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The effect of residents as teaching assistants on operative time in laparoscopic cholecystectomy

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Abstract

BACKGROUND: We examined the effect of primary surgeon (PS) and teaching assistant (TA) seniority on operative time and outcomes for residents performing laparoscopic cholecystectomy (LC).

METHODS: This was a retrospective analysis of urgent LC at a county teaching hospital. Relevant data included postgraduate year (PGY) of the PS and TA and markers of disease severity. Primary outcome was operative time. Secondary outcomes were conversion to open cholecystectomy and complications.

RESULTS: There were 1,202 LCs; 415 included an intraoperative cholangiogram. On multivariable analysis, every PGY increase of PS decreased operative time by 3.2 minutes ($P = .02$). For every PGY increase of TA, operative time decreased 10.8 minutes ($P < .001$). Acute or gangrenous pathology increased conversion to open surgery ($P < .001$). Seniority of PS and TA was not associated with increases in conversion or complication rates.

CONCLUSIONS: Residents' operative time improves as experience with LC increases. These improvements become more profound after adjusting for the seniority of the TA.

The 80-hour work week and the more recent 16-hour rule for interns have negatively affected the productivity of general surgical trainees, with a resultant decrease in operative volume and autonomy.[1,2] At the same time, there is increasing emphasis on both simulation training and the measurement of operative proficiency. Laboratory simulation has been found to improve technical skill in the operating room for index laparoscopic procedures, but at the same time detracts from the time available for residents to train in the operating room.[3] Although a simulated procedure may improve the learning curve for residents once they enter the operating room, it cannot replace real-time experience. This is highlighted by a recent finding that graduating general surgery residents lack hands-on experience in more than half of the cases with which they are expected to be familiar.[4] In a recent survey, subspecialty fellowship program directors felt that 30% of their new fellows arrived to

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fellowship unable to independently perform a laparoscopic cholecystectomy (LC).[5] This is alarming, given that LC is one of the most commonly performed procedures during residency and in subsequent surgical practice.

Faced with shortened work hours and decreased opportunities to be in the operating room, training programs must focus on ways to maximize the operative experience. One such method is using a senior resident as a teaching assistant (TA) for more junior residents, who function as the primary surgeon (PS). The importance of the TA role is highlighted by the fact that the American Board of Surgery (ABS) now requires graduating residents to document at least 25 cases in which they serve as TA. It has been previously demonstrated that TAs can guide junior residents through index cases such as LC without sacrificing patient safety.[6]

Involvement of residents in operations has been noted to significantly increase the duration of cases compared to operations without resident involvement.[7–11] Resident participation is also associated with an increased risk for intraoperative and postoperative adverse events in emergency general surgery.[12,13] Few studies have specifically examined the impact of resident seniority in the roles of TA and PS on outcomes. The objective of this study was to analyze the effect of TA and PS seniority on operative time and outcomes of LC.

Methods

Patient inclusion/exclusion criteria

We performed a retrospective review of all urgent LC performed between January 1, 2011 and August 1, 2013 by the Trauma/Acute Care Surgery service at a Los Angeles County Level 1 Trauma Center and teaching hospital. Patients with a diagnosis of acute or chronic cholecystitis, as well as symptomatic cholelithiasis with complete intolerance to food or liquids, were identified from the institutional Acute Care Surgery data registry. Patients with an elevated total bilirubin who underwent endoscopic retrograde cholangiopancreatography and stone removal before surgery were included in the analysis. Exclusion criteria included patients with suspected gallstone pancreatitis (as we routinely perform intraoperative cholangiography [IOC]), those requiring cholecystostomy tube before cholecystectomy, acalculous cholecystitis, and patients who proceeded directly to open cholecystectomy. The study was approved by the Human Subjects Committee of the Los Angeles Biomedical Research Institute at Harbor-University of California at Los Angeles Medical Center, Torrance, CA.

Demographics and data collection

Preoperative data included patient gender, age, duration of symptoms, white blood cell (WBC) count, and gallbladder wall thickness observed on the right upper quadrant ultrasonograph. Gallbladder pathology was recorded as acute cholecystitis, gangrenous cholecystitis, chronic cholecystitis, or cholelithiasis.

