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Initial Japanese Experience of Laparoscopic Cholecystectomy Using a New Robot-Assisted System

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The object of this paper is to clarify the feasibility and safety of robot-assisted laparoscopic cholecystectomy. Acute or chronic cholecystitis is the most common disease in patients, caused by cholecystolithiasis. Minimally invasive laparoscopic surgery is often performed for treatment of cholelithiasis. We performed robot-assisted laparoscopic cholecystectomy for the treatment of 5 patients with cholecystolithiasis. The patient underwent laparoscopic cholecystectomy using the ViKY Endo-Control System (ViKY, EndoControl, Grenoble, France). The robot-controlled laparoscopic holder was placed at the right axilla. The laparoscopic operation was performed via conventional 4-port access using the ViKY system with voice activation. All patients were treated successfully by this robot-assisted laparoscopic procedure, without any complications. Mean docking time using the ViKY was 16 minutes, mean resection time of the gallbladder was 62.2 minutes, operative time was 94.6 minutes, and the mean amount of the blood loss was minimal. Our initial experience demonstrated that robot-assisted laparoscopy was feasible and safe in patients with cholecystolithiasis, providing patient advantages. We also discuss the advantages and disadvantages of robot-assisted laparoscopic surgery.

Key words: Robot-assisted surgery – Laparoscopic cholecystectomy – Cholecystolithiasis – Laparoscopic holder – Minimal invasive surgery

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Gallstone disease is one of the most common digestive diseases.[1] The prevalence of gallstones shows ethnic variability, with rates ranging from approximately 10% to 15%.[2] Large, longitudinal studies of patients with symptomatic gallstones have shown that 58% to 72% of patients have persistent symptoms and complications.[3,4] Most patients with symptomatic gallstones are recommended to undergo cholecystectomy to alleviate symptoms of pain and jaundice and to prevent complications, such as pancreatitis, cholangitis, and cholecystitis.[5] Laparoscopic cholecystectomy is considered to be the gold standard for the treatment of gallstones.[6–8]

Robot-assisted laparoscopic surgery has been available since the 1990s, starting with robotically-controlled laparoscopic holders using AESOP system (Computer Motion, Inc, Goleta, California).[9,10] Thereafter, ViKY system also came into use in laparoscopic surgery in 2007 (EndoControl, Grenoble, France).[11,12] We have adopted use of robot-assisted laparoscopic cholecystectomy as a further minimally invasive technique, and discuss the advantages and disadvantages observed from our initial experiences.

Materials and Methods

Laparoscopic operation was performed under general anesthesia with epidural analgesia by 1 of the authors. The patient was placed in the supine position with legs astride and arms opened. The robotically-controlled laparoscopic holder was docked into the right lateral surgical rails and placed at the level of the right axilla for the laparoscopic cholecystectomy. The robots could be controlled with voice activation. A Bluetooth earpiece (EndoControl) was utilized to aurally control the platform's 3 degrees of freedom: in/out, left/right, up/down. An Olympus 10-mm videolaparoscope (Olympus, Viscera Elite, Tokyo, Japan) was then coupled with the system.

The traditional 4-port access laparoscopic approach was performed. In brief, a 12-mm trocar (XECEL, Ethicon Endo-Surgery Inc, Cincinnati, Ohio) was initially inserted through a 1.5-cm longitudinal incision via the umbilicus following CO_2 pneumoperitoneum at 10 mmHg pressure. A 10-mm port was placed at the subxiphoidal region. Two additional trocars (5 mm) were positioned at the right subcostal area at the midclavicle and anterior axilla lines. Fig. 1 shows the intraoperative settings of the ViKY system. A monitor is located in the upper central portion of the operation bed. ViKY arm is fixed to the right side of the operation bed. The ViKY driver of the EndoControl system with a laparoscope is set in the patient umbilical portion. The ViKY control unit is placed in the left foot side of the patient. The ViKY system units consist of control unit, driver, and surgical arm, as shown in Fig. 2. ViKY system provides 3 motorized scope movement; up or down movement, left or right side movement, and zoom in or out movement, as shown in Fig. 3.

