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# Effect of Resident Involvement on Patient Outcomes in Complex Laparoscopic Gastrointestinal Operations



Matthew D Whealon, MD, Monica T Young, MD, Michael J Phelan, PhD, Ninh T Nguyen, MD, FACS

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- BACKGROUND:** Multiple studies examining the impact of resident involvement on patient outcomes in general surgical operations have shown an associated increase in morbidity and operative time. However, these studies included basic and advanced laparoscopic and open operations. The aim of this study was to examine the impact of resident involvement on outcomes specifically in patients who underwent complex minimally invasive gastrointestinal operations.
- STUDY DESIGN:** The American College of Surgeons NSQIP database was reviewed for patients who underwent laparoscopic colectomy and laparoscopic paraesophageal hernia and anti-reflux procedures between 2002 and 2010. Data were analyzed based on operations performed with a resident involved compared with those performed by an attending surgeon without resident involvement. Primary end points included risk-adjusted 30-day mortality, 30-day reoperation, and 30-day serious morbidity. Secondary end points were operative time, hospital length of stay, and 30-day overall morbidity.
- RESULTS:** A total of 31,736 cases were analyzed; 63.3% of cases had a resident involved in the operation and 36.7% were performed by an attending without resident involvement. Operative time was significantly longer in cases performed with a resident (162 vs 138 minutes in attending-only cases;  $p < 0.01$ ), however, there were no significant differences between groups with regard to hospital length of stay (4.5 vs 4.5 days, respectively). Compared with cases without resident involvement, risk-adjusted outcomes for cases with resident involvement showed no significant differences in 30-day serious morbidity (odds ratio = 1.03; 95% CI, 0.94–1.14;  $p = 1.0$ ), 30-day mortality (odds ratio = 0.83; 95% CI, 0.60–1.15;  $p = 1.0$ ), or 30-day reoperation (odds ratio = 0.93; 95% CI, 0.81–1.06;  $p = 1.0$ ).
- CONCLUSIONS:** Resident involvement in complex laparoscopic gastrointestinal procedures is associated with an increase in operative time with no impact on postoperative outcomes. (J Am Coll Surg 2016;223:186–192. © 2016 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)
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In the current era of surgical training, there is considerable emphasis on appropriate resident supervision and patient safety. This presents a challenge when attempting to

balance patient safety with autonomy in resident education. Current resident training involves not only traditional open operations, but also highly complex laparoscopic operations. Several previous studies have evaluated surgical outcomes associated with resident involvement in general and vascular surgical cases.<sup>1-6</sup> These studies have reported an increase in operative times in cases with resident involvement and a concomitant increase in overall morbidity. Compared with open operations, complex laparoscopic surgical procedures have a high degree of technical difficulty, steeper learning curves, and they limit the attending surgeon's ability to control the operation when a resident is in the surgeon's operative position. Many of the studies mentioned evaluated both open and laparoscopic operations, however, few

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From the Department of Surgery, School of Medicine (Whealon, Young, Nguyen) and Department of Statistics (Phelan), University of California, Irvine, CA.

Correspondence address: Ninh T Nguyen, MD, FACS, Department of Surgery, University of California Irvine, School of Medicine, 333 City Bldg West, Suite 1600, Orange, CA 92868. email: [ninhn@uci.edu](mailto:ninhn@uci.edu)

specifically examined complex laparoscopic gastrointestinal procedures. The aim of this study was to evaluate the effect of resident involvement on outcomes in complex laparoscopic gastrointestinal procedures.

## METHODS

### Database

The American College of Surgeons (ACS) NSQIP database is the first nationally validated, outcomes-based program designed for the purpose of improving surgical quality of care. It is composed of >500 hospitals that collect and receive hospital-level data on preoperative risk factors, intraoperative variables, and 30-day morbidity and mortality after inpatient and outpatient surgical procedures. A trained surgical clinical reviewer is used at participating hospitals to standardize data capture and ensure reliability. Additional information about the ACS NSQIP sampling strategy, data abstraction, and program specifics can be found on the ACS NSQIP website.<sup>7</sup>

