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Prospective validation of the safety of a laparoscopic cholecystectomy training paradigm featuring incremental autonomy

Tarik D. Madni, Evan Barrios, Jonathan B. Imran, Luis Taveras, Audra T. Clark, Holly B. Cunningham, Alana Christie, Stephen Luk, Herb A. Phelan, Michael W. Cripps*

Department of Surgery, University of Texas Southwestern Medical Center, Dallas, TX, USA

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ABSTRACT

Background: Surgical training is under scrutiny for the effect increased resident autonomy may have on patient outcomes. We hypothesize that as laparoscopic cholecystectomy (LC) difficulty increases, there will be increased involvement by senior residents and attending physicians with no differences in complications.

Methods: Ten acute care surgeons were asked to fill out a postoperative questionnaire regarding surgical difficulty after every LC between 11/9/2016 and 3/30/2017. Either the Jonckheere-Terpstra test, Mantel-Haenzel chi square test, or ANOVA was used to test for the association between perioperative data and surgical difficulty.

Results: A total of 190 LCs were analyzed. PGY level, percent of surgery time with attending surgeon involvement, partial cholecystectomy rate, and length of operation all significantly rose with increasing level of difficulty ($p < 0.001$) with no significant differences in 60-day emergency room bounce-backs, readmission, or complication rates.

Conclusions: We found that as LC difficulty increases, so does attending surgeon and/or senior resident involvement, without increased morbidity.

Introduction

Over the past decade, faculty surgeons have become increasingly concerned with the ability of general surgery residents to enter independent practice post-graduation. With over 80% of general surgery graduates opting for advanced fellowship training,[1] whether new resident graduates are either *competent* enough in their clinical abilities or *confident* enough to practice independently has become a growing national debate.[2]

Several reasons explain a shift in resident competency and confidence. From the advent of the 80-h workweek,[3] an increased focus on minimally invasive training,[4] and external pressures on faculty surgeons for both increased productivity and resident supervision,[5] many factors have contributed to both decreased resident autonomy and operative experience. In addition, surgical training is under constant scrutiny for the effect that resident autonomy may have on patient outcomes.[6,7] Concern for increased operative times, length of stay, and complications are all given as a rationale for decreased resident autonomy and involvement.[8–10] However, while some may argue that increased faculty supervision may decrease the complication rate for more complex procedures, residents may be denied the opportunity to master the “bread and butter” operations of general surgery, which they will need for post-graduation autonomy.[11]

In a recent national survey of general surgery categorical residents, 38% of residents were either unsure or did not think that a 5-year general surgery residency prepared them for independent practice.[12] While some may argue that case variety and complexity has increased in recent years (i.e., open versus laparoscopic, endovascular, or endoluminal), it has come to national attention that recent resident graduates may even have trouble

* Corresponding author. University of Texas Southwestern Medical Center, Division of General and Acute Care Surgery, 5323 Harry Hines Blvd., Dallas, TX, 75390-9158, USA.

E-mail addresses: Tarik.madni@utsouthwestern.edu (T.D. Madni), Evan.barrios@utsouthwestern.edu (E. Barrios), Jonathan.imran@utsouthwestern.edu (J.B. Imran), Luis.taveras@utsouthwesern.edu (L. Taveras), Audra.clark@utsouthwestern.edu (A.T. Clark), Holly.cunningham@utsouthwestern.edu (H.B. Cunningham), alana.christie@utsouthwestern.edu (A. Christie), stephen.luk@utsouthwestern.edu (S. Luk), Herb.phelan@utsouthwestern.edu (H.A. Phelan), michael.cripps@utsouthwestern.edu (M.W. Cripps).

