

A little slower, but just as good: postgraduate year resident versus attending outcomes in laparoscopic ventral hernia repair

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Abstract

Introduction The purpose of this study was to analyze the effect of residents on patient outcomes in laparoscopic ventral hernia repair (LVHR). We hypothesized that increasing postgraduate year (PGY) level would correlate with better outcomes.

Methods The American College of Surgeons National Surgical Quality Improvement Program database was queried from 2005 to 2011 for elective LVHR. Attending only cases were used as the control, and resident cases were stratified into junior (PGY 1–3), chief (4–5), and fellow (6+) cases. Standard statistical tests and multivariate regression controlling for age, body mass index, Charlson comorbidity index, smoking, functional status, and inpatient cases were performed for trainee involvement and PGY level.

Results There were 6,841 ventral hernia repairs that met inclusion criteria: 2,773 attending and 4,068 resident cases. There were 1,644 junior, 1,983 chief, and 441 fellow cases. Patients were similar between the attending and resident groups. The resident group had a higher rate of inpatient cases, general complications, longer operative time, and hospital length of stay. After controlling for confounders in multivariate analysis, only operative time was significantly

different; resident cases were 17.7 min longer (CI 15.0–20.6; $p < 0.001$). There was no significant difference in the rate of wound or major complications, readmission, reoperation, or mortality between attending and resident cases. Demographics were not significantly different between the PGY level strata. On multivariate regression by PGY level with attending alone as the reference, only operative time was significantly different. Juniors (15.7 min, CI 12.2–19.2), chiefs (18.0 min, CI 14.7–21.3), and fellows (24.9 min, CI 19.1–30.7) had significantly longer cases than attending alone; all $p < 0.001$.

Conclusion Trainee involvement during LVHR does not change the clinical outcomes for patients as compared to those performed by an attending only. Operative time is significantly longer with increasing PGY level, perhaps indicating the complexity of the operation or increasing trainee involvement as primary surgeon. However, patient care does not suffer, affirming the current surgical training curriculum is appropriate.

Keywords Hernia · Ventral hernia · Laparoscopic ventral hernia repair · NSQIP · Resident outcomes · Surgical education · Resident · Fellow

Surgical training is dependent on appropriate and comprehensive hands-on experience in the operating room. A controversy exists regarding the level of trainee experience and ensuing associated surgical outcomes. A recent systematic review of the effect of clinical supervision on patients and residency education outcomes across a variety of specialties (i.e., psychiatry, emergency medicine, surgery, anesthesia, and internal medicine) demonstrated that enhanced supervision in already-supervised activities resulted in improved patient- or education-related

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outcomes [1]. However, many of the studies in the aforementioned meta-analysis spanning from 1966 to 2010 were limited by small sample sizes, nonrandomized designs, and a lack of objective measures of clinical supervision [1].

The advent of the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) has enabled us to utilize this large, national database to further probe into the influence of residents on surgical outcomes. In 2011, Raval et al. looked at outcomes for both general surgical and vascular procedures utilizing the NSQIP data. Adjusting for operative time in regression modeling, the group found slightly higher morbidity rates, with approximately 6.1 additional morbidity events, but slightly decreased mortality rates, with 1.4 fewer deaths per 1,000 procedures. They concluded that these were clinically small effects and demonstrated the safety of resident involvement in surgical care and possibly protective effect with regard to mortality [2]. Since then, several other authors have utilized NSQIP data to reveal an association of resident involvement and increased risk of 30-day morbidity, including higher rates of major complications, wound infection, bleeding, sepsis, venous thromboembolism, return to operating room, and longer operative time, and risk of intraoperative transfusions for various surgical procedures (e.g., laparoscopic gastric bypass, breast reduction surgery, partial nephrectomy, partial colectomy, extremity amputation, complex oncologic surgery, and joint arthroplasty) [3–9]. One study showed that postgraduate year (PGY) experience was inversely related to risk of surgical complications [4]. Two additional studies have shown that while trainee cases have higher rates of 30-day postoperative complications, they were offset by improved 30-day mortality when residents were involved [2, 8].

