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Surgery

ROBOTIC SURGERY: FUTURE OF SURGERY

Dr Madhav Madhsudan Singh — Commanding officer , 322 Fd Hospital C/O 56 APO

Dr Amita Jain* — Classified Surgeon And Assoc Prof Army college of medical sciences , New Delhi
*Corresponding Author

Maj Gen (Dr) Mahavir Singh VSM Retd — Dean , Amity Medical School , Gurugram , Harayana

ABSTRACT It has been nearly 20 years since the first appearance of robotics in the operating room. In that time, much progress has been made in integrating robotic technologies with surgical instrumentation, as evidenced by the many thousands of successful robot-assisted cases. Robotic technology offers the unique opportunity to control the operational process outside the actual location, with the skilled and often expert operators not necessarily being physically present.

KEYWORDS : Robotic Surgery, Application, Limitation, SWOT analysis

INTRODUCTION

A surgical robot is a self-powered, computer-controlled device that can be programmed to aid in the positioning and manipulation of surgical instruments, enabling the surgeon to carry out more complex tasks.

Two master-slave systems have received approval by the US Food and Drug Administration (FDA) and are in use[1,2] – the *da Vinci* Surgical System (Intuitive Surgical, Mountain View, California[3,4] and the *ZEUS* system (Computer Motion, Goleta, California). Each system has 2 basic components linked together through data cables and a computer[5]:

- *The surgeon's master console* is the robot's user interface that provides the master surgeon with the following functions:
- A 3-dimensional view of the surgical field relayed from an endoscopic camera inside the patients body in control of the robot that creates a sense of being "immersed" into the surgical field.
- Master manipulators, which are handles or joysticks that the surgeon uses to make surgical movements that are then translated into real-time movements of the slave manipulators docked on the patient. Motion scaling (conversion of large natural movements to ultraprecise micromovements) and tremor filtering increase accuracy and precision of the surgeon's movements.[6]
- A control panel to adjust other functions, such as focusing of the camera, motion scaling, and accessory units.
- *Patient-side slave robotic manipulators* are robotic arms that manipulate the surgical instruments and the camera through laparoscopic ports connected to the patient's body. The *da Vinci* system handles surgical instruments with microarticulations near the tip (*EndoWrist*) that can duplicate motions of the human wrist, including rotation (7 degrees of freedom, ie, the greatest possible motion around a joint).

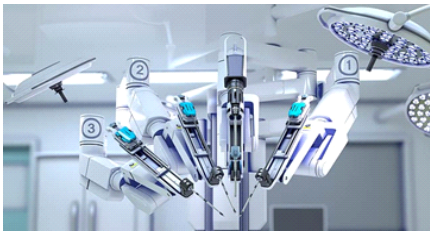

Fig 1: Robotic Arm

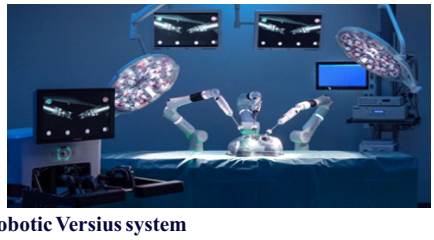

Fig 2: Robotic Versius system

Clinical Applications of Robotic Surgery[7]

A large number of clinical applications are available or performed across the globe as under:

Robot-assisted cardiac surgery :

- Atrial Septal Defect Repair
- Coronary Artery Bypass Surgery
- Hybrid Coronary Artery Bypass and Angioplasty
- Mitral Valve Repair
- Robotic Adhesiolysis
- Robotic Cryoablation

Robotic Gastroenterologic Surgery :

- Adrenal Gland Resection
- Bile Duct Resection
- Colon Resection
- Gastric Resection
- Pancreatic Resection
- Partial Liver Resection
- Rectal Resection
- Splenectomy
- Antireflux operations, Heller's myotomy, gastric bypass, gastrojejunostomy, esophojectomy, gastric banding colectomy.

Robotic Thoracic Surgery:

Mediastinal

- Biopsy of Tumors
- Removal of Pericardial Cysts
- Removal of Tumors and Cysts
- Thymectomy
- pericardiectomy, lobectomies, and tumor enucleations

Esophageal

- Esophagectomy
- Esophageal Myotomy
- Fundoplication (for GERD/Acid Reflux)
- Hiatal Hernia Repair
- Resection of Esophageal Diverticulum

Lung Cancer

- Lobectomy with Lymph Node Dissection
- Lung Nodule Biopsy
- Segmental Resection with Lymph Node Dissection
- Wedge Resection with Lymph Node Dissection

Robotic Gynecologic Surgery :

- Complex Pelvic Dissections
- Fertility-Sparing Surgery for Gynecologic Cancers
- Hysterectomy
- Lymph Node Dissections

- Myomectomy
- Oophorectomy/Salpingectomy
- Radical Hysterectomy
- Radical Resection of Endometriosis
- Radical Trachelectomy
- Risk-Reduction Surgery
- Supracervical Hysterectomy
- Staging Procedures for Gynecologic Cancers
- Microsurgical fallopian tube reanastomosis

Robotic Genitourinary surgery[8] :
- Open retropubic radical prostatectomy is the gold standard treatment for localised prostate cancer.
- Nephrectomy and pelvic lymph node dissection

Robotic pediatric surgery[9]:
- Pyeloplasty for ureteropelvic junction obstruction, antireflux procedures for gastroesophageal reflux disease
- Pediatric congenital heart diseases, such as ligation of patent ductus arteriosus

Cost-effectiveness

An important issue in robotic surgery are the higher costs compared with regular surgery. Several costs comparisons have been made in the past few years. The latest robotic da Vinci S system will cost approximately € 1.5 million in Europe plus € 150.000 yearly for maintenance. Instruments are available at approximately € 250 per instrument used, however, price changes are expected with current currency fluctuations.

