



## LEGAL AND ETHICAL CONSIDERATION OF ROBOTICS IN SURGERY

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### Abstract

Robotic surgery has transformed the medical landscape, enhancing precision, minimizing invasiveness, and improving patient outcomes. However, its integration brings about significant legal and ethical challenges that require thorough consideration. Legally, a major concern is around accountability, particularly since multiple parties—surgeons, hospitals, and manufacturers—are involved. The lack of standardized training, credentials, and clear guidelines muddles the issue of liability, leaving all parties exposed to potential legal consequences. Informed consent also takes on a new layer of complexity, as patients need to be well-informed about risks tied to robotic malfunctions, the surgeon’s experience, and available alternatives to ensure they maintain their autonomy.

On the ethical side, critical issues include patient safety, privacy, equal access to care, and professional responsibility. The introduction of robotic systems brings new risks, like technical failures and software glitches, which demand strict safety protocols and continuous training for surgeons to maintain their skills. Moreover, the high costs of these robotic systems raise ethical questions about equitable access, potentially increasing disparities in healthcare. It’s crucial that transparency is prioritized in the informed consent process, allowing patients to fully grasp the benefits, risks, and the surgeon’s level of expertise with the technology.

Additionally, the interaction between humans and machines sparks ethical discussions about accountability and the moral obligations of both surgeons and manufacturers. Key ethical principles—beneficence, non-maleficence, autonomy, and justice—should guide the careful use of robotic surgery. As technology continues to advance quickly, there’s an urgent need to create clear legal frameworks, standardized training, and ethical guidelines to tackle these emerging issues effectively. Failing to do so could erode public trust and impede the safe and equitable adoption of robotic systems in surgical procedures.

While robotic surgery brings remarkable clinical advantages, it also poses intricate legal and ethical dilemmas that we need to address proactively. Crafting thorough regulations, ensuring surgeon competency, and protecting patient rights are crucial steps to ethically and legally unlock the full potential of robotic surgery. The future of robotic surgery hinges on achieving a balance between technological advancements and responsible ethical and legal oversight to ensure the best possible patient care and maintain public trust.

## KEYWORDS

Robotic surgery, legal standards, ethical standards, India, liability, informed consent, Indian medical council, national medical commission, access to care, product liability, autonomy, medical devices law.

**Introduction**

Robotic surgery stands out as a groundbreaking development in modern medicine, bringing with it greater precision, less invasiveness, and improved outcomes for patients across different surgical fields. As this technology becomes more integrated into everyday practice, it not only showcases remarkable advantages but also presents complex legal and ethical dilemmas that require careful consideration. The implementation of robotic systems in surgery introduces specific issues related to patient safety, informed consent, surgeon training, and accountability, all of which notably differ from traditional surgical techniques.

From a legal standpoint, robotic surgery complicates the realm of medical liability. In traditional surgery, accountability typically falls on the surgeon and the healthcare facility. However, with robotic surgery, there are multiple parties involved, including the surgeon, the hospital, and the manufacturer of the robotic system. This multiplicity raises challenging questions about liability when complications arise—whether they come from human error, a robotic malfunction, or design flaws in the system. The current legal frameworks seem underdeveloped and inconsistent, lacking clear policies to comprehensively address these concerns. Surgeons should not assume that using robots lessens their legal responsibility; courts usually see robots as tools that aid rather than replace the surgeon's judgment. As a result, determining liability in robotic surgery cases tends to be complex and often decided on a case-by-case basis, underscoring the urgent need for updated laws and regulations suited to this advancing technology.

On the ethical side, robotic surgery pushes at the core principles of patient autonomy,

informed consent, fairness, and professional responsibility. Patients need to be made fully aware not just of the general risks associated with surgery but also of the specific risks tied to robotic systems, including potential technical issues and the surgeon's familiarity with the technology. Open and transparent communication is essential to uphold patient autonomy and facilitate informed choices. Additionally, the high costs that come with robotic surgery systems raise important questions about equal access to care, potentially widening disparities between well-funded hospitals and those with fewer resources. Ethical practice demands a balance between innovation and fairness, ensuring that advancements in technology don't end up being privileges available only to a select few.

