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Robotic-Assisted Surgery in Oncology: Advancements, Clinical Benefits, Challenges, and Future Perspectives

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Abstract: *Cancer remains one of the leading causes of mortality worldwide, creating an increasing demand for innovative treatment approaches that improve patient outcomes while minimizing surgical complications. Among the most significant technological advancements in modern medicine is robotic-assisted surgery, which has transformed oncologic procedures through enhanced precision, improved visualization, and minimally invasive techniques. Robotic surgical systems combine advanced robotics, computer science, medical imaging, and artificial intelligence to assist surgeons in performing highly complex procedures with greater accuracy than conventional techniques. Their adoption has expanded rapidly across various oncological specialties, including urology, gynaecology, thoracic surgery, colorectal surgery, and head and neck surgery.*

This paper presents a comprehensive review of robotic-assisted surgery in oncology by examining its historical development, technological evolution, clinical applications, advantages, limitations, and future prospects. The paper also discusses the growing integration of artificial intelligence, machine learning, image-guided navigation, and digital technologies that are shaping the next generation of robotic surgical platforms. Furthermore, economic considerations, ethical concerns, accessibility challenges, and future research directions are analysed. While robotic surgery has demonstrated numerous perioperative benefits such as reduced blood loss, shorter hospital stays, faster recovery, and improved surgical precision, challenges including high implementation costs, prolonged learning curves, limited tactile feedback, and unequal global accessibility continue to influence its adoption. The review concludes that robotic-assisted surgery will remain a fundamental component of precision oncology as technological innovation continues to improve both clinical outcomes and healthcare efficiency.

Keywords: Oncology, Robotic Surgery, Surgical Robotics, Artificial Intelligence, Computer-Assisted Surgery, Cancer Treatment, Minimally Invasive Surgery, Precision Medicine.

I. INTRODUCTION

Cancer continues to represent one of the most significant global health challenges. According to the World Health Organization (WHO), millions of new cancer cases are diagnosed each year, and cancer remains among the leading causes of death worldwide [1], [2]. Population aging, environmental factors, unhealthy lifestyles, genetic predisposition, and improved diagnostic capabilities have all contributed to the increasing prevalence of various cancers [1]–[3]. As the global cancer burden rises, healthcare systems require innovative technologies capable of improving treatment effectiveness while reducing patient morbidity [1], [3].

Surgery remains the primary treatment option for many localized solid tumours [3]. The objective of oncologic surgery is the complete removal of malignant tissue while preserving healthy organs and minimizing damage to surrounding anatomical structures. Traditionally, cancer surgery was performed using open surgical techniques that required large

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incisions, prolonged hospitalization, significant postoperative pain, increased blood loss, and lengthy recovery periods [4], [5]. Although these procedures achieved favourable oncological outcomes, they often resulted in higher complication rates and reduced quality of life during postoperative recovery [4], [5].

The introduction of minimally invasive laparoscopic surgery represented a major advancement in surgical oncology by reducing incision size, postoperative pain, and hospital stay [4], [5]. However, conventional laparoscopy presents several technical limitations. Surgeons operate using rigid instruments with limited degrees of freedom while viewing a two-dimensional monitor [4], [5]. These limitations may reduce precision during complex oncologic procedures performed in anatomically confined regions such as the pelvis or thoracic cavity [4], [6], [7].

Robotic-assisted surgery was developed to overcome many of these challenges [4], [8]. Rather than replacing surgeons, robotic systems function as highly sophisticated computer-controlled instruments that accurately translate the surgeon's hand movements into precise instrument actions [4], [8]. Modern robotic platforms incorporate three-dimensional high-definition visualization, tremor elimination, articulated instruments with multiple degrees of freedom, motion scaling, ergonomic surgeon consoles, and advanced imaging integration [4], [9]. These capabilities enable surgeons to perform delicate dissections and reconstructions with enhanced control and accuracy [4], [6], [8].

The introduction of the da Vinci Surgical System in the early 2000s marked a significant milestone in the evolution of robotic surgery [4], [9]. Since then, robotic-assisted procedures have become increasingly common across numerous surgical specialties, particularly oncology [6], [7], [9]–[11]. Today, robotic surgery is routinely used in the treatment of prostate, colorectal, gynaecologic, thoracic, renal, liver, pancreatic, and head and neck cancers [6], [7], [9]–[11]. Continuous advances in robotics, computer vision, artificial intelligence, and machine learning have further expanded the capabilities of these systems, positioning robotic surgery as a cornerstone of precision medicine [12]–[15].

From a software engineering perspective, robotic-assisted surgery represents the convergence of several advanced technologies, including real-time operating systems, robotic control algorithms, computer vision, image processing, sensor fusion, artificial intelligence, cloud computing, cybersecurity, and data analytics [8], [14]–[16]. Modern surgical robots process vast amounts of information from imaging devices, surgical instruments, and patient monitoring systems in real time, enabling surgeons to make informed decisions during complex procedures [8], [14], [15]. Consequently, robotic oncology has become an interdisciplinary field that integrates medicine, robotics, software engineering, biomedical engineering, and artificial intelligence [8], [12], [14], [15].

Despite its many advantages, robotic-assisted surgery also faces significant challenges. High acquisition and maintenance costs, limited accessibility in low-resource healthcare settings, steep learning curves for surgeons, and concerns regarding long-term cost-effectiveness continue to influence widespread adoption [4], [15], [17]. Furthermore, ongoing ethical and regulatory discussions address issues such as patient safety, data privacy, software reliability, cybersecurity, and the future role of autonomous robotic systems in clinical practice [14]–[16].

The primary objective of this review is to examine the current state of robotic-assisted surgery in oncology by evaluating its technological evolution, clinical applications, benefits, limitations, market growth, and future developments. Special emphasis is placed on the integration of software technologies and artificial intelligence, highlighting their growing role in improving surgical precision, clinical decision-making, and personalized cancer treatment [12]–[15].

Review approach. This narrative review draws on peer-reviewed literature, institutional publications, and technical resources concerning robotic-assisted surgery in oncology. The manuscript describes searches of PubMed, IEEE Xplore, and Google Scholar using combinations of the terms robotic surgery, surgical robotics, oncology, artificial intelligence, and minimally invasive surgery, with English-language material from 2000 to 2025 prioritized. Because a reproducible search log, complete search strings, screening counts, and formal risk-of-bias assessment are not reported, the review should be interpreted as narrative rather than systematic. No meta-analysis was performed.

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II. LITERATURE REVIEW

Robotic-assisted surgery has attracted substantial research attention over the last two decades due to its potential to improve surgical precision, reduce complications, and enhance patient outcomes [4], [6]–[8], [10], [11], [13], [14]. Numerous clinical studies, systematic reviews, and meta-analyses have evaluated its effectiveness across various oncological specialties [6], [7], [10], [11], [13], [14].