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with core general surgery operations.[13] Focusing on the laparoscopic cholecystectomy (LC), a survey of fellowship directors indicated that 30% of them felt that new fellows could not perform an LC independent of attending surgeon supervision and guidance.[13] As the LC is one of the most common general surgical operations performed, and general surgery residents have completed 114 LCs on average by graduation,[14] this statistic is concerning. One possible explanation for this finding is that while residents are scrubbed into a case, they may not be given the level of graduated autonomy they need to successfully perform the procedure in independent practice. Faculty and administrators may be concerned that giving increasing levels of autonomy to surgery residents may affect overall patient outcomes[5]; however, resident-added morbidity and mortality has been extensively debated in the literature.[7,15,16]

At our institution, we perform over 1000 LCs per year. The general training pathway for this operation consists of attending physicians taking interns through easier outpatient LCs while the more difficult inpatient LCs are performed by third-year residents supervised by a chief resident as first assistant and an attending physician who is physically present but who may or may not be scrubbed. As the case progresses with the third-year resident functioning as primary surgeon, the chief resident and attending physician monitor progress and safety of the dissection as it proceeds. Should the difficulty of the case exceed the skill set of the third-year resident, the chief resident will typically take over as operating surgeon and the attending physician will move to the role of first assistant. If the difficulty of the case appears too great, the attending physician will assume the role of primary surgeon. Finally, the faculty surgeon in conjunction with the chief resident decide when additional procedures, such as intraoperative cholangiograms (IOC), are indicated. Our anecdotal experience for a generation of training surgical residents is that this paradigm is safe while also offering an optimal educational experience for the resident corps, but we lacked evidence to validate this impression. We therefore performed this investigation with the hypothesis that as LC difficulty increases at our institution, there would be increased involvement by either surgeons with elevated PGY levels or attending physicians with no differences in postoperative outcomes.

Methods

Design and procedures

This study was approved by the institutional review board at the University of Texas Southwestern Medical Center. The Parkland Memorial Hospital acute care surgery (ACS) faculty perform urgent LC, inpatient LC, and elective LC as part of the group's practice pattern. All patients at Parkland Memorial Hospital who underwent LC by the ACS service between 11/2016 and 3/2017 were eligible to be included in the study. Ten ACS faculty were asked to individually fill out a subjective, postoperative questionnaire after each LC regarding case difficulty in addition to the level of chief resident and attending surgeon participation. At our institution, faculty surgeons are physically present and supervising during all LCs. Further, most of them reserve scrubbing into the case for instances when an upper level/chief is not present or if the case demonstrates a level of complexity that requires their technical skill and abilities. This questionnaire was only allowed to be filled out in the immediate postoperative period by faculty surgeons to eliminate any potential time bias from the surveys being filled out later.

Measures

Information on perioperative factors collected by the questionnaire included: difficulty of surgery (rated on a 5-point Likert-type scale that ranged from 1 [least difficult] to 5 [most difficult]), partial or open cholecystectomy requirements (yes/no), normality of anatomy (normal/abnormal), performance and reason for IOC (none, routine, concern for ductal stones, concern for abnormal biliary anatomy), PGY level of the primary surgeon that ranged from 1 (intern) to 6 (fellow), cases that required attending surgeon involvement grouped by how long the surgeons intervened (0–25%, 25–50%, 50–75%, or 75–100% of total operative time), and time in minutes from incision start to cystic duct closure with either clips or staples (i.e., time to clip). Patient demographics collected from the medical record included: age (years), gender, length of operation (minutes), postoperative/pathologic diagnosis (acute cholecystitis, chronic cholecystitis, biliary dyskinesia, biliary pancreatitis, choledocholithiasis, symptomatic cholelithiasis), length of stay (days), and postoperative complications within 60 days (yes/no). Postoperative complications were defined as small-bowel obstruction, retained gallstones, biloma, wound infection, and cystic duct leak, as these were outcomes which were thought to be potentially affected by less operative expertise.

