ROBOTIC SURGERY: THE FUTURE OF MINIMAL INVASIVE SURGERY

Abstract

Robotic surgery is emerging as the latest technique in minimal invasive surgeries. Robotic surgery is performed using a robot-assisted surgery system, the robot being under the operative control of the surgeon. The robotic system currently being used is the leader-follower type, the da Vinci surgical system (intuitive surgery).This chapter describes not only the current state of robotic surgery but also the future development of robotic surgery systems in gastrointestinal, urological and other surgeries.

Keywords: Robotic Surgery, Invasive Surgery, da Vinci surgical system

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I. INTRODUCTION

Surgery is a large field which requires many minimal invasive surgeries mainly in gastrointestinal and urological surgeries. Laparoscopy has been widely accepted by surgeons world over, the 1990's having been the so called laparoscopic revolution. Surgeries like laparoscopic cholecystectomy have become the standard operative procedure for cholelethiasis mainly because of shorter hospital stays, reduced post operative morbidity and better cosmetic outcomes for the patients. However, complex procedures like pancreatectomy proved difficult to be performed laparoscopically due to technical issues. Only some new technology could overcome the limitations experienced by the surgeon in laparoscopic surgeries. Since beginning of 21st century, robotic surgery has proved to overcome the limitations of conventional laparoscopic surgeries and lead to future development in surgical field. Presently robotic surgery has been adopted by surgeons all over the world, mainly for urological surgeries, various gastrointestinal cancer surgeries and bariatric surgery.

The da vinci robotic system has been approved in the US since 2000. However, till 2009, not many surgeries were being performed by robotic system. Main fields of concern in using robotic systems was difficulty in operating the system , how useful it was as compared to laparoscopy ,cost factor , and installation and controlling the system. It was observed finally that robotic system operations were beneficial to patients because it required less hospitalization, better recovery and lesser incidences of deaths during operations. When applying criteria of Health Technology Assessment, robotic surgery has proved to be costly especially purchase and maintenance of technology and operating time is also more as compared to conventional approaches of surgery.

Robotic surgery has effectively addressed the limitations of laparoscopic and other minimal invasive procedures, it is expected to grow much more in coming years and 'almost all surgeries can and will be performed by robotic help in the future'. This will change the existing surgical training pattern, and will also require special training such as use of robotic simulators and telemonitoring.

II. WHAT IS ROBOTIC SURGERY?

Surgery is a large field which requires many minimal invasive surgeries mainly in gastrointestinal and urological surgeries. Laparoscopy has been widely accepted by surgeons in the 1990's, in fact there has been a so called laparoscopic revolution. Surgeries like laparoscopic cholecystectomy have become the standard operative procedure for cholelethiasis mainly because of shorter hospital stays, reduced post operative morbidity and better cosmetic outcomes for the patients. However, complex procedures like pancreatectomy proved difficult to be performed laparoscopically due to technical issues. Only some new technology could overcome the limitations experienced by the surgeon in laparoscopic surgeries. Since beginning of 21st century, robotic surgery has proved to overcome the limitations of conventional laparoscopic surgeries and lead to future development in surgical field. Presently robotic surgery is being adopted by surgeons all over the world, mainly for urological, cardiac, gynecologic, various gastrointestinal cancer surgeries and bariatric surgery.

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Robotic surgery has addressed the limitations of laparoscopic and other minimal invasive procedures to a large extent, and it is expected to expand much more in coming years. Almost all surgeries can and will be performed by robotic help in the future". This will change the existing surgical training pattern, and will also require special training such as use of robotic simulators and telemonitoring .

III. HISTORY OF ROBOTIC SURGERY

The history of robotic surgery started at NASA-National Aeronautics and Space Administration. The concept was developed by Scott Fisher who introduced the first head mounted display. This gave the viewer a three dimensional virtual environment. Engineer Phil Green then developed a system of robotic telemanipulation at Stanford Research Institute. In 2000, the da vinci system became commercially available in United states for use. Presently more than 1700 robotic systems have already been installed worldwide.

IV. CLINICAL APPLICATIONS OF ROBOTIC SURGERY

Robotic surgery has allowed surgeons to perform complex and advanced surgeries with more precision with minimal invasive procedures. In laparoscopy, surgeon has to stand and remain in specific positions throughout the surgery. Whereas in robotic surgery, surgeon is more comfortable, sitting on control console, thus less exerted physically. Laparoscopic camera gives the surgeon a two dimensional image, robotic surgery gives the surgeon a 3-dimensional view which helps the surgeon have better perception of surgical field , camera is also more steady and convenient. Robotic arm manipulation gives the surgeon a wider range of motion and he is able to carry on more complex surgical movements.

In a relatively short period of time, robotic surgery has taken over a wide spectrum of surgeries especially gastrointestinal and urological surgeries. Till date results have shown lower mortality, morbidity and hospital stay duration as compared to conventional laparoscopic operations. But still there are not enough studies on robotic surgery; more procedure specific trails have to be performed before robotic surgery can be widely accepted in everyday surgical practice.

