A new era in laparoscopic surgery

Evaluation of robot–assisted laparoscopic procedures

Gamal A. Khairy, FRCS, *Mohammed Fouda,* FRCS, *Amal Abdulkarim,* CABS, *Abdulaziz Al-Saigh,* FRCS, *Khaled Al-Kattan,* FRCS.

ABSTRACT

Objective: To present the experience with the advanced technology of robot-assisted laparoscopic surgery at our institute.

Methods: We reviewed and present patients who had robot-assisted laparoscopic surgical procedures, between April 2003 and March 2004, at King Khalid University Hospital, Riyadh, Kingdom of Saudi Arabia. All procedures were carried out using the da Vinci system (Intuitive Surgical, Mountain View, Ca, USA). We recorded the time for system setup, operating time, morbidity and postoperative hospital stay.

Results: We performed 42 robot-assisted laparoscopic operations. The most frequently performed operations were robot-assisted cardiac procedures (n=25), laparoscopic cholecystectomy (n=9) other operations were: thymectomy (4), apical bullectomy (2), and one for each adrenalectomy, and lung volume reduction. The median time to install and drape the robotic system was 15 minutes. In 2 patients (4.7%) we converted the procedures to conventional laparoscopy or open. There was postoperative wound infection at the site of the port in one patient. The average postoperative hospital stay was similar to conventional laparoscopic procedures.

Conclusions: Robot-assisted minimally invasive surgery is feasible, safe and may become the surgical procedure of the future.

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Minimally invasive surgery techniques have revolutionized surgery. The benefits of laparoscopic procedures for the patients, compared with open surgery, are clear and well documented.[1-4] However, there are several limitations and drawbacks inherent in conventional laparoscopy which prevented its use in many surgical fields. The drive to introduce operating robots into the operating theatre is for several reasons related to their intrinsic properties: these include 3 dimensional spatial accuracy, reliability, and precision.[5] In April 2003, our institute performed the first robot-assisted surgical procedure in Saudi Arabia. In this retrospective study, we present our experience with this advanced technology of telemanipulation system in the surgical field.

Methods. Patients who had robot-assisted laparoscopic surgical procedures between April 2003 and March 2004, at King Khalid University Hospital, Riyadh, Kingdom of Saudi Arabia are included. One patient, who needed a coronary artery bypass graft and replacement of an ascending aortic aneurysm was excluded from the study, although started by the robot, because the left subclavian vein was accidentally injured and the patient had a crash sternotomy to stop the bleeding.

From the Department of Surgery, College of Medicine and King Khalid University Hospital, Riyadh, *Kingdom of Saudi Arabia.*

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Address correspondence and reprint request to: Dr. Gamal A. Khairy, Assistant Professor & Consultant General Surgeon, Department of Surgery, College of Medicine and King Khalid University Hospital, PO Box 7805, Riyadh 11472, *Kingdom of Saudi Arabia.* Tel. +966 (1) 4671575. Fax. +966 (1) 4679493. E-mail: gkhairy@ksu.edu.sa

We have to admit that it was a wrong patient selection as he had huge aortic aneurysm, and distorted vascular anatomy with hugely dilated neck veins. All surgical procedures were performed using the da Vinci system (Intuitive Surgical, Mountain View, Ca, USA). This consists of 3 main parts: a 3-armed robotic cart, carrying the camera system and instruments, a 3-dimensional camera system, and a console where the operating surgeon is seated. The surgeon's elbows are supported by a bar, and his forehead resting on the console while he looks at a display providing a 3-D image. From the console, the operating surgeon can control both the robotic arms and the 3-dimensional camera system with 2 manipulators (pincer-like graspers) at the console. The da Vinci system was positioned precisely in a specific area according to the type of operation. The operating surgeon sits at the console, and the assistant will be at the operating table. He will be the one to introduce the Veress needle, the ports and other necessary tools. In cholecystectomy, for example, the assistant will retract the gallbladder, clip the cystic duct and artery and change the instruments as needed. Each trocar has a certain position according to the type of operation; in cholecystectomy, the camera trocar is introduced at the level of the umbilicus, the right robot arm trocar positioned in the left hypochondrium and the left arm in the right hypochondrial region. The time necessary for system setup and total operating room time, postoperative hospital stay and morbidity were recorded.

Results. Forty-two robot-assisted laparoscopic operations were performed. Twenty-three patients were male and 19 females, age ranging between 21-65 years. The most frequently performed procedures were robot-assisted cardiac procedures (n=25) and robot-assisted laparoscopic cholecystectomy (n=9). Other operations included: thymectomy (4), apical bullectomy (2), and one for each adrenalectomy and lung volume reduction. The median time to install and drape the robotic system was 15 minutes, and this was almost the same in all types of operations. This setup time decreased as the experience of the operating team increased, but the real operating time was not reduced significantly. In 2 patients (4.7%), the procedures (thymectomy, cholecystectomy) were converted to conventional thoracoscopy in the first case and open surgery in case of cholecystectomy due to arm position and distorted anatomy consecutively. The main hospital stay was 2 days. There were no mortalities, and one patient (cholecystectomy) developed postoperative superficial wound infection at the site of the port.