### Selection and description of participants

The ACS NSQIP database was examined retrospectively for all patients who underwent laparoscopic colorectal procedures or laparoscopic paraesophageal hernia repair and anti-reflux surgery between January 1, 2002 and December 31, 2010. After 2010, the data on the level of resident involvement in a particular operation were not consistently available. Appropriate diagnosis and procedural codes were selected using the ICD-9 diagnosis codes and CPT codes, respectively. Patients with a post-operative diagnosis of esophagitis (ICD-9 codes: 530.10, 530.1, 530.11, 530.12, 530.19), Barrett esophagus (530.85), diaphragmatic hernia (553.3), colon cancer (153, 153.1, 153.2, 153.3, 153.6, 153.8, 153.9, 211.3), and diverticulitis (562.11, 562.13), who underwent elective, inpatient, laparoscopic paraesophageal hernia repair or anti-reflux surgery (CPT 43280, 43281, 43282) or a laparoscopic colorectal procedure (CPT 44204, 44205, 44206, 44207, 44208, 44210, 44211, 44212) were included. Patients undergoing emergent procedures were excluded from analysis.

### Demographics and outcomes variables

Data were evaluated based on the operations performed with a resident or fellow present (PGY1 to 10) and compared with those without resident involvement (PGY0). Variables used in the evaluation were provided by the NSQIP database and included patient demographic characteristics (age, sex, and ethnicity), BMI, preoperative functional health status, American Society of Anesthesiologists Physical Status Classification, as well as patient

comorbidities (diabetes mellitus, smoking, alcohol use, COPD, congestive heart failure, MI, coronary artery disease, peripheral vascular disease, renal insufficiency, steroid use, transient ischemic attack, and stroke). Mean number of comorbidities was calculated for each group.

Primary end points were risk-adjusted 30-day mortality, 30-day serious morbidity, and 30-day reoperation rate. Secondary end points were operative time, hospital length of stay, and 30-day overall morbidity. Serious morbidity was defined as the presence of one of the following perioperative complications: deep incisional surgical site infection, organ space surgical site infection, pneumonia, pulmonary embolism, progressive renal insufficiency, acute renal failure, stroke or cardiovascular accident, MI, bleeding requiring transfusion, deep vein thrombosis or thrombophlebitis, sepsis, septic shock, cardiac arrest requiring CPR, or ventilator requirements >48 hours. Thirty-day reoperation was defined as any major surgical procedure that required the patient to be taken to the surgical operating room for intervention of any kind.

### Statistical analysis

Statistical analysis was performed using SAS software, version 9.3 (SAS Institute) and the R statistical environment. Binary outcomes were compared using chi-square tests with Yates correction. Continuous variables were compared using 2-sample *t*-tests with unequal variance. Risk-adjusted multivariate logistic regression analysis was performed for 30-day mortality, serious morbidity, and reoperation. Independent variables used for risk adjustment included demographic characteristics, functional status, American Society of Anesthesiologists Physical Status Classification, and comorbidities. Robust SEs were used for inference to guard against model misspecification; Holm's method was used to account for multiple comparisons in the risk-adjusted analyses.<sup>8,9</sup> Comparisons were considered statistically significant if the *p* value was <0.05. All reported *p* values are 2-sided.

## RESULTS

A total of 31,736 cases were analyzed; 10,901 (34%) paraesophageal hernia repair or laparoscopic anti-reflux procedures, and 21,171 (66%) laparoscopic colorectal procedures. Resident involvement occurred in 20,087 cases (63.3%) and 11,649 cases (36.7%) were performed by an attending surgeon without resident involvement. Demographics and comorbidities for patients in the attending and resident groups are shown in [Table 1](#). There were small differences in age, race, BMI, preoperative functional health status, rates of COPD, previous cardiac surgery, history of steroid use, alcohol abuse, and

**Table 1.** Demographic Characteristics and Comorbidities of Patients Who Underwent Complex Laparoscopic Gastrointestinal Surgery According to Resident Involvement

