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Review Article

Surgery Section

Robotic-assisted Surgery and its Impact on Patient Outcomes: A Narrative Review

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ABSTRACT

Robotic-assisted surgery is an advanced surgical technique that combines the skill of a surgeon with the precision and capabilities of robotic systems. This approach has revolutionised the field of medicine by providing enhanced visualisation, improved dexterity, and greater control during surgical procedures.The most widely used robotic system is the da Vinci surgical System, which allows surgeons to perform minimally invasive surgeries with smaller incisions, reduced blood loss, and faster recovery time for patients. Robotic-assisted surgery has been successfully applied in various specialities, including gynaecology, urology, general surgery, and thoracic surgery. It offers benefits such as enhanced surgical precision, better outcomes, and improved postoperative quality of life. However, the decision to use robotic-assisted surgery depends on factors such as patient suitability, surgeon expertise, and the availability of robotic systems. Ongoing advancements in robotic technology continue to shape the future of surgical practice, with the potential for further improvements in surgical techniques and patient care. Overall, robotic-assisted surgery represents a significant milestone in surgical innovation, providing a promising approach to improve surgical outcomes and patient well-being. The present narrative review describes the effect of robotic surgery in different disciplines and its effects on surgical outcomes.

Keywords: Colorectal, Da Vinci, Gynaecology, Myomectomy, Prostate, Thoracic

INTRODUCTION

Surgery is a medical speciality that has been practiced for centuries and has evolved significantly over time with advancements in technology, anaesthesia, and surgical techniques. The primary goal of surgery is to improve a patient's health or quality of life by physically altering or repairing a part of their body. Surgeries can be broadly categorised into two main types: elective and emergency. Elective surgeries are planned in advance and are usually not urgent, allowing both the patient and the surgical team to prepare adequately [1-4]. Surgical procedures can be performed using traditional open techniques or minimally invasive approaches.

Open Surgical Procedure

Open surgery involves making a larger incision to access the affected area directly, while minimally invasive surgery involves making smaller incisions and using specialised instruments, cameras, and video monitors to guide the surgeon. Minimally invasive techniques often result in less pain, shorter hospital stays, and faster recovery time for patients [5]. Advancements in surgical techniques and technology have revolutionised the field of surgery. For instance, robotic-assisted surgery allows surgeons to perform complex procedures with enhanced precision and control. Additionally, techniques such as laparoscopy, endoscopy, and arthroscopy have enabled less invasive treatment options for various conditions [4].

Minimally Invasive Surgical Procedure

A number of significant technical developments in surgery during the past several years have revolutionised the discipline and enhanced patient outcomes. These methods entail employing tiny incisions, specialised tools, and cameras to carry out surgical procedures. Robotic surgery has become increasingly popular. Surgical accuracy, dexterity, and visualisation are improved for surgeons using robotic devices like the da Vinci Surgical System. The surgeon may operate from a console with a 3D image of the surgical site, and the robotic arms are capable of performing complex motions. The surgical disciplines of urology, gynaecology, general surgery, and cardiothoracic surgery have all utilised this technique [5]. Image-guided surgery has been made possible by advancements in imaging technologies, including Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and ultrasound. Real-time imaging allows surgeons to accurately find and target regions of interest during operations. In neurosurgery, orthopaedic surgery, and several cancer operations, this technology is extremely useful. Surgical navigation systems direct surgeons through surgeries by using computerised tracking and imaging techniques [6]. These technologies offer immediate input on how surgical tools are situated in relation to the anatomy of the patient. They improve accuracy and lower the likelihood of problems in complicated procedures like spine surgery and joint replacement. Single-Incision Laparoscopic Surgery, often known as SILS, is a specialised type of minimally invasive surgery that entails carrying out the whole treatment through a single, tiny incision, frequently buried within the navel [7]. The benefit of this method is that it leaves almost no scars and further reduces bodily damage. The development of patient-specific models, implants, and surgical guidance is now possible because to 3D printing technology. With continual research and development, the discipline is always changing with the goal of further advancing surgical procedures, promoting patient safety, and improving surgical results [8]. Robotic-assisted surgery minimises the risk of human error, which is why it is necessary to have the in depth knowledge about the procedure. Also, robotic-assisted surgeries are only deployed in specific surgeries, therefore more comprehensive studies are required for extending its usage to other unexplored medical and surgical procedures.

