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# APPLICABILITY OF ROBOTIC SURGERY FOR BETTER SURGICAL OUTCOME

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## ABSTRACT

In traditional open surgeries the post-operative infections are common complications with reduced clinical outcome. The major limitations associated with traditional surgeries are large incisions, increased operating time, surgical marks, blood loss and higher recovery time. After the introduction of laparoscopic surgery, the minimally invasive approach has become important in many surgical fields due to its advantages over open surgery. The laparoscopic surgery has drawback that it is stressful for surgeons because of its ergonomic discomfort. The robotic surgical system provides improved technologies including superior 3D views, improved dexterity with an internal connected EndoWrist that truly mimics the movement of surgeons hand, minimize tremor and ergonomic which make them superior to conventional laparoscopy. Thus it can facilitate technically demanding operations and maximize the comfort of surgeons. Robotic surgery has been rapidly adopted in many fields of surgery. The robotic assisted surgery is improving patient outcomes through improved precision, stability and dexterity.

**KEYWORDS:** Robotic surgery, laparoscopy, clinical outcomes, complication rate.

## INTRODUCTION

The post operative infections are most common complications after surgery and it leads to associated mortality and morbidity in open surgeries. According to Centre for Disease Control and Prevention (CDC), surgical site infection is the second most commonly reported hospital acquired infection. Recently the laparoscopy and robot assisted surgery have been used successfully because of their safety and efficacy.[1]

The minimally invasive technique has become popular in surgical procedures due to it's advantages over open procedures, like decreased hospital stay, reduced post operative pain, return to daily activities etc. The laparoscopic technique was introduced in 1980s.[2] The introduction of minimally invasive technique is one of the most important surgical advances in the last four decades. The benefits of this approach include decreased surgical trauma, improved cosmetic outcome, less post operative pain, reduced hospital stay and rapid return to normal activities. The robotic surgery is designed for greater dexterity and precision and it help to overcome the limitations of pre existing minimally invasive techniques and open surgery.

The successful use of robotic surgery has been fueled by rapid patient recovery time, reduced blood loss and less pain compared to traditional open surgery.[3] The robotic surgery field generates around 3 billion dollars per year and it is expected to grow 15% per year until 2022.[4] The da Vinci surgical system provide improved technologies with 3-D views and improved dexterity.[5] Robotic surgery has been rapidly adopted in various surgical procedures due to it's technical demanding and provide maximum comfort of surgeon.[6] A recent cohort study including 169404 patients reported that the use of robotic surgery was increased from 1.8% to 15.1% during the 2012 to 2018. Also after the adoption of robotic surgery, the performance of laparoscopic technique declined 0.3%.[7]

## HISTORY OF ROBOTIC SURGERY

Robot surgery was first performed in 1985 by Kwoh et.al using Puma 560, a robot to perform neuro surgical biopsies with greater precision. Puma 560 was again used after three years by Davies et.al to conduct trans urethral resection of prostate. This leads to the development of PROBOT (1988), a robot designed for prostate surgery. In 1992 ROBODOC was introduced by Integrated Surgical Supplies Ltd. for hip replacement surgeries. The first surgical robot approved by FDA was ROBODOC.[8] The concept of robotic telepresence technology was introduced by Stanford Research Institute, the Department of Defence and the National Aeronautics and Space Administration.[9] In 1990's a robotic system ARTEMIS, developed with a surgeon console and two robotic arms have greater degrees of freedom.[10] A voice controlled robotic endoscope, AESOP was introduced in 1994 and it was followed by ZEUS system, the first fully integrated robotic surgical

system. In 1997, the da Vinci surgical system released and it was approved by FDA in 2000. It is the commercially available robot for minimally invasive surgery.[11] The MARO Robotic Interactive Orthopaedic Arm and Acrobot systems were released subsequently. In 2008 Neuroarm introduced was the first image guided magnetic resonance imagining-compatible robotic device capable of performing neurosurgical procedures.[12] The da Vinci Si was launched in 2009.