Taylor et al. laid the foundation for computer-integrated surgery by describing the role of robotics in enhancing surgical accuracy through advanced sensing, imaging, and robotic manipulation [8]. Their work emphasized the importance of integrating robotics with computer-assisted navigation and real-time visualization to improve surgical performance [8].

Evidence on robotic-assisted radical prostatectomy has been reviewed extensively. Contemporary reviews describe favorable perioperative outcomes compared with open surgery in some settings, but functional recovery and cancer-control outcomes depend on patient selection, surgeon experience, and the comparator procedure. Robotic surgery should therefore not be described as universally superior to open or laparoscopic surgery [6], [7].

Evidence for robotic colorectal surgery is procedure-specific. Robotic platforms offer wristed instruments and three-dimensional visualization that can be useful in confined pelvic anatomy, but randomized and comparative evidence does not show a uniform advantage for every outcome or every colorectal procedure. Operative time, conversion, complications, and recovery vary with case complexity and team experience [6], [7], [10], [11].

Robotic approaches are used in selected gynecologic oncology procedures, including hysterectomy and lymph-node assessment. Their potential advantages include minimally invasive access and instrument articulation; however, comparative outcomes vary by cancer type, stage, surgical procedure, and the experience of the clinical team. Claims of lower morbidity or superior oncologic outcomes should be supported by procedure-specific evidence [6], [7], [10], [11].

Robotic-assisted thoracic procedures are used for selected lung and mediastinal operations. Three-dimensional visualization and articulated instruments may facilitate dissection in anatomically restricted spaces, but operative time, complications, recovery, and oncologic outcomes depend on the operation and comparator. These benefits should not be generalized to every thoracic cancer procedure [6], [7], [11].

Research is examining how artificial intelligence can support surgical planning, image analysis, workflow recognition, risk assessment, and postoperative review. These applications remain at different stages of development and clinical validation; performance in experimental datasets does not by itself establish improved patient outcomes. Validation, transparency, and assessment in real clinical workflows remain important requirements [12], [13], [14].

Digital technologies—including image-guided navigation, augmented reality, and surgical data analytics—may help clinicians visualize anatomy and plan selected procedures. Their clinical value depends on registration accuracy, workflow integration, usability, and validation for the particular operation. Evidence for augmented reality in orthopedic and maxillofacial oncologic surgery is developing, and findings should not automatically be generalized to all cancer specialties [13], [18].

Reported barriers include acquisition and maintenance costs, instrument and consumable expenses, training requirements, limited tactile feedback in many systems, and uncertainty about cost-effectiveness across procedures and health systems. Reviews also identify a need for stronger long-term evidence on recurrence, survival, quality of life, and costs [6], [7], [10], [11], [17].

Overall, the literature supports robotic-assisted surgery as an established approach for selected oncologic procedures, but it does not support a blanket claim that it is superior for every cancer or outcome. Continued collaboration among clinicians, engineers, and researchers is needed to evaluate safety, patient-centred outcomes, cost-effectiveness, and equitable access [6]–[8], [10]–[14].

III. EVOLUTION OF ROBOTIC SURGERY IN ONCOLOGY

The evolution of robotic-assisted surgery represents one of the most significant technological advancements in modern healthcare [4], [5], [8]. The integration of robotics into surgery has been driven by the need to improve surgical

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precision, reduce patient trauma, and overcome the limitations of conventional minimally invasive procedures [4], [8]. What began as research into remotely operated medical systems has evolved into sophisticated robotic platforms capable of assisting surgeons during highly complex oncological operations [5], [8], [19]. Fig. 1 summarizes this evolution.

A. Early Development of Surgical Robotics

The origins of robotic surgery can be traced to the late 1980s and early 1990s when researchers explored robotic technologies for military and space medicine [5], [19]. The United States National Aeronautics and Space Administration (NASA) and the Defense Advanced Research Projects Agency (DARPA) investigated the possibility of performing remote surgeries on astronauts and injured soldiers located far from specialized medical facilities [19], [20]. These early initiatives introduced the concept of telepresence surgery, where a surgeon could operate on a patient remotely using robotic manipulators [19], [20].

Although remote surgery was the initial objective, researchers soon recognized that robotic systems could significantly enhance conventional surgical procedures by improving precision, stability, and visualization [5], [8], [19]. This realization shifted research toward the development of robotic systems designed to assist surgeons rather than replace them [4], [5], [8].

The first commercially successful robotic surgical systems emerged during the late 1990s [4], [19]. These systems demonstrated that robotic technology could safely perform minimally invasive procedures while improving surgeon ergonomics and instrument control [4], [5].

B. Emergence of Robotic-Assisted Surgery in Oncology

Cancer surgery often involves operating in confined anatomical regions surrounded by delicate nerves, blood vessels, and vital organs. Even minor inaccuracies can affect postoperative function and long-term patient outcomes [6], [7], [10]. Consequently, oncology became one of the earliest specialties to benefit from robotic-assisted surgery [4], [6].

The introduction of robotic systems enabled surgeons to perform precise dissections while minimizing tissue trauma [4], [6], [8]. Procedures that were technically difficult using laparoscopic instruments became more manageable due to robotic articulation, motion scaling, and enhanced visualization [4], [9].

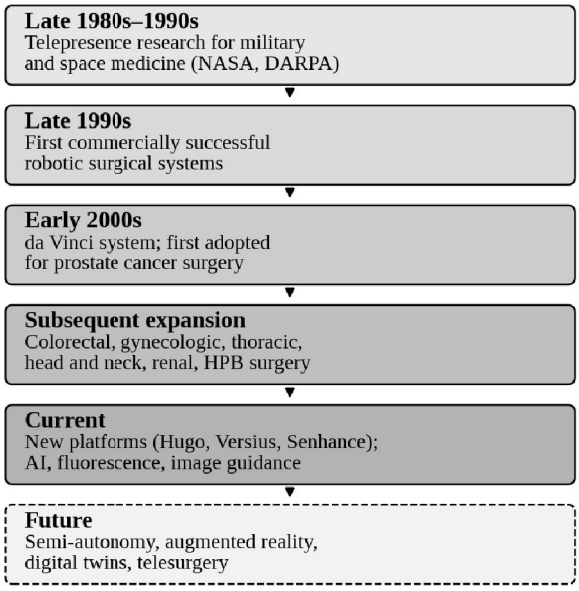

Fig. 1. Evolution of robotic-assisted surgery in oncology.