Specifically in regard to hernias, NSQIP data have also shown that laparoscopic inguinal hernias are performed faster by attending surgeons without residents; however, there was no difference in complication rates when residents were involved [10]. To date, no studies have evaluated the impact of trainee involvement on ventral hernia repair (VHR) including their PGY level as an indicator of surgical experience. The goal of this study was to analyze the effect of surgical trainee participation on patient outcomes in laparoscopic ventral hernia repair (LVHR).

Materials and methods

Data source

The ACS NSQIP database was used. Data from 2005 to 2011 were queried for use in the study; however, the PGY level variable was instituted in the NSQIP dataset in 2009;

therefore, only 2009–2011 data were included. NSQIP is a surgery-specific database that catalogs operations at participating institutions from across the United States, usually at large tertiary care academic and community centers. The database has evolved since its inception, both in number of variables recorded and purpose of its use. Original design was to help individual institutions monitor rates of surgical complications, compare their rates to similar hospitals, and implement strategies to decrease adverse events. Since then, the program has subsequently evolved into an expansive data repository facilitating researchers and clinicians to examine national trends in surgical outcomes. To date, over 400 hospitals participate in NSQIP data collection [11], and over 250 variables are now recorded on each participant.

Laparoscopic ventral hernia repairs were identified in NSQIP through CPT codes: 49654, 49655, 49656, and 49657. Only patients over 18 years old were included, and patients without attending alone classification or PGY level data were excluded. Preoperative demographics, comorbidities, laboratory values, operative details, postoperative 30-day complications, and disposition are recorded by dedicated abstractors specially trained in surgical outcomes and data collection. Outcomes of interest to us were death, wound, general, and major complications, as well as operative time and hospital length of stay (LOS). NSQIP has over 25 complications variables, but they are not categorized or grouped in a manner to allow for appropriate statistical analysis or reporting. Therefore, the authors classified complications into wound complications [wound disruption, and superficial and deep surgical site infections (SSI)], general complications [the component wound complications, intra-abdominal abscess, failure to wean ventilator, acute renal insufficiency, urinary tract infection, peripheral nerve injury, bleeding requiring transfusion, and deep vein thrombosis (DVT)/thrombophlebitis], and major complications [pneumonia, respiratory failure, pulmonary embolism, acute renal failure (ARF), cerebrovascular accident (CVA), cardiac arrest, myocardial infarction, sepsis, and septic shock].

Patients differ significantly by number and severity of comorbidities, and NSQIP records over 30 patient comorbidities. However, there is no global comorbidity scale on which to rate patients in NSQIP such as the Charlson comorbidity index (CCI) [12]. The CCI is a scoring system that has been extensively validated and specifically for surgery patients [13–15]. Age group and major comorbidities are ranked from one to six points. Points are then summated to provide a total patient score [16]. For example, patients with a score zero have a 99 % ten-year survival, and patients with a score of five have a 21 % ten year survival. Therefore, in order to control for number and severity of comorbidities, the authors matched the NSQIP

available variables to the CCI to create a NSQIP comorbidity index. Previous studies have verified that CCI adapted to large administrative databases have had similar sensitivity in stratifying mortality, [17, 18], and this strategy has been used in NSQIP by two prior studies [19, 20]. Comorbidities were given score points according to their relation to the original CCI.

