

Research Article

Robotic Cholecystectomy: Preliminary Experience and Future Perspectives

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Abstract

Background: The main advantages of robotics in general surgery may be for advanced minimally invasive procedures. Unlike other specialties, formal fellowship training opportunities for robotic general surgery are few. As a result, most surgeons currently develop robotic skills in practice and robotic cholecystectomy represents the operation of choice for general surgeons to acquire clinical da Vinci experience.

Methods: Before performing advanced robotic procedures, 2 surgeons completed the Intuitive Surgical da Vinci-Xi training course and agreed to work together on all procedures. We performed a retrospective review of our pilot series of robotic cholecystectomies and compared them with contemporaneous laparoscopic controls. The primary outcome was safety, and the Secondary outcome was learning curve.

Results: There were 10 procedures in the robotic arm and 15 in the laparoscopic Arm. One complication (port-site hernia) occurred in the laparoscopic arm, and only one robotic patient (surgical wound infection) experienced a complication. The mean time required to perform robotic cholecystectomy was significantly longer than laparoscopic surgery (70 v. 40 min, $p < 0.001$) due to the docking of da Vinci system. The mean time to clear the operating room was significantly longer for robotic procedures (20 v. 11 min, $p = 0.015$). Regarding learning curve, the mean operative time needed for the first 3 robotic procedures was longer than for the last 3 (80 v. 66 min, $p < 0.05$).

Conclusion: Our experience can suggest that robotic cholecystectomy is one means by which general surgeons may gain confidence in performing advanced robotic procedures and it confirms the reliability of this training course.

INTRODUCTION

Recent advances in minimally invasive surgery include laparoscopic and robotic surgery. In general surgery, advanced robotics will likely find its place in the most complex laparoscopic procedures where the enhanced dexterity and superior visualization will extend the feasibility of the minimally invasive approach, particularly in patients requiring advanced suturing and precise tissue dissection. Laparoscopic cholecystectomy (LC) is a first operation with which to begin robot applications for several reasons. First, gallstones disease is the most common of all abdominal diseases for which patients are admitted to hospital in developed countries, making it the most commonly performed laparoscopic procedure. Moreover, it is an operation with a very standardized approach to prevent complications. Therefore, we think that robotic cholecystectomy (RC) may allow general surgeons to acquire clinical da Vinci experience in a familiar setting. Our goal was to determine whether RC can be employed as a bridge to advanced robotic procedures in general surgery

with a retrospective review of our pilot series of RC, compared with contemporaneous laparoscopic controls. Furthermore, this experience can show the evolution of our learning curve even in a small number of patients.

MATERIALS AND METHODS

From 2002 to 2015, 1740 LC were performed at our Institution: 1250 for gallstones, 490 for acute cholecystitis. In the 2002 the gallbladder ante grade dissection (GAD) was introduced in our department and it became the surgical laparoscopic procedure of choice [1]. To begin robotic operations, 2 general surgeons enrolled in the Intuitive Surgical da Vinci Xi training course. Both surgeons had advanced laparoscopic surgical skills prior to robotic training and they agreed to work together on all robot-assisted procedures. We included all patients referred to the outpatient general surgery clinic for elective cholecystectomy as potential candidates for a da Vinci-assisted approach (Table 1). Patients with contraindications to laparoscopy or with a

history of prior abdominal surgery were deemed unsuitable for robotic procedures. We obtained consent for a da Vinci-assisted cholecystectomy. We informed patients of the innovative nature of the robotic approach that was used as a mean to improve skills with the da Vinci surgical system with the intent of moving on to more advanced procedures. No proven benefit to performing the surgery with this technology was offered. The primary outcome of this retrospective series was safety as indicated by complications, transition to laparoscopy and conversion to open surgery. The secondary outcome was learning curve, as indicated by duration of surgery. We compared these outcomes in a nonrandomized cohort of RC with a cohort of contemporaneous LC controls.

Surgical procedure

We prepared patients in both groups in the same way: with parenteral cefazolin but no anti-thrombosis prophylaxis unless indicated by age or comorbidities. Patients received general anesthesia. The patient was placed in a reverse Trendelenburg position with a 15° inclination and tilted to the left side.