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Initially, robotic surgery was primarily adopted for prostate cancer because the pelvic cavity presents considerable anatomical challenges [4], [6]. Positive clinical outcomes encouraged expansion into colorectal surgery, gynaecological oncology, thoracic surgery, hepatobiliary surgery, urological oncology, and head and neck cancer [6], [7], [9]–[11].
Robotic-assisted surgery is available for selected oncologic procedures in many specialist centres, but adoption and clinical indications vary across health systems and cancer types. Availability should not be equated with universal suitability or proven superiority over other surgical approaches [6], [7], [10], [11].

C. Technological Advancements

Modern robotic surgery has progressed far beyond simple robotic arms [8], [14], [15]. Contemporary systems integrate multiple advanced technologies that work simultaneously during surgical procedures [8], [9], [14], [15].
These include:

- High-definition three-dimensional imaging [9]
- Computer vision algorithms [13], [14]
- Real-time motion scaling [4], [9]
- Tremor filtration [4], [9]
- Fluorescence-guided imaging [9]
- Artificial intelligence-based image analysis [12]–[14]
- Augmented reality overlays [18]
- Integrated patient imaging [8], [18]
- Digital data recording [14], [15]
- Cloud-supported surgical analytics [14], [15]

These technologies collectively improve surgical precision while reducing surgeon fatigue during lengthy procedures [4], [8], [9].
Recent advances in graphics processing units (GPUs), high-speed processors, and artificial intelligence have significantly enhanced robotic performance [13]–[15]. Surgical systems are increasingly capable of recognizing anatomical landmarks, highlighting blood vessels, and assisting surgeons during complex dissections [13], [14], [18].
Future robotic systems are expected to incorporate predictive analytics capable of identifying potential complications before they occur [12]–[14].

D. Software Architecture in Robotic Surgery

Unlike conventional surgical equipment, robotic systems rely heavily on sophisticated software [8], [14]–[16]. Software serves as the communication bridge between the surgeon's console, robotic arms, imaging devices, sensors, and patient monitoring systems [8], [15].
The software architecture typically includes several interconnected modules (Fig. 2):

1. User Interface Module
2. Motion Control Algorithms
3. Instrument Tracking
4. Image Processing Engine
5. Computer Vision Module
6. Safety Monitoring System
7. Artificial Intelligence Support Module
8. Data Storage and Analytics
9. Network Communication Layer
10. Cybersecurity Framework [8], [14]–[16]

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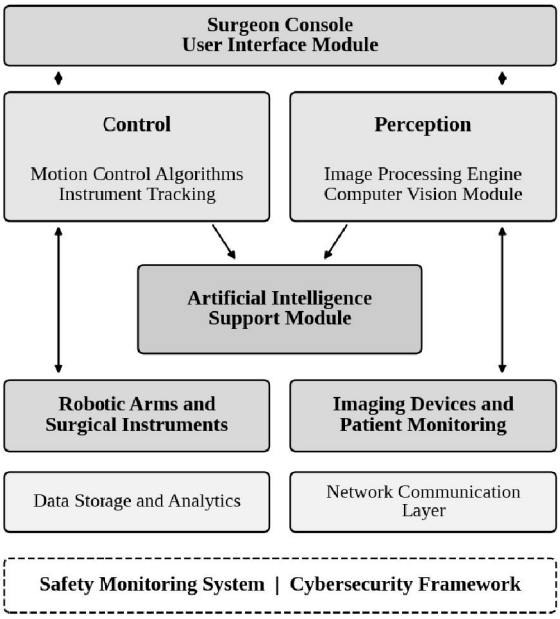

Fig. 2. Simplified software architecture of a robotic surgical system.

Real-time operating systems ensure that every surgeon movement is translated into accurate robotic motion with extremely low latency. Modern robotic systems process thousands of sensor inputs every second to maintain surgical accuracy and patient safety [8], [14], [15].

Machine learning algorithms are also beginning to analyze previous surgical procedures, enabling intelligent recommendations during future operations [12]–[14].

IV. ROBOTIC SURGICAL SYSTEMS USED IN ONCOLOGY

Several robotic surgical platforms have been developed for clinical use. Although they differ in design, all aim to improve surgical precision while supporting minimally invasive techniques [4], [8], [9], [15].

A. da Vinci Surgical System

The da Vinci Surgical System is currently the most widely used robotic platform in oncologic surgery [4], [9]. Developed by Intuitive Surgical, it has transformed minimally invasive cancer surgery across multiple specialties [4], [9].

The system consists of four major components [4], [9]:

- Surgeon Console
- Patient Cart
- Robotic Arms
- Vision Cart

The surgeon sits comfortably at the console while controlling robotic instruments through master controllers. The robotic arms reproduce every hand movement with remarkable precision while filtering natural hand tremors [4], [9].

Key features include:

- Three-dimensional high-definition visualization [9]
- Seven degrees of instrument freedom [4], [9]
- Motion scaling [4], [9]
- Tremor elimination [4], [9]
- Wristed instruments [4], [9]

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- Integrated fluorescence imaging [9]

Applications include:

- Radical prostatectomy [6], [9]
- Partial nephrectomy [9]
- Hysterectomy [9], [10]
- Colectomy [7], [9]
- Lung lobectomy [9], [11]
- Oropharyngeal tumour removal (Transoral Robotic Surgery) [9]

B. Hugo Robotic-Assisted Surgery System

The Hugo Robotic-Assisted Surgery (RAS) System represents one of the newest entrants into the surgical robotics market [15].

Unlike traditional integrated robotic platforms, Hugo features independent robotic arm carts that can be positioned individually according to surgical requirements [15].

Advantages include:

- Flexible operating room setup [15]
- Modular architecture [15]
- Improved portability [15]
- Advanced digital visualization [15]
- Reduced equipment footprint [15]

The system has demonstrated promising results in urological and gynaecological oncology and continues to expand into additional cancer procedures [15].

C. Versius Surgical Robot

Developed by CMR Surgical, Versius emphasizes surgeon ergonomics and accessibility [15].

Unlike larger robotic platforms, Versius uses compact robotic arms that mimic natural human arm movements [15].

Important characteristics include:

- Portable robotic arms [15]
- Modular design [15]
- High-definition visualization [15]
- Improved ergonomics [15]
- Smaller operating room requirements [15]

Its flexible architecture makes it particularly attractive for hospitals seeking robotic capabilities without major infrastructure modifications [15].

D. Senhance Surgical System

The Senhance Surgical System incorporates several innovative technologies that distinguish it from earlier robotic platforms [15].

These include:

- Eye-tracking camera control [15]
- Haptic feedback [15]
- Reusable instruments [15]
- Open surgical console [15]
- High-definition imaging [15]

One notable advantage is the inclusion of tactile feedback, allowing surgeons to experience resistance while manipulating tissues—a capability absent in many robotic systems [4], [15].