Study design

The study was constructed in order to elucidate trainee effect on operative outcomes following LVHR and secondarily to evaluate the effect of level of training. After identifying a study group, cases were separated into cases with trainee involvement or attending alone (AA). Cases involving trainees were divided into three cohorts by classic surgical resident designations, with interns to PGY 3 residents termed as junior level residents, PGY 4 and 5 designated as chiefs, and PGY 6 and greater labeled as fellows. This PGY designation reflects the academic year following medical school and not necessarily the clinical year for residents who have participated in research or intra-residency fellowships as a separate year. Therefore, it is possible that PGY 6 or 7 trainees could be chief residents or clinical fellows, but given the added maturity gained by the additional year and the lack of the ability to differentiate the two given the NSQIP data, the authors chose to follow the standard five-year course for General Surgery residency. The trainee group was then compared to the AA group for operative outcomes. Furthermore, PGY groups were compared to each other with the AA group as the reference standard. Multivariate regression was performed on significant outcomes to isolate if trainee status or PGY level was independently associated with morbidity or mortality.

Statistical analysis

Descriptive statistics are reported as means with corresponding standard deviations for continuous variables and percentages for categorical variables for by trainee involvement and PGY level. Bivariate analyses were performed by trainee status and PGY level to evaluate the effects of patient demographics, comorbidities, and operative details on outcomes. Categorical variables were evaluated using Pearson's chi-squared and Fisher's exact test where appropriate. Continuous and ordinal variables were evaluated using Wilcoxon–Mann–Whitney, and the Kruskal–Wallis tests. Multivariate regression was then performed controlling for age, body mass index (BMI), CCI, smoking, functional status, and inpatient cases. Odds ratios with corresponding 95 % confidence intervals are used to report the results of the multivariate regression

models. Statistical significance was set at $p \leq 0.05$, and all reported p values are two-tailed. All data were analyzed using Statistical Analysis Software, version 9.3 (SAS Institute, Inc., Cary, NC).

Results

Patient characteristics

There were 6,841 LVHR in the study period that met inclusion criteria. Of these, 2,773 were performed by AA, and 4,068 were performed in conjunction with a trainee. Chief residents performed the most LVHR (1,983) followed by junior residents (1,644) and fellows (441). On average, the population was middle aged (57.0 ± 13.5 years), obese (BMI: 33.5 ± 8.2 kg/m²), and with few comorbidities (CCI: 0.4 ± 0.8). The most common comorbidity was diabetes (16.8 %), followed by exertional dyspnea (9.2 %), and COPD (4.3 %). For the population as a whole, there were low rates of wound complications (1.2 %), general complications (3.6 %), major complications (2.4 %), 30-day readmission (5.7 %), reoperation (2.4 %), and death (0.3 %). Patient characteristics are compared between AA and trainee cases, and by PGY level in Table 1. LVHR patients were statistically similar between AA and trainee cases for every demographic and comorbidity except for race. Additionally, patients were very similar regardless of the level of the trainee involved.

Operative details

Case details by trainee involvement are summarized in Table 2. Resident cases were more likely to be inpatients ($p < 0.001$), but were no more likely to be emergent or have contaminated or dirty wounds. Additionally, operative time was significantly longer in the trainee group when compared to AA ($p < 0.001$). However, AA and trainee cases had no difference in preoperative laboratory values, ASA classification, or intraoperative transfusion requirements ($p > 0.05$). Case details by PGY level are summarized in Table 3. There were more inpatient cases and longer operative time in increasing PGY groups ($p < 0.001$).

Patient outcomes

Laparoscopic ventral hernia repair patient 30-day outcomes by trainee involvement are summarized in Table 4. Trainee cases had similarly low rates of complications on the whole, but had statistically higher rates of general complications, UTI's, acute renal failure, and unplanned re-tubation ($p \leq 0.05$). Additionally, the hospital LOS was 0.2 days longer in the trainee group on average ($p \leq 0.05$).

