSQIP database have been progressively increasing over the years. In 2012, ACS NSQIP included over 150 variables involving about 543885 cases from 315 academic and community-based hospitals in United States. The variables collected include data on preoperative risk factors, intraoperative variables, 30-d postoperative mortality and morbidity outcomes for all patients aged 18 years and older undergoing major surgical procedures in the inpatient and outpatient settings. A trained surgical clinical reviewer captures this data prospectively by a variety of methods including medical chart abstraction using an 8 d cycle. To date, the ACS NSQIP has had a 95% success rate in capturing the 30 d outcomes for all cases in the database. The accuracy and reproducibility of its data has been well documented<sup>[19]</sup>.

In studies that use nonrandomized databases such as the ACS NSQIP there is a potential for selection bias. In order to minimize these problems, propensity score matching was employed in this study. This allowed the two groups of patients to be more closely matched, which provides a more accurate comparison of the outcomes between the two groups.

## MATERIALS AND METHODS

### Patient selection

Participant user files (PUF) from the years 2005 to 2011 of the ACS NSQIP database were combined into a single database. Patients undergoing a partial colectomy were included. Current Procedural Terminology (CPT) codes 44205, 44204 and 44207 were chosen as representing laparoscopic right, left and sigmoid colectomies respectively. CPT codes

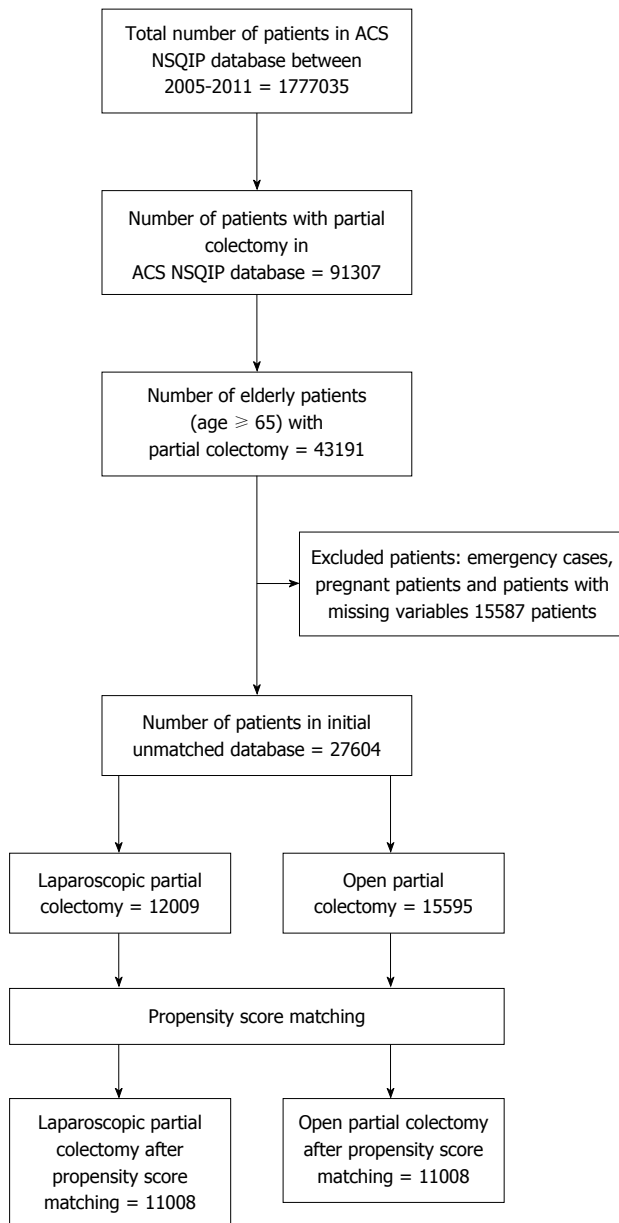


Figure 1 Flowchart outlining patient selection.

44160, 44140 and 44145 were chosen as representing open right, left and sigmoid colectomies. Rectal procedures were not included, and neither were cases with colostomies or ileostomies. We excluded emergency cases, pregnant patients and database entries with missing data.