Determination of postgraduate year level and roles of resident and attending

At our institution, all LCs are performed by junior residents as the PSs. A senior resident serves as a TA in the vast majority of LCs, guiding and assisting the PSs. At the discretion of the attending surgeon, senior residents who are judged to have reached competency (supervision without direction) in the role of PS are allowed to act as the TAs under close attending supervision. TAs are typically chief residents (postgraduate year [PGY] 6) or subchiefs (PGY 5). All residents in the study completed the Fundamentals of Laparoscopic Surgery (SAGES, Los Angeles, CA) during their research (PGY 4) year. At the time of our study, no junior resident had completed a simulation course in LC before learning in the operating room (such a course has since been instituted). Attending surgeon presence in the operating room is stratified by whether the attending is scrubbed (level 1) or not scrubbed (level 2) into the case. The institutional policy regarding attending surgeon involvement requires the attending surgeon to be present to identify the "critical view of safety" before cystic duct and artery ligation and transection. Level 1 attending involvement for the purposes of LC is generally restricted to more complex cases, cases requiring open cholecystectomy and those where iatrogenic injury and subsequent repair are required. For this reason, the multivariable logistic regression analysis was performed with and without the level of attending involvement as a covariate for both the primary and secondary outcome measures.

Determination of resident PGY level and their respective operative roles, as well as attending involvement, were made by review of the operative notes. Residents were considered to be the PSs if they were the residents who were primarily performing the operation. This designation was readily determined from operative records, as the resident surgeon who performs the dissection at our institution is listed as PS is also responsible for the preliminary operative dictation. Residents were considered to be the TAs if they were listed as assistant surgeons on the operative note and other residents were listed as the PSs. In rare instances, the attending surgeon was listed as the assistant surgeon, and only one resident participated in the case. In that circumstance, the attending was considered to be the TA. Our program is a 6-year residency, which includes a research year between clinical years 3 and 4. Thus, the levels of PGY involvement ranged from PGY 1 to PGY 6. Research year residents were designated as PGY 4.

Primary outcome

The main outcome measure was the length of the operative procedure. Operative time was measured by

procedure start (time of initial incision) and stop (incision closure) times as noted in the intraoperative anesthesia records. To eliminate the potentially confounding effect on procedure time, cases in which an IOC was performed (other than those obtained to delineate a biliary injury) were excluded from the analysis of the primary outcome, procedure time.

Secondary outcomes

Secondary outcomes included the conversion to open cholecystectomy and 30-day postoperative complications. Complications were classified as procedural (bile duct injury [BDI], cystic duct stump leak, biloma requiring external drainage, retained common bile duct stone, superficial/deep surgical site infection) and medical (pneumonia, urinary tract infection, cardiac arrhythmia, respiratory failure requiring intubation, acute kidney injury [rise in creatinine by .3 mg/dL or 50% in 48 hours or oliguria]).

Statistical analysis

Patient demographic data as well as other continuous data, such as procedure time, are reported as mean with 95% confidence interval (CI) or median with interquartile range (IQR) if not normally distributed. Categorical variables are reported as percentages. Differences in procedure time by resident year of PS and TA were tested using the Kruskal-Wallis test. Multivariable linear regression analysis was performed to determine the independent effects of the PGY PS and TA level on differences in procedural time. For the purpose of linear regression, attending surgeons were designated as PGY 7 for those cases in which they acted as TAs. Variables included in the analysis were PGY level of the PS, PGY level of the TA, admission WBC, and finding of acute or gangrenous cholecystitis on final pathology. Risk of complication or conversion to open surgery was assessed using the chi-square test, with multivariable logistic regression analysis taking into account the same previously mentioned variables. Model fit was assessed with the Hosmer-Lemeshow goodness-of-fit test. *P* values less than .05 were considered significant. Analyses were performed with SAS, version 9.3 (SAS Institute, Inc, Cary, NC).

Results

There were a total of 1,202 LCs during the study period. Patients were predominantly female (75%) with a mean age of 40.5 years (95% CI, 39.7 to 41.3). Average duration of symptoms before presentation was 3.3 days (95% CI, 3.1 to 3.5). Median WBC count was 10.6 $\times$ 10^9/L (IQR, 7.9 to 13.8). Mean gallbladder wall thickness on ultrasound was 3.4 mm (95% CI, 3.3 to 3.5 mm). As demonstrated in Table 1, most of the PSs were at the PGY 2 or PGY 3 level, whereas most of the TAs were at the PGY 5 or 6 level.