V. LIMITATIONS OF ROBOTIC SURGERY

Limitations of laparoscopy	Robotic solutions
- Two- dimensional vision of surgical field	-Three dimensional view of field.
- Impaired depth perception	-proper depth perception

-	Movements in laparoscopy are counterintuitive	-movements are intuitive
-	Unstable camera held by assistant	-surgeon controls the camera
-	Uncomfortable position of surgeon	-surgeon comfortably seated on consol

Although robotic surgery is rapidly developing all over the world, it has not yet reached its full potential. The major concern is cost effectiveness. The major part of increased cost is the initial cost of purchasing the robot, estimated at about 25 crore with yearly maintenance of 1 crore. Both these are expected to decrease in coming years as more and more robotic surgeries are taken up by the surgeons. Operating time of robotic surgery and even decreased hospital stay will also ultimately contribute to the cost effectiveness of robotic surgery.

Other limitations include the bulky apparatus of robotic equipment currently being used. A bigger operating room of 24*24 is required for surgery. Additionally, there is lack of tactile feedback to the surgeon. Special training and more technical support is required in robotic surgery.

VI. ROBOTIC SURGICAL EDUCATION

Surgical training has not much changed for more than a century. Surgeons in training have always gained surgical Training through experience and supervised trial and error on patients. This training has its limitations that it requires more cases and surgical trained is quite prolonged. It also compromises patient's safety in hands of under training surgeons .Robotic surgery creates a new medium of acquiring surgical skill through simulation of all the surgeries that can be done by a robot. Surgical robots can help the surgical trainers by allowing the surgeons to practice procedure on reconstructions of anatomy of actual patients. Virtual reality visual stimulation and soft tissue models that can recreate the feel of human tissues will help the surgeons in getting ready for the surgery scheduled the next day on real patients. Trainee surgeons can even be guided through tele-monitoring. In tele- monitoring system, tele-robotic surgery can be done by a surgeon who operates the robotic arm from miles away. The surgeons commands are relayed to the surgical unit by fibre optic cables. The first tele-robotic surgery was Cholecystectomy performed by surgeons in NewYork on a patient in Strasbourg, France in 2001. Since then, many tele-robotic surgeries have been performed and many trainee surgeons have been educated all over the world with help of tele-monitoring systems.

VII. INDIAN SCENERIO IN ROBOTIC SURGERY

According to latest data, till end of October 2021, more than 76 robotic installations have been installed in India in government and private institutions. More than 500 surgeons have been trained to do robotic surgery and many are under training. There are nine systems in government-funded institutions, these include, All India Institute of Medical Sciences New Delhi, SGPGI Lucknow, PGIMER Chandigarh, All India Institute of Medical Sciences Rishikesh, All India Institute of Medical Sciences Jodhpur, Safdarjung Hospital New Delhi, Jawaharlal Institute of Post-Graduate Medical Education and Research and Delhi State Cancer Institute. Apart from government-funded institutions and medical colleges, India boasts a plethora of privately-run training institutes that proffer comprehensive instruction in the domain of robotic surgery, including training courses, fellowships, and observership. In

addition to formal training initiatives, junior faculty members and residents may also partake in informal training activities pertaining to robotic-assisted surgeries. At present, the prevailing modus operandi entails consultants embarking upon rigorous training regimens via robotic surgery fellowships, whereby they progressively transition from executing conventional open surgeries to conducting robotic-assisted procedures. Concurrently, as these consultants and faculty members transition their surgical practices, junior faculty, fellows, and residents acquire requisite proficiencies and invaluable hands-on experience through didactic learning and active involvement in such procedures. This trend reflects the widespread acceptance of robotic-assisted surgeries within the broader purview of the general public, as well as the collective endorsement extended by governmental and private entities alike.

Intuitive, the sponsor of the da Vinci robotic system offers a series of training courses that are necessary before using the robot in a clinical setting. These courses are divided into four phases: Phase 1 provides an introduction to da Vinci Technology, Phase 2 focuses on training participants in the technology itself, Phase 3 involves conducting initial case series, and Phase 4 emphasizes ongoing development. In addition to these training modules, Intuitive's platform also includes videos covering different surgical specialties.

India got its first urologic robotic installation at the All India Institute of Medical Sciences, New Delhi, in 2006. The following years have seen exponential growth of robotic surgeries in India.The robotic system being used at present is the da vinci X1,3rd generation. More than 500 surgeons have been trained in robotic surgery in India and more than 14000 surgeries have already been performed throughout India. Growth of robotic surgery in India is expected to be rapid and exponential because of the availability of a large number of cases, rapidly growing economy and expanding healthcare sector. The main concern is to bring down the cost of robotic installation, maintenance and surgery. The focus is on training the younger generations of surgeons in robotic surgery, surgeons are being sent for training to various centres like Cochin.

Figure 1: Robotic arm

Figure 2: Surgeon on Robotic Consol

Figure 3: The da Vinci Robotic Surgical System

Figure 4: Operating Robotic Surgical Unit at SMS Medical College and Hospital, Jaipur (Rajasthan) led by Dr. Rajendra Bagree, Sr. Professor.

VIII. CONCLUSION

Robotic surgery is fast developing but still in its infancy stage. Robotic surgery has improved the precision and dexterity of surgeons, allowing them to perform difficult operations that could not have been performed effectively with conventional laparoscopic approach. Robotic surgery has proven not only to be the safer option but also more favourable to the patients in regards to surgical morbidity and hospital stay. The main concern is the cost of equipment and its maintenance and technical training required to

operate the robotic system these concerns need to be resolved so that robotic surgery can become mainstream everyday surgical procedure.

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