### Propensity score matching

A propensity 1:1 matched analysis was then performed to identify similar patients groups in the LC and OC groups. The first step of the propensity score matching consisted of fitting a logistic regression to model the probability of receiving a LC. The covariates included in the regression were age, body mass index (BMI), sex, site of surgery, American Society of Anesthesiology (ASA) class 3 and above, cardiac, pulmonary, neu-

rological, renal and bleeding disorders, diabetes mellitus and steroid usage. In the second step, LC patients were matched with OC patients based on the predicted probability (propensity score). The result was more balanced groups in the selected covariates.

### Statistical analysis

The two groups were then compared using a bivariate analysis approach. Patient demographics, comorbidities, intraoperative complications and post-operative complications were then compared between the two groups using bivariate analysis.  $\chi^2$  test was used for categorical variables and student's *t* test was used for continuous variables. Fisher's exact test was used for categorical variables with very small expected frequencies. Results were reported as mean ( $\pm$  SD) for continuous variables and frequency for nominal and ordinal variables. *P* values < 0.05 were considered significant. OR with 95%CI were reported when applicable. Analyses were performed using SPSS 20 (IBM SPSS Inc., Chicago, IL).

## RESULTS

The NSQIP database between 2005 and 2011 had a total of 1777035 patients. Of these patients, there were 91307 who had a partial colectomy, with 43191 aged 65 and above (Figure 1). 15587 patients were excluded on the basis of being emergent cases, pregnant patients, or the dataset not being complete in the ACS NSQIP database. This left an index unmatched database of 27604 elderly partial colectomy patients. This original group had 12009 (43%) laparoscopic patients and 15595 (57%) open patients. The preoperative characteristics of these groups are outlined in Table 1. The groups are different in almost all demographic and comorbidity categories.

After propensity matching, we were left with a total of 22016 patients - 11008 patients in each of the laparoscopic and open cohorts. These are the groups that were used for comparison in our study, and their pre-operative characteristics are compared in Table 2. As a result of the propensity matching the two groups are essentially similar in terms of their demographics and rate of comorbidities. There were no significant differences between the groups in terms of cardiac, pulmonary, neurological, renal, hematological or endocrine comorbidities.

Intraoperative characteristics of the matched cohorts are shown in Table 3. The operative duration in the LC cohort is slightly higher than in the OC cohort (LC 152 min, OC 144 min, *P* < 0.001). The LC cohort had slightly lower need for transfusions (LC 2.3%, OC 2.8%, *P* < 0.001). There was no statistically significant difference in intraoperative events, such as cardiac arrest, myocardial infarction and unplanned intubation between the groups, although these numbers were quite small.

**Table 1 Preoperative characteristics of elderly patients undergoing partial colectomy before propensity score matching *n* (%)**

Characteristics	Laparoscopic colectomy ( <i>n</i> = 12009)	Open colectomy ( <i>n</i> = 15595)	<i>P</i> value
Age, mean ± SD	75.94 ± 7.15	74.87 ± 6.92	< 0.001
BMI, mean ± SD	27.30 ± 6.38	27.17 ± 7.09	< 0.001
Gender			0.416
Female	7401 (61.6)	9536 (61.1)	
Male	4608 (38.4)	6059 (38.9)	
Procedure			< 0.001
Right partial colectomy	3122 (25.9)	3773 (24.2)	
Left partial colectomy	6614 (55.1)	8492 (54.5)	
Sigmoidectomy	2273 (19.0)	3330 (21.3)	
Indication			< 0.001
Benign	4769 (39.7)	5447 (34.9)	
Malignant	4544 (37.8)	7454 (47.8)	
Unknown	2696 (22.4)	2694 (17.3)	
ASA class			
I	155 (1.2)	115 (0.7)	
II	5418 (45.2)	4960 (31.8)	
III	5956 (49.6)	9225 (59.2)	
IV	477 (4.0)	1278 (8.2)	
V	3 (0.02)	17 (0.1)	
ASA III, IV or V	6436 (53.6)	10520 (67.5)	< 0.001
Alcohol	359 (2.9)	408 (2.6)	0.061
Current smoker	1062 (8.8)	1689 (10.8)	< 0.001
Cardiac diseases	8489 (70.7)	11350 (72.8)	< 0.001
Hypertension	8232 (68.5)	10936 (70.1)	0.005
History of CHF	119 (1.0)	297 (1.9)	< 0.001
History of MI	56 (0.5)	169 (1.1)	< 0.001
History of angina	80 (0.7)	200 (1.3)	< 0.001
History of PCI	957 (8.0)	1431 (9.2)	< 0.001
History of PCS	959 (8.0)	1495 (9.6)	< 0.001
Pulmonary diseases	836 (7.0)	1519 (9.7)	< 0.001
Dyspnea	1600 (13.3)	2723 (17.4)	< 0.001
History of COPD	821 (6.8)	1428 (9.2)	< 0.001
Ventilator dependent	4 (0.02)	58 (0.4)	< 0.001
Pneumonia	20 (0.2)	71 (0.5)	< 0.001
Neurological disease	994 (8.3)	1689 (10.8)	< 0.001
History of CVA	347 (2.9)	613 (3.9)	< 0.001
History of CVANO	355 (3.0)	591 (3.8)	< 0.001
History of TIA	516 (4.3)	801 (5.1)	0.002
History of tumor CNS	11 (0.1)	18 (0.1)	0.545
Renal diseases	62 (0.5)	173 (1.1)	< 0.001
History of renal failure	15 (0.1)	56 (0.4)	< 0.001
Dialysis dependent	52 (0.4)	137 (0.9)	< 0.001
Bleeding disorders	487 (4.1)	1009 (6.5)	< 0.001
Steroid use <sup>1</sup>	365 (3.0)	580 (3.7)	0.002
Diabetes	3166 (26.4)	3193 (20.5)	< 0.001

