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Single-Site Robotic Cholecystectomy

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ABSTRACT

Background: Laparoscopic single-incision surgery is fraught with significant technical drawbacks but has witnessed increased growth mainly for its presumed aesthetic advantages. Recently, a single-site robotic platform has been introduced to alleviate some of the technical challenges with laparoscopic single-site surgery, although literature on this topic is scant. The aim of this study is to analyze the experience of a single surgeon with single-site robotic cholecystectomies since the U.S. Food and Drug Administration gave its approval in December 2011, and to evaluate the robotic platform's safety and short-term surgical outcomes.

Methods: From February 1st 2012 to February 28th 2013, patients who underwent single-site cholecystectomy at an academic institution in the United States were retrospectively reviewed from a prospectively maintained database. The following variables were analyzed: age, sex, body mass index, previous surgeries, total operative time, port insertion time, docking time, console time, estimated blood loss, closure time, conversion to open or multiport approach, postoperative outcomes for wound infection, bile leak, biliary ductal injury, right hepatic artery injury, reoperations, readmission, and mortality. Indication for cholecystectomy was symptomatic gallbladder disease. No exclusion criteria were used and no cost analysis was performed.

Results: During the study period, 31 patients were enrolled. The mean patient age, body mass index, weight, and operative time was 33.6 years, 32.2 kg/m^2, 86.3 kg, and 81.4 minutes, respectively. There were no conversions to the open or traditional multiport approach, and no major complications of biliary ductal or hepatic artery injury, bile leak, reoperations, or mortality occurred. There was 1 case of superficial wound infection.

Conclusions: Single-site robotic cholecystectomy is feasible and safe and requires a minimal learning curve to transition from traditional multiport to single-port robotic cholecystectomy.

Key Words: Robotic cholecystectomy, Single site.

INTRODUCTION

Singleincision surgery has the main scope to minimize the number of skin incisions, while maintaining similar ergonomics as traditional multiport surgery, and to provide the same or better patient outcomes.[1–3] The transition from multiport to single-site laparoscopic surgery had been challenging due to the severe loss of ergonomics, unstable platform, high learning curve, lack of first assistance, and counterintuitive instruments.[4–6] Despite the inferior number of incisions that might translate to better aesthetics than traditional multiport surgery does, the single-site technique might be associated with increased technical difficulties and possibly adverse outcomes such as trocar-site hernias or visceral injuries. The robotic single-site platform was introduced in December 2011 as a counterpart for multiport robotic surgery with an intention of overcoming the drawbacks of single incision laparoscopy. Current literature with this platform is limited with initial studies in small series with long operative times in patients with lower body mass index. Because of these limitations, the main aim of this study was to evaluate safety, feasibility, and outcomes for single-site robotic cholecystectomies, in a high-volume robotic center that performs multiport robotic cholecystectomies. Cost analysis for this platform was not performed in the present study.

MATERIALS AND METHODS

During the period between February 2012 to February 2013, data on 31 patients who underwent robotic single-site cholecystectomy at a tertiary academic center by a single surgeon were prospectively collected and reviewed retrospectively for mean age, sex, body mass index, pre-

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vious surgeries, total operative time, port insertion time, docking time, console time, estimated blood loss, closure time, conversion to open or multiport approach, postoperative outcomes for wound infection, bile leak, biliary ductal injury, reoperations, readmission, and mortality. Inclusion criteria included age >18 years and indications for cholecystectomy were symptomatic gallbladder disease. No exclusion criteria were used.

PROCEDURE

The operative room was set up by nursing staff trained in robotic platform. All the patients were positioned in reverse Trendelenburg, supine position with the da Vinci robot (Intuitive Surgical, Inc., Sunnyvale, California) docked from the patient's right shoulder. The abdomen was entered at the umbilicus through a 2- to 3-cm semilunar incision. A single-site port was inserted through the umbilicus and positioned with the target anatomy pointing toward the gallbladder. (The port has 4 lumens that provide access for 2 single-site semirigid robotic instruments, the 8.5-mm 3-dimensional high-definition scope, a 5/10 mm accessory port, and fixed insufflation tubing.)

The robotic arms were attached to the cannulas, with special attention given toward maximizing the range of motion for the surgeon's arms. The first assistant then retracts the gallbladder cranially while a grasper and monopolar hook were used to dissect the triangle of Calot. Visualization is achieved through an 8.5-mm camera and dissection of the gallbladder is the same as with a multiport cholecystectomy. Hem-o-lok clips (Teleflex Incorporated, Research Triangle Park, North Carolina) are placed to transect the cystic duct and artery. Finally, the gallbladder is dissected off the gallbladder fossa and removed through the umbilical port, and the fascial defect was closed with interrupted sutures.