Discussion. George Kelling, in 1901 was the first to examine the intra-abdominal cavity with an endoscope, and Jacobaeus in 1911, reported the first large series of laparoscopic surgeries.[6] It was not until the invention of the video clip or Charged Coupling Device (CCD) in the mid 1980s that video laparoscope became possible and laparoscopy as we know it today began.[7] During the last decade it has become the treatment of choice for routinely performed surgical interventions in the abdomen, such as cholecystectomy. However, there are several limitations and drawbacks to conventional laparoscopy which prevented its use in many other surgical fields. These drawbacks include limited movement, the inability to perform high-precision sutures, unnatural positions for the surgeons, and flat vision.[8] Robotic surgery was thought to overcome these limitations and allow extension of minimally invasive surgery to an increasing number of patients.

These drawbacks initiated the search for tools to support the surgeon, by enhancing dexterity and visualization.[9] The concept of telemanipulation surgery was also developing concurrently to enable remote surgery. This would allow the surgeon to operate from a safe zone on "soldiers close to the battlefield" or, even in future, to perform surgery in space stations. The outcome of these efforts was the development of phototype systems that will enable the surgeon to work over a short distance, and a computer supporting the surgeons dexterity and vision in his operating room.[10]

As reviewed by Richard Satava, [11] the introduction of Robotics in surgery has evolved slowly over the past 11 years. Himpens and colleagues,[12] in March 1997 performed the first telesurgical laparoscopic cholecystectomy. Our institute used the da Vinci System for all robot-assisted laparoscopic procedures, and we found it much easier to handle especially performing dissection and suturing in small cavities, in comparison to conventional laparoscopy.

There are 18 different robotic instruments that belong to the da Vinci system that are appropriately called "endowrist instruments". The unique design of the instruments tip literally recreates the same flexible movements of a human wrist. This simulated wrist movement allows the laparoscopic surgeon the same 7 degrees of freedom of mobility as the human hand, at the tip of the laparoscopic instrument. This is opposed to the traditional laparoscopic instrument, which is limited by a fixed pivot point and only 5 degrees of freedom (1: in and out, 2: left and right; 3: up and down; 4: rotational; and 5: grip). In effect, maneuvering the da Vinci instruments is like miniaturizing your hands and wrists and placing them into cavities they normally could never fit into, thereby permitting the performance of delicate, precise dissection and suturing in the smallest cavity, through small skin incisions. Such advanced instrument tip capabilities overcome the limited degrees of freedom and fixed

trocar axis points found in today's standard laparoscopic instruments.[13-15]

The current study includes various procedures from different surgical specialities. Our experience, so far, allowed us not only to assess the feasibility of working with this novel technology but also the possibility of applying it in surgical fields where we never used laparoscopy. One of these areas where robotic surgery is transforming medicine and generating the most excitement is minimally invasive cardiac surgery.[16] Several groups have developed robotic procedures that expanded laparoscopic techniques into this previously unexplored territory, and with encouraging results.[17,18] Currently, we have carried out enough cases of left internal mammary artery (LIMA) harvesting using the robot in preparation for the next step (the anastomosis), which will be carried out using other standard suturing technique and magnetic coupler. In our institute we believe that robotic assistance will be of great help in the context of hybrid revascularization, a complex procedure in which surgeons and cardiologist work together in one room to revascularize the ischemic heart using combined surgical and interventional cardiology techniques. In this complex procedure the robot will first dissect the LIMA and to perform the anastomosis of that graft on the left anterior descending artery on a beating heart, a process which will be replaced very soon by using magnetic coupler to replace standard suturing techniques. After achieving this, the cardiologist will take over and dilate the other stenosed vessels using drug eluting stents. In the other surgical specialities, we expect that more complex surgical procedures will be performed using the robotic system. Inter-city telesurgery can be the next evolution in the near future, whereby patients can get the benefit of being operated by an expert surgeon in another city or even in another country.

In 2 patients (4.7%) we converted the procedures to conventional laparoscopy or open surgery due to technical difficulties and this is similar to conversion rates reported for standard laparoscopic surgery.[19,20] The main hospital stay was similar to that reported for standard laparoscopic procedures.[21]

Although setup is still an issue of concern in relatively short endoscopic procedures, it decreased to an average of 15 minutes in most of our procedures, as the operating team's gained more experience. The time loss should decrease further with improvement in the ergonomics of the system and in the design of operating theatres, to easily integrate the robotic systems.

Because the currently used systems are the first generation of robotic telemanipulators, several shortcomings still need to be addressed. The unanimous disadvantage is the lack of haptic feedback (force feedback) from using the robot.[22-25] All those using these procedures required eyesight to judge tension, which can lead to unnecessary perforations or suture tears. Also, the bulky and expensive computers need to be replaced by handheld instruments with the same hand and wrist-like instrument tips currently only seen with the robot. Finally, for the da Vinci system, the half-life of 10 cases for the instruments raises questions about the cost effectiveness of the system.

In conclusion, robot-assisted minimally invasive surgery is feasible, safe and has now become a reality and may become the surgical procedure of the future. More and more complex surgical procedures could be approached through small incisions. Robotic instruments and 3-D monitoring will become routine and continue to improve patient care by providing the surgeons with the most precise, least traumatic ways of treating surgical diseases.

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