Laparoscopic cholecystectomy was performed in a normograde fashion after ligation and cut off of the cystic artery and cystic duct using the ViKY EndoControl system. Robot docking time, gallbladder resection time, operation time, and blood loss were evaluated.

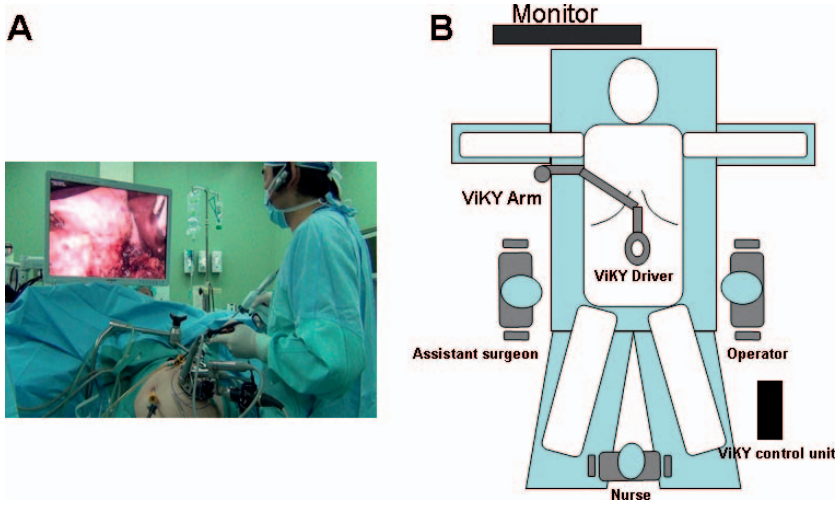

Fig. 1 Practical image for setting and positioning of ViKY EndoControl system to a patient in the operation room. (A) Intraoperative photograph from patient's foot side view. (B) A monitor is located in the upper central portion of the operation bed. ViKY arm is fixed to the right side of the operation bed. The ViKY driver of the EndoControl system with a laparoscope is set in the patient umbilical portion. The ViKY control unit is placed in the left foot side of the patient.

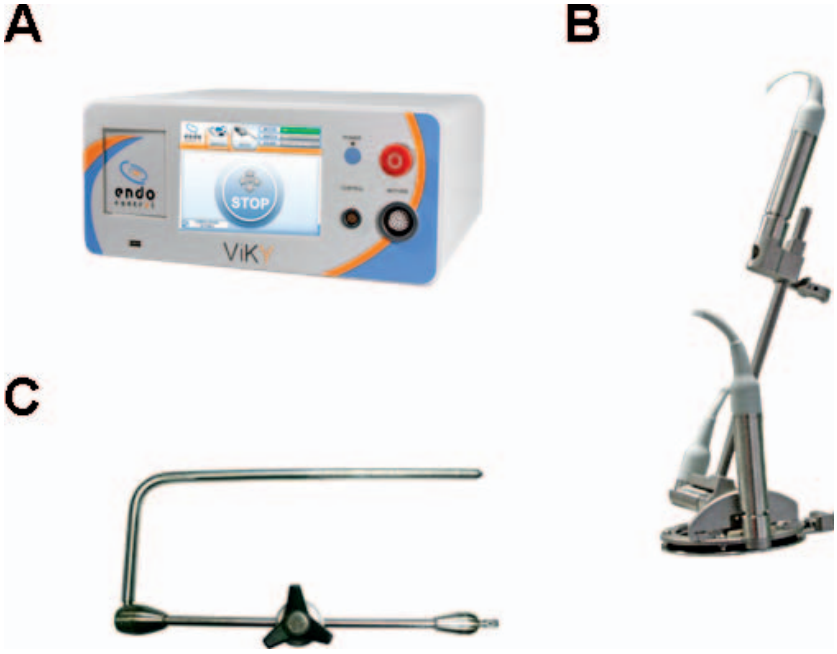

Fig. 2 ViKY EndoControl system; control unit (A), driver (B), and surgical arm (C).