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E. Emerging Robotic Technologies

Beyond commercially available systems, researchers are developing next-generation robotic technologies designed specifically for oncology [12]–[15].

1) AI-Assisted Surgical Robots

Artificial intelligence algorithms analyze real-time surgical video to identify organs, nerves, blood vessels, and tumor margins [12]–[14].

- Potential benefits include:
- Improved safety [13], [14]
- Reduced complications [12], [13]
- Enhanced surgical planning [14]
- Intelligent instrument guidance [13], [14]

2) Image-Guided Robotic Surgery

Image-guided systems integrate MRI, CT, PET, and ultrasound imaging directly into robotic surgery [8], [18]. This allows surgeons to visualize hidden tumors and critical structures during operations [18].

- Applications include:
- Brain tumors [18]
- Liver tumors [18]
- Pancreatic cancer [18]
- Kidney cancer [18]

3) Augmented Reality Surgery

Augmented reality overlays digital anatomical models onto the surgeon's field of view [18].

Benefits include:

- Better spatial awareness [18]
- Improved tumor localization [18]
- Enhanced blood vessel identification [18]
- Safer dissections [18]

4) Autonomous Robotic Assistance

Current surgical robots remain fully surgeon-controlled [4], [8], [15]. However, researchers are developing semi-autonomous systems capable of assisting with repetitive tasks such as [13], [14]:

- Suturing [13], [14]
- Needle positioning [13], [14]
- Tissue tracking [13], [14]
- Camera navigation [13], [14]
- Instrument positioning [13], [14]

Although fully autonomous cancer surgery remains experimental, these developments indicate the future direction of robotic oncology [12]–[15].

Table I: Comparison of Open, Laparoscopic, and Robotic Surgery

Parameter	Open Surgery	Laparo-scopic Surgery	Robotic Surgery
Incision Size	Large	Small	Small
Blood Loss	High	Moderate	Low
Recovery Time	Long	Moderate	Short
Hospital Stay	Long	Moderate	Short
Visualization	Direct Vision	2D/HD Camera	3D HD Magnified Vision
Instrument Movement	Human Hand	Limited	Seven Degrees of Freedom
Precision	Moderate	High	Very High

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Surgeon Fatigue	High	Moderate	Low
Tremor Elimination	No	No	Yes
Learning Curve	Moderate	High	High
Equipment Cost	Low	Moderate	Very High
AI Integration	None	Limited	High

The comparison highlights that robotic-assisted surgery combines the benefits of minimally invasive techniques with advanced computer-assisted technologies. While the initial investment and training requirements are considerable, the enhanced precision, visualization, and ergonomics make robotic systems particularly valuable for complex oncologic procedures where surgical accuracy directly influences patient outcomes [4], [6], [8], [9].

V. APPLICATIONS OF ROBOTIC-ASSISTED SURGERY IN ONCOLOGY

Robotic-assisted surgery has expanded across several oncologic specialties, including urology, gynecology, colorectal surgery, thoracic surgery, and selected hepatopancreatobiliary and head-and-neck procedures [6], [7], [10], [11]. Three-dimensional visualization and articulated instruments can assist surgeons in anatomically restricted spaces. However, the magnitude of any perioperative benefit differs by procedure and comparator, while long-term oncologic outcomes remain incompletely established for some applications [6], [7], [10], [11].

A. Prostate Cancer

Prostate cancer remains one of the most common cancers among men worldwide and was one of the earliest diseases to benefit from robotic-assisted surgery [1], [6]. Radical prostatectomy requires meticulous dissection around delicate neurovascular bundles responsible for urinary continence and erectile function. Damage to these structures can significantly affect postoperative quality of life [6].

Robotic-assisted radical prostatectomy provides surgeons with magnified three-dimensional visualization and wristed instruments capable of fine movements within the confined pelvic cavity. Motion scaling and tremor filtration further enhance precision during nerve-sparing procedures [4], [6], [9].

For robotic-assisted radical prostatectomy, evidence suggests that some perioperative outcomes may be more favorable than with open surgery, including blood loss and length of stay. Functional outcomes such as continence and sexual function are influenced by baseline patient factors, nerve-sparing feasibility, surgeon experience, and follow-up duration. Available evidence does not establish universal superiority in cancer control over other established approaches [6], [7].

B. Colorectal Cancer

Colorectal cancer surgery can involve technically demanding dissection, particularly in the narrow pelvis. Robotic articulation and three-dimensional visualization may help with selected procedures, but the comparative benefit over conventional laparoscopy varies across outcomes and patient groups [6], [7], [10], [11].

Robotic-assisted colorectal procedures provide articulated instruments and a stable three-dimensional view. These features may be useful during total mesorectal excision and other complex pelvic operations; nevertheless, they should be presented as technical capabilities rather than proof of better oncologic outcomes in every case [6], [7], [10], [11].

Benefits reported in clinical studies include:

- Reduced conversion from laparoscopic to open surgery (reported variably across studies; outcome depends on procedure and comparator) [6], [7], [10], [11]
- Lower intraoperative blood loss (reported variably across studies; outcome depends on procedure and comparator) [6], [7], [10], [11]
- More precise pelvic dissection (reported variably across studies; outcome depends on procedure and comparator) [6], [7], [10], [11]
- Better preservation of autonomic nerves (reported variably across studies; outcome depends on procedure and

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comparator) [6], [7], [10], [11]
- Shorter postoperative recovery (reported variably across studies; outcome depends on procedure and comparator) [6], [7], [10], [11]
- Earlier return of bowel function (reported variably across studies; outcome depends on procedure and comparator) [6], [7], [10], [11]

These technical features may be particularly relevant in low rectal tumors, but their effect on margins, recurrence, function, and quality of life must be judged from procedure-specific comparative evidence [6], [7], [10], [11].

C. Gynecological Oncology

Robotic-assisted surgery is used for selected gynecologic malignancies, including endometrial and cervical cancers, and in some other carefully selected cases. The appropriate approach depends on cancer type and stage, patient factors, available expertise, and evidence for the specific procedure [6], [7], [10], [11].

Articulated instruments and magnified visualization may assist surgeons working in deep pelvic anatomy. These technical features do not, by themselves, establish that robotic surgery is more accurate or safer than conventional laparoscopy; comparative outcomes vary by procedure and patient group [6], [7], [10], [11].

Patients frequently experience:

- Smaller incisions [10]
- Reduced postoperative pain [10]
- Lower infection rates [10]
- Less blood loss [10]
- Faster recovery [10]
- Shorter hospital stay [10]

The improved ergonomics also reduce surgeon fatigue during lengthy pelvic procedures [4], [10].