## TECHNOLOGY IN ROBOTIC SURGERY

The general surgical robotic system consist of three parts: a patient-side robot, a vision cart, and the robotic master console. The operation is conducted through remote master console by surgeon using a combination of hand controls and foot pedals. The camera movement and horizontal orientation is controlled using one foot pedal and the focus is controlled by next pedal. The next pedal is designed with a clutching mechanism that help in repositioning of hand controls. The monopolar and bipolar energy sources is controlled by another set of pedals. Patient-side cart is wheeled in between the patient's legs, and the robotic arms are attached to stainless steel robotic trocars through docking. The hand controls regulate the two robotic instruments or camera at a time. From the master console the surgeon is capable of manipulating, repositioning, grasping, retracting, cutting, dissecting, coagulating, and suturing. A three-dimensional imaging is arranged in master console through a stereoscopic viewer. A bedside assistant is required in robot-assisted cases to perform the instrument exchanges, suction and irrigation, suture introduction and retrieval, and additional retraction.[13] (figure1)

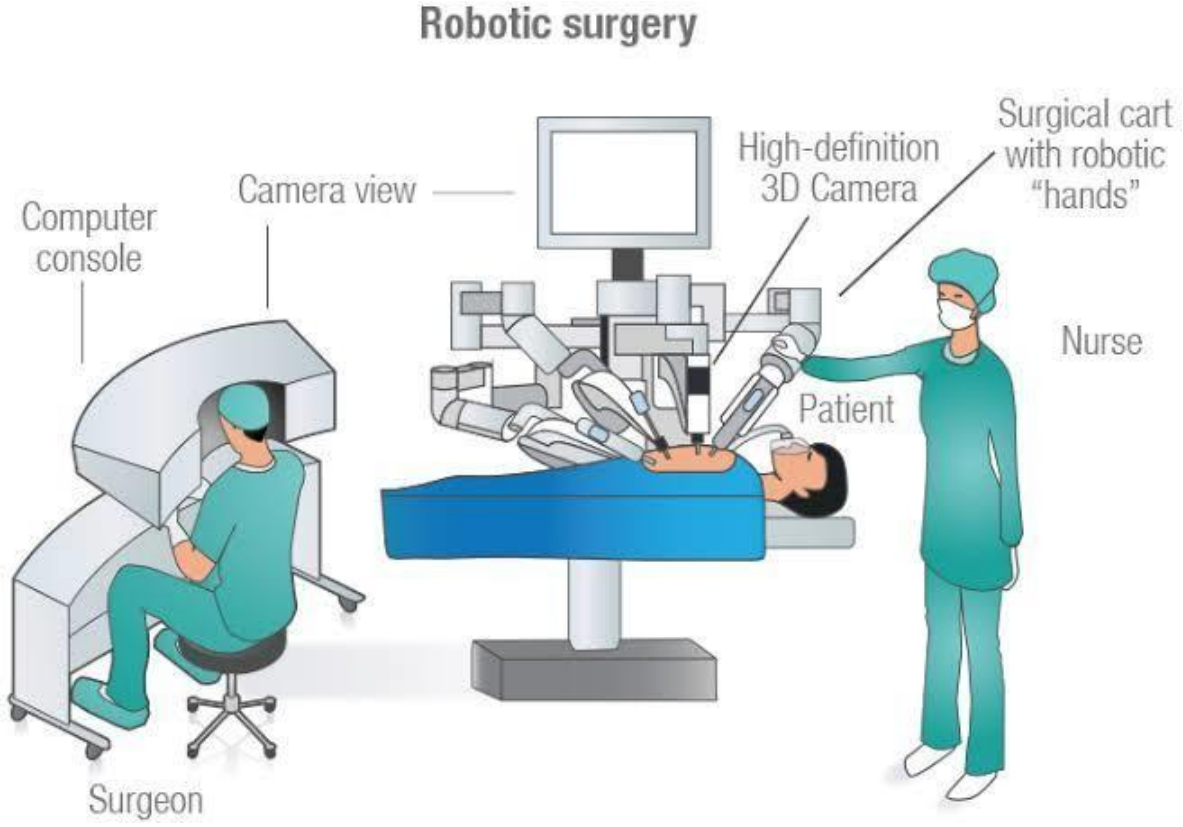


**Fig. 1: Robotic surgery.**

## CLINICAL EFFECTIVENESS

Robotic surgery provide better precision and accuracy in clinical procedure because of its 3D dexterity and it offer less surgical complications.[14] The recent surgical procedures using robotic system indicates decreased postoperative surgical and non-surgical complications, reduced blood loss, better recovery rates, and reduced length of stay in comparison with open surgery.[15] The increased length of surgery time is the one concern regarding the robotic assisted surgery.[16] In some specialities the robotic surgery in obese patients are reported to have reduced operative time compared with open surgery.[17] In geriatric patients robotic surgery produce better outcome with reduced complications and length of hospital stay.[18] Various studies in robotic surgery among different specialities shown that there is no difference in outcome between younger and older patient found that age alone is not a risk factor.[19] Robotic technique enables complex procedures with complete physical fitness in shorter duration of time and these make this technique more adopted.[20]

A systematic review conducted through the literatures of robotic surgery for past 30 years conclude that robotic surgery has lower blood loss at 50.5%, reduced transfusion rate at 27.2%, decreased length of hospital

stay at 69.5%, and reduction of complications rate at 63.7% when compared to open surgery. Operative time is 7.3% higher than the open surgery.[21]