<sup>1</sup>Use of steroid in the 30 d prior to surgery for a chronic medical condition. BMI: Body mass index; ASA: American Society of Anesthesiologists; CHF: Congestive heart failure; MI: Myocardial infarction; PCI: Percutaneous coronary intervention; PCS: Previous cardiac surgery; PVD: Peripheral vascular disease; COPD: Chronic pulmonary obstructive disease; CVA: Cerebrovascular accident with neurological deficit; CVANO: Cerebrovascular accident without neurological deficit; TIA: Transient ischemic attack; Tumor CNS: Tumor involving central nervous system.

Postoperative 30-d outcomes of both the cohorts are shown in Table 4. There were significantly fewer complications in the LC group (LC 15.2%, OC 23.8%, *P* < 0.001). These were lower in every single subcategory of cardiac, pulmonary, renal and infectious complications. Patients in the LC cohort had

**Table 2 Preoperative characteristics of elderly patients undergoing partial colectomy after propensity score matching *n* (%)**

Characteristics	Laparoscopic colectomy ( <i>n</i> = 11008)	Open colectomy ( <i>n</i> = 11008)	<i>P</i> value
Age			
mean ± SD	75.12 ± 6.97	75.21 ± 6.98	0.857
median ± IQR	74 ± 11	74 ± 12	0.332
BMI (mean ± SD)	27.31 ± 6.42	27.23 ± 7.05	0.368
Gender			0.021
Female	6685 (60.7)	6852 (62.2)	
Male	4323 (39.3)	4156 (37.8)	
Procedure			0.013
Right partial colectomy	2549 (23.2)	2736 (24.8)	0.003
Left partial colectomy	6237 (56.7)	6099 (55.4)	0.061
Sigmoidectomy	2222 (20.1)	2173 (19.8)	0.409
Indication			< 0.001
Benign	4361 (39.6)	3966 (36.0)	
Malignant	4193 (38.1)	5431 (49.3)	
Unknown	2454 (22.3)	1611 (14.6)	
ASA class			
I	127 (1.1)	110 (1.0)	
II	4563 (41.5)	4563 (41.5)	
III	5852 (53.2)	5673 (51.5)	
IV	463 (4.2)	658 (6.0)	
V	3 (0.02)	4 (0.03)	
ASA III, IV or V	6318 (57.4)	6335 (57.5)	0.817
Alcohol	341 (3.0)	289 (2.6)	0.036
Current smoker	1051 (9.5)	993 (9.0)	0.178
Cardiac diseases	7905 (71.8)	7845 (71.3)	0.370
Hypertension	7654 (69.5)	7614 (69.2)	0.559
History of CHF	116 (1.1)	134 (1.2)	0.252
History of MI	51 (0.5)	57 (0.5)	0.563
History of angina	75 (0.6)	86 (0.7)	0.384
History of PCI	902 (8.2)	807 (7.3)	0.017
History of PCS	924 (8.4)	894 (8.1)	0.463
Pulmonary diseases	815 (7.4)	778 (7.1)	0.336
Dyspnea	1526 (13.7)	1513 (13.7)	0.432
History of COPD	801 (7.3)	758 (6.9)	0.259
Ventilator dependent	3 (0.02)	3 (0.02)	1.000
Pneumonia	18 (0.2)	24 (0.2)	0.354
Neurological disease	921 (8.4)	896 (8.1)	0.540
History of CVA	333 (3.0)	305 (2.8)	0.261
History of CVANO	323 (2.9)	307 (2.8)	0.518
History of TIA	347 (3.2)	353 (3.2)	0.818
History of tumor CNS	10 (0.1)	6 (0.1)	0.317
Renal diseases	57 (0.5)	55 (0.5)	0.850
History of renal failure	12 (0.1)	13 (0.1)	0.841
Dialysis dependent	49 (0.4)	48 (0.4)	0.919
Bleeding disorders	466 (4.2)	425 (3.9)	0.161
Steroid use <sup>1</sup>	353 (3.2)	318 (2.9)	0.170
Diabetes	2077 (18.9)	2040 (18.5)	0.522

