Chapter

Telesurgery and Robotics: Current Status and Future Perspectives

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Abstract

The concept of telehealth has revolutionized the healthcare delivery system. Based on this concept, telesurgery has emerged as a promising and feasible option, providing surgical care to remotely located patients. This has become possible by advancements in the robotic system combined with the cutting-edge technology of telecommunication. Since the ability to perform telepresence surgery was hypothesized, consistent development and research in this novel area have led to the beginning of telesurgical care, which can fulfill the demand for surgical care in remote locations. In addition to the benefits of robotic-assisted minimally invasive surgery, telesurgery eliminates geographical barriers, which helps patients have better access to quality surgical care. It may reduce the overall financial burden by eliminating the travel expense of the patients, providing expertise through the telepresence of experienced surgeons, and reducing the operating room personnel. The telesurgical approach is also being utilized for telementoring, i.e., real-time guidance and technical assistance in surgical procedures by highly skilled surgeons. Despite the numerous technological improvements in telesurgery, its widespread implementation in clinical setting still lags, mandating the identification of the offending factors that limit its clinical translation.

Keywords: telesurgery, robotic surgery, medical robotics, telemedicine, remote surgery

1. Introduction

Telehealth and telemedicine involve transferring expertise, through which patients can be examined, monitored, and treated without transporting the patient. Telemedicine is based on data acquisition, storage, transfer, processing, and display. This breakthrough came after the revolution in communication technology, such as high-speed data connections and management information systems [1, 2]. Patients can communicate with doctors from their homes using technology or a telehealth kiosk. Nowadays, telemedicine is an integral part of health services in many countries, and upcoming hospitals will attract patients from all over the world without geographical restrictions.

2. Telesurgery

The concept of telemedicine has been applied to provide surgical care to remotely located patients and is termed "Telesurgery" or "Telepresence Surgery" or "Remote Surgery." [3]. Initially considered as a "science fiction," it has now been materialized and will continue to be the reality in today's era. This revolutionized surgical care delivery has become possible by advancements in the robotic system. Since the establishment of the robotic surgery, the surgeon typically controls these robots by staying by the patient's side. In telesurgery, the robotic system still remains in direct contact with the patient, whereas the surgeon sits on a console at a remote location and performs the surgical task. As a backup, a surgical team remains in the operating room to proceed with the surgery as and when required [4]. Here, the advanced communication technology enables the surgeon to control the endoscopic camera and manipulate the robotic arm attached to the patient cart with real-time feedback. This emerging surgical system requires advanced wireless networking and robotic technology to perform the surgery [5]. The main objective of telesurgery is to eliminate unnecessary travel for patients and accompanying persons, apart from providing high-quality surgical care from expertise worldwide.

3. Evolution of telesurgery

The concept of telesurgery came into existence since U.S. National Aeronautics and Space Administration (NASA) started exploring the possibility of providing treatment to the astronauts in space long back in 1970 [6]. The invention of the endoscope, followed by the development of a video computer chip that allowed the magnification and projection of images onto television screens, was a breakthrough in introducing laparoscopic surgery [7]. This minimally invasive approach changed the era of surgery and created a possibility for evolution of telesurgery.

In the late 1980s, Scot Fisher and Joseph Rosen hypothesized the ability to perform telepresence surgery using a robotic system. Computer-assisted surgical tools have emerged after constant advancement in surgical instruments and techniques, followed by a gradual evolution from automated biopsy robots to high-end modern robotic surgical systems for visceral surgery (like the ZEUS Surgical System and the da Vinci System). The development of AESOP (automated endoscopic system for optimal positioning) followed by the ZEUS operating system from computer motion was an outstanding achievement in the development of robotic surgery. A parallel innovation of SRI green telepresence, which was refined further by Intuitive Surgical, conferred in the revolutionary development of the current da Vinci System [8]. Implementation of the telesurgery concept in a broader way could be possible after introducing mainly two robotic systems, i.e., the ZEUS Surgical System by Computer Motion and the da Vinci Surgical System by Intuitive Surgical. These modern robotic systems work on a master-slave technology where the surgeon sits at a console kept a few feet away from the patient cart, enabling the surgeon to view real-time three-dimensional imaging of the operative site. Complex software translates the surgeon's hand movement and manipulates the robotic arm accordingly, attached to the articulating surgical instruments and endoscope [9].