Variable	Without resident involvement (n = 11,649)	With resident involvement (n = 20,087)	p Value
Age, y, mean $\pm$ SD	60.4 $\pm$ 14.4	59.4 $\pm$ 14.4	<0.01*
Sex, female, %	55.2	55.9	NS
Race, white, %	80.6	76.8	<0.01*
BMI, kg/m <sup>2</sup> , mean $\pm$ SD	29.1 $\pm$ 6.0	28.9 $\pm$ 6.1	<0.01*
Preoperative functional health status, %			
Independent	97.8	98.2	0.02*
Partially dependent	2.0	1.5	<0.01*
Totally dependent	0.2	0.2	NS
American Society of Anesthesiologists Physical Status Classification, %			
I and II No disturbance/mild disturbance	64.7	64.7	NS
III Severe disturbance	33.3	33.4	NS
IV Life threatening	1.8	1.8	NS
V Moribund	0.01	0.01	NS
Comorbidity, n, mean $\pm$ SD	0.87 $\pm$ 0.9	0.83 $\pm$ 0.9	<0.01
Diabetes, %	11.1	10.6	NS
COPD, %	4.3	3.8	0.03*
Congestive heart failure, %	0.35	0.37	NS
MI (last 6 mo), %	0.22	0.20	NS
Previous cardiac surgery, %	3.5	4.1	0.02*
Coronary artery disease, %	5.1	4.7	NS
Chronic renal failure, %	0.26	0.26	NS
Peripheral vascular disease, %	0.76	0.74	NS
History of CVA/stroke, %	2.9	2.7	NS
Steroid use, %	2.1	3.2	<0.01*
Smoking, %	15.2	15.1	NS
Alcohol abuse (>2 drinks/d), %	3.2	2.7	<0.01*

\*p &lt; 0.05.

overall comorbidity count between the 2 groups. Although these numbers reached statistical significance, likely a result of the large population size, they likely did not represent any clinically relevant differences.

On univariate analysis, mean operative time was significantly longer for the resident group compared with the no resident involvement group (161.9  $\pm$  69.7 minutes vs 138.3  $\pm$  65.9 minutes, respectively; p < 0.01). There were significantly higher rates of sepsis and prolonged mechanical ventilation in patients in the resident group vs the no resident group (1.82% vs 1.49% respectively; p = 0.03) and (0.95% vs 0.62%, respectively; p < 0.01). There were no significant differences between groups in hospital length of stay, 30-day reoperation, 30-day serious morbidity, 30-day overall morbidity, and 30-day mortality (Table 2).

Table 3 lists the risk-adjusted multivariate regression analysis for 30-day reoperation, serious morbidity, and mortality. Compared with the group without resident

involvement, risk-adjusted outcomes for cases with resident involvement showed no significant differences between groups for 30-day serious morbidity (odds ratio [OR] = 1.03; 95% CI, 0.94–1.14; p = 1.0), 30-day mortality (OR = 0.83; 95% CI, 0.60–1.15; p = 1.0), and 30-day reoperation (OR = 0.93; 95% CI 0.81–1.06; p = 1.0). For specific complications, there was a significantly increased rate of prolonged mechanical ventilation for patients in the resident group (adjusted OR = 1.58; 95% CI, 1.20–2.07; p = 0.02).

## DISCUSSION

Patient outcomes with resident involvement in the quality of surgery still remains a frequent point of debate. Resident education is important to prepare the next generation of surgeons, however, the issue of the negative impact of resident involvement on patient outcomes is of concern. In our analysis of the ACS NSQIP database

**Table 2.** Univariate Analysis of Postoperative Outcomes of Patients Who Underwent Complex Laparoscopic Gastrointestinal Surgery According to Resident Involvement

Outcome	Without resident involvement (n = 11,649)	With resident involvement (n = 20,087)	p Value
Operative time, min, mean ± SD	138.3 ± 65.8	161.9 ± 69.6	<0.01*
Length of stay, d, mean ± SD	4.5 ± 11.3	4.5 ± 5.0	0.83
30-d reoperation, %	3.25	3.05	0.31
Overall morbidity, %	11.68	12.33	0.09
Serious morbidity, %	6.04	6.07	0.92
Cardiac arrest, CPR required	0.18	0.17	0.82
Deep incisional SSI	0.58	0.45	0.11
Organ space SSI	1.61	1.57	0.78
Progressive renal insufficiency	0.25	0.32	0.27
Acute renal failure	0.23	0.25	0.76
Pulmonary embolism	0.40	0.38	0.73
Stroke/CVA	0.20	0.11	0.06
Myocardial infarction	0.28	0.27	0.88
Bleeding transfusion	0.97	0.94	0.76
Deep vein thrombosis/thrombophlebitis	0.52	0.60	0.40
Sepsis	1.49	1.82	0.03*
Septic shock	0.64	0.73	0.36
On ventilator >48 h	0.62	0.95	<0.01*
Pneumonia	1.11	1.16	0.67
30-d mortality, %	0.59	0.46	0.12

\*p &lt; 0.05.