<sup>1</sup>Use of steroid in the 30 d prior to surgery for a chronic medical condition. BMI: Body mass index; ASA: American Society of Anesthesiologists; CHF: Congestive heart failure; MI: Myocardial infarction; PCI: Percutaneous coronary intervention; PCS: Previous cardiac surgery; PVD: Peripheral vascular disease; COPD: Chronic pulmonary obstructive disease; CVA: Cerebrovascular accident with neurological deficit; CVANO: Cerebrovascular accident without neurological deficit; TIA: Transient ischemic attack; Tumor CNS: Tumor involving central nervous system.

lower rates of unplanned return to the operating room (LC 4.1%, OC 5.3%, *P* < 0.001). Length of stay was shorter in the laparoscopic group (LC 6.61 d, OC 9.62 d, *P* < 0.001). Finally, the laparoscopic cohort had lower



**Table 3** Intraoperative characteristics of elderly patients undergoing partial colectomy after propensity score matching

Characteristics	Laparoscopic colectomy ( <i>n</i> = 11008)	Open colectomy ( <i>n</i> = 11008)	<i>P</i> value
Operative time (min), mean ± SD	151.75 ± 66.15	143.56 ± 78.60	< 0.001
Anesthesia time (min), mean ± SD	209.47 ± 78.54	200.72 ± 91.29	< 0.001
Blood transfusions, <i>n</i> (%)	250 (2.3)	307 (2.8)	< 0.001
Intraoperative occurrence			0.143
Cardiac arrest	1	5	
Myocardial infarction	3	5	
Unplanned intubation	5	11	

mortality than the open colectomy group (LC 1.6%, OC 2.9%, *P* < 0.001).

## DISCUSSION

This study demonstrates that laparoscopic partial colectomy has better outcomes than open partial colectomy in the elderly patient. There are fewer complications, shorter lengths of stay, and lower mortality. A recent meta-analysis of colorectal surgery by Antoniou *et al.*<sup>[20]</sup> involving 66592 patients supports our conclusion of lower mortality (2.2% in laparoscopic vs 5.4% in open approach) and overall morbidity (19.3% vs 26.7% in open approach). Similar results are reported in the meta-analysis by Seishima *et al.*<sup>[21]</sup> showing LC to have lower risk of perioperative mortality (OR = 0.55, *P* < 0.01) and postoperative complications (OR = 0.55, *P* < 0.01) when compared with open surgery. In a randomized control study involving 535 patients by Frasson *et al.*<sup>[22]</sup>, the laparoscopic approach was associated with an overall complication rate of 20% in comparison to 42% in the open group. Senagore *et al.*<sup>[23]</sup> also report similar results in the laparoscopic group with shorter length of stay and lower direct hospital costs. These positive trends are also seen in octogenarians<sup>[16]</sup>. In a pooled analysis involving 11 studies, the laparoscopic approach was associated with lower incidence of postoperative cardiac complications, wound complications, earlier return of bowel function and shorter lengths of stay<sup>[17]</sup>. All of these small sample size studies and meta-analyses concluded that LC is safer and has better short term outcomes. Our analysis based on a large well validated ACS NSQIP database replicates these findings in a very large database of patients and confirms the benefits of the minimally invasive approach. More importantly, our study employed propensity matching to make sure the groups of patients were similar pre-operatively, and still found the same results.