Table 1 Patient characteristics for laparoscopic ventral hernia repair by trainee involvement

	Attending only <i>n</i> = 2,773	Trainee <i>n</i> = 4,068	<i>p</i> value	Junior <i>n</i> = 1,644	Chief <i>n</i> = 1,983	Fellow <i>n</i> = 441	<i>p</i> value
Age (years)	57.4 ± 13.7	56.8 ± 13.4	NS	56.9 ± 13.6	56.9 ± 13.4	56.0 ± 12.6	NS
Male (%)	39.8	41.2	NS	41.8	40.7	41.4	NS
Caucasian (%)	92.1	87.3	<0.001	88.8	86.7	84.3	<0.001
BMI (kg/m ²)	33.7 ± 8.1	33.4 ± 8.3	0.0	33.4 ± 8.5	33.4 ± 8.1	33.6 ± 8.4	NS
Charlson comorbidity index	0.4 ± 0.8	0.4 ± 0.8	NS	0.4 ± 0.8	0.4 ± 0.8	0.3 ± 1.0	NS
Systemic (%)							
Independent functional status	98.9	98.7	NS	98.7	98.8	98.4	NS
Smoker	19.2	19.4	NS	20.6	19.5	15.2	NS
EtOH use	2.6	2.4	NS	3.0	2.1	1.8	NS
Preoperative SIRS	0.8	0.8	NS	0.7	0.7	1.9	NS
Preoperative sepsis/shock	1.0	1.0	NS	0.9	0.8	1.9	NS
>10 % body mass loss last 6 months	0.4	0.5	NS	0.4	0.7	0.5	NS
Endocrine (%)							
Steroid use	1.8	2.5	NS	2.4	2.4	1.8	NS
Diabetes	17.7	16.2	NS	16.3	16.7	13.4	NS
Cardiac (%)							
Congestive heart failure	0.3	0.2	NS	0.4	0.1	0	NS
MI last 6 months	0.1	0.1	NS	0.1	0.2	0	NS
Prior CVA	2.1	2.4	NS	2.0	2.1	0.9	NS
History of cardiac surgery	4.5	5.2	NS	5.6	4.7	4.3	NS
Pulmonary (%)							
COPD	4.3	4.3	NS	4.5	4.1	4.3	NS
Exertional dyspnea	9.7	9.6	NS	9.1	9.4	8.6	NS
Renal (%)							
ESRD	0.5	0.6	NS	0.6	0.6	0.2	NS
Acute renal failure	0.1	0.2	NS	0.2	0.2	0	NS
Hematologic/oncologic (%)							
Bleeding disorder	2.4	2.8	NS	3.5	2.4	1.8	NS
Disseminated cancer	0.7	0.7	NS	0.4	0.8	1.4	NS
Chemotherapy last 30 days	0.5	0.5	NS	0.6	0.3	0.7	NS
Radiation therapy last 30 days	0.2	0.1	NS	0.1	0.1	0.2	NS

BMI body mass index, *SIRS* systemic inflammatory response syndrome, *CVA* cerebrovascular accident, *COPD* chronic obstructive pulmonary disease, *ESRD* end-stage renal disease

Table 2 Operative details by trainee involvement

	Attending alone <i>n</i> = 2,773	Trainee <i>n</i> = 4,068	<i>p</i> value
Inpatient	41.9	53.7	<0.001
Emergency case (%)	2.1	2.3	NS
Wound class (%)			
Clean	86.8	88.9	NS
Clean-contaminated	11.9	10.1	
Contaminated	1.0	0.8	
Dirty/infected	0.3	0.3	
Operative time (min)	92.2 ± 55.3	114.6 ± 65.3	<0.001

The outcomes of trainee cases by PGY level are summarized in Table 5. Complications rates were similar between all PGY groups despite years of training and experience. Cardiac arrest was the only complication that was higher for the fellow group, and LOS was longer in this group as well ($p \leq 0.05$).