DISCUSSION

Robotic-assisted Surgeries

Overall, surgery plays a critical role in modern medicine, offering life-saving interventions, alleviating symptoms, and improving the quality of life for countless individuals worldwide Robotic-assisted surgery, also known as robot-assisted surgery, is an advanced surgical technique that combines the expertise of a surgeon with the precision and capabilities of robotic systems. It involves the use of robotic platforms to assist surgeons in performing complex procedures with enhanced accuracy, control, and visualisation. In robotic-assisted surgery, the surgeon controls the robotic system from a console, using hand and finger movements to manipulate robotic arms equipped with surgical instruments [9]. The system

translates the surgeon's movements into precise actions performed by the robotic arms, which are capable of rotating, bending, and manoeuvring with a high degree of dexterity. The surgeon views the surgical site in real-time through a magnified 3D high-definition camera, providing a detailed and immersive visualisation of the operative field. One of the key components of robotic-assisted surgery is the surgical robot itself. The most well-known and widely used robotic surgical system is the da Vinci Surgical System, developed by Intuitive Surgical. The da Vinci system consists of a console where the surgeon sits, robotic arms that hold and manipulate the surgical instruments, and a vision system that provides a magnified view of the surgical site [10,11].

Robotic system allows for precise and delicate movements, reducing the risk of human errors and providing greater surgical accuracy. The high-definition 3D camera provides a detailed view of the surgical site, enabling the surgeon to see anatomical structures more clearly. The robotic arms can rotate and bend with a wider range of motion than the human hand, allowing for improved manoeuvrability in tight spaces. Robotic-assisted surgery often requires smaller incisions compared to traditional open surgery, resulting in less scarring, reduced blood loss, and faster recovery times for patients. The robotic system can reduce any human error that may occur due to jerky or tremulous hand movement that may arise during prolonged surgeries. Robotic-assisted surgery has the potential for remote or telesurgery, where a surgeon can operate on a patient in a different location using the robotic system. This can be particularly valuable in cases where specialised expertise is not locally available. It's important to note that robotic-assisted surgery is not entirely autonomous. The robotic system is controlled by the surgeon throughout the procedure, and the surgeon remains in complete control of all actions performed by the robot [9].

Robotics in Urosurgery

A minimally invasive surgical approach used to treat prostate cancer is robotic prostate surgery, more precisely robotic-assisted radical prostatectomy. The treatment makes use of a robotic surgical technology, such as the da Vinci Surgical technology, to help the physician remove the prostate gland with precision and control. A whole prostate gland, including the malignant tissue, is removed during a robotic-assisted radical prostatectomy. During the surgery, the robotic technology gives the surgeon better visualisation, dexterity, and tool control. Robotic prostate surgery attempts to reduce the possibility of developing erectile dysfunction after surgery, hence, nerve preservation is a crucial component of the procedure. The robotic device enhances the surgeon's capacity to spare the nerves while removing the prostate by enabling accurate dissection and identification of the nerves. To determine whether cancer has progressed beyond the prostate, a lymph node dissection may occasionally be carried out during robotic prostate surgery. This aids in estimating the disease's severity and directing future therapy choices. A thorough dissection of the lymph nodes is made possible by the robotic system's better visualisation and exact instrument control [11].

Compared to open surgery, robotic prostate surgery has a number of benefits, including smaller incisions, less blood loss, a decreased chance of complications, shorter hospital stays, and quicker recovery periods. The robotic technology gives the surgeon more accuracy and manoeuvrability, enabling more precise prostate removal with less harm to the surrounding tissues. Robotic prostate surgery demands a surgeon with advanced training and skills. It's crucial to remember that whether or not a patient chooses to have robotic prostate surgery relies on a number of variables, including the cancer's stage and severity, the patient's general health, and personal preferences [12,13].