Laparoscopic Limitations/Robotic Solutions

Robotic surgery has successfully addressed the limitations of traditional laparoscopic and thoracoscopic surgery,] thus allowing completion of complex and advanced surgical procedures with increased precision in a minimally invasive approach.

Table 1 : Laparoscopic Limitations/Robotic Solutions

Laparoscopic Problems/ Limitations	Robotic Surgery Solutions/ Potential
Two-dimensional vision of surgical field displayed on the monitor impairs depth perception	Binocular systems and polarizing filters create 3-dimensional view of the field
Movements are counterintuitive (ie, moving the instrument to the right appears to the left on the screen due to mirror-image effect)	Movements are intuitive (ie, moving the control to the right produces a movement to the right on the viewer)
Unstable camera held by an assistant	Surgeon controls camera held in position by robotic arm, allowing solo surgery
Diminished degrees of freedom of straight laparoscopic instruments	Microwrists near the tip that mimic the motion of the human wrist
Surgeon forced to adopt uncomfortable postures during operation	Superior operative ergonomics: surgeon comfortably seated on the control console
Steep learning curve	Shorter learning curve

Advantage of Robotic surgery

With the introduction of the ZEUS robotic surgical system (Computer Motion), the ability to remotely operate laparoscopic instruments became a reality. US Food and Drug Administration approval in July 2000 of the da Vinci robotic surgical system (Intuitive Surgical, Sunnyvale, CA) further defined the ability of a robotic-assist device to address limitations in laparoscopy. This includes a significant improvement in instrument dexterity, dampening of natural hand tremors, three-dimensional visualization, ergonomics, and camera stability. As experience with robotic technology increased and its applications to advanced laparoscopic procedures have become more understood, more procedures have been performed with robotic assistance.

- Better InSIte_ vision (3D)
- Digital camera zoom
- Camera stability
- Improved dexterity
- Decreased operative time
- Elimination of fulcrum effect
- Better ergonomics for surgeon
- Motion scaling
- Elimination of physiological hand tremor
- Telesurgery possible
- Telementoring possible
- Least complication
- Relatively less pain and faster recovery compared to open surgery
- Surgery more accurate and precise than open or standard non-robotic laparoscopic prostate surgery.
- less blood loss and shorter hospital stay

Limitations of Robotic Surgery

Some of important limitations are

- Absolute higher cost for robotic operations
- Bulkiness of the robotic equipment
- Lack of tactile and force feedback to the surgeon
- Procedure is highly technical.
- High costs
- Maintenance system
- Bulky size of the robotic system
- Sometimes difficult access to patient
- Separation surgeon from the operating field
- No tactile feedback
- Chance of breakdown
- Use of 8 mm ports
- Monopoly of single market leader
- Robotic surgery (efficacy, costs and training)
- Adverse effects are rare, include incontinence, erectile dysfunction, possible formation of blood clots in the leg veins, and infection.

SWOT ANALYSIS OF ROBOTIC SURGERY

Strengths

- Economies of Scale
- Unique Technology
- Niche Market Leader
- No fulcrum constraint
- Less invasive comparing to the main competitor
- Less bulky
- Good combination between precision and gross movement Integrated vision system
- 2 vision systems − Application of diagnostic sensors intraoperatively through the working channel
- Bimanual robot with high dexterity
- Less invasive comparing to the main competitor
- Less bulky externally
- More dofs

Weakness

- Still Big incision
- Missing high frequency coagulation system
- Changeable End effectors
- Stapling
- Lack of Pneumoperitoneum
- Technological constraints (miniaturization, electrical insulation,..)
- Cleaning and sterilization
- Limited workspace
- Integration of standard instrumentation
- Safety issues

Opportunity

- New surgical procedures can arise
- Collect new incomes (new patients coming to the hospital)
- Hospital /surgeons participating to leading edge research projects
- Improve healthcare delivery
- Advantages in suturing
- Use new technologies/reputation/marketing chance for their resume
- Big market − No real competitor on the market of robotic single port surgery

Threat

- Continuous focus on technological advancements
- Threat of negative publicity due to one mishap/accident
- Big new training sessions for the surgeons and assistants
- New procedures for cleaning, sterilization, set-up, to de defined
- Not yet defined outcome for all the surgical procedures
- IP − Big competitors − Long time to market (need for cashflow coverage)

CONCLUSION

Although still in its infancy, robotic surgery is a cutting-edge development in surgery that will have far-reaching implications. While improving precision and dexterity, this emerging technology allows surgeons to perform operations that were traditionally not amenable to minimal access techniques. As a result, the benefits of minimal access surgery may be applicable to a wider range of procedures. Robotic surgery has demonstrated some clear benefits. It remains to be seen where these benefits will outweigh the associated costs over the long term. In the future, surgical robots should be smaller, less expensive, easier to operate, and should seamlessly integrate emerging technologies from a number of different fields. Such advances will enable continued progress in surgical instrumentation and, ultimately, surgical care[10]. It is recommended that the surgeon performing robotic laparoscopic prostatectomy have done at least 200 of these procedures. The procedure should be done at centers of excellence, supporting high tech robotic programs.

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