The most common complication after colorectal surgery is surgical site infection (SSI)<sup>[24]</sup>. SSI in colorectal surgery is associated with significant economic burden

**Table 4** Post-operative outcomes of elderly patients undergoing partial colectomy after propensity score matching *n* (%)

Characteristics	Laparoscopic colectomy ( <i>n</i> = 11008)	Open colectomy ( <i>n</i> = 11008)	<i>P</i> value	OR/CI
Overall complications <sup>1</sup>	1676 (15.2)	2622 (23.8)	< 0.001	1.56 (1.48-1.65)
Cardiac complications	109 (1.0)	160 (1.5)	0.002	1.47 (1.15-1.87)
Cardiac arrest	50 (0.4)	80 (0.7)	0.008	1.60 (1.13-2.28)
Myocardial infarction	71 (0.6)	88 (0.8)	0.176	1.24 (0.91-1.69)
Pulmonary complications	489 (4.4)	729 (6.6)	< 0.001	1.49 (1.33-1.67)
Pneumonia	239 (2.2)	375 (3.4)	< 0.001	1.57 (1.34-1.84)
Unplanned intubation	217 (2.0)	326 (3.0)	< 0.001	1.50 (1.27-1.78)
Ventilated for more than 48 h	165 (1.5)	294 (2.7)	< 0.001	1.78 (1.48-2.15)
Pulmonary emboli	69 (0.6)	87 (0.8)	0.148	1.26 (0.92-1.73)
Deep venous thrombosis	97 (0.9)	179 (1.6)	< 0.001	1.85 (1.44-2.36)
Renal complications	421 (3.8)	656 (6.0)	< 0.001	1.56 (1.38-1.76)
Progressive renal insufficiency	54 (0.4)	98 (0.9)	< 0.001	1.81 (1.30-2.53)
Acute renal failure	50 (0.4)	72 (0.7)	0.046	1.44 (1.01-2.06)
Urinary tract infection	339 (3.1)	524 (4.8)	< 0.001	1.55 (1.35-1.77)
Infections	1170 (10.6)	1951 (17.7)	< 0.001	1.67 (1.56-1.78)
Sepsis	274 (2.5)	468 (4.3)	< 0.001	1.71 (1.46-1.98)
Septic shock	156 (1.4)	284 (2.6)	< 0.001	1.82 (1.50-2.21)
Superficial incisional infection	582 (5.3)	968 (8.8)	< 0.001	1.66 (1.51-1.84)
Deep incisional infection	96 (0.9)	150 (1.4)	0.001	1.56 (1.21-2.02)
Organ space infection	206 (1.9)	347 (3.2)	< 0.001	1.68 (1.42-1.99)
Wound disruption	84 (0.8)	144 (1.3)	< 0.001	1.71 (1.31-2.24)
Return to operating room	451 (4.1)	588 (5.3)	< 0.001	1.30 (1.16-1.47)
Length of stay (d), mean ± SD	6.61 ± 6.73	9.62 ± 8.33	< 0.001	-
30-d mortality	173 (1.6)	316 (2.9)	< 0.001	1.83 (1.52-2.19)

<sup>1</sup>Any one of cardiac, pulmonary, renal or infectious complications.

and prolonged recovery, and it affects the quality of life significantly<sup>[25]</sup>. Our analysis showed an infection rate of 10.6% in the LC group in comparison with 17.7% in the OC group. A similar ACS NSQIP based analysis of colorectal procedures involving all age groups show an infection rate of 9.5% with the laparoscopic approach in comparison to 16% with the open approach<sup>[26]</sup>. The reasons for lower SSI with the laparoscopic approach might include reduced blood transfusions and reduced wound contact with the colon<sup>[27]</sup>. Elderly age is known to be a risk factor for respiratory and cardiac complications. This is probably due to higher incidence

of comorbidities in this cohort and preoperative comorbidities have shown to be an important predictor of postoperative adverse outcomes<sup>[28,29]</sup>. After matching for pre-operative cardiac, respiratory, neurological and renal comorbidities, our study showed a lower incidence of pneumonia and need for mechanical ventilation, as well as lower incidence of cardiac and renal complications with the laparoscopic approach. These lower rates of complications seen with the laparoscopic approach are probably related to there being less pain related splinting of diaphragm causing less postoperative atelectasis and pneumonia<sup>[30,31]</sup>. While our study does not explicitly look at cost, length of stay impacts the costs, and LC was associated with a significantly shorter recovery period<sup>[32]</sup>.