Robotic kidney surgery, more particularly robotic-assisted radical and partial nephrectomies, is a minimally invasive surgical technique used to treat a variety of kidney disorders, including kidney cancer and some benign kidney tumours. A robotic surgical device, such as the da Vinci Surgical device, is used during the procedure to help the physician execute precise and controlled surgery on the kidneys. Robotic-assisted partial nephrectomy is a surgical operation used to remove part of the kidney, while leaving the healthy kidney tissue in place. It is frequently used to treat tiny kidney tumours or tumours that are located in a way that avoids the need to completely remove the kidney. Precision dissection, suturing, and preservation of the blood arteries feeding the kidney are all made possible by the robotic system. The main objective of partial nephrectomy is to preserve kidney function, and robotic assistance makes it easier to remove tumours precisely while causing the least amount of harm to healthy kidney tissue [14,15].

In situations where kidney cancer has advanced or for bigger tumours that cannot be adequately treated with partial nephrectomy, robotic-assisted radical nephrectomy entails the total removal of the kidney, along with any surrounding tissues or lymph nodes. During the surgery, the robotic system gives the surgeon better visibility, dexterity, and control, enabling careful dissection and removal of the kidney and related tissues. Renal reconstruction may need difficult reconstructive treatments, such as mending or reconstructing the arteries or urine collecting system. The surgeon may complete complex reconstructive procedures with the robotic system's accuracy and manoeuvrability while retaining maximal renal function [15].

Robotics in Surgical Gastroenterology

In situations of oesophageal cancer or serious benign diseases, a robotic oesophagectomy is a minimally invasive surgical operation used to remove all or a portion of the oesophagus. Compared to conventional open surgery, the robotic technology enables accurate oesophageal dissection and repair with a wider range of motion. The use of robotic arms by surgeons to access difficult-to-reach places and carry out precise suturing leads to better results and fewer problems [16-19].

It's crucial to remember that the accessibility and suitability of robotic-assisted treatments, such as oesophagectomy and enucleation, might differ based on the particular medical facility, the level of surgical skill, and patient characteristics. Based on the needs of each patient and the advice of the surgical team, the decision to proceed with robotic surgery is taken [20].

A minimally invasive surgical technique called robotic colorectal surgery, or more particularly robotic-assisted colorectal surgery, is used to treat a variety of colorectal disorders, such as colorectal cancer, inflammatory bowel disease, and benign colorectal tumours. A robotic surgical device, such the da Vinci Surgical device, is used during the procedure to help the physician execute precise and controlled surgery on the colon and rectum. Depending on the exact problem being treated, a section of the colon or rectum may be removed during robotic-assisted colorectal surgery. During the surgery, the robotic technology gives the surgeon better visualisation, dexterity, and tool control. To implant robotic arms fitted with surgical tools and a high-definition 3D camera, small abdominal incisions are created. Surgery using robotic assistance is becoming more common for the treatment of colorectal cancer. It may entail techniques like robotic-assisted Total Mesorectal Excision (TME) or robotic-assisted low anterior resection. These procedures try to preserve as much good intestinal tissue as they can while removing the malignant tissue. Precision dissection and suturing are made possible by the robotic technology, improving results and lowering problems. Robotic-assisted surgery can be used to treat inflammatory bowel diseases like Crohn's disease or ulcerative colitis. To remove the diseased colon or rectum, surgeons may use techniques like proctocolectomy

or robotic-assisted colectomy. The features of the robotic system enable accurate surgical manoeuvres and aid in attaining the best results. Rectal prolapse, diverticulitis, and other benign colorectal disorders are among the benign colorectal conditions that can be treated using robotic surgery. The exact removal of polyps and repair of the afflicted regions made possible by the robotic technology enhance patient outcomes and lower hazards [21].