Robotic procedure

Using open first trocar entry, we inserted a 12-mm trocar (R2) at the umbilicus. We obtained a pneumoperitoneum of 12 mm Hg. Then we inserted 3 8-mm da Vinci trocars under direct visualization, one in the right lower (R1) and two in the left upper quadrants to triangulate the gallbladder and to its traction (R3,4), and we placed a 5-mm accessory port (T acc) in the left lower quadrant for the Airseal system and the aspiration (Figure 1). We then docked da Vinci by bringing it over the patients' right shoulders (Figure 2). A unique advantage of the robotic platform is the uncompromised 3-dimensional high-definition stable visualization, as opposed to laparoscopic surgery where the visualization is made unstable with every movement of the other instruments. For the robotic operation, the available instruments include graspers, Maryland and dissectors, scissors, monopolar cautery, suction irrigator, and Hem-o-lok clip appliers. The procedure of gallbladder antegrade dissection involves incision of the visceral peritoneum from the infundibulum away from Calot's triangle along the gallbladder bed up to the fundus; then the dissection continues from the fundus up to the infundibulum. We resected the gallbladder from the gallbladder fossa using cautery. In this way, the gallbladder is left pedunculated by the cystic artery and cystic duct, which can be clipped and divided in turn. This method of dissection has allowed safe and complete preparation of the cystic duct. In fact, the cystic duct is isolated, identified, clipped, and divided (at the end of the dissection) more easily. Then, its position and connections with the common bile duct (CBD) can be seen. We placed the specimen in an Endocatch bag and removed it through the umbilical port. We then closed the port sites and skin. LC was done using the same technique with 4 ports, electrocautery, a 30° laparoscope and others typical laparoscopic instruments.

Statistical analysis

We compared the mean duration of values in both groups using the Student t test. A p value of less than 0,05 was considered statistically significant.

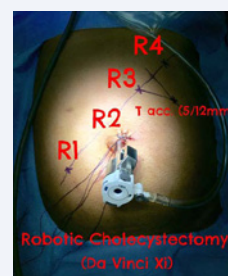


Figure 1 Position of 8-mm da Vinci trocars.

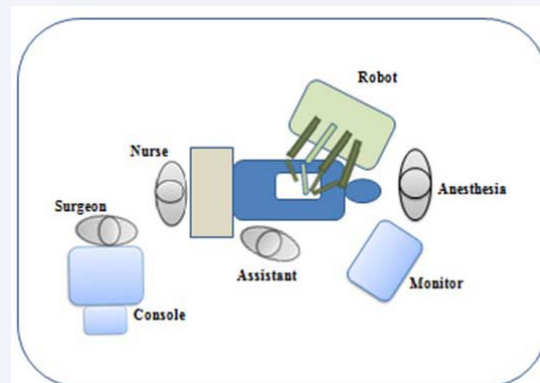


Figure 2 Arrangement of the operating room for da Vinci cholecystectomy.

RESULTS

A total of 10 patients underwent RC in our department in the first month of utilization of da Vinci surgical system. These patients were compared with 15 controls who received contemporaneous LC. Indications for surgery were most commonly uncomplicated gallstones in the robotic arm and gallstones, acute cholecystitis and one case of gallstones in a cirrhotic patient (Child A) in the laparoscopic arm. Three patients with choledocholithiasis underwent endoscopic-retrograde-colangio-pancreatography (ERCP) with sphincterotomy for CBD clearance before cholecystectomy (Table 1). All patients affected by acute cholecystitis underwent laparoscopic cholecystectomy within 24 hours to 72 hours after the admission. Regarding the primary outcome of safety, there were no serious complications in either group; there were no case of biliary duct injuries and hemorrhages. One patient in the robotic group presented surgical wound infection and one complication in the laparoscopic group was incision AL hernia at a 12-mm port site requiring elective repair. In the robotic arm there were no transitions to laparoscopy, nor were there any conversions to open surgery. Figure 3,4 summarize our findings regarding the secondary outcome. The amount of surgical time required for robotic procedures, including docking, was significantly greater than that in laparoscopic procedures (70 v. 40 min, $p < 0.001$). The docking phase, a specific phase of the robotic surgeries, was on average 15 minutes. Similarly, the time needed to clear the operating room after the completion of the procedure was significantly longer in the robotic group (20 v. 11 min, $p < 0.001$). Anesthesia time was also longer in the robotic group (22 v. 19 min), though this

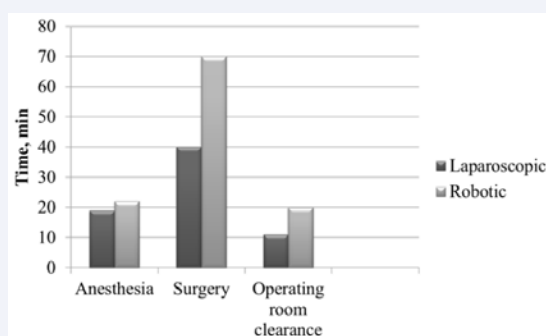


Figure 3 Operative time compared between the two procedures.