## COST EFFECTIVENESS

Cost of robotic surgery depends on a number of different variables like type of procedures, cost attribution, facility, surgical volume etc. A retrospective study conducted to compare the cost of robotic surgery with their laparoscopic technique reported that robotic surgery creates higher cost. The higher cost is associated with the cost of equipment and the increased surgical volume make it cost effective. The reduced length of hospital stay make robotic surgery cost advantage.[22]

The investment for acquiring robotic technology is high, and to reduce the cost the institutions should maximize caseloads, if possible keep the robot operational for longer and use it for multiple indications, especially those with high potential impact on patient outcome and cost savings. Cost minimization analysis of robotic radial prostatectomy reported that shorter length of stay reduces the hospitalization cost compared to open and laparoscopic surgery.[23]

## SURGICAL APPLICATIONS

- **Neurosurgery**

In neurology the robotic surgery improved the feasibility and effectiveness of complex procedures. Recently sophisticated systems are introduced for procedures like brain tumour removal, deep electrode placement for stereo electro encephalopathy recording etc.[24]

- **Orthopaedic surgery**

Orthopaedic is the one of the first area were robotic surgery is applied. The use of robotic systems has increased with short term surgical outcomes when compared with traditional orthopaedic procedures.

- **Gastric surgery**

Various studies shown that the robotic surgery in gastric cancer is safe and has better patient outcome in postoperative oral intake, hospital stay and complication rate.[25] Also the surgery require longer operative time and is more expensive.[26] Robotic surgery is also applied in the field of bariatric surgery.

- **Colorectal surgery**

In colorectal surgery the robotic system has applied in rectal cancer surgery. Because the surgical robots are focused in complex procedures or in surgeries that are difficult to perform using laparoscopic approach.[27]

- **Liver surgery**

A study performed to compare the clinical outcome and cost in liver surgery reported that robotic liver resection had reduced blood loss, morbidity, ICU and hospital stay. This leads to decreased cost for robotic surgery. The liver resection using robotic surgery is financially comparable to open procedure.[28]

- **Endocrine surgery**

Reports shown that robotic thyroidectomy is safe with excellent cosmesis. The short term outcomes are comparable with endoscopic or open thyroidectomy in terms of complication, including permanent recurrent laryngeal nerve injury.[29]

- **Cardiac surgery**

Using da Vinci robotic system the Total Endoscopic Coronary Artery Bypass (TECAB) can be performed with reduced postoperative pain, better cosmesis, and faster healing.[30] The cardiac robotic surgery is successful with better patient satisfaction.

- **Gynaecologic surgery**

In gynaecology the application of robotic surgery is in oncology. The study revealed that the surgery result in reduced blood loss and shorter duration of hospital stay. The operative time is comparable to open surgery and is associated with less complication rate.[13]

## COST/BENEFIT ANALYSIS OF ROBOTIC SURGERY

- **Length of hospital stay**

Length of stay is influenced by post -operative pain, Peri- operative blood loss and complication rates. The robot assisted surgeries are associated with reduced post operative length of stay compared to the open surgery. A observational cohort study reported that the robotic prostatectomy was experienced with shorter length of hospital stay than open prostatectomy.[23] The decreased length of stay counterbalance the increased operative room cost associated with robotic surgery.

- **Blood loss and transfusion rates**

Several studies evidence that robotically performed surgeries are associated with reduced blood loss and transfusion rates.

- **Cost of robotic surgery**

The cost of robotic surgery include capital acquisition cost, training expense for health care professionals, equipment maintenance, repair of equipment and operating room setup time. The cost for robotic surgery is high compared to other surgical techniques, bu**t** the reduced complication rate and better clinical outcome make it more feasible.

- **Incidence of complications**

The robotic surgery reduces the complication rates compared to other minimally invasive procedures and open surgery.

- **Operative time**

Robotic surgery was reported to be associated with reduced operative time than laparoscopic prostatectomy and increased operative time compared with open hysterectomy and prostatectomy.

- **Patient return to usual activity**

The robotic surgical procedure may have rapid return to their normal life and better patient outcome compared to their open or minimal invasive technique.

## CONCLUSION

The robotic surgery has expanded the range of minimally invasive surgery and it leads to new surgical demands. In robotic assisted surgeries only the operating time is higher than the traditional open surgeries. On the other hand the blood loss, complication rate, length of hospital stay are reduced. Robotic assisted surgery leads to improved surgical outcome in healthcare industry. This technique have the potential to improve safety and effectiveness of surgeries.

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