D. Thoracic Oncology

Lung cancer continues to be one of the leading contributors to cancer-related deaths across the globe[1], [2]. Surgery can be a potentially curative option for appropriately selected patients with early-stage disease. Robotic-assisted thoracic surgery offers a minimally invasive option for selected operations, although outcomes must be compared with video-assisted thoracoscopic and open approaches rather than assumed to be superior [6], [7], [11].

Robotic-assisted thoracic procedures include selected lobectomies, segmentectomies, and mediastinal lymph-node dissections. Suitability depends on tumor characteristics, patient fitness, surgical expertise, and local resources [6], [7], [11].

Advantages include:

- Improved visualization of pulmonary anatomy [11]
- Greater instrument maneuverability [11]
- Precise lymph node removal [11]
- Reduced postoperative pain [11]
- Lower complication rates [11]
- Faster recovery [11]

These benefits have contributed to increasing adoption of robotic thoracic surgery in specialized cancer centers [11].

E. Head and Neck Cancer

Head and neck tumors often develop near structures responsible for speech, swallowing, breathing, and facial appearance [9]. Conventional surgical procedures often involve large incisions, which may compromise functional recovery and affect the patient's cosmetic results.

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Transoral robotic surgery (TORS) allows surgeons to remove selected tumors through the mouth using robotic instruments without external incisions [9]. High-definition visualization and flexible instrumentation enable precise tumor excision while preserving healthy tissue [9].

Major benefits include:

- No visible external scar [9]
- Improved cosmetic outcome [9]
- Preservation of swallowing function [9]
- Better speech recovery [9]
- Reduced hospital stay [9]
- Lower postoperative discomfort [9]

TORS has become increasingly important in treating selected cancers of the oropharynx, tongue base, and larynx [9].

F. Kidney Cancer

Partial nephrectomy has become the preferred treatment for many localized kidney tumors because it preserves healthy kidney tissue while removing the cancerous lesion [9].

Robotic-assisted partial nephrectomy offers enhanced precision during tumor excision and reconstruction of the remaining kidney. The robotic platform facilitates delicate suturing that minimizes warm ischemia time, an important factor in preserving long-term kidney function [9].

Clinical outcomes commonly include:

- Improved preservation of renal function [9]
- Lower blood loss [9]
- Reduced postoperative complications [9]
- Faster recovery [9]
- Excellent oncologic control for appropriately selected patients [9]

G. Liver and Pancreatic Cancer

Operations involving the liver and pancreas are among the most technically demanding procedures in surgical oncology because of complex vascular anatomy and the need for meticulous tissue handling [9].

Robotic systems provide improved visualization and instrument dexterity that assist surgeons during liver resections, distal pancreatectomy, and selected pancreaticoduodenectomy procedures [9].

Potential advantages include:

- Improved precision near major blood vessels [9]
- Better visualization of hepatic anatomy [9]
- Reduced blood loss [9]
- Enhanced intracorporeal suturing [9]
- Smaller incisions [9]

Although robotic hepatopancreatobiliary surgery continues to evolve, increasing experience and technological improvements have expanded its role in carefully selected patients [9].

H. Breast Cancer

While breast-conserving surgery and mastectomy remain predominantly conventional procedures, robotic techniques are emerging in selected reconstructive and nipple-sparing operations [9].

Robotic-assisted nipple-sparing mastectomy aims to reduce visible scarring while preserving cosmetic appearance. Improved visualization and minimally invasive access may contribute to enhanced patient satisfaction without compromising cancer treatment when appropriate candidates are selected [9].

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Current research continues to evaluate long-term oncological safety and cost-effectiveness before widespread adoption [9].

I. Clinical Outcomes Across Cancer Types

Comparative studies and systematic reviews report a range of perioperative outcomes for robotic-assisted surgery relative to open and conventional minimally invasive approaches. Outcomes commonly assessed include blood loss, incision size, postoperative pain, length of stay, return to activity, complications, and surgeon ergonomics; the direction and size of differences vary by procedure and comparator [6], [7], [10], [11].

- Reduced intraoperative blood loss.
- Smaller surgical incisions.
- Lower postoperative pain.
- Shorter hospitalization.
- Faster return to normal activities.
- Lower wound infection rates.
- Improved surgeon ergonomics.
- Enhanced visualization of anatomical structures.

A systematic review of randomized trials found that robotic-assisted surgery may modestly reduce length of stay and, compared with open surgery, may reduce blood loss or complications in some settings. It did not establish a general survival advantage over conventional surgery, and effects differed by cancer type and comparator. Therefore, the principal demonstrated benefits should be described as procedure-specific perioperative outcomes rather than universal superiority in oncologic control [7].

Table II: Applications of Robotic-Assisted Surgery in Major Oncological Specialties

Cancer Type	Common Robotic Procedure	Major Clinical Benefits
Prostate Cancer	Radical Prostatectomy	Improved nerve preservation, lower blood loss, faster recovery
Colorectal Cancer	Colectomy, Total Mesorectal Excision	Precise pelvic dissection, reduced conversion to open surgery
Endometrial and Cervical Cancer	Robotic Hysterectomy, Lymphadenectomy	Reduced pain, shorter hospitalization, improved visualization
Lung Cancer	Robotic Lobectomy	Better access, reduced postoperative pain, faster recovery
Head and Neck Cancer	Transoral Robotic Surgery	No external incision, preservation of speech and swallowing
Kidney Cancer	Partial Nephrectomy	Improved renal preservation, precise tumor removal
Liver Cancer	Hepatic Resection	Enhanced vascular visualization, reduced blood loss
Pancreatic Cancer	Distal Pancreatectomy	Improved precision during complex reconstruction
Breast Cancer	Nipple-Sparing Mastectomy (Selected Cases)	Better cosmetic outcomes, minimally invasive access

Robotic-assisted surgery has expanded from a niche technology into an established component of multidisciplinary cancer care. Its greatest strengths lie in procedures requiring exceptional precision within confined anatomical spaces. Although adoption varies among specialties and healthcare systems, the continued evolution of robotics, imaging, and artificial intelligence is expected to broaden the scope of robotic oncology while improving both patient outcomes and surgical efficiency [6], [7], [9]–[11].

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VI. ADVANTAGES OF ROBOTIC-ASSISTED SURGERY IN ONCOLOGY

The rapid adoption of robotic-assisted surgery in oncology is largely attributed to its ability to improve surgical precision while reducing the physical burden on patients and surgeons. Although robotic systems do not replace the surgeon, they provide enhanced control over complex procedures by integrating advanced imaging, robotic manipulation, and computer-assisted technologies. Numerous studies have reported favorable perioperative outcomes across a wide range of cancer surgeries [4], [6]–[8], [10], [11].

A. Enhanced Surgical Precision

One of the most significant advantages of robotic-assisted surgery is its exceptional precision. Traditional laparoscopic instruments are rigid and offer limited movement, whereas robotic instruments are designed with articulated joints that closely mimic the movement of the human wrist. Most systems provide seven degrees of freedom, allowing surgeons to perform delicate dissections and suturing with greater accuracy [4], [8], [9].