Statistical analysis

Demographic characteristics of the patients were described using the sample mean and standard deviation for continuous variables and the frequency and percentage for categorical variables. Either the Jonckheere-Terpstra test, Mantel-Haenzel chi square test, or ANOVA was used to test for the association between perioperative data and LC difficulty. The Mantel-Haenzel chi square test for ordinally-scaled response was used to analyze the association of LC difficulty with categorical variables, ANOVA was used to analyze the association of LC difficulty with continuous measures, and the Jonckheere-Terpstra test was used for doubly-ordered categorical data. Multinomial logistic regression was used to analyze the odds of attending surgeon intervention and length of operation for each level of difficulty. All tests were performed at the two-sided 0.05 significance level with Bonferonni-adjusted p values. Statistical analyses were carried out using SAS software, version 9.4 (SAS Institute, Cary, NC).

Results

A total of 190 LCs received difficulty scores. The distribution of difficulty scores per faculty rater is shown in Table 1. PGY-3 residents performed 155/190 (82%) of the cases. Regarding the difficulty of surgery, there were 44 level 1 gallbladders (23%), 66 level 2

Table 1
Scores of laparoscopic cholecystectomy difficulty, per surgeon rater.

Rater	*Difficulty of surgery N (%)*					Total LCs performed
	1	2	3	4	5	
1	2 (10)	8 (38)	5 (24)	3 (14)	3 (14)	21
2	1 (50)	0 (0)	1 (50)	0 (0)	0 (0)	2
3	2 (8)	11 (42)	10 (38)	2 (8)	1 (4)	26
4	11 (24)	5 (11)	21 (46)	5 (11)	4 (9)	46
5	2 (50)	1 (25)	1 (25)	0 (0)	0 (0)	4
6	6 (19)	10 (32)	8 (26)	4 (13)	3 (10)	31
7	7 (32)	9 (41)	3 (14)	0 (0)	3 (14)	22
8	6 (30)	3 (15)	7 (35)	2 (10)	2 (10)	20
9	2 (12)	4 (24)	5 (29)	3 (18)	3 (18)	17
10	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)	1

(35%), 37 level 3 (20%), 30 level 4 (16%), and 13 level 5 (7%). Most cases (84%) required attending surgeon intervention/involvement for 0–25% of the procedure time (for 6% of cases: 25–50%, 7%: 50–75%, 3%: 75–100%). Seven (3.8%) LCs had associated IOCs. Four (2.2%) IOCs were performed routinely per faculty preference, 1 (0.5%) was performed to look for ductal stones, and 2 (1.1%) were performed to further define biliary anatomy. Further patient, as well as peri- and postoperative characteristics, are illustrated in Table 2. PGY level, percent of surgery time with attending surgeon involvement, partial cholecystectomy rate, and length of operation all significantly rose as the difficulty increased; however, no significant differences were seen in 60-day emergency room bounce-backs, 60-day readmission rates, time to clip, or complication rates and increasing level of difficulty (Table 3). No significant correlation was found between IOC occurrence and LC difficulty. Regardless of difficulty, cases performed by PGY 1–3 residents as the primary surgeon had lower percentages of time the attending surgeon spent operating, while PGYs 5 and 6 almost always primarily performed cases with the attending surgeon operating greater than 50% of the time. The single exception was for the PGY 5 level, which had 1 instance of 0–25% attending surgeon presence during a LC with a difficulty of 1. A complete breakdown of PGY level compared to attending surgeon involvement stratified by difficulty is seen in Table 4. Significantly increased odds of attending surgeon intervention and length of surgery were found between each level of increasing difficulty on multinomial logistic regression (Table 5).

Discussion

With almost 80% of general surgery residents choosing fellowship instead of autonomous practice after graduation,[1] the general surgery residency experience has undergone changes which many attending physicians who act as surgeon-educators would view as detrimental.[17] Specifically, a recent survey of fellowship directors noted that 21% of new fellows arrived unprepared for the operating room, 66% were deemed unable to operate for 30 unsupervised minutes of a major procedure, and 30% could not independently perform an LC.[13] In turn, concerns of resident competence and confidence in both autonomous practice and fellowship have come into the spotlight.[2,18] Such concern is supported by a recent meta-analysis performed by Elfenbein et al. (2016), which noted that the majority of surveys of categorical general surgery residents report that they have low confidence post-graduation.[2] Concern about resident competence is further demonstrated by a recent survey from the Southeastern Surgical Congress, which noted that only 40% of members felt resident graduates from the work hour restriction era were clinically prepared for practice.[18] From increasing minimally invasive, endoscopic, endovascular, and nonoperative strategies[19] to duty hour restrictions,[20] several reasons suggest themselves for this phenomenon.

