Single-Site Robotic Cholecystectomy at an Inner-City Academic Center

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ABSTRACT

Introduction: We investigate the safety and efficacy of single-site robotic cholecystectomy compared to laparoscopic cholecystectomy at an inner-city academic medical center.

Materials and Methods: Retrospective analysis comparing single-site robotic to laparoscopic cholecystectomies from August 1, 2013, to January 31, 2015, was conducted. Age, gender, race, body mass index (BMI), total operative time (docking and console time for robotic cases), length of stay, comorbidities, and conversion to open procedures were examined. The χ^2 and Student's t test were used for categorical and continuous data, respectively. A $P \leq 0.05$ was considered statistically significant.

Results: From August 2013 to January 2015, 70 single-site robotic cholecystectomies and 70 laparoscopic cholecystectomies were performed. Patients were older (mean age, 40.3 years vs 47.6 years; $P = .0084$), had a higher mean BMI (29.5 vs 32.4 kg/m^2; $P = .011$), and had a higher assigned ASA (American Society of Anesthesiologists) classification ($P = .024$) in the laparoscopic than in the single-site group. Hypertension was more common in the laparoscopic group ($P = .0078$). Average docking time was 11.5 (SD 5.7) minutes, and the average console time was 52.8 (SD 22.5) minutes in the single-site group. Total operating time for the laparoscopic and single-site groups was not significantly different (111.5 minutes vs 106.0 minutes; $P = .38$). There were more conversions to open procedures in the laparoscopic compared to the single-site group (11 vs 1; $P = .007$). There were no biliary tree injuries and no deaths in either group.

Conclusion: Single-site robotic cholecystectomy is safe to perform in an inner-city academic hospital setting. Surgical resident involvement does not adversely affect outcomes.

Key Words: Education, Minimally invasive surgery, Outcomes, Robotic surgery.

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INTRODUCTION

Since its introduction in 1985 by Mühe,[1] laparoscopic cholecystectomy has become the gold standard for treating symptomatic gallbladder disease. The first studies introducing single-site robotic cholecystectomy (SSRC) were published in 2011, after approval by the U.S. Food and Drug Administration.[2] Although single-site laparoscopic cholecystectomy (LC) is associated with a steep learning curve, related to the decreased ergonomics and limited maneuverability, SSRC can potentially overcome these limitations.[3] At our institution, after the surgeon gains experience with the robotic system by performing multiport robotic cholecystectomies, SSRC becomes the procedure of choice for robot-assisted cholecystectomy. Our goal was to determine the safety and efficacy of the procedure, given our unique circumstances as a general-surgery residency training program affiliated with an inner-city hospital with a predominantly Afro-Caribbean patient population. We examined the outcomes of our first 70 consecutive SSRCs compared to laparoscopic cholecystectomies (LCs).

MATERIALS AND METHODS

We performed a retrospective analysis of SSRCs from August 2013 to January 2015 and compared them to LCs performed during the same period. All surgeries were performed with the da Vinci robot system (Intuitive Surgical, Sunnyvale, California). We obtained institutional review board exemption status for our study. We looked at age, gender, race, body mass index (BMI), total operative time (docking and console time for robotic cases), length of stay, comorbidities, and conversion to open procedures. All patients in this study were ≥18 years of

age and had symptomatic gallbladder disease. We used univariate analysis to compare the LC and SSRC groups. The χ^2 test was used for categorical data, and Student's t test was used for continuous data, where $P \leq .05$ was considered statistically significant. Statistical analysis was performed with the R statistical language, ver. 3.1.2 (http://www.r-project.org).