Case 1: An 83-year-old Japanese man visited our hospital complaining of right hypochondriac discomfort. Abdominal ultrasonography revealed a hepatic tumor at the posteroinferior segment of the liver. Abdominal computed tomography also indicated a solitary hepatic tumor with the characteristics of hepatocellular carcinoma. After ViKY setup, a pneumoperitoneum was established using the open technique at the umbilicus. Robot-assisted laparoscopic cholecystectomy was completed via the 4-port fashion prior to partial hepatic resection.

Case 2: A 79-year-old Japanese man suffered from upper abdominal pain and visited our hospital. Abdominal ultrasonography and CT revealed gallbladder swelling with gallstones. After percutaneous transhepatic gallbladder drainage (PTGBD), robot-assisted laparoscopic cholecystectomy was performed.

Case 3: A 64-year-old Japanese woman complained of occasionally suffering from epigastralgia starting 2 years prior to admission. Recurrent cholecystitis with cholecystolithiasis was diagnosed, and robot-assisted laparoscopic cholecystectomy was performed.

Case 4: A 60-years-old woman suffered from epigastralgia since several years ago and diagnosed as cholecystolithiasis by abdominal ultrasonography on general check-up. Laparoscopic cholecystectomy was performed using a robot-assisted system.

Case 5: A 52-years-old woman was referred to our hospital for the treatment of cholecystolithiasis. Robot-assisted laparoscopic cholecystectomy was

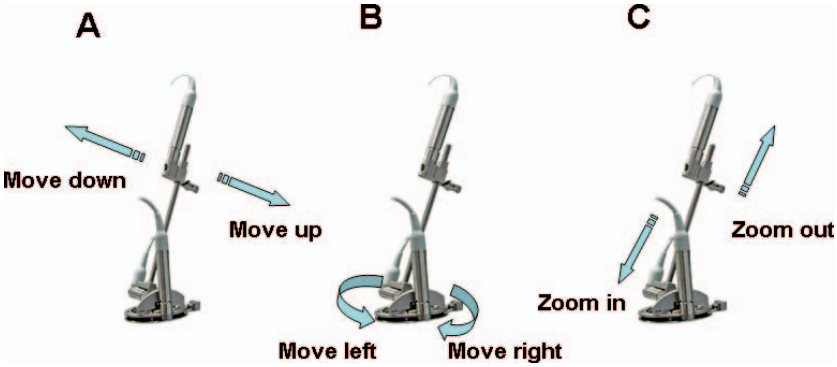

Fig. 3 ViKY EndoControl system provides 3 motorized scope movements. (A) Up or down movement. (B) Left or right side movement. (C) Zoom in or out movement.

Table 1 Patient characteristics and completion time

Case	Age	Gender	BMI	Docking time	Resection time	Operation time
1	82	M	26.7	32	56	120
2	79	M	27	14	89	121
3	64	F	29.6	14	69	91
4	60	F	18.9	11	55	79
5	52	F	20.1	10	42	62

performed. All patients' characteristics were summarized in Table 1.

Results

All robot-assisted laparoscopic cholecystectomies were performed successfully without additional port insertion or open conversion. Mean ± SD of patient body mass index (BMI) was 24.5 ± 1.4. Mean docking time of the ViKY was 16 ± 10.7 minutes. The docking time for each case gradually decreased with operator experience, and accessibility could be achieved in approximately 10 minutes. Increased experience with the ViKY system may further shorten docking time. No intraoperative complications were observed. Mean resection time of the gallbladder was 62.2 ± 16.6 minutes, and operative time was 94.6 ± 17 minutes. Fig. 4 shows the completion times of gallbladder resection, total operation time, and ViKY docking times. The resection time in Case 1 was shortest due to having a normal gallbladder with liver disease. Blood loss was minimal in all cases. All patients' postoperative courses were uneventful.

Discussion

This study demonstrated our initial experience and feasibility of a new, compact robotic, voice-activated laparoscope for improvement of laparoscopic guidance during cholecystectomy. This robotic endoscope driver contributed to a stable laparoscopic image in addition to other benefits during laparoscopic operation.