Another significant ethical and legal aspect is the training and credentialing of surgeons who perform robotic procedures. Given the complexity of robotic systems, there's a critical need for thorough and standardized training programs to guarantee a surgeon's competence and patient safety. However, the existing credentialing processes often lack consistency or proper regulation, which can jeopardize the quality of care. Ongoing professional development and assessment are key as robotic technologies progress, reinforcing the ethical responsibility to uphold high surgical standards.<sup>12</sup>

While robotic surgery opens the door to a new era of surgical advancement with great potential to enhance patient outcomes, it also brings a host of intricate legal and ethical challenges. Tackling these issues calls for the

<sup>12</sup> Pai SN and others, 'In the Hands of a Robot, from the Operating Room to the Courtroom: The Medicolegal Considerations of Robotic Surgery' [2023] *Cureus*

Mavroforou A, Michalodimitrakis E and Hatzitheo-Filou C (2010) 29 *Legal and ethical issues in robotic surgery*

Vijayanath V and others, 'Robotic Surgery: Consent and Medico-Legal Aspect' (2024) 11 *Indian Journal of Forensic and Community Medicine* 74

creation of comprehensive guidelines, strong training and credentialing systems, clear legal frameworks for liability, and a dedicated commitment to ethical principles centered around patient care. As the field moves forward, the blend of legal and ethical considerations will be crucial in determining how responsibly robotic surgery is integrated into healthcare.

### Robotics in Surgery

Robotics in surgery, often referred to as robotic-assisted surgery, marks a major leap forward in technology that has reshaped how surgeries are performed across various medical fields. This overview delves into the evolution, different types, systems, and notable examples of robotic surgical systems, highlighting their influence on surgical accuracy, patient care, and what lies ahead.

The journey of robotic surgery began in the late 20th century, with the first systems getting FDA approval in the early 2000s. Groundbreaking platforms like the Da Vinci Surgical System and the ZEUS Robotic Surgical System ushered in a new chapter for minimally invasive surgeries. These systems were crafted to boost surgeons' abilities by offering better visualization, greater dexterity, and enhanced control compared to conventional open or laparoscopic methods.

As the years passed, robotic surgical systems continuously improved. Key advancements include better arm articulation, enhanced imaging technologies, and more user-friendly interfaces, making these platforms more intuitive and adaptable. This progress is fueled by the demand for greater precision, less surgical trauma, quicker recovery times, and wider applications of surgical procedures. Consequently, robotic surgery has become a vital part of practices in urology, gynecology, general surgery, cardiothoracic surgery, neurosurgery, and otolaryngology.

### Types of Robotic Surgical Systems

**Telemanipulators:** These are systems where the surgeon controls robotic arms from a console. The movements of the surgeon are scaled and

translated into precise actions by the robotic arms. The Da Vinci Surgical System is a leading example, offering high-definition 3D visualization and wristed instruments that mimic human hand movements.

**Autonomous or Semi-Autonomous Robots:** Though less common, these systems can carry out certain tasks with minimal human oversight, like suturing or manipulating tissue, under supervision.

**Hybrid Systems:** These combine aspects of telemanipulation and autonomous functions, aiming to boost surgical efficiency and safety.

### Notable Examples of Robotic Surgical Systems

**Da Vinci Surgical System:** Created by Intuitive Surgical, the Da Vinci system is the most widely adopted robotic platform around the world. It features multiple robotic arms, a high-definition 3D vision system, and advanced instruments that replicate human movements with exceptional precision. Surgeons can perform intricate procedures like prostatectomies, heart valve repairs, and gynecological surgeries with minimal invasiveness. This system has evolved through several generations, with the latest Xi model providing more capabilities, better ergonomics, and enhanced imaging.

**ZEUS Robotic Surgical System:** Developed by Computer Motion, ZEUS was one of the first FDA-approved robotic systems. While its usage has decreased over time, it played a crucial role in the early stages of robotic surgery, particularly in transatlantic surgeries like the very first robotic-assisted cholecystectomy.

**Senhance Surgical System:** Produced by TransEnterix, the Senhance system includes features like haptic feedback and eye-tracking camera control, focusing on giving surgeons fine control and a tactile feel during procedures.

**Versius and Hugo RAS:** Newer systems such as Versius (by CMR Surgical) and Hugo RAS (from Medtronic) are designed to be more affordable

and portable, aiming to make robotic surgery more accessible globally.<sup>13</sup>

### Components of Robotic Surgical Systems

**Surgeon Console:** This is the control center where the surgeon operates the robotic arms while viewing the surgical area through high-definition 3D visualization. The console converts the surgeon's hand movements into precise instrument actions.