Table 1 Procedure details for LC with breakdown of case performance by PGY

Procedure variable	n (1,202)	%
Primary surgeon PGY level		
1	110	9.2
2	446	37
3	318	26.5
4	37	3.1
5	244	20.3
6	47	3.9
Teaching assistant PGY level		
2	2	.2
3	5	.4
4	99	8.2
5	307	25.5
6	682	56.7
Attending	107	8.9
Acute/gangrenous path	514	42.3

LC = laparoscopic cholecystectomy; PGY = postgraduate year.

Attending faculty served as TA in only a minority (9.2%) of cases. Overall median PGY level of the PS was 3 (IQR, 2 to 4), whereas the median PGY of the TA was 6 (IQR, 5 to 6). On final pathology, 42.3% of patients had evidence of acute or gangrenous cholecystitis on pathology, whereas 55.1% of cases had chronic cholecystitis. Patients with only cholelithiasis on pathology accounted for 2.6% of cases.

Primary outcome

There were 415 patients who underwent an IOC for reasons other than to identify a complication. After excluding these patients from the analysis of operative time, 787 remained. The median operative time was 92 minutes (IQR, 67 to 128). On univariate analysis, the following factors were associated with differences in procedure time: PGY level of PS ($P < .001$), PGY level of TA ($P < .001$), and acute or gangrenous pathology ($P < .001$). On univariate analysis, WBC count was not associated with case duration ($P = .9$). On multivariable linear regression analysis, for every year increase in the PGY level of the PS, case duration decreased by 3.2 minutes (95% CI, .5 to 6 minutes, $P = .02$). For every year increase in the PGY level of the TA, case duration decreased by 10.8 minutes (95% CI, 5.4 to 16.2 minutes, $P < .001$). Acute and/or gangrenous pathology was found to increase case duration by 26.4 minutes (95% CI, 19 to 33.8, $P < .001$).

Secondary outcomes

Of 1,202 patients, 83 patients (6.9%) required conversion to open cholecystectomy. On univariate analysis, variables associated with conversion to open cholecystectomy included higher WBC (12.2 vs 10.5 $\times$ 10^9/L; Wilcoxon, $P < .001$) and acute or gangrenous pathology (odds ratio

[OR], 5.5; 95% CI, 3.2 to 9.4; $P < .001$; Table 2). PGY of the PS and TA were not associated with conversion to open (Wilcoxon, $P = .3$ and $P = 1.0$, respectively).

On multivariable logistic regression analysis, only acute or gangrenous pathology was associated with increased conversion to open surgery (OR, 5.5; 95% CI, 3.2 to 9.4; $P < .001$). Neither level of the PS or TA was associated with conversion to open on multivariable analysis (OR for PS, 1.1; 95% CI, .9 to 1.3; $P = .5$ and OR for TA, 1.0; 95% CI, .7 to 1.3; $P = .9$). Hosmer-Lemeshow goodness of fit for the multivariable logistic regression model P value equals to .1.

The overall complication rate was 3.1%. There were 8 bile duct injuries (.7%). Two patients required hepaticojejunostomy, 3 patients had repair of injury over T-tube, and 3 patients had smaller injuries safely repaired primarily. Cystic duct stump leak occurred in .4% of patients. The incidence of biloma requiring drainage was .4%, and .5% of patients required endoscopic retrograde cholangiopancreatography for a retained stone. Superficial and deep surgical site infections occurred in 1% and .6% of patients, respectively. There were no postoperative strokes, myocardial infarctions, or pulmonary emboli within 30 days of the procedure. There was 1 patient death. Comparisons of patients with and without complication are described in Table 3. There was a nonsignificant trend toward a longer procedure time among patients with complications. On univariate analysis, there was no association between complications and the PGY level of the PS ($P = .4$) or TA ($P = .7$). On multivariable logistic regression analysis, no factor was significantly associated with increased incidence of complication. Hosmer-Lemeshow fit for the model P value equals to .3.