After merging with Computer Motion in 2003, Intuitive Surgical dominated the robotic surgical market and discontinued the Zeus platform as the da Vinci robot had several advantages over it. As in laparoscopic surgery, depth perception was a significant problem resolved substantially by the da Vinci system using a 3D immersive camera, while the Zeus system has a 2D screen display. Furthermore, the da Vinci system controls the surgical instrument using an "Endowrist," which mimics wrist

Year	Description
1920	The term "Robot" was first introduced by a Czech playwright "Karel Capek" in his hit play, "Rossum's Universal Robots."
1979	The Robot Institute of America sets a definition of the robot as "A reprogrammable, multi-functional manipulator designed to move materials, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks."
1980	The "Green SRI telepresence surgical system" was developed by a joint venture of Stanford Research Institute (SRI) & National Aeronautics and Space Administration (NASA) Ames Research Center.
1984	Scot Fisher and Joseph Rosen were the surgical robotics pioneers who proposed the idea of using robotic arms to do telesurgery and researched in collaboration with NASA.
1985	The first industrial robot developed for clinical application was modified "PUMA 200" (Programmable Universal Manipulation Arm; Unimation, Stanford, California, USA) to precisely execute CT-guided brain biopsies.
1992	The "ROBODOC" (Integrated Surgical Systems, Sacramento, CA, USA) was developed with modification of the basic principles of the PUMA arm and was approved for hip replacement surgery.
1994	The "AESOP" (Computer Motion, Inc., Santa Barbara, CA, U.S.A.) was the first robotic surgical tool approved by the US Food and Drug Administration for laparoscopic surgery
1991-1997	"PROBOT" was developed by Harris et al. to perform transurethral prostate resection with ultrasound guidance.
1997	The prototype of "da Vinci Surgical System" was developed by Intuitive Surgical, Sunnyvale, CA.
2000	The "da Vinci Surgical System" (Intuitive Surgical, Sunnyvale, CA) was commercialized and approved for laparoscopic surgery.
2001	The "Zeus Surgical System" (Computer motion, Goleta, California, USA) was approved for laparoscopic surgery.
September 2001	The first trans-Atlantic procedure (known as "Operation Lindbergh") was Robot-assisted laparoscopic cholecystectomy using the Zeus Robotic platform. A surgeon in New York (USA) operated on a patient in Strasbourg (France).
2003	After the merger of Intuitive Surgical & Computer Motion, Zeus robotic platform was discontinued.
February 2003	The world's first telerobotic surgical service was established between St. Joseph's Healthcare Hamilton, a teaching hospital affiliated with McMaster University, and North Bay General Hospital, a community hospital 400 km away.
2006-2014	The next generation of the da Vinci surgical system i.e. "da Vinci S," "da Vinci Si," and "da Vinci Xi" were developed in years 2006, 2009, and 2014 respectively.
2017	The "Senhance" surgical system (TransEnterix, Morrisville, NC, USA) received FDA approval in October 2017 for laparoscopic abdominal procedures.
2017	NAVIO robotic system by Smith and Nephew 2020 for semi-autonomous joint arthroplasty.
2020	MAKO robotic system by Stryker was released for join arthroplasty.
2020	CorPath robotic intervention arm for use in coronary intervention during COVID pandemic

Table 1.
Historical timeline of the evolution of robotic system and telesurgery.

movement with natural movement with seven-degree freedom. The da Vinci Xi™ (Intuitive Surgical, 2014) is the most recent iteration of da Vinci systems, which has been redesigned to be more ergonomic and thinner and have well-arranged robotic arms to conserve space. Moreover, it has been upgraded with fluorescence imaging and near-infrared technology to better visualize vessels, tissue perfusion, and bile duct. Still, there is a lack of haptic feedback, which needs further improvement.