**Robotic Arms:** Equipped with surgical instruments, these arms are manipulated remotely by the surgeon, offering a range of motion that exceeds human capabilities.

**Vision System:** High-definition cameras, often featuring 3D imaging, provide magnified views of the surgical site, enhancing depth perception and spatial awareness.

**Instrument Modules:** Specialized tools like scissors, forceps, and suturing devices are attached to the robotic arms, allowing for various surgical actions.

### Applications Across Surgical Specialties

**Urology:** Common procedures like robotic prostatectomy, nephrectomy, and bladder surgeries benefit from precise dissection and techniques that spare nerves.

**Gynecology:** Operations such as hysterectomy, myomectomy, and treatments for endometriosis gain from less invasive methods paired with superior visualization.

**General Surgery:** Cholecystectomies, hernia repairs, and colorectal surgeries are progressively being performed with robotic assistance.

**Cardiothoracic Surgery:** Robotic-supported mitral valve repairs, coronary artery bypass surgeries, and various thoracic procedures

enhance surgical outcomes and speed up recovery.

**Neurosurgery and Otolaryngology:** Robotic systems provide assistance in complex skull base surgeries and sinus procedures, where precision is key.

Robotics in surgery has come a long way from its early beginnings to now offering sophisticated systems that significantly improve surgical capabilities. Innovations like the Da Vinci Surgical System have changed the game for minimally invasive procedures, providing advantages such as heightened precision, reduced patient risks, and quicker recovery times. As technology continues to progress, the integration of AI, enhanced affordability, and broader training opportunities are likely to expand the role of robotic surgery in healthcare. Though challenges remain, the path<sup>14</sup> forward suggests that robotic systems will become a fundamental component of surgical practice, leading to enhanced patient outcomes and surgical excellence around the globe.

**The legal aspects** surrounding robotics in surgery primarily center on liability, informed consent, regulations, training, and the roles of various parties involved.

#### 1. Liability and Responsibility in Robotic Surgery

**Surgeon Liability:** Surgeons are still the main legal figures accountable for robotic-assisted surgeries. Even with advanced robotic systems at play, courts have consistently ruled that surgeons must apply their professional judgment, maintain control throughout the procedure, and intervene when necessary. Think of the robot as a high-tech tool that assists, not

<sup>13</sup> Dr. Amitabha Chakrabarti, 'Ethical Implications of Robotic Surgery' 'Ama Code of Medical Ethics' Opinions Related to Robotic Surgery' (2023) 25 AMA Journal of Ethics  
'Ethical Considerations in the Use of Robotic Surgery'  
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a substitute for the surgeon's expertise. If injuries happen due to a surgeon's mistake, poor control of the robot, or failure to act during a robotic malfunction, the surgeon can be held liable for medical malpractice.

**Hospital Liability:** Hospitals and healthcare institutions also carry a legal responsibility in robotic surgeries. They need to ensure that their facilities, equipment maintenance, and team training adhere to required standards. If a hospital neglects proper maintenance of robotic systems—like skipping calibration or necessary repairs—or fails to provide adequate training for their surgeons and staff, they could be held liable. Hospitals should have protocols in place for regular upkeep and ongoing education about robotic technologies for their medical teams.

**Manufacturer Liability:** The manufacturers of robotic surgical systems are liable for any flaws in design, production, or software that lead to surgical mistakes or patient harm. If a robot malfunctions due to hardware issues, software glitches, or lack of testing, the manufacturer can be held accountable. This includes responsibilities for insufficient instructions, inadequate training materials, or not warning about potential risks. Courts might assess whether the manufacturer adhered to regulatory standards and if the product was reasonably safe for its intended use.

**Shared and Emerging Liability Issues:** The overlap of surgeon, hospital, and manufacturer liability creates a complex legal playing field. Disputes often turn into "finger-pointing" between parties, which complicates litigation. As robots become more autonomous, determining liability becomes even trickier, necessitating a closer look at how much human control exists versus machine automation.