RESULTS

From August 2013 to January 2015, 70 SSRCs and 70 LCs were performed for symptomatic gallbladder disease. The characteristics of the patients and the procedures are shown in **Table 1**. The patients in the LC group had a higher mean age than those in the SSRC group (40.3 years vs 47.6 years; $P = .0084$) and a higher mean BMI (29.5 kg/m^2 vs 32.4 kg/m^2; $P = .011$). The LC group was noted to have a higher assigned ASA (American Society of Anesthesiologists) classification than the SSRC group ($P = .024$). However, given the subjective nature of ASA classification, we also examined comorbid conditions in our patients and found that only hypertension was significantly more common in the LC group ($P = .0078$). The average docking time for SSRCs was 11.5 (SD 5.7) minutes, and the average console time was 52.8 (SD 22.5) minutes. We noted that docking and console time had a tendency to decrease with more experience. Total operating time in the SSRC group was, on average, 111.5 (SD 31.1) minutes, whereas in the LC group, it was 106.0 (SD 41.0) minutes, which was not a statistically significant difference ($P = .38$).

Pathology results are shown in **Table 2**. There was no difference in incidence of chronic cholecystitis in the LC vs SSRC group (54 [77.1%] vs 59 [84.3%]; $P = .39$). However, there was a higher incidence of acute cholecystitis in the LC than in the SSRC group (20 [28.6%] vs 7 [10.0%]; $P = .01$), and several of these were cases of acute on chronic cholecystitis (9 [12.6%] vs 6 [8.6%]; $P = .58$). The majority of cases had concomitant cholelithiasis (62 [88.6%] LC vs 64 [91.4%] SSRC; $P = .78$). There was a single conversion to open procedure in the SSRC group versus 11 in the LC group ($P = .007$). There was a statistically significant relationship between conversion to open and acute cholecystitis ($P = .04$) when all LC cases were analyzed. However, when the 6 emergent LC cases (as defined by ASA classification) were excluded, of which 1 procedure was converted to open, the relationship did not reach statistical significance ($P = .07$).

There were more patients in the SSRC group than in the LC group who had elective surgery with same-day discharge

(46 vs 20; $P < .001$). We also found that there was a longer length of stay (LOS) in the LC group compared to that in the SSRC group, although the difference did not reach statistical significance (LC, 5.1 (SD 15.6); SSRC, 1.5 (SD 3.8) days; $P = .065$). On closer examination, we found that the LOS in 1 LC case was 130 days, in which LC was performed urgently during a prolonged illness. When this outlier was removed, the average LOS for the LC group was 3.2 days (SD 3.6), and the difference in LOS reached statistical significance ($P = .006$). There were two 30-day readmissions in the SSRC group, one for a retained stone requiring ERCP and biliary stenting and the other for a small hematoma that was conservatively treated. There were three 30-day readmissions in the LC group, 2 for acute on chronic pancreatitis, with a third admitted for postoperative pain control. There were no biliary tree injuries and no deaths in either group.

DISCUSSION

All LCs performed during the study period were performed by surgeons with more than 20 years' experience. There were differences in patient characteristics in the LC group compared with those in the SSRC group. Both groups on average were in their fourth decade, although the LC group tended to be older. Although the LC group also had a higher BMI, both groups were in the overweight-to-obese range. The LC group was assigned a higher mean ASA classification and had a higher incidence of acute cholecystitis. However there were no differences in gender and race between the 2 groups, and, as noted, we had a predominance of African-American/Afro-Caribbean patients. Closer inspection of the comorbidities was conducted, because ASA classification alone has been cited as insufficient to describe the physical status of patients[4] and is known to have interobserver variability.[5–8] This subanalysis demonstrated that hypertension alone was significantly more common in the LC group, perhaps explaining the shift toward higher assigned ASA scores in the LC group.

