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# AI TECHNOLOGIES AND MODERN ROBOTICS IN SURGERY

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**Abstract:** in this article we will discuss about robotic surgery. Its evolution, principles, benefits and challenges, also about its future.

**Key words:** robotic surgery, robot-assisted surgery, surgery, laparoscopy, biopsy, telepresence, telemanipulations, robotic arm, incisions.

Each year 313 million classical surgeries are performed while over 12 million robotic surgery procedures were completed in the whole world until this day. Comparing to traditional surgeries it is noticeably evident which is massively different. According to the Cleveland Clinic's statistics up to 94% of the robot-assistant surgeries are successful, compared to traditional surgeries where the percentage is lower for 10-15% which is notable difference.

Robotic surgery allows doctors to perform many types of complex procedures with more precision, flexibility and control than is possible with traditional procedures. Robotic surgery is often performed through tiny incisions. But sometimes it's used in open surgeries.

Most often, a robotic surgery system includes a camera arm and mechanical arms with surgical instruments attached to them. The surgeon controls the arms while seated at a control center, called a console, near the operating table. The surgeon sees a magnified, high-definition, 3D views of the surgical site.

The surgeon leads other team members who assist during the operation.

Robotic surgery doesn't replace your surgeon. It's just one of many methods they use to do procedures. In fact, research shows that robotic surgery offers similar outcomes to laparoscopic surgery.

Although the term and existence of "robots'' is relatively new, the idea of autonomously operating machines can be dated for centuries. The term "robot" was concepted by Joseph Capek in 1921, in his play Rossom's Universal Robots, which originally came from the Czech word "robota", meaning "labor". The term rapidly became corrupted to reflect a machine-oriented repetitive task. Computer assistance, robotics, automation, and virtual reality are quite new concepts, and more recently they have been applied to healthcare assistance. The last decades have witnessed an exponential growth in medical technology, with the robotic platform applied to surgery one of its most remarkable events. Robots were used in the surgical

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world more than 30 years ago, and have become a new standard of care, yielding interesting results.
First used for surgical disciplines with fixed anatomical landmarks, such as neurosurgery and orthopedics. The Programmable Universal Machine for Assembly (PUMA), an industrial robot developed by Unimation (Westinghouse Electric, Pittsburgh, PA) was used in 1985 to manipulate surgical instruments for stereotactic brain biopsies and then for resection of astrocytomas of the thalamus. In 1992, the ROBODOC orthopedic system (Integrated Surgical Systems Inc., Sacramento, CA) was used to perform total hip replacements in order to increase the precision of the milling of the femoral cavity, programmed preoperatively based on imaging, and updated in real time based on perioperative data.
The history of robotic surgery started with the concept of telepresence developed by virtual reality pioneer Scott Fisher at the National Aeronautics and Space Administration (NASA) Ames Research Center. He developed the first head mounted display (HMD), which immersed the viewer in a three-dimensional (3D) virtual environment. At the instigation of plastic surgeon Joseph Rosen, engineer Phil Green developed a system of robotic telemanipulation for microsurgery at Stanford Research Institute (SRI). The combination of these two ideas – telepresence and robotized telemanipulation – mark the beginning of telesurgery, or remote surgery, a concept that the US Army would later make use of to try to develop a system capable of performing remote surgical procedures in a hostile environment, such as a battlefield. Green and Rosen developed a prototype at SRI for use in hand surgery to microsuture blood vessels and nerves. This system consists of a control console connected to a surgical unit for remote manipulation of interchangeable instruments with force feedback, and 3D visualization of the surgical field on a high definition screen .
The first model of the robotic arm approved in 1994 for usage, the AESOP 1000, was controlled using pedals. Its future generation, the AESOP 2000 designed 2 years later, replaced the pedals with a voice control system, allowing the surgeon to have control of the endoscope, providing a ‘‘third hand”. By using its voice, the AESOP 2000 eliminated the necessity of an assistant to hold the endoscope. The platform evolved to AESOP 3000 increasing the degrees of freedom, and had its final platform with the AESOP HR (HERMES Ready), having integrated voice control and functions such as operating room lighting and movement of the operating table. When idealized, the robotic AESOP was designed to improve image stability and reduce the medical personnel required in the operating room, showing numerous documented advantages over traditional human-assisted camera holding, especially replacing the need for a surgical assistant who may become fatigued during long procedures. Not completely satisfied, however, the surgical procedures demanded not only the concept of telemanipulation of the video camera but also surgeons’ movements.
A Robotic-assisted surgery benefits for the surgeon is better visualization which causes an enhanced dexterity, leading to a more precise surgery.
Currently, surgical robot systems serve to supplement and augment a surgeon’s skills. The main part of the device uses robotic arms fitted with tiny laparoscopic clamps that can be fitted with various tools to aid in the operation of minimally invasive surgical procedures.
The surgeon operates the device from a nearby terminal using precise controls. The controls are designed to mimic the hand movements of the surgeon so even complex procedures can be performed through minimally invasive incisions.