**2. Informed Consent in Robotic Surgery:** For robotic surgeries, obtaining informed consent goes beyond the usual requirements to include specific details related to robotic technology. Patients need to be made aware of:

- The role of robotic systems in their surgery
- The surgeon's experience and training in robotic procedures (which isn't always mandatory)
- The areas of surgery that will be assisted by robots
- The low risk of robotic malfunction or failure
- The benefits and alternatives of robotic surgery compared to traditional methods

By providing this detailed information, patients can better grasp the distinct risks and advantages associated with robotic procedures, which supports both legal compliance and patient rights.

**3. Regulatory Oversight and Standards:** Robotic surgical systems are under the watch of government agencies to ensure safety, efficacy, and quality control before and after they're approved for use. However, the rapid pace of advancement in robotic and autonomous technologies can outstrip existing regulatory frameworks.

- Approval processes that examine both hardware and software safety
- Monitoring adverse events and device performance after market approval
- Standards for equipment maintenance, software updates, and cybersecurity
- Requirements for surgeon credentialing and training specific to robotic systems

Regulatory bodies are increasingly focused on crafting guidelines that address the unique risks of robotic and AI-driven surgeries to safeguard patients and clarify legal obligations.

**4. Training, Credentialing, and Competence:** Proper training and credentialing of surgeons and operating room staff are crucial legal factors to help reduce risks and liability. Hospitals and medical institutions need to:

- Set up standardized training for robotic system use

- Require credentialing and certification before surgeons can carry out robotic surgeries independently

- Provide ongoing education and skills assessments to keep up with evolving technology

- Keep records of surgeons' experience and training

Not providing adequate training or credentialing can lead to liability for hospitals and elevate malpractice risks for surgeons.

5. Risk Management and Quality Assurance: Hospitals and surgical centers should establish risk management strategies tailored to robotic surgeries, including:

- Regularly maintaining and calibrating robotic systems to prevent issues

- Creating protocols for responding to robotic failures during surgery

- Keeping comprehensive documentation of robotic system use and technical issues

- Reporting adverse events to regulatory agencies and manufacturers

Effective risk management not only reduces legal exposure but also enhances patient safety by ensuring robotic systems work as intended and that surgical teams are ready to handle any complications.

6. Documentation and Transparency: Documenting everything accurately and thoroughly is vital in robotic surgery to support legal defenses and ensure patient safety. This involves:

- Detailed operative notes that specify how much robotic assistance was provided

- Records of discussions around informed consent that cover robotic risks

- Documentation of surgeon training and credentialing

- Logs of equipment maintenance and software updates

Transparency in documentation helps clarify the roles of all parties involved and serves as evidence in case of legal disputes.

The legal considerations of robotics in surgery emphasize the importance of clearly defining liability among surgeons, hospitals, and manufacturers; ensuring thorough informed consent; enforcing strict regulatory oversight; maintaining high training and credentialing standards; implementing solid risk management practices; and ensuring meticulous documentation. Together, these elements create a solid foundation for legal accountability and patient safety in the rapidly evolving domain of robotic surgery.

Robotic surgery represents a major leap forward in medical technology, providing improved precision, less trauma, and quicker recovery times. However, incorporating this technology into healthcare brings up complex **ethical issues** that need careful consideration to guarantee patient safety, fairness, and respect for their rights.

1. Patient Safety and Quality of Care: At the heart of all medical practices lies patient safety, which is crucial, especially when it comes to robotic surgery. While these robotic systems can enhance precision and lessen trauma, they also come with new risks that need vigilant oversight. Issues like mechanical failures or software glitches can arise unexpectedly during surgery, potentially endangering patients. Moreover, surgeons require in-depth training to operate these sophisticated machines, and during their learning phase, the possibility of mistakes can increase. Consequently, hospitals and surgical teams have an ethical duty to rigorously assess robotic systems before they're used clinically, maintain the equipment thoroughly, and ensure that surgeons are fully proficient. Surgeons should also be prepared to take manual control if the robot encounters problems, guaranteeing that patient safety never takes a backseat. This need for vigilance aligns with the ethical principle of nonmaleficence—doing no harm to patients.

2.Accountability and Responsibility: Robotic surgery adds complexity to the traditional accountability model in healthcare. In conventional surgeries, the surgeon is solely accountable for the procedure's outcomes. However, with the involvement of robots, liability can become blurred. If something goes wrong, it may stem from the surgeon's decisions, a malfunction in the robotic system, or a design flaw by the manufacturer. Ethical practices require clear guidelines that delineate who is responsible for various types of mistakes. While surgeons must maintain active oversight during robotic procedures, manufacturers and healthcare institutions also hold some responsibility for ensuring the technology is safe and used properly. Clear accountability not only protects patient rights but also builds trust in robotic surgery.