Motion-scaling technology translates large hand movements into smaller, controlled instrument movements, while tremor-filtering algorithms eliminate natural hand tremors. These features are particularly valuable in oncologic procedures involving delicate nerves, blood vessels, and vital organs [4], [9].

B. Superior Visualization

Robotic platforms provide high-definition, three-dimensional visualization with magnification that can significantly exceed the capabilities of conventional laparoscopy. Enhanced depth perception enables surgeons to distinguish between healthy tissue, tumors, blood vessels, and nerves with greater confidence [8], [9].

Many modern systems also incorporate fluorescence imaging using indocyanine green (ICG), allowing surgeons to evaluate tissue perfusion, identify lymphatic pathways, and better define anatomical structures during surgery [9].

C. Reduced Blood Loss

Precise tissue handling and improved visualization contribute to lower intraoperative blood loss in many robotic procedures. Reduced bleeding improves the surgeon's field of view and decreases the likelihood of blood transfusions, which may lower the risk of transfusion-related complications [6], [7], [10], [11].

D. Faster Recovery

Because robotic-assisted surgery is typically performed using minimally invasive techniques, patients often experience [4], [6], [7], [10], [11]:

- Smaller surgical incisions
- Reduced postoperative pain
- Lower infection rates
- Less tissue trauma
- Shorter hospitalization
- Faster return to normal activities

Earlier recovery may also allow patients who require chemotherapy or radiotherapy to begin additional treatment sooner.

E. Improved Surgeon Ergonomics

Conventional open and laparoscopic procedures can be physically demanding for surgeons. Robotic systems allow surgeons to operate from an ergonomic console while seated, reducing neck, shoulder, and back strain during lengthy procedures. Improved ergonomics may help reduce fatigue and support consistent performance throughout complex operations [4], [10].

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F. Integration with Digital Technologies

Modern robotic systems increasingly incorporate digital technologies such as [14], [15]:

- Artificial intelligence
- Computer vision
- Intraoperative imaging
- Surgical data analytics
- Machine learning
- Cloud-based performance analysis

These technologies can support surgical planning, workflow optimization, and postoperative quality improvement [13]–[15].

VII. GROWTH OF ROBOTIC SURGERY IN ONCOLOGY

Use of robotic-assisted surgery has increased over the past two decades, but uptake differs substantially by specialty, country, institution, and procedure. Published reviews describe expansion into several oncologic fields while also noting high costs, longer operating times in some settings, and incomplete long-term evidence [6], [7], [10], [11].

A. Increasing Clinical Adoption

Initially concentrated in academic medical centers, robotic surgery is now available in many tertiary hospitals and specialized cancer institutes. Procedures have expanded beyond urology to include colorectal, gynecologic, thoracic, hepatobiliary, renal, and head-and-neck oncology [6], [7], [9]–[11].

Several factors have accelerated adoption [1], [4], [15]:

- Increasing incidence of cancer worldwide.
- Greater patient preference for minimally invasive procedures.
- Advances in robotic hardware and software.
- Expansion of surgeon training programs.
- Growing evidence supporting improved perioperative outcomes.

B. Market Growth

The surgical robotics market has attracted investment and competition among manufacturers. Market size and growth estimates vary by report and should be accompanied by a named, dated market source and a clear definition of the market being measured. This review does not independently establish a precise market-growth rate [9], [15].

Key market drivers include [1], [15]:

- Aging populations requiring cancer treatment.
- Increasing healthcare expenditure.
- Development of AI-enabled robotic systems.
- Demand for precision medicine.
- Expansion into emerging healthcare markets.

Future adoption will depend on clinical evidence, affordability, operating-room infrastructure, training capacity, maintenance support, and whether a robotic approach offers meaningful value for a specific procedure [6], [7], [15], [17].

C. Role of Artificial Intelligence

Artificial intelligence has become an important contributor to the evolution of robotic surgery. AI-based systems are being developed to assist surgeons by [12]–[14]:

- Identifying anatomical landmarks.
- Recognizing surgical instruments.
- Predicting potential complications.

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- Providing real-time workflow guidance.
- Assessing surgical performance after procedures.

Machine learning models trained on large datasets may also contribute to surgical education by identifying best practices and providing objective feedback [13], [14].

VIII. CHALLENGES AND LIMITATIONS

Important limitations include the cost of acquisition and maintenance, the learning curve, limited tactile feedback in many systems, technical dependence, and unequal access. Their practical importance differs by platform, procedure, and health system [6], [7], [15], [17].

A. High Acquisition and Maintenance Costs

Robotic systems require substantial capital investment and may also incur costs for maintenance, instruments, consumables, software, and training. Whether these costs are justified depends on local case volume, the procedure performed, outcomes, and the comparator; economic value should not be assumed across all settings [6], [7], [15].

Financial and infrastructure constraints can limit access to robotic surgery in resource-constrained health systems. Affordability should be assessed alongside training, maintenance, service support, and the availability of effective alternative procedures [6], [7], [15].

B. Learning Curve

Robotic surgery requires structured training, supervised practice, and assessment of technical and non-technical skills. Training curricula and assessment approaches vary, and evidence for the transfer of simulator performance to clinical outcomes remains an important consideration [17].

During the initial learning phase, operating times and team workflow may be affected while the surgeon and operating-room team develop proficiency. The size and duration of the learning curve vary by procedure and prior experience [7], [17]:

- Procedures may require longer operating times.
- Team coordination is especially important.
- Efficiency improves gradually with experience.

Comprehensive simulation-based training programs have been developed to shorten this learning curve while maintaining patient safety [17].

C. Limited Haptic Feedback

Unlike conventional surgery, many robotic systems provide limited tactile sensation. Surgeons cannot directly feel tissue resistance and instead rely heavily on visual information. Although high-definition imaging partially compensates for this limitation, the absence of force feedback remains an area of active research [4], [15].

D. Technical Dependence

Robotic-assisted surgery depends on integrated hardware, software, instruments, imaging, and—in connected systems—communications. Potential failure modes include software or hardware malfunction, instrument problems, network interruption, and power loss; risk controls and contingency procedures must be defined for each platform and institution [8], [9], [16].

- Software malfunction
- Hardware failure
- Network communication errors
- Instrument failure
- Electrical power interruption

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Risk mitigation requires manufacturer safeguards, institutional protocols, maintenance, staff training, and a rehearsed plan for converting to an alternative approach if a system becomes unavailable. Specific safety features differ across platforms and should be verified against the relevant manufacturer documentation [9], [16].