RESULTS

Of the 31 subjects, 25 were women (80.6%) and 6 were men (19.3%) with a mean age of 33.6±13.4 years (range, 19–70), mean body mass index of 32.2±7 kg/m^2 (range. 22.31–46), and a mean weight of 86.3±19.2 kg (range, 52–125) as shown in **Table 1**. The most common preoperative and postoperative diagnosis was symptomatic cholelithiasis (**Table 2**). There was a previous history of abdominal surgery in 11 patients (35.4%).

A 300-mm curved cannula was used in 28 patients (90.3%) and a 250-mm curved cannula in 3 patients (9.6%). **Table 3** depicts different timelines of the surgical procedure. The mean operative time was 81.4±21 minutes (range, 45–127) and the average time for insertion of the port was 12±4.8 minutes (range, 4–31). The mean robot docking time was 5.2±5.9 minutes (range, 2–35), and the mean surgeon console time was 36±16.7 minutes (range, 15–81). The average time for closure of fascia and skin was 24.6±6.7 minutes (range, 11–35). The average estimated blood loss was 8.3±4.1 ml (range, 5–15). Mean length of hospital stay was 0.3±0.65 days (range, 0–2). Twenty-four procedures (77.4%) were performed on an outpatient basis. In comparison, mean operative time for multiport robotic cholecystectomy for the same surgeon at the same academic setting was 89 minutes.

Table 1.
Patient Demographics

Mean Age	33.9 years
Sex	
Male	6
Female	24
Mean BMI	32.08 kg/m^2
Mean weight	86 kg
Complications	1

BMI, body mass index.

There were no intraoperative complications. Two patients required placement of an additional 5-mm trocar for a suction catheter in the right midabdomen. No cases required conversion to open or to traditional multiport technique. One patient had a superficial wound infection that was treated with a course of oral antibiotics and resolved without any further consequence. In short-term follow-up of all patients for <90 days, there were no biliary leaks, no right hepatic artery injury, and no bile duct or other inadvertent injuries to the surrounding structures. All patients were satisfied with the aesthetic results of the scar (**Fig. 1**).

DISCUSSION

While the cosmetic result of single-site laparoscopic surgery is self-evident, the technique suffers from loss of ergonomics.[7] This is due to the lesser degree of freedom offered by laparoscopic instruments, compounded by working in a parallel setup with lack of first assistance and an unstable visual field. Together, these factors make single-site laparoscopic surgery an option primarily for expert laparoscopic surgeons. Thus, as a result of this higher learning curve, and subsequent challenge to extend its use to more complex

Table 2.
Pre- and Postoperative Diagnosis of the Patients

Diagnosis	Preoperative Diagnosis	Postoperative Diagnosis
Symptomatic cholelithiasis	21	12
Chronic gallstone cholecystitis	6	12
Acute and chronic gallstone cholecystitis	1	2
Acute cholecystitis secondary to choledocholithiasis	1	1
Acute cholecystitis with 26-wk pregnancy	1	1
Biliary dyskinesia	1	1
Acute and chronic gallstone cholecystitis with empyema	0	1
Symptomatic cholelithiasis and umbilical hernia	0	1

Table 3.
Mean Timings of Different Steps Involved During the Operation in Minutes

Total operative time	81.96
Port insertion	12.2
Dock time	5.33
Console time	36.36
Fascial/skin closure time	24.5

Figure 1. Postoperative image of the operative site showing aesthetic scar around the umbilicus.

cases, the ability to disseminate this technique remains a concern.[8] This increased technical challenge for the benefit of fewer trocar-site incisions that might translate into better cosmesis can potentially come with increased perioperative risk of the procedure, such as biliary ductal injury or hepatic arterial injury with long-term increased risk of ventral hernia at the port site.

The single-site robotic platform was approved by the U.S. Food and Drug Administration in December 2011. This platform can help to address the limitations of the laparoscopic technique by providing a stable visual field, with movement of the arms switched by computerized inversion and instruments that offer a higher degree of freedom.[9–11] Furthermore, unlike the multiport cholecystectomy procedure, docking of the robot for single-site cholecystectomy is recommended from the patient's right shoulder, with the patient positioned supine in a minimal reverse Trendelenburg position (15°). In our experience, we have found that using more inclination in the reverse Trendelenburg (30°–45°), with the patient table tilted to minimal left lateral decubitus position, is optimal for unimpeded visualization. Additionally, we first place the patient in the maximum reverse Trendelenburg position in order for gravity to allow the transverse colon and bowels to move caudally and then into final operative position.