While the causal relationships of such low confidence can be complex, many reasons can be identified within the general surgery training programs themselves. For example, in a recent survey of program directors, 121 operations were identified that a general surgery resident should be competent performing after graduation. Only 18 of the 121 procedures were performed an average more than 10 times during residency on a national level, and 83 of the procedures were performed less than 5 times.[17] In addition, since the advent of work hour restrictions, there has been a significant shift of operative volume from junior to senior-level residents.[21] While advanced laparoscopic skills may require more senior hands as compared to the traditional open approach, senior residents may now find themselves in the “learning role” instead of the traditional “teaching role” in later stages of their training. As such, it is possible one reason for low confidence and competence post-graduation may be a general lack of operative experience in such core procedures. Looking specifically at our institutional LC model, often attending physicians take interns through easier outpatient LCs while the more difficult inpatient LCs are performed by third-year residents supervised by a chief resident and an attending physician. By graduation, our surgeon chiefs averaged roughly 147 LCs compared to the national average of 116 in 2017. This operative experience is further supported in Table 4, which shows that our early-to-mid–level residents often do not need additional faculty support while performing LCs as they are capable of being the primary surgeon with chief resident guidance. Regarding higher PGY levels, Table 3 shows PGY level increased with difficulty while Table 4 also shows a trend that PGYs 5 and 6 almost always performed harder cases with the attending surgeon operating greater than 50% of the time. The multinomial logistic regression in Table 5 further shows that increasing difficulty increased attending surgeon involvement. Thus, we conclude that only our most difficult LCs require more senior residents and additional faculty support.

Additional to the concern about decreased resident operative experience and confidence, current resident competence in performing core general surgical procedures has also been rated poorly by faculty attending surgeons. In a survey of over 400 faculty surgeons regarding over 500 residents using the 4-level Zwisch scale, George et al. (2017) found attending surgeons thought PGY 5 residents in their final 6 months of training achieved the highest Zwish level, supervision only (i.e., near-independence), in only 33.3% of core procedures defined as cholecystectomy, inguinal/femoral hernia repair, appendectomy, ventral hernia repair, and partial colectomy.[22] Briefly explained, the Zwish scale consists of 4 levels (Show and Tell, Active Help, Passive Help, and Supervision Only) which represents progressively less guidance by faculty and more resident involvement in a procedure.[22] In another study utilizing

Table 2
Patient and surgical characteristics.

	N (%)
Gender	
Female	157 (82.6)
Male	33 (17.4)
PGY level	
1	6 (3.2)
2	14 (7.4)
3	155 (81.6)
5	12 (6.3)
6 (fellow)	3 (1.6)
Percent of surgery time requiring attending surgeon	
0–25%	160 (84.2)
25–50%	12 (6.3)
50–75%	13 (6.8)
75–100%	5 (2.6)
Partial cholecystectomy	7 (3.7)
Conversion to open surgery	2 (1.1)
Abnormal anatomy	28 (14.7)
Difficulty of surgery	
1	44 (23.2)
2	66 (34.7)
3	37 (19.5)
4	30 (15.8)
5	13 (6.8)
60-day bounce-back to ER	20 (10.5)
60-day readmission to ACS services	9 (4.7)
Complications	9 (4.7)
	Mean ± std. dev.
Age, years (range)	40.0 ± 14.2 (18–84)
Time to clip, minutes	48.6 ± 43.4
Length of operation, minutes	78.5 ± 30.8

Abbreviations: ER: emergency room, ACS: acute care surgery.