3.Informed Consent and Patient Autonomy: Honoring patient autonomy involves ensuring that individuals are well-informed about their treatment options and consciously agree to proceed with surgery. Robotic surgery complicates this process, as patients might struggle to grasp the nuances of advanced technology. Surgeons have an ethical responsibility to break down what robotic surgery involves, outlining its potential benefits—like smaller incisions and less pain—alongside the risks, such as possible technical failures and the surgeon's familiarity with the robot. It's also essential for patients to learn about alternative surgical methods. Open and honest communication empowers patients to make well-informed choices about their care, thus respecting their autonomy and dignity.

4.Equity of Access and Justice: The high costs associated with robotic surgical systems can limit access to wealthier hospitals and patients, raising ethical concerns about fairness in healthcare. If only affluent individuals or those in urban areas can access these advanced surgeries, it could <sup>15</sup>exacerbate existing

healthcare disparities. The healthcare community has an ethical duty to strive for affordability and access to robotic surgery for underserved groups. This may involve investing in more cost-effective technologies, expanding training opportunities to a broader range of hospitals, and advocating for insurance coverage that doesn't favor specific socioeconomic groups. Ensuring equitable access aligns with the ethical principle of justice, which seeks a fair distribution of healthcare resources.

5.Surgeon Training and Competency: Robotic surgery demands that surgeons acquire new skills distinct from traditional surgical techniques. Ethical considerations here include ensuring that surgeons get thorough training and certification before they perform robotic procedures independently. Continuous education is also vital as technology rapidly evolves. Without adequate training, patient safety could be jeopardized, violating ethical obligations to promote well-being (beneficence) and avoid harm (nonmaleficence). Healthcare institutions are responsible for establishing stringent credentialing standards and supporting surgeons in maintaining their skills, ensuring patients receive competent and safe care.

6.Preservation of Human Judgment and Surgeon Autonomy: As robotic systems advance, some incorporate automation or AI that can assist or even make certain decisions during surgeries. This raises ethical questions about the potential decline of the surgeon's role. If surgeons become overly dependent on robots or act merely as overseers, their critical thinking and manual skills might suffer. It's crucial that robotic systems enhance, rather than replace, human judgment. Surgeons must retain the ultimate decision-making power and accountability for patient outcomes. Upholding surgeon autonomy ensures that ethical reasoning, empathy, and professional

<sup>15</sup> Wightman SC and others, 'The Ethics of Robotic Surgical Systems Is a Conversation of Informed Consent' (2020) 5 Video-Assisted Thoracic Surgery 24

Marketsandmarkets "Future of Humanoid Robots in North America: A New Era Driven by AI Innovation" (2025)

responsibility remain key elements of surgical care.

7. Privacy, Data Security, and Cybersecurity: Engaging in robotic surgery involves handling sensitive patient information, such as medical images and physiological data. Safeguarding this information is an ethical obligation to protect patient confidentiality and build trust. The digital nature of robotic systems makes them susceptible to cybersecurity risks, including hacking or data breaches that could jeopardize patient safety and privacy. Healthcare providers and manufacturers must put in place strong security measures—like encryption and secure data storage—and comply with regulations such as HIPAA. Patients ought to be informed about how their data is used and protected. Ethical management of data is essential in safeguarding patient rights and fostering trust in robotic technologies.

8. Transparency, Explainability, and Trust: For robotic surgery to gain widespread acceptance, patients and healthcare professionals need to have confidence in the technology. This requires transparency about how robotic systems function, their limitations, and the evidence backing their use. Manufacturers and medical institutions should share clinical outcomes, including any complications or failures, to facilitate informed decision-making. Surgeons must also be able to clearly explain the robot's role in the procedure to their patients. Building trust through transparency and explainability is key to ensuring that robotic surgery rests on solid scientific evidence and genuinely benefits patients.