The single-site robotic platform is currently only approved for cholecystectomy. It has a single-site port with 4 lumens that provide access for 2 single-site semirigid robotic instruments, the 8.5-mm 3-dimensional high-definition endoscope, a 5- to 10-mm accessory port, and an insufflation adaptor. The single-site port currently comes in only 1 size and fits through a 2.5-cm incision placed through the umbilicus. The goal of the single-site port is to maximize the range of motion at the end effector of the robot with maximum achievable triangulation of the instruments externally, and with minimal collision. Because the port is of a fixed length, in cases where there is a significant subcutaneous layer, the port may get buried under the skin.[10] We have not found this to be a hindrance in our experience and, moreover, a "U" stitch can be placed from fascia to skin to collapse the space.

The curved cannula accommodates instruments used for transection, cutting, ligation, dissection electrocautery, grasping, and suction/irrigation. It comes in 2 sizes, 5×250 mm and 5×300 mm, and the choice of which to use depends on the end-organ distance of either 12 to 23 cm or 17 to 28 cm, respectively. As these are curved cannulas, the size of 300 mm or 250 mm does not equate to 30-cm or 25-cm traditional straight trocars, respectively. Depending on the patient's body habitus, the estimated distance between the port and the end target (i.e., costal margin) is identified externally, and the appropriate size is selected at the surgeon's discretion. Furthermore, each cannula is marked distally with a "V" mark; when it is located at the top of the single-site port, it equates to the tip of the cannula coming into laparoscopic view. The V mark on the 5×300mm cannula also indicates the location of the tip of the 5×250 mm. This gives the surgeon an idea for choosing the appropriate cannula. For the most part, however, the longer cannula tends to work better for retraction of the gallbladder fundus, as the working area is more cranial than the costal margin is. If the cannula is shorter to the working area, there is internal rotation of the right working hand over the left hand in retracting the infundibulum. If the cannula is longer, it typically rests over the liver and requires the first assistant to retract the gallbladder cranially.

The da Vinci Si system software automatically detects and reassociates the surgeon's hands with the instruments, giving the console surgeon the perception that the left hand is controlling instruments on the left side of the visual field while the right hand is controlling instruments on the right side of the field.[12] Of all the available features, this is an undeniable advantage of the system that makes the approach simple, intuitive, and plausible even for a trainee. We have confirmed this with fellows who have used the system effortlessly.

In our experience, we have found that the procedure can be performed with a 0° camera, without the need to switch to a 30° or 45° camera for optimal visualization of the critical structures, as happens with single port laparoscopic cholecystectomy. Additionally, a unique advantage of the robotic platform is the uncompromised 3-dimensional high-definition stable visualization, as opposed to laparoscopic single-site surgery where the visualization is made unstable with every movement of the other instruments.

For this operation, the available instruments include graspers, Maryland dissectors, scissors, monopolar cautery, suction irrigator, and Hem-o-lok clip appliers. While this limited set of U.S. Food and Drug Administration–approved instruments for cholecystectomy is sufficient to perform the procedure, we have found them to be suboptimal in comparison to regular multiport instruments. The horizontal segment of the monopolar hook and the Hem-o-lok are smaller, particularly for dissection of a dilated cystic duct and require complete skeletonization of the duct for the clip to lock into position. As such, we find the movements and maneuvers allowable with these instruments to be somewhat restrictive when compared with multiport robotic instruments, although still far better when compared with laparoscopic instruments.

The single-site robotic platform was used in all 31 cases of gallbladder disease without exclusion. All cases were performed to completion without converting to open or to complete multiport setup. In 2 cases, an additional 5-mm trocar was placed for a suction/irrigation catheter or for additional retraction and exposure. Two cases had longer total operative times than usual. In the first case, the patient's gallbladder was acutely inflamed with empyema along with chronic cholecystitis with challenging dissection and a fellow trainee mostly performed the second case. At short-term follow-up, there were no intraoperative or postoperative complications noted in this initial series. We have also found that this platform can be safely used to train fellows.

CONCLUSIONS

The single-site robotic cholecystectomy is feasible and safe to perform in patients with acute or chronic cholecystitis, with good short-term perioperative outcomes. This technique can be used to train residents and surgical fellows, although long-term rates of incisional hernia and cost associated with the procedures still need to be analyzed. Continued use of this platform will also determine if it is possible to perform more complex cases with a single incision.

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