E. Accessibility and Equity

Access to robotic surgery varies across regions and institutions. Differences in capital funding, infrastructure, trained personnel, maintenance support, and case volume can affect whether a programme is feasible and equitable [6], [7], [15], [17].

Potential responses include evaluating value for specific procedures, expanding appropriate training, improving service and maintenance capacity, and considering platforms with different cost and infrastructure requirements. These measures do not remove the need to compare robotic surgery with effective alternatives [6], [7], [15], [17].

IX. ETHICAL AND CYBERSECURITY CONSIDERATIONS

As surgical systems become more software-dependent and connected, patient safety, privacy, cybersecurity, accountability, and validation require explicit consideration [13], [14], [16].

A. Patient Safety

Robotic systems should be used within established clinical governance and patient-safety processes. Surgeons retain responsibility for clinical decisions; new software and AI functions require appropriate verification, validation, oversight, and regulatory review before clinical use [13], [14], [16].

B. Data Privacy

Robotic platforms may process surgical video, instrument telemetry, and patient information. Institutions should apply appropriate access controls, data minimization, secure storage, retention policies, and applicable privacy requirements; the precise obligations depend on jurisdiction and system design [13], [16].

C. Cybersecurity

Connected medical devices can face cybersecurity risks. Risk management should be based on current device-specific guidance and include secure design, access control, vulnerability management, software updates, incident response, and network protections as appropriate to the device and its environment [16].

AI-assisted surgical tools raise questions about transparency, bias, accountability, data quality, and external validation. They should support clinical judgment rather than be treated as independently reliable decision-makers; performance and safety need evaluation in the intended clinical setting [12], [13], [14].

As AI capabilities expand, transparency and accountability become increasingly important. AI systems should support—not replace—clinical judgment, and their recommendations should be interpretable and validated using robust clinical evidence. Ethical deployment requires careful evaluation of bias, reliability, and patient consent when AI-assisted decision support is used [12]–[14].

Table III: Advantages and Limitations of Robotic-Assisted Oncology Surgery

Aspect	Advantages	Limitations
Surgical Performance	High precision, tremor elimination, superior dexterity	Requires specialized training
Patient Outcomes	Less blood loss, reduced pain, shorter hospital stay	Benefits may vary by procedure and surgeon experience
Visualization	High-definition 3D imaging, fluorescence guidance	Dependent on advanced equipment
Surgeon Experience	Improved ergonomics and reduced fatigue	Learning curve for new users
Technology	AI integration, digital analytics, image guidance	Software complexity and maintenance requirements
Cost	Potential long-term efficiency gains	High acquisition and operating costs

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Accessibility	Expanding availability in major centers	Limited access in many regions
Safety	Multiple built-in safety mechanisms	Reliance on reliable hardware and software

Robotic-assisted surgery has demonstrated clear perioperative advantages and continues to reshape the practice of oncologic surgery. However, widespread adoption depends on balancing technological innovation with affordability, surgeon training, patient safety, and equitable access. Addressing these challenges through continued research and interdisciplinary collaboration will be essential to maximizing the clinical benefits of robotic oncology [4], [15], [17].

X. FUTURE SCOPE OF ROBOTIC-ASSISTED SURGERY IN ONCOLOGY

Future development may combine robotic hardware with AI, machine learning, advanced imaging, augmented reality, and computational modelling. These technologies have potential to support planning and decision-making, but many applications remain investigational or require further clinical validation; expected benefits should be framed as possibilities rather than established outcomes [12]–[14], [18].

A. Artificial Intelligence–Assisted Surgery

AI methods are being studied for surgical video analysis, anatomical and instrument recognition, risk assessment, and decision support. Their usefulness depends on data quality, generalizability, clinical validation, and integration into workflows; they should not be presented as routinely detecting all tumor boundaries or reliably preventing complications [12]–[14].

Machine-learning systems may eventually support risk prediction, workflow analysis, and surgical education. However, evidence of technical performance does not necessarily demonstrate improved patient outcomes, and the quality of validation in published surgical AI research remains variable [12], [13].

B. Augmented Reality and Mixed Reality

Augmented reality can overlay preoperative or intraoperative information onto a surgical view. A systematic review focused on orthopedic and maxillofacial oncologic surgery describes both technical and clinical opportunities, while also highlighting implementation challenges; its findings should not be generalized to all oncologic procedures [18].

Potential applications include:

- Real-time tumor localization.
- Visualization of hidden blood vessels.
- Identification of lymph nodes.
- Navigation around critical nerves.
- Surgical planning for complex resections.

AR and image-guided systems may assist visualization and planning in selected procedures, but improvements in accuracy or complications must be demonstrated for each intended use [18].

C. Digital Twins and Personalized Surgery

Digital twin technology involves creating a virtual representation of an individual patient's anatomy using medical imaging and clinical data. Surgeons can simulate different surgical approaches before the actual operation, allowing them to identify potential risks and optimize treatment strategies.

- Digital twins may support:
- Personalized surgical planning.
- Virtual procedure rehearsal.
- Prediction of postoperative outcomes.
- Education and surgical training.
- Improved multidisciplinary treatment planning.

As computational modeling advances, digital twins may become a routine component of precision oncology.

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D. Semi-Autonomous Robotic Assistance

Although current robotic systems remain entirely surgeon-controlled, research is progressing toward semi-autonomous functions. These systems may eventually assist with repetitive or technically demanding tasks while remaining under direct human supervision [13], [14].

Examples include:

- Automated camera positioning.
- Intelligent instrument tracking.
- Continuous tissue stabilization.
- Assistance with suturing.
- Needle guidance during reconstruction.

The surgeon will continue to retain responsibility for clinical decision-making, while automation is expected to reduce workload and improve procedural consistency.

E. Remote Robotic Surgery

Telesurgery uses robotic systems and communications links to enable a surgeon to operate at a distance. The 2001 transatlantic robot-assisted procedure demonstrated technical feasibility, but routine long-distance cancer surgery remains constrained by latency, reliability, infrastructure, governance, and cybersecurity [16], [20].

Before wider clinical use, remote robotic surgery requires reliable low-latency communication, cybersecurity safeguards, clear legal and regulatory responsibility, emergency contingencies, and appropriate training [16], [20].

- Reliable low-latency communication.
- Robust cybersecurity measures.
- Legal and regulatory considerations.
- Emergency contingency planning.
- Standardized training and credentialing.

Although routine long-distance cancer surgery is not yet common, continued advances in communication infrastructure may expand its future role [20].

F. Future Research Directions

Several research areas require continued investigation to maximize the benefits of robotic-assisted oncology surgery [6], [7], [10], [11], [15], [17]:

1. Long-term oncological outcomes across different cancer types.
2. Cost-effectiveness in diverse healthcare systems.
3. Integration of explainable AI into clinical workflows.
4. Development of advanced haptic feedback technologies.
5. Cybersecurity frameworks for connected robotic platforms.
6. Standardized surgeon training and competency assessment.
7. Environmentally sustainable robotic system design.
8. Improved accessibility in resource-limited settings.