Table 3
Association of difficulty of surgery with other surgical parameters.

	Difficulty of surgery					*q*
	1 (n = 44)	2 (n = 66)	3 (n = 37)	4 (n = 30)	5 (n = 13)	
N (%)						
Gender						
Female	39 (88.6)	56 (84.8)	28 (75.7)	26 (86.7)	8 (61.5)	0.0793
Male	5 (11.4)	10 (15.2)	9 (24.3)	4 (13.3)	5 (38.5)	
PGY[a]						
1	6 (13.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	<0.0001
2	8 (18.2)	4 (6.1)	1 (2.7)	1 (3.3)	0 (0.0)	
3	29 (65.9)	62 (93.9)	34 (91.9)	23 (76.7)	7 (53.8)	
5	1 (2.3)	0 (0.0)	2 (5.4)	6 (20.0)	3 (23.1)	
6	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (23.1)	
Percent of surgery time requiring attending surgeon[a]						
0–25%	43 (97.7)	64 (97.0)	29 (78.4)	20 (66.7)	4 (30.8)	<0.0001
25–50%	0 (0.0)	2 (3.0)	4 (10.8)	4 (13.3)	2 (15.4)	
50–75%	0 (0.0)	0 (0.0)	3 (8.1)	5 (16.7)	5 (38.5)	
75–100%	1 (2.3)	0 (0.0)	1 (2.7)	1 (3.3)	2 (15.4)	
Partial cholecystectomy						
No	44 (100.0)	66 (100.0)	37 (100.0)	29 (96.7)	7 (53.8)	<0.0001
Yes	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.3)	6 (46.2)	
Abnormal anatomy						
No	44 (100.0)	56 (84.8)	28 (75.7)	22 (73.3)	12 (92.3)	0.1540
Yes	0 (0.0)	10 (15.2)	9 (24.3)	8 (26.7)	1 (7.7)	
Bounce-back to ER						
No	40 (90.9)	59 (89.4)	32 (86.5)	27 (90.0)	12 (92.3)	>0.99
Yes	4 (9.1)	7 (10.6)	5 (13.5)	3 (10.0)	1 (7.7)	
Readmitted to surgical services						
No	41 (93.2)	63 (95.5)	34 (91.9)	30 (100.0)	13 (100.0)	>0.99
Yes	3 (6.8)	3 (4.5)	3 (8.1)	0 (0.0)	0 (0.0)	
Complications						
No	42 (95.5)	63 (95.5)	34 (91.9)	29 (96.7)	13 (100.0)	>0.99
Yes	2 (4.5)	3 (4.5)	3 (8.1)	1 (3.3)	0 (0.0)	
Mean ± std. dev.						
Age, years	34.8 ± 13.3	40.5 ± 13.7	37.9 ± 13.1	45.8 ± 15.0	48.3 ± 14.7	0.0243
Time to clip, minutes	45.2 ± 76.4	37.4 ± 13.1	45.8 ± 15.7	65.7 ± 35.1	85.2 ± 33.2	0.0072
Length of operation, minutes	60.8 ± 20.9	67.9 ± 16.2	82.6 ± 20.1	99.6 ± 34.3	131.5 ± 44.0	<0.0001

Except where indicated, the Mantel-Haenzel chi square test for ordinally-scaled response was used to analyze the association of difficulty of surgery with categorical variables, and ANOVA was used to analyze the association of difficulty with continuous measures. Provided q values are Bonferonni-adjusted p values.
[a] Jonckheere-Terpstra test for doubly-ordered categorical data was used.

Table 4
Association of difficulty of case, PGY level, and percent of surgery time requiring attending surgeon.