Multivariate analysis

After controlling for confounding variables, the only outcome measure that remained significant by trainee involvement or PGY level was operative time. General

Table 3 Operative details comparing postgraduate year (PGY) level group

	Junior <i>n</i> = 1,644	Chief <i>n</i> = 1,983	Fellow <i>n</i> = 441	<i>p</i> value
Inpatient	49.9	54.8	62.4	<0.001
Emergency case (%)	2.7	2.2	1.1	NS
Wound class (%)				
Clean	90.8	88.5	83.5	<0.001
Clean-contaminated	7.9	10.6	15.7	
Contaminated	1.0	0.6	0.9	
Dirty/infected	0.4	0.3	0	
Operative time (min)	110.8 ± 62.4	115.3 ± 64.4	125.5 ± 77.9	<0.001

Table 4 Postoperative complications and outcomes by trainee involvement

(%)	Attending alone <i>n</i> = 2,773	Trainee <i>n</i> = 4,068	<i>p</i> value
Wound complications	1.3	1.2	NS
Superficial SSI	0.9	0.8	NS
Deep SSI	0.3	0.3	NS
Wound disruption	0.1	0.2	NS
General complications ^a	3.0	4.1	0.018
Intra-abdominal abscess	0.6	0.8	NS
Ventilator >48 h	0.3	0.7	0.0
Acute renal insufficiency	0.3	0.2	NS
Bleeding requiring transfusion	0.3	0.4	NS
DVT/thrombophlebitis	0.2	0.4	NS
Urinary tract infection	0.6	1.2	0.011
Major complications	2.1	2.7	NS
Acute renal failure	0.04	0.3	0.034
Pulmonary embolism	0.1	0.4	NS
Unplanned intubation	0.4	0.8	0.027
Pneumonia	0.7	0.7	NS
Myocardial infarction	0.1	0.3	NS
CVA	0.1	0.1	NS
Cardiac arrest	0.2	0.3	NS
Sepsis	0.8	0.9	NS
Septic shock	0.3	0.6	NS
Reoperation	2.6	2.3	NS
Readmission	5.5	5.8	NS
Length of stay (days)	2.0 ± 8.0	2.2 ± 4.5	<0.001
Death	0.3	0.3	NS

SSI surgical site infection, DVT deep vein thrombosis, CVA cerebrovascular accident

^a Includes the component variables of wound complication

complications and LOS were equivalent between AA and trainee and by all PGY level comparisons. Operative time was on average 17.7 min longer when trainees participated. However, operative time decreases with decreasing PGY

level, with junior residents having 15.7 min longer cases than AA, compared to 24.9 for fellows (Table 6).

Discussion

As efficient, high-quality, low-cost care has become the primary goal surrounding the current health care reform debate [21], surgeons are faced with increasing pressure to improve surgical outcomes. Quality improvement efforts in surgery have largely focused on reducing risk of complications and mortality after surgical procedures. Specifically aimed to address these goals, numerous published studies have evaluated the effect of surgical trainee participation on procedural outcomes. However, the true impact of resident involvement in the operating room has remained elusive, as results differ by study and by surgical type. With this study, the authors demonstrate that inclusion of residents and fellows in laparoscopic ventral hernia repair does not increase the risk of patient morbidity or mortality.

In this study of over 6,500 LVHR within the NSQIP database, clinical outcomes were comparable whether the operation involved a trainee or was performed by an attending alone. Surgical trainee participation in LVHR was independently associated with longer operative times and may indicate the additional time required to teach and learn surgical skills; however, this increase in operative time was not associated with worse patient outcomes. Additional explanations may be due to increased surgical complexity, such as an increased number of prior abdominal surgeries, amount of adhesiolysis, and hernia size. These variables are not recorded in NSQIP but are frequently more prevalent at teaching institutions where complex and recurrent cases are often encountered [22]. Furthermore, level of resident involvement in cases cannot be estimated from this dataset, and residents could have been anywhere on the spectrum of operating independently to merely observing operations. Regardless, increased operative time in the trainee group did not result in increased complication rates in LVHR, which could signify appropriate teaching by attending staff.