First, the robot-assisted system allowed the outcome of the surgery to be completely dependent on the operator's experience and skill. Usually, laparoscopic operation is performed by an operator, an assistant, and a laparoscopist. Laparoscopists tend to be inexperienced surgeons, and require time to be able to work well with the operator. On the other hand, if a more experienced surgeon performs the role of the laparoscopist, the operator must be

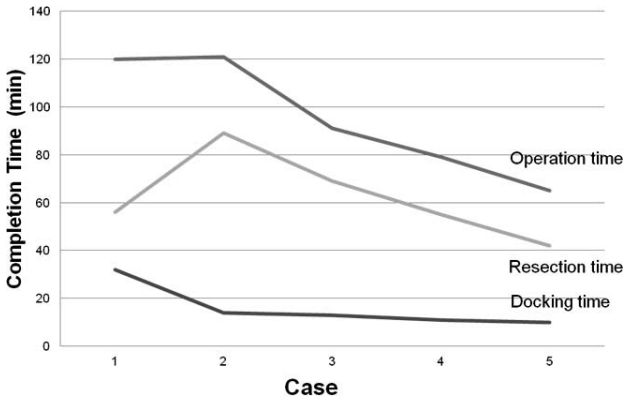

Fig. 4 Operation, resection of the gallbladder, and ViKY docking times. Each completion time is gradually shortening by case.

attentive to the experienced surgeon. Manual handling by endoscopist would make the scope blurring and contact with patient's organ. These facts lead to the operator's increased stress and fatigue. The ViKY system enables direct, precise, stable vision control by an operator. Direct control of the scope makes it possible to perform the procedure easily and reduce operator's stress and fatigue on the skilled operator with use of the ViKY system. A single operator well experienced with the ViKY system may be perfectly adequate for performing a procedure.

Second, a ViKY system allows reduction of the number of attendees required for the operation. Usually, laparoscopic surgery requires 3 physicians to perform the operation. Reduction in the number of required physicians with use of the ViKY system leads to freeing the operating hands of the scopist and facilitating increasing quality of operations. However, in an academic hospital setting that trains unskilled surgeons, the benefit of this system may not be particularly applicable.

Third, this system may allow solo surgery. Some investigators demonstrated the safety and efficiency of the solo surgery of laparoscopic cholecystectomy with a robot camera holder.[13,14] Although the lack of procedural advice from the assistant operator may be an issue, solo surgery may be made possible with use of robotic advice and announcement of possible risk during the procedure. Additionally, further single-port operation may be made possible with use of this system.

In our experience, we have had no issues regarding use of this robot-assisted system. Because the ViKY system is an endoscopic support system and cannot directly manipulate organs and tissues,

there is no risk of direct organ or tissue injury. However, further accumulation of experience is warranted to assess the safety of this robot-assisted system. Docking time of the ViKY was 16 ± 10.7 minutes, although the number of cases was low. Further performance of this procedure and accumulation of experience should further shorten the docking time and better adapt the robot-assisted system to laparoscopic surgery.

Well experienced surgeons of the robotic system indicated as an advantage that a good, clear, and stable view of the operation area was maintained over a long time period, once achieved by the use of the robotic camera holder. In contrast, short-term position changes of the camera made a surgeon stressful and tedious.[13,14] A restriction of the surgeon's comfort was also reported as a disadvantage of the robotic system in the laparoscopic operations.[15] Further technical innovations and surgeon skills are required to overcome these disadvantages.

A robotic system to guide the camera during laparoscopic surgery was first introduced using the AESOP system.[9,10] ViKY system also came into use in laparoscopic surgery in 2007.[11,12] There are some differences between the AESOP and ViKY systems. In brief, the ViKY system is completely sterilizable and fits directly on the patient, whereas AESOP system is nonsterilizable and does not fit directly. The ViKY system is more compact than the AESOP system. Both robots can be controlled with voice activation or foot pedals.