Level 1 attending involvement

Overall, there were 331 LCs (27.2%) with level 1 attending involvement. After removing cases which had an IOC, 235 cases (29.9%) had a level 1 attending. Level 1 involvement was associated with increased case duration: median procedure time 103 minutes (IQR, 70 to 160 minutes), vs 90 minutes for level 2 involvement (IQR, 66.5 to 118.5 minutes), $P < .001$. When attending involvement was included in the multivariable linear regression analysis with the PGY level of the PS and TA, level 1 attending involvement was associated with an increased case duration of 28.4 minutes (95% CI, 20.2 to 34.6; $P < .001$). With multivariable analysis including level 1 and level 2 attending involvement, improvements in procedure time by PGY year were greater for both the PS (3.9 minutes; 95% CI, 1.3 to 6.5 minutes; $P = .003$) and TA (14.9 minutes; 95% CI, 9.3 to 20.1 minutes; $P < .001$). In addition, level 1 attending involvement was more likely for cases that required conversion to open surgery (OR, 17.9; 95% CI, 9.6 to 33.6; $P < .001$). Complications were not associated with level 1 vs level 2 attending involvement.

Table 2 Comparison of operative details for cases requiring conversion to open cholecystectomy

Variable	Conversion (n = 83)	LC (n = 1,119)	P value
Procedure time (min)	173 (135–225)	93 (70–121)	<.001
Primary surgeon year	3 (2–4)	3 (2–4)	.3
Teaching assistant year	6 (5–6)	6 (5–6)	1.0
White blood cell count ($\times 10^9$/L)	12.2 (9.3–16.4)	10.5 (7.8–13.6)	<.001
Acute/gangrenous pathology	65 (78.3%)	449 (40.1%)	<.001

Median with interquartile range shown for continuous variables.
LC = laparoscopic cholecystectomy.

Table 3 Patients with and without complications

Variable	Any complication (n = 37)	No complication (n = 1,165)	P value
Procedure time (min)	105 (83–141)	95 (71–128)	.06
Dissecting resident year	2 (2–4)	3 (2–4)	.4
Teaching resident year	6 (5–6)	6 (5–6)	.8
White blood cell count ($\times 10^9$/L)	10.6 (7.3–14.3)	10.6 (7.9–13.8)	.9
Acute/gangrenous pathology	18 (72%)	496 (42.5%)	.4

Median with interquartile range shown for continuous variables.

Comments

We examined the outcomes of 1,202 consecutive urgent LCs for presumed acute cholecystitis performed by surgical residents with a 2nd more senior resident serving as a TA in most (91.8%) cases. To our knowledge, this represents one of the largest series specifically examining the impact of resident-led and resident-performed procedures on operative times and outcomes of LC. In a subanalysis of 787 patients who did not undergo the IOC, operative time significantly decreased as the PGY level of both the PS and the TA increased. BDI and overall complication rates were not adversely affected by the PGY level of the PS or the TA, or by whether the TA was a senior resident or an attending.

Opportunities for surgical resident autonomy in the operating room have significantly decreased. Numerous factors are cited for this loss. Attending surgeons are under more pressure in terms of monitoring and maintaining excellent surgical outcomes, and there is an understandable concern that resident involvement will adversely affect this

increasingly scrutinized end point. Similarly, surgeons are more encumbered by the greater emphasis on efficiency in the operating room. These previously mentioned concerns were highlighted in a recent survey by Teman et al[14], which reported factors that prevented awarding residents with autonomy in the operating room. Other variables reported by the authors included the expectations of attending surgeon involvement by the hospital and patients, the resident's observed clinical skill, and the attending surgeon's confidence level with the operation. Although it is convenient to invoke the duty hour rules as the primary culprit, the erosion of autonomy likely predates the duty hour rule. A less frequently cited, but important factor that adversely affected surgical resident autonomy was the change by the Centers for Medicare and Medicaid Services on November 22, 2002 that required the attending physician to be physically present during the critical or key portions of the service that a resident performs to bill for the service.

Previous studies have identified how resident participation affects operative time. As expected, any case where teaching is added to the flow of the procedure will lengthen the case duration. A large study of the National Surgical Quality Improvement Program (NSQIP) database by Davis et al[7] found that LC performed by residents lengthened case duration by 47.7% (from 44 minutes to 65 minutes). Interestingly, the study also found that junior residents, senior residents, and fellows all prolonged operative time similarly. Johnson et al observed a 2.6-minute decrease in procedure time for LC as PGY of the operating resident increased.[8] In addition, although operative time decreased for senior vs junior residents in a single institution study by Kauvar et al, there was no difference in operative time based on the level of attending seniority.[9] A small study by Wang et al[11] did not find any difference in operative time with increasing PGY. The present study differs from these other studies in that it adds an additional element of the resident as both surgeon and teacher. It also emphasizes that the duration of the operation is more influenced by the PGY level of the TA than the PGY level of the dissecting resident.