9. Ethical Innovation and Conflict of Interest: The introduction of robotic surgery can often be influenced by financial incentives and competitive pressures. This raises ethical concerns regarding the potential for adopting new technologies too hastily, driven by profit rather than patient welfare. Surgeons and institutions must disclose any conflicts of interest, like financial ties with manufacturers, to uphold transparency. Ethical innovation

demands thorough evaluation through clinical trials, unbiased reporting of outcomes, and adherence to professional standards. Prioritizing patient welfare over commercial interests will ensure that robotic surgery evolves responsibly and sustainably in medicine.<sup>16</sup>

## ROBOTICS IN INDIA

The US FDA gave a approval to the Da Vinci system, a technology that is revolutionary for robot urological surgery, back in 2000. Acknowledging the efficacy of the technology, AIIMS (New Delhi) amalgamated the technique into surgical practice; consequently, India became the first Asian country to grant formal approval. Robotic surgery's expansion has displayed promising results in India. The count is of 66 new robotic surgery centers at the present. There was a total of 71 robotic installations until July in 2019. For robotic-assisted surgery, over 500 of the country's most dexterous surgeons have been professionally mastered well enough to ease the medical practice in order to improve expertise in operations. In India, 12,800 operations have been conducted using these techniques. This has occurred over the past dozen years.

## Laws governing in India for robotics in surgery

The Code of Medical Ethics Regulations from 2002 doesn't ban the use of robotic technology. However, it does require doctors to inform patients when such technology is being used.

As for guidelines on how robotics should be supervised and implemented in surgeries, the National Medical Commission (NMC) has yet to provide specific details.

The Drugs and Cosmetics Act of 1940 covers a wide array of medical devices, including any

<sup>16</sup> Haltaufderheide J and others, 'The Ethical Landscape of Robot-Assisted Surgery: A Systematic Review' (2025) 19 *Journal of Robotic Surgery*  
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TRINDADE EN and others, 'Ethical and Legal Aspects Concerning Robotic Surgery in Brazil' (2024) 51 *Revista do Colégio Brasileiro de Cirurgiões*

software that's meant for use with these devices, all classified under "drugs." This legislation helps maintain high standards for quality, safety, and effectiveness when it comes to the registration, import, and sale of medical devices.

The Medical Devices Rules of 2017 have brought some optimism by offering a modern framework for regulating medical devices, including robotic surgical systems. That said, a quick look at the regulations shows they're quite brief and lack depth.

Lastly, the Indian Medical Council's regulations on Professional Conduct, Etiquette, and Ethics from 2002 provide oversight for any misconduct in the medical field. They clearly outline the expected behavior for registered healthcare professionals, which includes those who perform surgeries with robotic assistance.

The Digital Personal Data Protection Act of 2023 is a significant piece of legislation. It's truly a game changer when it comes to data protection and privacy. The main goal of this law is to ensure that the collection and processing of digital personal data are done legally.

According to the IT Act of 2002, along with the IT (Reasonable Security Practices and Procedures and Sensitive Personal Data or Information) Rules from 2011, any personal data collected during surgical procedures is considered sensitive. This means it needs to be handled with great care.

In India, more than 12,800 robotic surgeries have been carried out in the last 12 years. Current estimates indicate that about 60,000 robotic-assisted surgeries take place each year.

Robotic surgery has experienced remarkable growth in India over the past decade, partly due to a rise in the number of trained surgeons and the installation of robotic systems. By 2023, there were 100 robotic setups across the nation, with over 800 skilled robotic surgeons available. Experts believe there's still a lot of room for growth in the field of robotic surgery in India,

which has also introduced its own surgical robotics system, SSI Mantra, now being used in various hospitals. In AIIMS in New Delhi was the first institute to have a surgical robot. Since 2000 robotic surgery have been performed in India. Hospitals that perform robotic surgery are Manipal Hospitals and Apollo Hospitals

The emergence of robotic surgery marks a major step forward in the evolution of medical practices, offering remarkable precision, less invasive procedures, and the possibility of better patient outcomes. However, as this technology becomes more of a standard in surgical care, it also brings a range of legal and ethical dilemmas that need thoughtful consideration to keep the

<sup>17</sup>human aspect of medicine at the center. From a human standpoint, robotic surgery isn't solely about technological progress; it's about improving care quality while protecting the dignity, rights, and welfare of both patients and medical professionals.