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The controls are also programmed to compensate for and filter out any hand tremors from the operating surgeon. The robotic arms are also designed to mimic the functionality of the human wrist, meaning that surgeons can perform complex movements with precision.
Robotic surgery has many applications. Specifically, robotic surgery is often used to make complex procedures easier to perform. Examples of robot-assisted surgical procedures include:
→ Robotic kidney surgery
→ Robotic prostate surgery
→ Robotic colorectal surgery
→ Robotic coronary artery bypass
→ Robot-assisted cancer surgery
→ Robotic cardiac surgery
→ Gallbladder removal
→ Hysterectomy
→ Kidney transplant
→ Kidney removal (total or partial)
→ Single-site robotic gallbladder surgery
→ Head-and-neck surgery
→ Joint replacement surgery
Robotic surgery offers many benefits to patients compared to open surgery. Robotic-assisted procedures are typically minimally invasive, requiring only small incisions, which leads to less blood loss, reduced pain, and lower risk of infections compared to traditional open surgeries. This results in shorter hospital stays and faster recovery times, allowing patients to return to their daily activities much sooner. Another major benefit is the improved visualization that robotic systems provide; high-definition, 3D cameras offer magnified views of the surgical site, enabling more precise operations even in delicate procedures such as cardiac, neurosurgical, and oncological surgeries. Furthermore, robotic surgery reduces surgeon fatigue, as the system's ergonomic design allows for better posture and comfort during lengthy procedures.
Despite its numerous advantages, robotic surgery has several limitations that hinder its widespread adoption. One of the most significant challenges is its high cost, as robotic surgical systems, such as the da Vinci Surgical System, require millions of dollars for initial investment, along with high maintenance expenses and specialized training programs for surgeons. This leads to limited availability, especially in developing countries and smaller hospitals that cannot afford such systems. Additionally, robotic surgery faces technical limitations, including the lack of tactile feedback, which makes it difficult for surgeons to assess tissue resistance, and the risk of system malfunctions, such as software glitches or power failures, which could impact patient safety. Furthermore, mastering robotic-assisted surgery requires a steep learning curve, making it challenging for even experienced surgeons to transition from traditional techniques. Another drawback is the longer setup time, as robotic systems require careful calibration before procedures, which can delay emergency surgeries. Moreover, robotic surgery is not suitable for all procedures, as certain complex operations still require direct manual intervention. Lastly, the lack of standardization across different robotic systems makes training and adaptation difficult. While technological advancements continue to address these challenges, robotic surgery still has significant barriers to overcome before becoming universally accessible and fully autonomous.

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The future of robotic surgery is promising, with advancements in artificial intelligence (AI), automation, miniaturization, and telesurgery set to revolutionize the field. One of the most anticipated developments is the integration of AI-driven decision support systems, which will assist surgeons by analyzing real-time data, predicting complications, and enhancing precision. Fully autonomous robotic surgery is also a possibility, where AI could perform specific procedures with minimal human intervention, reducing the risk of human error. Another key trend is the miniaturization of robotic systems, allowing for even less invasive procedures. The development of microrobots and nanorobots could enable precise interventions inside the body, potentially eliminating the need for large incisions altogether. Additionally, telesurgery (remote surgery) is expected to expand, enabling expert surgeons to perform procedures on patients in different parts of the world using advanced robotic systems and 5G technology. This could be especially beneficial for patients in rural or underserved areas who lack access to specialized surgeons. Moreover, ongoing improvements in haptic feedback technology will address one of the current limitations of robotic surgery by allowing surgeons to "feel" tissues virtually, improving surgical precision. However, challenges such as high costs, ethical concerns, and regulatory approvals will need to be addressed for these technologies to become mainstream. As research and innovation continue, robotic surgery is likely to become more accessible, efficient, and safe, fundamentally transforming the way surgeries are performed and expanding the possibilities of modern medicine.

In conclusion robotic surgery has transformed modern medicine by enhancing precision, reducing recovery times, and improving surgical outcomes. Despite its benefits, challenges like high costs and technical limitations hinder widespread adoption. However, with advancements in AI, automation, and telesurgery, the future holds great promise. As technology evolves, robotic surgery is set to become more accessible and efficient, shaping the future of healthcare.

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