Concern for resident operative experience and autonomy is reflected by recent changes made by the ABS. The ABS now allows up to 50 cases logged as TA in the chief resident year to be counted toward major case totals.[15] More recently, the ABS is now requiring all residents to have experience with at least 25 cases as TA to become board eligible. Finally, general surgery residents will be required to have at least 250 cases (including first assist cases) by the end of the PGY 2.[16]

A major concern is whether using residents as teachers in the operating room is safe for patients. The .7% rate of BDI in the present study on the surface appears to be high. However, these were all urgent LC with a preoperative diagnosis of acute cholecystitis. Although only 42.3% were confirmed to have acute cholecystitis on final pathology, virtually all the patients had evidence of acute or chronic inflammation, with only 2.6% having simple cholelithaisis. Gallbladder inflammation has been reported to increase the risk of BDI by almost 3.5 times.[17] In a national study of more than 56,000 cholecystectomies in Italy, the overall rate of BDI was .42% and was significantly higher (.56%) with acute cholecystitis.[18] Thus, the relatively high BDI rate in the present study must be tempered by the higher risk population being reported herein. It should also be emphasized that an attending was present in all cases to confirm the "critical view of safety" before cystic duct and artery transection.

Schwartz et al[6] compared LC outcomes at 2 institutions. At 1 institution, residents served as TAs to other residents, whereas at the 2nd affiliated institution (a community hospital), the same group of residents were taught by attendings. There was no difference in complication rate, although the residents as teachers group had a higher conversion rate and higher incidence of acute pathology. The BDI rate was only .19%. The study differed from the present one; however, in that it included a large proportion of elective LC patients. The study of resident supervision by Itani et al[20] in the Veterans Affairs system found no difference in morbidity or mortality for cases in which the attending was scrubbed in the room or only available to supervise and as needed.

An important, but unresolved question is at what PGY level is autonomy appropriate for LC. In a study examining resident autonomy by Meyerson et al[19], residents felt that they could perform an LC with minimal attending supervision by the PGY 4 level, although this differed from the faculty perception that residents should only be granted such autonomy at the PGY 5 level. However, when the resident case logs were reviewed in the previously mentioned study, neither resident nor attending goals for trainee autonomy had been met. This suggests residents would likely benefit from earlier autonomy in the environment of support that our current training system allows. We feel that our system of using residents as TAs helps to foster trust based on a close knowledge of the limitations for each individual who will be guiding another resident through a case. This is not the only way to support autonomy among residents, but we feel it has substantial benefits that translate to other aspects of our training program.

Recognizing the significant impact that residents acting as teachers can have on operative time, they may benefit from a more structured simulation of how to teach laparoscopic procedures. Simulation in LC has been extensively studied, as has its impact on resident performance in the operating room.[3,21–23] The study of residents who completed a comprehensive simulation course for LC by Palter et al[22] were found to perform better on the first 4 of the 5 LC than their untrained colleagues, although the learning curves were equivalent by the 5th case. It may be that the case benefit of the surgeon teacher is iterative and requires many cases before any individual begins to hone their ability to teach. However, in seeing the impact of teaching skill on operative time in our study, it would be of interest to examine this finding in a laboratory setting.

The present study is not without limitations. First, this is a retrospective study. As such, although the roles of dissecting resident and surgeon teacher are expected to be clearly delineated in the operative record, there is no way to ensure this. For instance, it is possible that a senior resident allowed a more junior resident to complete 75% of a case, but then took over the role of dissecting resident for a particularly challenging portion. In addition, case duration may have been affected by extrinsic delays that are commonly cited at studies that compare large teaching institutions to private community hospitals. In an operating room where there are anesthesia, nursing and surgical trainees, there are lots of opportunities for both education and delay. Finally, although we identified an association with conversion to open and prolonged cases with level 1 attending involvement, there is no way to determine if the attending was scrubbed before or after the decision to open was made. Thus, this finding likely is a correlation with the complexity of the case and not a causative one.

As resident case volume is diminished, surgical training programs must look for ways to maximize the educational benefit of an operative case. We found that there is a substantial benefit in the experience of the resident who is acting as a surgeon teacher. This benefit, as measured by case duration, was more drastic than the technical experience gained by advancing PGY of the dissecting resident. This suggests a significant value in using our residents as teachers, particularly for such index general surgery procedures as the LC. Such practice is safe and likely continues to serve the trainee well as they continue on in their surgical career.

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