	PGY				
	1 (n = 6)	2 (n = 14)	3 (n = 155)	5 (n = 12)	6 (n = 3)
Percent of surgery time requiring attending surgeon, N (%)					
Difficulty = 1	**(n = 6)**	**(n = 8)**	**(n = 29)**	**(n = 1)**	**(n = 0)**
0–25%	6 (100)	8 (100)	28 (96.6)	1 (100)	–
25–50%	0 (0)	0 (0)	0 (0)	0 (0)	–
50–75%	0 (0)	0 (0)	0 (0)	0 (0)	–
75–100%	0 (0)	0 (0)	1 (3.4)	0 (0)	–
Difficulty = 2	**(n = 0)**	**(n = 4)**	**(n = 62)**	**(n = 0)**	**(n = 0)**
0–25%	–	3 (75.0)	61 (98.4)	–	–
25–50%	–	1 (25.0)	1 (1.6)	–	–
50–75%	–	0 (0)	0 (0)	–	–
75–100%	–	0 (0)	0 (0)	–	–
Difficulty = 3	**(n = 0)**	**(n = 1)**	**(n = 34)**	**(n = 2)**	**(n = 0)**
0–25%	–	0 (0)	29 (85.3)	0 (0)	–
25–50%	–	0 (0)	4 (11.8)	0 (0)	–
50–75%	–	1 (100)	1 (2.9)	1 (50.0)	–
75–100%	–	0 (0)	0 (0)	1 (50.0)	–
Difficulty = 4	**(n = 0)**	**(n = 1)**	**(n = 23)**	**(n = 6)**	**(n = 0)**
0–25%	–	1 (100)	19 (82.6)	0 (0)	–
25–50%	–	0 (0)	4 (17.4)	0 (0)	–
50–75%	–	0 (0)	0 (0)	5 (83.3)	–
75–100%	–	0 (0)	0 (0)	1 (16.7)	–
Difficulty = 5	**(n = 0)**	**(n = 0)**	**(n = 7)**	**(n = 3)**	**(n = 3)**
0–25%	–	–	4 (57.1)	0 (0)	0 (0)
25–50%	–	–	2 (28.6)	0 (0)	0 (0)
50–75%	–	–	1 (14.3)	2 (66.7)	2 (66.7)
75–100%	–	–	0 (0)	1 (33.3)	1 (33.3)

the Zwish scale by Meyerson et al. (2014), actual resident procedural autonomy was found to be significantly lower than expected by both faculty and residents in ten commonly performed general surgical procedures.[11] As such, actual resident confidence may be higher than their true competence demonstrates. Given these deficiencies, and apparent autonomy gap, it becomes imperative to explore why resident operative experience and ability is on the decline.

In an era of declining reimbursement and increasing litigation and productivity requirements, focus has shifted away from the training of future doctors towards hospital quality metrics. In a recent survey of 116 attending surgeons at 7 institutions, the largest factors that prevent increasing resident autonomy in the operating room are a focus on patient outcomes, expectation by the patient and hospital of attending surgeon involvement, and productivity/efficiency requirements. Regarding productivity, the presence of residents alone has demonstrated to be a major factor in increased operative times,[23–28] which can eventually lead to increased costs. Just having a general surgery resident program has been noted to specifically increase operative times and overall care-associated charges.[29] The cost of training residents from increased operative time alone has been calculated to be as high as $47,000 per resident over the course of his or her training.[30]

While quality improvement metrics have been used to improve patient outcomes (i.e., decreased complication rates, decreased length of stay, etc.), resident autonomy has become affected and unrightfully so. Numerous studies have demonstrated little to no

Table 5
Multinomial logistic regression analysis of difficulty of surgery with other surgical parameters.