Our LC open conversion rate was 15.7%, above the conversion rate of 5–10% reported in the literature.[9,10] This difference may have arose from the significantly higher rate of acute cholecystitis in the LC compared to the SSRC group, seeing that acute cholecystitis is a known risk factor for conversion to open cholecystectomy.[11] However, these results are in keeping with the observation that patients who present at inner-city hospitals tend to have higher rates of acute cholecystitis and that safe outcomes in LC can be achieved provided the surgeons recognize a

Table 1.
Results Comparing SSRC to LC

Characteristics*	SSRC (n = 70)	LC (n = 70)	*p*-value
Age,. mean years (SD)	40.3 (15.2)	47.6 (17.2)	0.0084
Sex, %			0.65
Male	10 (14.3)	13.0 (18.6)	
Female	60 (85.7)	57.0 (81.4)	
BMI, mean kg/m²(SD)	29.5 (6.2)	32.4 (7.4)	0.011
Race, %			0.34
Black	53.0	59.0	
White	15.0	9.0	
Asian-Pacific	2.0	1.0	
Length of stay, meandays (SD)	1.5 (3.8)	5.1 (15.6)	0.065
Elective case, %	46.0	20.0	< 0.001
ASA classification, %			0.024
I	8.0 (11.4)	3.0 (4.3)	
II	46.0 (65.7)	37.0 (52.9)	
III	14.0 (20.0)	29.0 (41.4)	
IV	0.0 (0.0)	1.0 (1.4)	
Smoking, %	12.0	12.0	1.0
Drug abuse, %	1.0	2.0	1.0
Diabetes mellitus, %	10.0	19.0	0.12
Coronary artery disease, %	1.0	3.0	0.64
Hypertension, %	16.0	33.0	0.0078
Hyperlipidemia, %	5.0	11.0	0.20
Asthma, %	9.0	9.0	1.0
COPD, %	0.0	3.0	0.26
Chronic kidney disease, %	1.0	3.0	0.64
Endstage renal disease, %	1.0	2.0	1.0
Hepatitis C, %	0.0	1.0	1.0
HIV, %	2.0	1.0	0.97
Docking time, meanmin (SD)	11.5 (5.7)	—	—
Console time, mean min (SD)	52.8 (22.5)	—	—
Total OR time, mean min (SD)	111.5 (31.1)	106.0 (41.0)	0.38
Open conversion,, %	1.0 (1.4)	11.0 (15.7)	0.007
30-day readmission,, %	2.0 (2.8)	3.0 (4.3)	1.0

Abbreviations: COPD, chronic obstructive pulmonary disease; OR, operating room.

*Missing data not included in calculations.

need for liberal conversion to open.[12] We had a single case in the SSRC group that required conversion to open (1.4%), with the final pathology revealing acute on chronic cholecystitis. Most patients with symptomatic gall-bladder disease present to our institution via the emergency department or via inpatient referrals. Of the 2 surgeons who performed SSRC, the surgeon responsible for most of the cases had no exclusion criteria and performed

Table 2.
Pathology Results

Findings*	SSRC (n = 70)	Laparoscopic Cholecystectomy (n = 70)	P
Acute cholecystitis	7 (10.0)	20 (28.6)	0.01
Chronic cholecystitis	59 (84.3)	54 (77.1)	0.39
Acute or chronic cholecystitis	6 (8.6)	9 (12.6)	0.58
Cholelithiasis	64 (91.4)	62 (88.6)	0.78
Fibrosis	8 (11.4)	8 (11.4)	99

Data are expressed as the number of cases (% of the total group).
*Missing data not included in calculations.

all cholecystectomies with the robot during the study time frame. However, there were more surgeons who perform only LC, and likely the higher number of acute cases in the LC group was a result of this selection bias, which may have resulted in fewer elective cases with same-day discharge in the LC group than in the SSRC group. We acknowledge that the worse outcomes of the LC group could be a result of these ill patients' having only the laparoscopic option available to them when they presented. Of note, there are groups that perform all resections of acute symptomatic gallbladders via the robotic platform, with excellent outcomes.[13] If these system obstacles can be overcome, there may be a role for the use of SSRC in emergent cholecystectomies, in which the superior imaging and ergonomics may afford a safer dissection and removal of the diseased gallbladder. In our series, the open conversion rate for SSRC was well beneath the accepted conversion rate reported in the LC group. The mean LOS in the SSRC group was lower than that in the LC group, with the difference approaching statistical significance. Readmission rates were comparable in the 2 groups. Whether these outcomes will hold if SSRC is regularly performed by all the surgeons at our institution in patients presenting with emergent symptomatic gallbladder disease has yet to be seen.