The main strength of this study is its large sample size from a robust database. The ACS NSQIP database is one of the largest, well validated, risk adjusted current database designed to track surgical outcomes based on relevant set of perioperative variables. ACS NSQIP database has been demonstrated to improve outcomes and decrease expenses<sup>[33-35]</sup>. The hallmark of this data is that it is collected prospectively and strictly audited. This prevents the pitfalls of accruing data from small institutional databases. Another strength of our study is the use of propensity matching which further minimizes the bias associated with patient selection.

We recognize that there are limitations to our study. Although the ACS NSQIP database is one of the largest available, it does not represent every hospital as it includes only participating hospitals. In addition, we are only able to analyze the data that has been recorded. For example we can only group the patients into colectomies based on which part of the colon was removed, but any differences in surgical technique have not been recorded. And in terms of complications we have access to the number of complications in each category, but the severity of each complication (e.g., Clavien-Dindo classification) is not available. Nonetheless, the extremely large size of the database allows for many of these deficiencies to not impact on the results. It is unlikely that the complications in one group were all severe while the complications in the other group were all minor.

Another limitation is the non-randomized nature associated with any large database. These are essentially cohort studies, and there is always a chance for selection bias. However, by incorporating propensity score matching into this study, we have significantly minimized the risk of this. And finally, other factors such as the surgeon's experience and procedure volume are known to impact the outcomes but were not explored in this study<sup>[36]</sup>.

Of course, each patient and each situation needs to be evaluated individually. In some cases there might be specific reasons why an open approach might be preferable, such as extensive prior surgery, a large

mass or phlegmon, or surgeon comfort level. However, in the absence of specific contraindications our study showed better results with a laparoscopic approach.

In conclusion, this ACS NSQIP based study shows that even in elderly patients laparoscopic partial colectomy has better outcomes than those seen with open partial colectomy. There were decreases in every category of complications, they had shorter lengths of stay and lower mortality. This improvement in outcomes was seen even after matching the two groups by propensity scoring, ensuring that the two groups had similar rates of pre-operative comorbidities. Although a randomized control trial could be done to further the strength of the evidence, we feel the current data indicates that elderly patients requiring a partial colectomy should be offered a laparoscopic approach unless otherwise contraindicated.

## COMMENTS

### Background

Traditionally colon surgeries were done with an open approach. The introduction of laparoscopic techniques and improvement in the technology and instruments enabled the surgeons to adopt the laparoscopic approach for colectomies. Patients aged 65 years and above have increased comorbidities and are at risk for more complications, especially with longer operations. The question is whether the benefits of laparoscopic colectomy extend to the elderly population as well.

### Research frontiers

The major areas to evaluate are mortality, morbidity and lengths of stay. Mortality and morbidity are generally considered within the first 30 d, and morbidity can be further subdivided into different types of complications, such as cardiac, pulmonary, renal and infectious complications.

### Innovations and breakthroughs

The current study used a very large national database that has been well validated, the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database. In addition, the current study employed propensity matching in order to minimize any pre-operative differences between the open and laparoscopic groups.

### Applications

This study shows that the laparoscopic approach was associated with lower mortality, lower complications of every type and shorter lengths of stay. This is important when surgeons are faced with elderly patients requiring a partial colectomy. This study points to the laparoscopic approach being the preferred method in the absence of any contraindications. Future research areas would include a large scale randomized control trial in this patient population.

### Terminology

Partial colectomy refers to removal of a part of the colon. In this particular study this included an anastomosis between the remaining parts, as colostomy cases were excluded. Elderly in this study referred to patients aged 65 and above. Propensity matching refers to the statistical methods employed in order to ensure that two different groups are matched to become similar with respect to the chosen variables.

### Peer-review

This is a large database study of colorectal surgery in the elderly, which is overall well written and nicely structured. The conception of the study is simple but the results are robust and well backed by the rather straightforward method.

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