SSI, surgical site infection.

and examining resident involvement in complex laparoscopic gastrointestinal operations, we found that resident involvement was associated with an increased operative

time only; there was no statistically significant difference in the risk-adjusted 30-day mortality, serious morbidity, or reoperation rates.

**Table 3.** Multivariate Analysis of Outcomes by Resident Involvement for Complex Laparoscopic Gastrointestinal Surgery

Outcome	Risk-adjusted odds ratio (95% CI)	Adjusted p value*
30-d mortality	0.83 (0.60–1.15)	1.00
30-d reoperation	0.93 (0.81–1.06)	1.00
Serious complications	1.03 (0.94–1.14)	1.00
Cardiac arrest, CPR required	0.93 (0.54–1.62)	1.00
Deep incisional SSI	0.79 (0.57–1.08)	1.00
Organ space SSI	0.97 (0.81–1.17)	1.00
Progressive renal insufficiency	1.31 (0.84–2.06)	1.00
Acute renal failure	1.12 (0.70–1.78)	1.00
Pulmonary embolism	0.96 (0.66–1.38)	1.00
Stroke/CVA	0.61 (0.34–1.09)	1.00
MI	1.02 (0.66–1.58)	1.00
Bleeding transfusion	1.06 (0.83–1.35)	1.00
Deep vein thrombosis/thrombophlebitis	1.25 (0.91–1.72)	1.00
Sepsis	1.22 (1.02–1.47)	0.52
Septic shock	1.16 (0.88–1.54)	1.00
On ventilator >48 h	1.58 (1.20–2.07)	0.02
Pneumonia	1.05 (0.84–1.30)	1.00

\*Adjusted p value for multiple comparisons using Holm's method.<sup>9</sup>

SSI, surgical site infection.

Table 4 lists selected articles on the effect of resident involvement on common open and laparoscopic general and vascular operations. Our study uniformly agrees with previous studies and found an increase in operative time associated with resident involvement on a mean of 24 to 30 minutes per case.<sup>1-6,10</sup> This result is not surprising because one would expect that there would be increased operative time associated with a resident performing the surgical operation. There are 2 aspects of learning when a resident surgeon learns a new operation. First is the knowledge and understanding of the important steps of the operation. Second is the technical proficiency in performing the important elements of the procedure. In cases with resident involvement, the attending surgeons participate in the key component of operation and educate the residents on the important steps of the operation. However, technical implementation of these steps often requires additional time due to the limited operative experience of the resident surgeon. Previous studies have shown that operative times improve as the surgeon advances along the learning curve.<sup>11,12</sup> Some studies have suggested that increased operative times might be associated with increased rates of wound infections and venous thromboembolism.<sup>4,13-15</sup> However, the prolonged operative times in our study did not translate into worse outcomes.

In the context of complex laparoscopic gastrointestinal operations, our study did not show any significant difference in overall 30-day mortality, reoperation, or serious morbidity in cases with resident involvement. When we evaluated individual complications, only the risk-adjusted rate of prolonged mechanical ventilation (defined in NSQIP as mechanical ventilation for >48 hours) was significantly increased in the resident group. At teaching institutions, resident impact on patient care reaches farther than just the operating room and includes resident involvement in the care of the patient in the postoperative period. It is possible that the increased rate of prolonged mechanical ventilation might be a reflection of the inexperienced residents' intensive care management skills.<sup>13</sup> In contrast to previous studies, we did not find an increase in postoperative morbidity in surgical cases with resident involvement. Iannuzzi and colleagues<sup>1</sup> found an increase in both major and minor complications and in rates of reoperation in open and laparoscopic colectomy. Raval and colleagues<sup>2</sup> and Tseng and colleagues<sup>5</sup> demonstrated slightly higher morbidity rates in laparoscopic and open general surgery cases with resident involvement. However, both studies found a substantial reduction in 30-day mortality with resident involvement. It was postulated that a reduction in mortality related in part to early recognition of complications in cases with resident involvement can lead to earlier