In usual robotic surgeries, where both console and robotic arms are directly connected to several meters of cable wire, there is no time lag in communication because data transmission from the console to the surgical device and back to the console is almost instantaneous. Thus, the surgeon sees his movements on the computer interface as he performs the surgery. When robotic telesurgery was conceptualized, the primary concern was the time delay in communication between the surgeon console and surgical robot due to moving the surgical system to a more remote location. Thus, the surgeon's real-time interventions could be milliseconds or even seconds behind the visualization of the operating field, which can lead to catastrophic outcomes during surgery. As proved in studies, a time lag of more than 150–200 milliseconds is harmful [10]. So seamless robotic telesurgery requires robust communication media between console and robot with negligible latency. To provide safe telesurgery services, collaborating with the telecommunications sector to build a secure, dependable, high-speed data transmission across enormous distances with unnoticeable delays is of utmost importance.

The world's first telesurgery was the "Lindbergh Operation," a transatlantic cholecystectomy on a 68-year-old female patient in Strasbourg, France, performed on September 7, 2001 by Professor Jacques Marescaux in New York City. ZEUS system was used for this landmark surgery, and France telecom provided the spare fiber optic ATM (automated teller machine) lines to minimize the latency and optimize connectivity. The average time delay during surgery was 135 milliseconds, which is impressive considering the data traveled over 8600 miles (14,000 kilometers) from the surgeon's console to the surgical system and back [11]. This milestone in surgery was a big inspiration for establishing the first dedicated telerobotic surgical service in Canada. Since then, various robotic telesurgeries have been performed worldwide.

The timeline of evolution of the robotic system and telesurgery has been summarized in **Table 1**.

4. Benefits of telesurgery

Telesurgery is an extension of the telemedicine/telehealth concept that has become possible with the advancement of the surgical robot and sophisticated telecommunication technology. So the benefits of telesurgery encompass the inherent advantage of telehealthcare as well as robotic-assisted minimally invasive surgery, which are mentioned below:

I. Benefits related to the Minimal Invasive Approach include less amount of blood loss, shortened hospital stay, shorter recovery, and early return to work [12].

II. Benefit related to robotic-assisted minimally invasive surgery (i.e., teleoperation) includes:

a. Ergonomical posture of the surgeons with more dexterity than conventional laparoscopy.

b. Enhances the accuracy of motion as operators' physiological tremors can be filtered out in real time with accelerometer technology [13].

c. High-resolution (3-D) cameras allow surgeons to see close-ups of surgical sites that are not easily accessible [14].

d. Robotic arm provides easy access to hard-to-reach areas such as the pelvis.

e. Improved surgical accuracy reduces the chances of damage to surrounding structures and significantly reduces the risk of blood loss and infection [13, 14].

III. Specific benefits related to telesurgery include:

a. Delivery of high-quality surgery to remote settings, such as underserved rural areas, battlefields, and space stations.

b. Provides an opportunity for patients to receive surgical care by surgical experts from all over the world without going outside of their local hospitals. It is beneficial for patients for whom medical travel is not feasible due to financial constraints, travel-related health risks, travel restrictions, or time delays.

c. Real-time collaborations between surgical professionals from various healthcare facilities can benefit patients who require complicated microsurgical techniques and other complex surgeries.

d. Telesurgery may be a potential solution to the global shortage of competent surgeons.

e. During the COVID-19 era, apart from the benefit related to the need of lesser number of operating room staff in robotic surgery, the main benefit of telesurgery was the physical separation of the surgeon from the patients, thus reducing the interpersonal contact and spread of infection [15]. Telesurgery could also provide care when travel restrictions during a pandemic are the main reasons limiting medical care.