Legally, bringing robotics into the operating room complicates the usual ideas of responsibility and accountability. Traditionally, surgeons have been the primary decision-makers and bearers of liability, but now they share this responsibility with manufacturers, software developers, and healthcare organizations. This shifting of accountability raises important questions about how liability should be divided when things go wrong due to device failures, software glitches, or problems with human-machine interactions. It also highlights the crucial need for clear regulatory guidelines that define the roles and responsibilities of everyone involved. Without clear parameters, patients might struggle to seek justice, and healthcare providers could face uncertainties that hinder the adoption of beneficial technologies.

<sup>17</sup> Morris MX and others, 'Ethical, Legal, and Financial Considerations of Artificial Intelligence in Surgery' (2022) 89 The American Surgeon 55  
Rathnayake AP, 'Legal and Ethical Facets of Robotic Surgery: A Suggestion for a Guideline' (2024) 15 Sri Lanka Journal of Forensic Medicine, Science & Law 29  
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the legal requirement for informed consent becomes even more critical in robotic surgeries. Patients need to be fully aware not just of the general risks connected to surgery, but also the specific risks, benefits, and limitations of robotic assistance. This means a transparent discussion about the surgeon's experience with the technology, the chance of technical issues, and the current understanding of long-term recovery outcomes.

Ethically, incorporating robotics into surgery challenges the medical community to uphold essential principles like beneficence, non-maleficence, autonomy, and justice in a rapidly evolving environment. One of the biggest ethical issues is ensuring fair access to robotic surgical care. The high costs of acquiring and maintaining robotic systems often limit their availability to well-funded hospitals and private clinics, leading to disparities that reflect broader social inequalities. This brings up serious questions about justice and fairness, as patients from underprivileged communities may be excluded from potentially better surgical options. Addressing this inequality requires deliberate policy efforts and resource allocation aimed at inclusivity and making advanced medical technologies accessible to all.

Another ethical consideration is finding a balance between innovation and patient safety. While robotic surgery shows great promise, evidence supporting its superiority over traditional methods for many procedures is still inconclusive or limited. The ethical duty to "do no harm" means that surgeons and healthcare institutions need to be cautious, thoroughly evaluate outcomes, and avoid rushing into adopting technology simply for market competitiveness. This is particularly crucial given the FDA's warnings regarding insufficient evidence in some robotic cancer surgeries, which raises concerns about putting patients at risk from unproven treatments. The human aspect also emphasizes that a surgeon's expertise, judgment, and empathy are irreplaceable in the surgical process. Even though robotic systems can improve precision

and reduce fatigue, they're only tools that rely on the operator's skills and decisions. Keeping the "surgeon-in-the-loop" model is vital to ensure that human oversight is prominent at every stage of the procedure. Patients often have high expectations from robotic surgery, sometimes viewing it as foolproof or inherently better. This misunderstanding can lead to unrealistic hopes and anxiety, which stresses the importance for surgeons to communicate clearly and compassionately, managing expectations while building trust. The therapeutic relationship between patients and providers shouldn't suffer because of technology; rather, it should be strengthened through openness, empathy, and collaborative decision-making.

Moreover, the introduction of robotics impacts surgeons too, who deal with steep learning curves and the pressure that comes from mastering complex systems. The ethical obligation to maintain competence necessitates continuous education and institutional support to prevent burnout and ensure patient safety. The human element in surgical care extends beyond the patient to include healthcare providers' well-being, as their ability to deliver compassionate, skilled care is key to positive outcomes.

Going forward, successfully incorporating robotic surgery into healthcare requires a comprehensive approach that aligns technological innovation with human values. This demands strong regulatory oversight to ensure device safety, effectiveness, and surgeon competency, alongside ethical stewardship that prioritizes patient welfare over business interests. It also calls for a commitment to equity, making sure advancements don't worsen existing disparities but instead contribute to more inclusive and fair healthcare systems. Education plays a crucial role, equipping both surgeons and patients with the knowledge needed to navigate the complexities of robotic surgery confidently and responsibly. Ultimately, the full potential of robotic surgery can be realized only when

technology acts as an extension of human ability instead of a substitute for human judgment and compassion. The future of surgery rests not on machines' superiority but on the collaboration between human skill and technological advancement, guided by a steadfast commitment to ethical principles and legal accountability. By embracing this balanced view, the medical community can ensure that robotic surgery improves the healing process, respects patient autonomy, and maintains the dignity of everyone involved. Thus, the integration of robotics in surgery becomes not just a technical achievement, but a profound reinforcement of medicine's mission to serve humanity.

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