Robotics in Gynaecology

Robotic gynaecologic surgery is the practice of conducting different gynaecological treatments using robotic equipment [19]. Robotic assistance may be used during hysterectomy, a surgical procedure to remove the uterus. The robotic technology enables a careful and exact dissection, improving the preservation of nearby structures and lowering the possibility of problems [20].

Myomectomy is a surgical treatment that removes uterine fibroids while leaving the uterus intact. The robotic system's improved vision and dexterity make it possible to remove fibroids more precisely. Compared to open surgery, this less invasive method has fewer scars, quicker recovery periods, and greater fertility preservation [21]. Endometriosis lesions can be excised or removed with robotic assistance. The endometrial implants may be precisely dissected and removed using the robotic system, causing the least amount of harm to the surrounding healthy tissue. The affected person may get excellent symptom reduction and an improvement in quality of life after robotic endometriosis surgery [20,22-24].

A surgical treatment known as a sacrocolpopexy is performed to treat pelvic organ prolapse, a condition in which the vagina or other pelvic organs sink or protrude from their natural placements. The robotic system is used in robotic-assisted sacro colpopexy to link a synthetic mesh to the sacrum and the top of the vagina in order to give support and restore the natural anatomy. Sacrocolpopexy performed robotically has benefits including enhanced visualisation, exact mesh implantation, and less postoperative discomfort [23-27].

The usage of robotic-assisted surgery is growing in the field of gynaecologic oncology. Procedures like robotic-assisted radical hysterectomy and lymphadenectomy for early-stage cervical cancer or robotic-assisted staging and debulking operations for ovarian cancer are just a few examples [28]. The features of the robotic system allow surgeons to carry out intricate treatments with higher accuracy and less invasiveness, improving patient outcomes. Plan of treatment varies depending upon the stage of disease and operability and varies from patient to patient [29-32]. Following are some studies that show success and progress in robotic-assisted surgeries [Table/Fig-1] [33-37].

Author	Year	Type	Conclusion
Park JS et al., [33]	2023	Randomised controlled trial	Robotic-assisted surgery did not substantially enhance the Total Mesorectal Excision (TME) quality compared to traditional laparoscopic surgery in individuals with intermediate or low rectal cancer.
Roh HF et al., [34]	2018	Systematic review and meta-analysis	With the exception of decreased predicted blood loss, robot-assisted laparoscopic surgery does not produce statistically superior treatment results while having greater operating costs. With conventional laparoscopic surgery the operating time and overall complication rate are much better.
Zeuschner P et al., [35]	2021	Cohort study	Robotic-assisted surgery demonstrated considerably improved results, especially with intracorporeal urinary diversion, in this large single-centre study comparing robotic-assisted surgery with open radical cystectomy while correcting for stage selection bias and surgical expertise.
Li A et al., [36]	2023	Prospective cohort study	In the near term, robotic-assisted surgery helped to enhance quality of life, with physical health reverting to its preoperative level and mental health improving across specialities.
Gu Z et al., [37]	2022	Retrospective cohort study	Bi-port robotic-assisted lobectomy was safe and showed potential effectiveness in patients with early stage operable lung cancer when compared to multi-port Robotic-Assisted Thoracic Surgery (RATS).

[Table/Fig-1]: Robotic-assisted surgery studies [33-37].

CONCLUSION(S)

In conclusion, robotic-assisted surgery has completely changed the way medicine is practised, benefiting both patients and doctors in multiple ways. The introduction of robotic devices, such the da Vinci Surgical System, has boosted surgical precision, improved visualisation, and dexterity, enabling for the more precise and controlled completion of difficult surgeries. Numerous specialities, including gynaecology, urology, general surgery, thoracic surgery, and more, have successfully used robotic-assisted surgery. Robotic assistance has tremendously helped procedures, including hysterectomy, prostatectomy, nephrectomy, and colorectal surgery, resulting in smaller incisions, less blood loss, shorter hospital stays, and quicker recovery periods for patients.

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