**Table 4.** Effect of Surgical Resident Involvement in General, Vascular, and Urologic Operations in Selected Articles

First author, year	Database	Procedure	Morbidity	Operative time, min	Reoperation	Mortality
Krell, 2014 <sup>4</sup>	MBSC	Laparoscopic RYGB	↑	↑	NA	NA
Iannuzzi, 2013 <sup>1</sup>	NSQIP	Laparoscopic colectomy and open colectomy	↑	↑ 30	↑	NSD
Davis, 2013 <sup>3</sup>	NSQIP	Laparoscopic cholecystectomy, colectomy, appendectomy, fundoplication, IH, and RYGB	↑	↑	NSD	NSD
Raval, 2011 <sup>2</sup>	NSQIP	General and vascular surgery	↑	↑	NA	↓
Tseng, 2011 <sup>5</sup>	NSQIP	Laparoscopic cholecystectomy, fundoplication, RYGB, IH, and open colectomy, IH, and thyroidectomy	↑	↑ 24	NA	↓
Kiran, 2012 <sup>6</sup>	NSQIP	All NSQIP surgical procedures	↑	↑ 25	NSD	NSD
Current study	NSQIP	Laparoscopic colorectal surgery and fundoplication	NSD	↑ 24	NSD	NSD

IH, inguinal hernia; MBSC, Michigan Bariatric Surgery Collaborative; NA, no data available; NSD, no statistical difference; RYGB, Roux-en-Y gastric bypass.

management of the patient's complication. Davis and colleagues<sup>3</sup> evaluated patient outcomes with resident involvement across multiple laparoscopic procedures and found an increase in morbidity across all procedures with resident participation, but no effect on 30-day mortality and reoperation rates.

There are several limitations to our study. The NSQIP database records only the highest level of resident involved in a procedure, therefore, we cannot determine the number of residents involved in a particular case. This fact is important in cases where a senior-level resident coaches a junior-level resident through a case. We were also unable to determine the extent of residents' operative involvement in the surgical cases. The NSQIP variable for resident involvement only documents that a resident was present for a portion of the case, but does not provide information on the extent of operative involvement of that resident. Additionally, we were unable to confidently distinguish between resident and fellow involvement in a given case. The PGY of the highest level trainee involved in the case is recorded, however, there can be variability in how the PGY is recorded; for example, a PGY7 could represent either a resident or a fellow. Given this variability, all trainees were considered "residents." This study also occurred during a period in which there was a change in resident duty hour restriction. In July 2003, the 80-hour workweek was implemented by the ACGME. These changes could have potentially impacted the resident case volumes and patient outcomes, however, a study by Hutter and colleagues<sup>14</sup> did not demonstrate any significant changes to overall resident case volume or patient outcomes during this period. Lastly, we were not able to determine the technical proficiency of the attending surgeon. For example, a newly graduated surgeon has less operative experience than a seasoned surgeon who has mastered his or her technical skill level. A recent *New England Journal of Medicine* study examining the variation in technical proficiency of attending surgeons performing laparoscopic Roux-en-Y gastric bypass showed that attending surgeons in the bottom quartile of technical skill based on peer-reviewed video analysis had patients with higher morbidity and mortality rates.<sup>15</sup> This is a very important finding that suggests that patient outcomes might be related more to the attending surgeon's skill than whether or not a resident is involved in the operation.

## CONCLUSIONS

There has been a longstanding debate about the possible negative impact of resident involvement on perioperative outcomes in general surgical cases. Laparoscopic

colorectal and hiatal hernia operations are now common gastrointestinal procedures performed at most medical centers. We examined the impact of resident involvement on patient outcomes in these complex laparoscopic gastrointestinal operations and found that resident involvement was associated with an increased operative time with no impact on perioperative outcomes.