ViKY is a completely sterilizable and reusable system and its cost approximately amounts to $80,000. There are no disposable parts for this system. Use of a reusable trocar, named "YelloPort plus," instead of a disposable trocar port, can reduce the cost of performance of 4-trocar laparoscopic surgery. Furthermore, use of reusable instruments can also reduce waste costs. Total costs will be offset by the accumulation of robotic laparoscopic operations.

In conclusion, robot-assisted laparoscopic cholecystectomy may be a reasonable candidate of operative method. Further accumulation of cases and long-term follow-up studies are required to evaluate this laparoscopic technique.

Acknowledgments

The authors have no conflicts of interest or financial disclosure to report. This study was conducted and approved in accordance with the ethical principles outlined in the Declaration of Helsinki. Informed consent or its equivalent was obtained from the patients for this study.

References

1. Sandler RS, Everhart JE, Donowitz M, Adams E, Cromin K, Goodman C *et al*. The burden of selected digestive diseases in United States. *Gastroenterol* 2002;**122**(5):1500–1511
2. Shaffer EA. Gallstone disease: epidemiology of gallbladder stone disease. *Best Prac Res Clin Gastroenterol* 2006; **20**(6):981–996
3. Lund J. Surgical indications in cholelithiasis: prophylactic cholecystectomy elucidated on the basis of long-term follow up on 526 nonoperated cases. *Ann Surg* 1960; **151**(2):153–162
4. Wenckert A, Robertson B. The natural course of gallstone disease. Eleven-year review of 781 nonoperated cases. *Gastroenterol* 1966; **50**(3):376–381
5. NIH Consensus 1993. Consensus Development Panel. Gallstones and laparoscopic cholecystectomy. (National Institutes of Health Consensus Development Panel on Gallstone and Laparoscopic cholecystectomy). *JAMA* 1993;**269**(8):1018–1024
6. Gallstones and laparoscopic cholecystectomy. NIH Consensus Statement. 1992;**10**(3):1–20
7. Palanivelu C, Jani K, Maheshkumar GS. Single-center experience of laparoscopic cholecystectomy. *J Laparoendosc Adv Surg Tech A* 2007;**17**(5):608–614
8. Konstadoulakis MM, Antonakis PT, Karatzikos G, Alexakis N, Leandros E. Intraoperative findings and postoperative complications in laparoscopic cholecystectomy: The Greek experience with 5,539 patients in a single center. *J Laparoendosc Adv Surg Tech A* 2004;**14**(1):31–36
9. Mettler L, Ibrahim M, Jonat W. One year of experience working with the aid of a robotic assistant (the voice-controlled optic holder AESOP) in gynaecological endoscopic surgery. *Hum Reprod* 1998;**13**(10):2748–2750
10. Geis WP, Kim HC, Brennan EJ Jr, McAfee PC, Wang Y. Robotic arm enhancement to accommodate improved efficiency and decreased resource utilization in complex minimally invasive surgical procedures. *Stud Health Technol Inform* 1996;**29**:471–481
11. Gumbs AA, Crovari F, Vidal C, Henri P, Gayet B. Modified robotic lightweight endoscope (ViKY) validation in vivo in a porcine model. *Surg Innov* 2007;**14**(4):261–264
12. Vibert E, Denet C, Gayet B. Major digestive surgery using a remote-controlled robot: the next revolution. *Arch Surg* 2003; **138**(9):1002–1006
13. Ballantyne GH. Robotic surgery, telerobotic surgery, telepresence, and telemonitoring. *Surg Endosc* 2002;**16**(10):1389–1402

14. Kalteis M, Pistrich R, Schimetta W, Pölz W. Laparoscopic cholecystectomy as solo surgery with the aid of a robotic camera holder. A case-control study. *Surg Laparosc Endosc Percutan Tech* 2007;**17**(4):277–282
15. Kondraske GV, Hamilton EC, Scott DJ, Fischer CA, Tesfay ST, Taneja R *et al*. Surgeon workload and motion efficiency with robot arm and human laparoscopic camera control. *Surg Endosc* 2002;**16**(11):1523–1527