Table 5 Postoperative complications and outcomes by PGY level group

(%)	Junior n = 1,644	Chief n = 1,983	Fellow n = 441	p value
Wound complications	1.2	1.3	0.9	NS
Superficial SSI	0.6	1.0	0.7	NS
Deep SSI	0.6	0.2	0.0	NS
Wound disruption	0.2	0.2	0.2	NS
General complications ^a	4.0	4.4	3.0	0.052
Intra-abdominal abscess	0.6	0.8	1.1	NS
Ventilator >48 h	0.6	0.8	0.5	NS
Acute renal insufficiency	0.2	0.1	0.5	NS
Bleeding requiring transfusion	0.4	0.4	0.2	NS
DVT/thrombophlebitis	0.5	0.4	0.5	NS
Urinary tract infection	1.3	1.3	0.7	NS
Major complications	2.6	2.6	3.0	NS
Acute renal failure	0.2	0.2	0.5	NS
Pulmonary embolism	0.4	0.3	0.5	NS
Unplanned intubation	0.6	0.9	0.9	NS
Pneumonia	0.8	0.6	0.9	NS
Myocardial infarction	0.2	0.4	0.2	NS
CVA	0.1	0.1	0	NS
Cardiac arrest	0.1	0.4	0.7	0.044
Sepsis	1.0	0.9	0.9	NS
Septic shock	0.5	0.7	0.5	NS
Reoperation	1.4	3.5	1.0	NS
Readmission	5.6	6.0	5.9	NS
Length of stay (days)	2.1 ± 4.6	2.3 ± 4.0	2.5 ± 5.6	<0.001
Death	0.1	0.3	0.7	NS

PGY postgraduate year, SSI surgical site infection, DVT deep vein thrombosis

^a Includes the component variables of wound complication

According to other studies utilizing NSQIP data, prolonged operative duration has been independently associated with a wide array of complications, including infectious and venous thromboembolic complications and increased length of hospital stay after adjusting for procedure and patient risk factors [6, 7, 23–25]. A recent systematic review also revealed that longer surgeries were associated with increased risk of surgical site infection, with a median odds ratio of 2.3 across 11 studies reporting significant results [26]. However, a number of authors have

Table 6 Multivariate analysis: LVHR outcomes by trainee status and PGY level

	OR or PE	CI	p Value
Attending versus trainee			
General complications	1.2	0.9–1.6	NS
Operative time (min)	17.7	15.0–20.6	<0.001
Length of stay (days)	−0.06	−0.3 to 0.4	NS
PGY level ^a			
Junior			
General complications	1.2	0.9–1.7	NS
Operative time (min)	15.7	12.2–19.1	<0.001
Length of stay (days)	−0.1	−0.5 to 0.3	NS
Chief			
General complications	1.3	0.97–1.7	NS
Operative time (min)	18.0	14.7–21.3	<0.001
Length of stay (days)	−0.02	−0.4 to 0.3	NS
Fellow			
General complications	0.7	0.4–1.4	NS
Operative time (min)	24.9	19.1–30.7	<0.001
Length of stay (days)	−0.03	−0.6 to 0.6	NS

OR odds ratio, PE parameter estimate, CI 95 % confidence interval, LVHR laparoscopic ventral hernia repair, PGY postgraduate year

^a Attending alone as the reference

examined the relationship of operative time and poor surgical outcomes after general surgical procedures and have found conflicting findings. For example, in a retrospective study of 231 partial right colectomies, Scheer et al. [27] found no adverse effect of increasing operative time on outcomes in segmental colectomies, but total abdominal colectomies lasting more than 270 min were associated with increased postoperative complications and length of stay. Liverani et al. [28], in a review of 250 open “clean” and “clean-contaminated” abdominal operations, found no association between length of procedure and the number of septic complications, anastomotic dehiscence, or length of stay. Dexter et al. [29] demonstrated no association between increased operative duration and increased risk of overall complications among 411 consecutive laparoscopic cholecystectomies. Given the current disparity of results in the surgical literature on the effect of operative time and complications, this study provides further evidence that a relatively small increase in operative time for educational purposes, at least in LVHR, does not increase adverse operative outcomes.