	Odds ratio (95% CI)				
	Difficulty 2 vs. difficulty 1	Difficulty 3 vs. difficulty 1	Difficulty 4 vs. difficulty 1	Difficulty 5 vs.difficulty 1	*p*
Percent of surgery time requiring attending surgeon					
0–25%	reference	reference	reference	reference	<0.0001
25–100%	1.34 (0.12, 15.28)	11.86 (1.41, 99.97)	21.50 (2.57, 179.65)	96.75 (9.64, 970.88)	
Age, per 5 year increase	1.18 (1.02, 1.38)	1.10 (0.93, 1.31)	1.35 (1.13, 1.61)	1.42 (1.13, 1.79)	0.0049
Length of operation, per 5 min increase	1.15 (1.01, 1.30)	1.37 (1.19, 1.57)	1.51 (1.31, 1.75)	1.69 (1.43, 1.99)	<0.0001

Higher difficulty was associated with a higher percentage of involvement of an attending surgeon ($p < 0.0001$). The odds of having an attending surgeon involved for 25–100% of surgery time were 1.34 times higher when a surgery had a difficulty of 2 as compared to a difficulty of 1; similarly, the odds were 11.9 times higher for a difficulty of 3, 21.5 times higher for a difficulty of 4, and 96.8 times higher for a difficulty of 5 compared to a difficulty of 1.
Higher difficulty was also associated with older patients ($p = 0.0049$). The odds of a surgery having a difficulty of 2 were 1.2 times those of having a difficulty of 1 when comparing patients to those who were older (per 5 year increase); similarly, the odds were 1.1 times higher for a difficulty of 3, 1.4 times higher for a difficulty of 4, and 1.4 times higher for a difficulty of 5 compared to a difficulty of 1.
There was also an association between higher difficulty and longer surgery time ($p < 0.0001$). The odds of a surgery having a difficulty of 2 were 1.2 times those of having a difficulty of 1 when comparing patients whose length of surgery increased (per 5 min increase); similarly, the odds were 1.4 times higher for a difficulty of 3, 1.5 times higher for a difficulty of 4, and 1.7 times higher for a difficulty of 5 compared to a difficulty of 1.

impact of resident involvement on patient outcomes. Tseng et al. (2011) found involvement of a surgical resident actually may be associated with decreased patient mortality after a risk-adjusted overall analysis of 37,000 procedures using the National Surgical Quality Improvement Program Database (NSQIP).[16] Additionally, in 2012, Kiran et al. analyzed over 60,000 surgeries from the NSQIP database and found no change in mortality or major morbidity when residents were involved.[7] A minimal increase in both length of stay (0.13 days) and mild surgical complications was seen with resident involvement; however, this complications increase was largely due to superficial wound infections.[7] In a more recent NSQIP review of over 71,000 surgeries, Jolley et al. (2016) noted that resident involvement was safe and did not result in increased morbidity, mortality, or return to the OR. However, surgeries with residents had increased odds of longer lengths of stay in addition to longer surgical times.[6] Overall, these NSQIP reviews demonstrate safety with resident involvement. A major criticism of NSQIP reviews, however, is that the database can only count whether a resident participated in a case, and not the level of his or her participation.[28] In our study, we not only asked the attending surgeon to note the PGY level of the primary surgeon but also the degree of attending surgeon involvement. With regard to safety, as shown in Table 3, we saw no increase in complications, emergency room bounce-back, or readmission rates with increasing LC difficulty, as our harder LCs were performed by primary surgeons with higher PGY levels or with increased attending surgeon involvement (Table 5). As our mid-level PGY 3 providers performed 82% of the LCs noted in this study (Table 2), we find such residents adequately being prepared and trained for basic laparoscopic, general surgery practice.

Another reason for declining operative experience in residents generally may relate to the regulations behind training programs themselves. Duty hour restrictions (i.e., the 80-h workweek) were originally created to improve patient safety as well as resident well-being and education; however, these benefits have been debated in the literature.[20] Specifically, a recent systematic review noted while patient safety may see no overall improvement, resident education may be negatively affected by work duty restrictions.[20] Such a negative effect has been demonstrated among surgical residents specifically, as there has been an overall decline in the number of total surgeon and surgeon chief operative cases reported by residents since the implementation of work duty restrictions.[3] While the declines may be small (2.3% and 8.3%, respectively), a much more drastic decrease can be seen in both first assist and teaching assistant cases (79% and 66%, respectively).[3] The loss of teaching assist cases is particularly problematic for upper level residents, as these cases both solidify understanding of the procedure performed as well as allow the chief residents to continue to work on their teaching skills.[3] While productivity and quality metrics may decrease resident involvement in a procedure, newly hired faculty who are uncomfortable teaching the procedure may also not allow meaningful resident autonomy.[22]