Studies have suggested a higher rate of umbilical hernia formation after single-site procedures, with a recent meta-analysis of randomized controlled trials involving single-site procedures reporting a 2.2% incidence, compared to 0.7% in the conventional laparoscopic group,[14] most likely because of the larger incision that is required in performing an SSRC. We routinely perform a 2.5-cm incision at the

umbilicus, and at the 6-month to 2-year follow-up, we have not yet encountered a trocar-site hernia. There is a possibility that asymptomatic hernias have developed and have gone undetected; therefore, longer follow-up is necessary.

We found that surgical resident involvement in robotic cases is feasible and did not adversely affect robotic operative times. A survey of general surgery training programs from 2011 found that robotic surgery was offered in 56% of them.[15] A recent survey of general surgery residents at 240 Accreditation Council for Graduate Medical Education (ACGME)–approved training programs found that 96% of the residents had robotic systems at their institution, and 63% had participated in robot-assisted cases.[16] Since the adoption of robot-assisted surgery at our institution in 2013, we have gone through both an early-learning phase and an evolution in the way residents are trained to use robotic systems. All residents are required to complete online training modules for the robot and to demonstrate basic proficiency based on scores from the robot training simulator provided with our robot system. Junior and senior residents are involved in all aspects of cases from start to finish. We found that, with increasing experience, docking times decreased. At our institution, senior residents also participate at the assistant console and, as they demonstrate proficiency and at the surgeon's discretion, they advance to performing the procedure in its entirety. We note that this level of involvement did not drastically affect our operative times compared to those in the LC group, as there was not a significant difference between the operative times of the 2 groups. We also found that there was a trend toward decreasing console time with more experience; yet, we hypothesize that our inclusion of residents in all aspects of the SSRC cases may explain the longer operative times in this group, as compared to the times published in the literature.[17,18]

One of the main criticisms of robotic surgery has revolved around the cost, with opponents citing the high costs associated with this new technology. A cost analysis from 2008 by Breitenstein et al.,[19] who compared multiport robotic cholecystectomy to LC, concluded that, although the technique is safe, the higher cost associated with the robotic procedure, attributed mainly to amortization and consumables, is problematic.[19] However, recent data repudiate these claims. A retrospective analysis comparing the cost of SSRC vs LC by Bedeir et al.,[13] who included 177 SSRCs and 281 LCs in their analysis, demonstrated that the total cost of performing a procedure was less in the SSRC group than in the LC group ($1319 vs $1737; P < .001). Of note, most of the savings were attributed to a reduc-

tion in supply costs. This information comes in light of another study by Frazee et al.,[20] who analyzed the cost of performing LCs at Medicaid reimbursement rates and concluded that 454 LCs would have to be performed to generate a positive margin. Although LC is the gold standard method for safely removing a gallbladder, there is little room for improvement on the technique or for reducing costs. As robotic surgery matures, new techniques and additional technologies may further decrease the cost, allowing surgeons to further reduce healthcare expenditures.

A weakness in our study is its retrospective design. The greater proportion of surgeons continue to perform LC at our institution, creating a probable selection bias that influenced the differences in the demographics of the LC and SSRC groups as well as the higher rate of acute cholecystitis in the LC group. However, overall, the 2 groups shared similar comorbidity characteristics.

In conclusion, we have found that SSRC is feasible and safe to perform in an inner-city hospital setting. Furthermore, resident involvement does not adversely affect operative times, and increasing experience trends toward improved operative times. Further randomized controlled prospective studies are warranted to determine whether the improved ergonomics and advanced imaging capabilities provided by the robotic approach may improve outcomes, particularly in the emergent setting.

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