Resident and fellow training in the operating room may imply longer operative times, but this association and its clinical significance are controversial. The longer operative duration with resident involvement is well established for various General Surgical procedures, including laparoscopic appendectomy, laparoscopic cholecystectomy, inguinal hernia

repairs, breast surgery, as well as for sub-specialties such as cardiothoracic surgery and orthopedic surgery [23, 30–34]. Two studies found that resident involvement, regardless of postgraduate level added approximately 15 min to certain general and vascular surgery procedures [32, 35]. Another study of six index general surgery procedures found a 20–47 % increase in operative time with resident participation, with the larger difference in time for basic procedures [36]. The most common complication reported as being associated with trainee involvement is surgical site infection [33, 35], and although the cause is likely multifactorial, wound infection may be related to prolonged operative time [26]. In regard to mortality, a single-institution study of 2,280 General Surgery procedures found no difference in operative time or mortality whether or not a resident was involved in the procedure; however, residents were associated with a decrease in length of stay [37]. Interestingly, in a prospective study of 686 pancreaticoduodenectomies, Relles et al. demonstrated for the first time that as residents build experience with this complex operation, patient outcomes improve. This is consistent with volume–outcome relationships for attending physicians and high-volume hospitals [22, 38]. In these regards, length of operation is an important quality metric for all surgical procedures, and strategies aimed at reducing operative times, including surgical simulation and maximizing learning, are important to consider for patient outcomes [23]. However, as this study demonstrates a lack of association between increased resident operative times and increased complication rates, this metric cannot be the final measure of trainee education.

Operative time was found to be significantly longer with increasing PGY level, with junior residents taking significantly more time than chiefs, who took less time than fellows. However, it is unclear whether this is due to the difficulty of the operation or increasing resident or fellow participation. Other studies have evaluated the effect of resident level of experience on outcomes and found differing results. Some authors have shown no significant difference on the rates of morbidity, mortality, or reoperation between junior and senior residents [6, 7, 30–32, 39]. Similar to the authors' findings, others have also reported the slightly improved outcomes among junior residents compared to more senior residents in certain instances. For example, Uecker et al. and Kiran et al. reported decreased hospital length of stay and lower overall complications for cases involving PGY 1–2 residents compared to senior counterparts [33, 37] and increased rates of postoperative complications associated with fellows; one study even reported PGY 7 resident as predictive of prolonged hospital stay [34, 35]. Possible explanations for the increase in complications and length of stay despite increasing resident experience level may include more operative autonomy (i.e., reduced attending supervision), the learning curve for more advanced

operations, and/or participation of chief residents and fellows in more complex cases. Defining the cause of increased operative time in chief and fellow cases is difficult; however, the NSQIP variables provide some clues, as chief and fellow cases were significantly more likely to be inpatient and have higher wound classes ($p < 0.001$) and therefore are likely to require longer operative times and LOS. However, defining the operative contribution of the resident or the amount of time spent on intra-operative teaching in NSQIP is impossible, so the actual effect that resident participation has on operative time is based on our experience and inferences.

The study results emphasize the necessity of quality improvement efforts in surgical practice including tracking surgeon and patient outcomes to elucidate what factors result in, or in this case *do not result in*, adverse patient outcomes. Surgical residency should be recognized as a learning environment for acquiring an essential skill set and operative expertise and also as one in which the practice of safe, quality patient care is paramount. While operative time is increased in trainee cases for LVHR, patients, administrators, attending surgeons, residents, and fellows should be assured that participation in a learning environment does not have an adverse impact on patient outcomes. This study demonstrates that despite teaching an advanced laparoscopic surgical technique in a traditional clinical learning environment, patient care is maintained at a high standard.

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