5. Limitations of telesurgery

Being a novel concept for delivering surgical care, telesurgery is still in its nascent phase and needs continuous upgrading. At present, the following factors pertinent to telesurgery are a major hindrance to the widespread use of this technology:

1. Time lag or latency: This vital issue is related to telecommunication and is mainly due to data transmission over a network and video coding and decoding. This time delay is directly proportional to the distance between two far-reaching locations. It has a propensity for surgical error and puts the patient's safety in danger.

A time lag of fewer than 100 milliseconds is considered an ideal latency time that a dedicated telecommunication system can achieve. A latency time greater than 300 milliseconds produces significant inaccuracies in instrument handling. Research suggests that a simple telesurgical procedure can be safely performed without any significant surgical inaccuracy with a time lag of up to 700 milliseconds [16].

2. Difficulty in procurement and maintenance of equipment.

3. Purchase of robotic systems is a major obstacle worldwide, mainly for third-world countries, because of inflated costs.

4. Establishing a robust global network to connect every part of the world is a big obstacle to initiate telesurgical services. Affordability of high-speed telecommunication is also a big problem, especially in developing nations.

5. Cyber security threats: Hijacking of telecom networks in telesurgery has surfaced as a major concern in the recent years that can compromise the patient's safety.

6. Various legal and ethical concerns can be raised when surgery is done without an interaction between the patient and the operating surgeon, who belong to different countries and have different regulatory bodies/acts related to medical care [17].

7. As telesurgery needs the collaboration of multiple medical organizations, billing issues will be a big problem and will require a decent agreement among them.

6. Scope of advancement in telesurgery

Innovation of robotic platforms opened up the path for clinical translation of the concept of telesurgery and went side by side with the advancement in the robotic system. Further advancement in telesurgery needs the incorporation of various emerging technologies.

6.1 Haptic feedback

Tactile feedback has been a big concern since the advent of laparoscopic surgery and continues to be the Achilles heel in Robotic surgery. Here the surgeon touches the tissue with a long instrument having a hinge that goes inside the patient's body through the ports. This series of interfaces of contact with instruments at various levels leads to degradation in the haptic feedback, which is necessary for precise and delicate tissue manipulation. This can be achieved by upgrading the technology of the human-machine interface (HMI) and sensor-based robotic instruments, reflecting the force of instruments on surgeons' hands [18]. There is ongoing research for making a perfect haptic-enabled telesurgical system. It also requires a seamless network-based communication that can send the data of hand motion and instrument-tissue contact from the surgeon to the patient and the other way around. An alternative to overcome this feedback problem is haptic-assisted training, which requires shared control of two master HMIs and one slave robot [19].

6.2 A 3-D visual feedback system

Although it appears that haptic feedback is vital in manipulating delicate tissues, today's upgraded versions of robotic systems are still inefficient in providing this tactile input appropriately. In addition, the relevance of haptic feedback in robot-assisted performances of surgical tasks is yet to be proved. It has been hypothesized that visual feedback of local tissue deformation caused by tension, retraction, or needle insertion can compensate for the lack of sensory force feedback [20]. The 3-D display system can provide this high-definition visual feedback, but further improvement is required in this aspect.

6.3 High speed and quality telecommunication

The quality of telesurgery depends on the quality of presentation of the information transmitted in the form of digitized data from one center to another. The quality of shared data and latency depends upon the bandwidth (i.e., the capacity of data flow) of the network used to relay the processed data. It can be accomplished by a telecommunication network having wide bandwidth, minor delay, slight jitter, and minimal data loss. The network-level quality of service (QoS) control is also required, ensuring bandwidth reservation for telesurgery [21]. The integration of recently available high-speed 5G internet could meet the required bandwidth and reduce the time lag issue that plagues telesurgery.