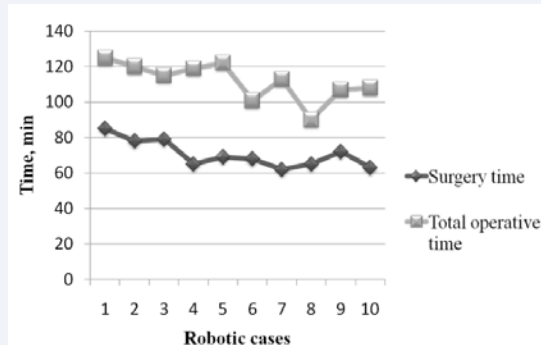


Figure 4 Learning curve for robotic cholecystectomy.

was not a significant finding (Figure 3). To evaluate the presence of a learning curve with robotic cholecystectomy (Figure 4), we compared the mean duration of surgery for the first 3 patients in the robotic arm with that of the last 3 patients in the robotic arm, with a result statistically significant (80 v. 66 min, $p < 0.05$). We obtained the same statistical result compared the mean duration of total operative time between the first 3 robotic procedures and the last 3 ones (120 v. 101 min, $p < 0.05$). These findings confirm the learning curve of surgeons and of the group of nurses, dedicated to Set-up the operating room for da Vinci system.

DISCUSSION

The main focus of our study was to evaluate our learning curve with robotic surgery. At the beginning robotic procedures may require more time than laparoscopic ones such as in our experience. Our total duration of surgery is in keeping with that in other centers implementing da Vinci system (Table 2). As our surgical and nursing teams become more accustomed to da Vinci, we see a trend toward decreased duration of surgery. Our results show that the work times for surgeons, anesthesiologists and nurses are longer for robotic procedures. This suggests that the entire operating room team experiences a learning curve with the robot. The anesthesiologist no longer has access to the patient's head during da Vinci operations owing to the bulk of the robot; perhaps that influences the time it takes to prepare the patient for surgery. Likewise, despite a formal training program through Intuitive Surgical, the nurses are not necessarily familiar with all robotic instruments. Similarly, the size of the robot limits the work space in the operating theatre, making

the work of the circulating staff more challenging. All surgeons prefer to begin with routine procedures like cholecystectomy and fundoplication before advancing to more complex ones such as pancreaticoduodenectomy or liver Resection [7,8]. It would appear that the opportunity to learn robotics on a routine, everyday procedure that mimics more complex ones is unique to general surgery. The learning curve to master the robot was of at least 10 procedures or more [9]. As a result of our experience, we are moving confidently to perform more advanced robotic procedures, including anti-reflux surgery, colon and rectum operations and an intestinal anastomosis lovingly handmade, because the advantages of robotics will likely be realized with the most complicated abdominal operations. The advantages of the da Vinci system are the dexterity of the Endo wrist, allowing complex minimally invasive tasks as well as 3-dimensional visualization of the surgical field. We found that both of these advantages far outweighed the absence of tactile feedback. The improved visualization and dexterity made the dissection of the Calot triangle more effective; however, we cannot conclude that the robot was more effective than standard laparoscopic instruments at this time. There are limitations to the robotic

Table 1: Patients' demographic and pathological data.

	Robotic cholecystectomy (RC) n 10	Laparoscopic cholecystectomy (LC) n 15
Mean age, yr	49	53
Proportion female, n (%)	6 (60%)	10 (67%)
Comorbidities, n	1 chronic lung disease 1 coronary artery disease 3 smokers	1 stroke 4 smokers 4 diabetes
BMI	25,8	27,1
ASA		
I	6	9
II	4	5
III	0	1
Indications for surgery		
-gallstones		
-choledocholithiasis	9	8
-Acute cholecystitis	1	2
-gallstones in cirrhotic patient	0	4
	0	1

Table 2: Mean duration of surgery in published series of da Vinci cholecystectomy.

Study	No. of patients	Mean duration of surgery min
Our study	10	70
Kim et al., [2]	10	57
Talamini et al., [3]	8	167
Hashizume et al., [4]	6	118
Hanisch et al., [5]	5	95
Chitwood et al., [6]	20	62

system as the absence of tactile feedback for the surgeon and from a staffing perspective, the necessity of a second experienced surgeon at the bedside to exchange the robotic instruments, retract for exposure and assist with the procedure, and it needs for larger and additional ports and for undocking the machine in case of cholangiography or change of patient position [10].

CONCLUSION

This experience may prove that even a new and complex surgical approach can safely be started by applying carefully all the standardized procedures. The robotic cholecystectomy provides the opportunity to develop familiarity with a wide set of procedure components that are ultimately applicable to more advanced robotic procedures. As such, it is one means by which general surgeons may gain confidence in advanced robotics.

COMPLIANCE WITH ETHICAL STANDARDS

Ethical approval: "All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."

Informed consent: "Informed consent was obtained from all individual participants included in the study."

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