## Author Contributions

Study conception and design: Young, Nguyen

Acquisition of data: Whealon, Young, Phelan

Analysis and interpretation of data: Whealon, Young, Phelan, Nguyen

Drafting of manuscript: Whealon, Nguyen

Critical revision: Whealon, Nguyen

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## Discussion



**DR DAVID BORGSTROM** (Morgantown, WV): Technical skill acquisition continues to be a hot topic in surgical education. How do we achieve technical competence in 5 years, and how do we accelerate the learning curve? Along with the explosion of minimally invasive surgery (MIS) techniques in the last 15 years, we are faced with external drivers of efficiency, accountability, and quality. Get it done quicker, better, and cheaper.

Technical skill acquisition is suffering. Numerous studies over decades have documented that operative times are longer with surgical training programs. More recently, articles have also suggested that morbidity and mortality are adversely affected. The authors have attempted to address the variables of resident involvement with complex laparoscopy. They chose laparoscopic antireflux surgery and laparoscopic colectomy, and queried the NSQIP database for answers. Not surprisingly, they found operative times were increased by resident involvement, but length of stay, serious morbidity, overall morbidity, and 30-day mortality were not affected by resident involvement.

This is an important paper. These findings lend further support to the quality of care provided in teaching hospitals. It is an excellent use of the NSQIP database.

Why did you lump antireflux surgery and laparoscopic colectomy for your analysis? These seem to me to be very different procedures done by different groups of surgeons. Are the conclusions the same if you separate the 2 groups?

From 2002 to 2010 there was great growth and technical development in MIS. Did you look for any changes over time? Were there decreases in time differentials over the study period?

Your manuscript noted that you tracked the postgraduate year (PGY) of the resident participating in the operation, but could not differentiate between resident and fellow. Did you consider a linear regression analysis for this, PGY year to time difference, or at least grouping, say, PGY 1 through 5, and comparing that with PGY 6 through 10?

**DR NINH NGUYEN** (Irvine, CA): The reason we lump the laparoscopic antireflux surgery with the laparoscopic colectomy is because they are both complex laparoscopic operations, and we wanted to make sure that we have a large enough sample size to determine if there are any differences between the 2 groups for uncommon adverse events such as death.

For your second question, I agree that between 2002 and 2010, there were a lot of variations in technique for both of these operations; however, these variations in technique and the learning curve should be similar between the 2 groups, with and without residents. We did not specifically analyze any changes in outcomes over this time period, but it would be an interesting question to answer.

Regarding the last question, we have our suspicion about the accuracy of the data points of the PGY levels of the resident that were entered into NSQIP. I know from our center that the surgical clinical reviewer often makes mistakes on entering the PGY level. Additionally, I think it is best to lump residents with fellows because they are both considered trainees, and this study aimed to determine if the presence of a trainee can have an impact on postoperative 30-day outcomes.

**DR LEIGH ANNE NEUMAYER** (Tucson, AZ): In regard to the costs, at my hospital they estimate \$150 per minute in the operating room. Although less than 30 minutes doesn't seem that long, I just calculated the costs for 23 minutes at \$150 per minute is \$3,450. If it is 30 minutes, it is \$4,500 per case. That is a high expense. How are we going to fix this problem?

**DR NINH NGUYEN** (Irvine, CA): That is a good point. There is a cost consequence to a teaching environment, but I would not just blame the prolonged operative time all on the residents. I think we also have to look at ourselves. The majority of us actually come into the operating room only for the key portion of the procedure because that is what the Centers for Medicare and Medicaid Services dictated. That means that for a laparoscopic operation, we normally come in when all of the trocars are placed and leave early and let the resident close. To reduce the operative time, the onus is on the attending to be there from start to closure of the incision. Therefore, if we want to reduce the operative time, we need to do a better job.

**DR WILLIAM CIROCCO** (Columbus, OH): I may have missed it. Can you comment on conversion rates to open operations and also the rate of hybrid procedures, hand-assist procedures, and single-port surgery?

**DR NINH NGUYEN** (Irvine, CA): Unfortunately, the NSQIP database does not have CPT codes for conversion to open or conversion to hand-assisted surgery, so we do not have any information regarding this data point.