6.4 Internet of things (IoT)

Remote monitoring in the healthcare industry is now feasible owing to IoT-enabled devices, which can keep patients safe and healthy while allowing clinicians to provide superior care. As sensor technology is improving gradually, IoT devices can also be incorporated into surgical devices, which can enable the recording of intraoperative events and the movement of instruments [22]. By analyzing the data created by these devices by artificial intelligence technology, procedures can be standardized by identifying the most appropriate use of surgical devices, which will help in ensuring the safety of surgery but requires proper validation before incorporation into telesurgery.

6.5 Concept of "one-to-many" remote surgery

This concept can be perceived as an expert surgeon seated in the master control room remotely, performing surgeries on multiple patients simultaneously. It is helpful for surgeries that require a combined approach, i.e., robotic-assisted minimal invasive and an open approach during different steps of the procedure. For example, the expert sitting in master control will perform specific steps requiring robotic assistance in patient A present at one hospital and then switch to take control of another surgical robot attached to patient B at a different hospital. Meanwhile, the rest of the steps requiring an open approach for patient A will be completed by the onsite local surgical team [23]. By using this concept, further attempts can be made to plan complex surgeries, mimicking the production line of car manufacturers, by transferring the control of robotic arms in a predestined sequence to a group of surgeons sitting in their master control room far from each other and skilled in specific steps of surgery.

6.6 Artificial intelligence in telesurgery

Artificial intelligence (AI) has transformed various industries in the past decade. The incorporation of AI into telesurgery is a brand-new concept that has sparked a lot of interest as a part of the surgical procedure that can be automated. Thus, AI reduces the cognitive and physical burdens of the surgical team and can increase the efficiency of surgery by reducing the operative time and increasing accuracy [24]. Simultaneously, it can also decrease the required number of staff in the surgical team. The utilization of AI in other industries has led to a substantial increase in efficiency, but its role in surgical procedures has not yet been proven. A significant amount of adaptation and further research is required to prove its performance and build up confidence in its use in surgical care.

7. Clinical application of telesurgery

Several projects researching the feasibility and practicability of telesurgery on human patients were completed at the beginning of the twenty-first century. Because of various obstacles in the clinical utilization of telesurgery, it has not picked up its pace and is still in the developmental phase. The first dedicated telesurgery center was established in Canada, and at present, North America is leading the market in telesurgery [25]. Globally, every human being has the right to access all the recent surgical facilities present worldwide, and telesurgery is the critical innovation fulfilling these promises. But such facilities are not readily available in the developing countries and the rural parts of developed countries. It is a paradox that the secluded population worldwide that can benefit from telesurgery is also the one that cannot afford it due to high cost or lack of essential telecommunication facilities. But it is expected that in the near future, this problem will be alleviated as the internet access is rapidly expanding and various new manufacturers of affordable robotic systems are emerging.

Patients' perspective about telesurgery is pretty promising as most of them are very enthusiastic about the concept of using the robot for surgeries. This inclination toward new technology results from the projected benefits of smaller incisions with better cosmetic outcomes, shorter hospital stays, faster recovery, and fewer complications because of the precise movement of the robotic instrument during surgery. Still, this technology needs further advancement and scrutiny by noble clinical trials with a higher evidence level.

Telesurgery has opened up the opportunity of treating patients who require immediate medical attention regardless of their location. This could prove lifesaving in extreme conditions such as space and battlefields where getting a usual hospital is impossible. However, many obstacles stand in accomplishing this vision, such as installing the robotic system in such places and providing a robust connection to run the telesurgery proficiently with negligible latency. Various research studies are going on to test the feasibility and clinical implication at such extreme locations.

For astronauts on the deep-space mission, many surgical emergencies such as fatal injuries, appendicitis, intracranial hematoma, or kidney stones can occur, which mandate urgent operations then and there. So for such space missions, telesurgical assistance should be considered. But again, the signal delay will be a detrimental factor due to the vast distance between the earth and the space station. An added problem is the feasibility of robotic surgery in a zero-gravity environment. NASA is carrying out a series of missions in an undersea laboratory, Aquarius, simulating the extreme environmental condition found in space. Some substantial progress has been achieved in teleoperation, control of the surgical robot, and other challenges related to space surgery, such as the behavior of the organs and bodily fluids in zero gravity, but it's still a long road ahead of us [26].