Giving autonomy to chief and upper-level residents has been demonstrated to be both safe and an effective training regimen in the literature. Experiments with chief-run services where attending surgeons needed to only supervise critical portions of an operation have not shown to affect 30-day post-op complications, major adverse events, or readmission rates.[31] In addition, a survey conducted among chiefs who participated on such services showed that graduates thought such an experience eased their transition to fellowship or independent practice.[31] These results parallel a similar study of chief-run services by Jarman et al. (2018) who noted such services can both increase resident autonomy as well as parallel a graduate's first year of practice.[32] Specifically looking at LCs, Shwartz et al. (2013) found no increase in LC-associated complications regardless if a senior surgery resident or faculty acted as a teaching assistant.[33] At our institution, specifically our ACS service, chiefs are allowed to walk juniors and mid-levels through core open and laparoscopic cases with faculty present for the critical components or until the chief asks for additional assistance. While we did not attempt to define or measure *competence* or *confidence* among our residents via such incremental autonomy, this training regimen has proven successful at our institution as shown by our finding that 84% of LCs required minimal attending surgeon involvement, and third-year residents performed the majority of the cases as the primary surgeon. Such results may allow the reader potentially *infer* competence and/or confidence among our mid-level and senior residents. Similar safety results have been demonstrated in the past, as Parikh et al. (2015) noted no difference in complication or operative times between surgeon chiefs or surgeon juniors (with a teaching assistant) as the primary surgeon.[34]

In this study, we have demonstrated that incremental resident autonomy with available and graduated, faculty assistance can be both a safe and effective way of managing a surgical training program. However, one final ethical thought must be addressed prior to adoption of such a training regimen. We assume more often than not at institutions with resident trainees, when consenting a patient or family member for surgery, a faculty member's name is on the consent form as the operative surgeon. One could argue that is misleading to only *supervise* an operation as faculty if his or her name is the primary surgeon on the consent. At our institution, we both strongly encourage and require our residents of all levels to introduce themselves to patients and their families pre-operatively and explain their role on the surgical team. Such transparency gives further clarity to both patients and families regarding who is caring for them during their illness.

We acknowledge a few limitations within our study. First, this study was derived from a single institution. Second, ten acute care surgeons performed LCs during this study. While they are all members of the same general and ACS division, they all likely have different opinions of surgical difficulty. Thus, a level 5 difficulty LC to one surgeon may be a level 3 or 4 to another. We have included Table 1 to show the distribution of difficulty scores among raters. In addition, we rated attending surgeon involvement in quartiles (i.e., 0–25%, 25–50%, 50–75%, 75–100%). It is unclear from this data if the attending surgeon had to scrub when involved for only up to 25% of the surgery time. Third, only 190 cases were analyzed. Complications from LC are fairly rare, as such, the power of the study may be too limited to truly assess differences in these outcomes. As a final limitation, complications were judged as wound infection, retained stone, small-bowel obstruction, biloma, or bile leak only. We felt these complications could be the direct result of the operative technique itself, and possibly resident involvement, and thus did not include other potential postoperative complications. We note, however, that increased operative times, and thus ventilation requirements, can be indirectly associated with other complications (i.e., pneumonia, venous thromboembolism, etc.).

Conclusions

We found that as LC difficulty increases at our institution, so does attending surgeon and/or chief resident involvement without increased complication rates, emergency room bounce-backs, or readmission rates. This study validates the safety of our training pathway that permits incremental autonomy. In addition, given that only 16% of LCs required more extensive attending surgeon involvement, this study demonstrates that our mid-level residents are capable of performing the majority of LCs in a highly autonomous fashion.

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Conflicts of interest

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Appendix A. Supplementary data

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