Continued collaboration among clinicians, software engineers, roboticists, and biomedical researchers will be important for evaluating clinical benefit, improving validation, addressing safety and access, and developing technologies responsibly [8], [12]–[14], [16]–[18].

XI. CONCLUSION

Robotic-assisted surgery is an established option for selected oncologic procedures. Robotics, imaging, and software have expanded surgeons' technical capabilities, particularly where articulated instruments and three-dimensional visualization are useful. However, clinical benefits vary by cancer type and procedure; evidence does not support

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claiming that robotic surgery is universally superior or that it consistently improves long-term cancer control [6], [7], [10], [11].

Important challenges include acquisition and maintenance costs, training requirements, limited tactile feedback in many systems, unequal access, and dependence on reliable hardware and software. Cybersecurity, privacy, and careful validation of AI-enabled features are also necessary for safe implementation [13], [15]–[17].

Future platforms may incorporate AI, machine learning, augmented reality, computational models, and advanced imaging. These developments could support planning and decision-making, but their clinical value must be demonstrated through appropriate validation and patient-centred evaluation [12]–[14], [18].

Robotic-assisted surgery may continue to contribute to precision oncology where it offers a meaningful benefit for a defined procedure and patient group. Evidence-based evaluation, transparent reporting, cost-effectiveness assessment, and equitable access will be important to ensuring that technological advances improve patient care [6], [7], [10]–[14].

REFERENCES

[1] World Health Organization, "Cancer," Fact sheet. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/cancer. Accessed: Oct. 22, 2026.

[2] International Agency for Research on Cancer, "Global Cancer Observatory." [Online]. Available: https://gco.iarc.who.int. Accessed: Oct. 22, 2026.

[3] National Cancer Institute, "Cancer Statistics," Bethesda, MD, USA. [Online]. Available: https://www.cancer.gov/about-cancer/understanding/statistics. Accessed: Oct. 22, 2026.

[4] M. A. Lanfranco, A. E. Castellanos, J. P. Desai, and W. C. Meyers, "Robotic surgery: A current perspective," Ann. Surg., vol. 239, no. 1, pp. 14–21, Jan. 2004.

[5] B. Davies, "A review of robotics in surgery," Proc. Inst. Mech. Eng. H, vol. 214, no. 1, pp. 129–140, 2000.

[6] S. B. Hays, G. Corvino, B. D. Lorié, et al., "Prince and princesses: The current status of robotic surgery in surgical oncology," J. Surg. Oncol., vol. 129, no. 1, pp. 164–182, 2024, doi: 10.1002/jso.27536.

[7] K. Yu, B. Zeng, Q. Zhou, and F. Sun, "The efficacy and safety of robot-assisted surgery in cancer patients: A systematic review of randomized controlled trials," Int. J. Surg., vol. 111, no. 2, pp. 2227–2239, 2025, doi: 10.1097/JS9.0000000000002205.

[8] R. H. Taylor, A. Menciassi, G. Fichtinger, P. Fiorini, and P. Dario, "Medical robotics and computer-integrated surgery," in Springer Handbook of Robotics, 2nd ed., B. Siciliano and O. Khatib, Eds. Cham, Switzerland: Springer, 2016, pp. 1657–1684.

[9] Intuitive Surgical, "da Vinci Surgical System." [Online]. Available: https://www.intuitive.com/en-us/products-and-services/da-vinci. Accessed: Oct. 22, 2026.

[10] M. M. Leitao Jr. et al., "The RECOURSE Study: Long-term oncologic outcomes associated with robotically assisted minimally invasive procedures for endometrial, cervical, colorectal, lung, or prostate cancer: A systematic review and meta-analysis," Ann. Surg., vol. 277, no. 3, pp. 387–396, 2023, doi: 10.1097/SLA.0000000000005698.

[11] F. Ricciardi et al., "The COMPARE Study: Comparing perioperative outcomes of oncologic minimally invasive laparoscopic, da Vinci robotic, and open procedures: A systematic review and meta-analysis of the evidence," Ann. Surg., vol. 281, no. 5, pp. 748–763, 2025, doi: 10.1097/SLA.0000000000006572.

[12] C. Varghese, E. M. Harrison, G. O'Grady, and E. J. Topol, "Artificial intelligence in surgery," Nat. Med., vol. 30, no. 5, pp. 1257–1268, 2024, doi: 10.1038/s41591-024-02970-3.

[13] N. Kenig, J. Monton Echeverria, and A. Muntaner Vives, "Artificial intelligence in surgery: A systematic review of use and validation," J. Clin. Med., vol. 13, no. 23, Art. no. 7108, 2024, doi: 10.3390/jcm13237108.

[14] D. A. Hashimoto, G. Rosman, D. Rus, and O. R. Meireles, "Artificial intelligence in surgery: Promises and perils," Ann. Surg., vol. 268, no. 1, pp. 70–76, Jul. 2018.

[15] Intuitive Surgical, Inc., "Annual Reports and Proxy Statements." [Online]. Available: https://isrg.intuitive.com/financial-information/annual-reports-and-proxy. Accessed: Oct. 22, 2026.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
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Impact Factor: 8.2

[16] U.S. Food and Drug Administration, "Cybersecurity in Medical Devices: Quality Management System Considerations and Content of Premarket Submissions," Guidance for Industry and FDA Staff, Jun. 2025. [Online]. Available: https://www.fda.gov/regulatory-information/search-fda-guidance-documents/cybersecurity-medical-devices-quality-management-system-considerations-and-content-premarket.
[17] J. O'Doleynik et al., "A comprehensive review of robotic surgery curriculum and training for residents, fellows, and postgraduate surgical education," Surg. Endosc., 2019, doi: 10.1007/s00464-019-06775-1.
[18] N. Nasir, L. Cercenelli, A. Tarsitano, and E. Marcelli, "Augmented reality for orthopedic and maxillofacial oncological surgery: A systematic review focusing on both clinical and technical aspects," Front. Bioeng. Biotechnol., vol. 11, Art. no. 1276338, 2023, doi: 10.3389/fbioe.2023.1276338.
[19] R. M. Satava, "Surgical robotics: The early chronicles: A personal historical perspective," Surg. Laparosc. Endosc. Percutan. Tech., vol. 12, no. 1, pp. 6–16, 2002.
[20] J. Marescaux et al., "Transatlantic robot-assisted telesurgery," Nature, vol. 413, no. 6854, pp. 379–380, 2001, doi: 10.1038/35096636.