Similarly, on the battlefield or in a natural disaster situation, telesurgery can offer a solution to provide surgical care at the site of injury and can save many lives. A semiautomated telerobotic device known as "Trauma Pod" has been created for such scenarios, which may conduct lifesaving surgeries and stabilize wounded soldiers on the battlefield. These are designed to be deployed rapidly in such unfavorable situations. These robots can also act as assistants, like a scrub nurse, in the operating room. These scrub nurse robots are automated to do different tasks such as changing tools, dispensing equipment, and tracking supplies. Various trials are going on to see the feasibility and further advancement in these trauma pods. Though these are currently being tested for first aid treatment such as putting intravenous lines, performing hemostasis, protecting airways, and placing monitor devices, we are hopeful, that the robot will be able to move beyond the current first-aid procedures [27].

8. Telementoring and telestration: a new domain for surgical training

The concept of telesurgery has opened up a new way of real-time teaching and training of surgical fellows. With this sophisticated communication technology, an expert surgeon present remotely mentors a trainee surgeon sitting in the operating room by controlling the endoscope to control the field of view throughout the entire procedure, as and when required. This unique way of training is known as "telementoring," which is considered an ideal method of skill-sharing and training. [28] An associated but slightly different method of real-time teaching is termed "telestration," in which the expert guides the trainees by freehand sketching or pointing out the structure by marking it over the trainees' video monitor. The remote surgeon and the surgeon with the patient will both have identical views of the surgical field. [29] At present, the Canadian Surgical Technologies & Advanced Robotics (CSTAR) is the leading facility globally, providing training via surgical telementoring and telestration. Some telesurgeons are also developing computer-based training modules that can be shared over the Internet.

Although robotic telesurgeries have been adopted since the beginning of the twenty-first century, telesurgery is not commonly used worldwide due to a lack of facility or proper training. So a robust training program is mandatory to make it available worldwide, which simultaneously ensures the patient's safety. It not only includes the training of the surgeon, but the whole surgical team, including nursing staff, OR technicians, anesthetists, and information technology technicians. Team training is necessary to attain the best clinical results. Even after a few successful robotic or telemanipulation surgeries, most surgeons will revert to traditional methods if they do not have qualified assistance from nurses and anesthesiologists. Comparative to conventional operations, these telesurgeries are technically demanding and need a well-trained surgical team, with each member an expert in their domain.

The training program's goal for robotic and telesurgery procedures should be focused on stepwise training of the surgeon. Like the traditional basic surgical skill program, this includes system training by didactic lectures, dry and wet laboratory training, and advanced procedure-specific training. After proficiently learning each step, the trainee should move on to the next level of surgical telemanipulation. Simultaneously, each step should undergo evaluation for the quality and clinical safety of the patient. Many training centers have developed and suggested adopting an objective-based curriculum for the training of surgical teams. Apart from providing training to young surgeons, these robotic and telesurgical training programs will promote academic writing and scientific publication.

9. Cost: benefit analysis

From a hospital-centric healthcare delivery model to a more sustainable and effective patient-centric model has been made possible with the introduction of telesurgery. It has revolutionized healthcare delivery by expanding it into a global patient base. However, cost remains a significant challenge hindering its global acceptance, especially in low and middle-income countries. The total expenses can be categorized into the initial investment and maintenance costs. Initial investment includes the cost of the robotic system, infrastructure development, and the cost of procurement of equipment and disposables.

Until now, Intuitive Surgical company's da Vinci system has been the best known and most used system. The estimated cost of a top-of-the-line robotic system ranges from $ 1 to 2.5 million. According to Intuitive Announces First Quarter Earnings, 6920 da Vinci Surgical Systems have been installed worldwide as of March 31, 2022. [30]

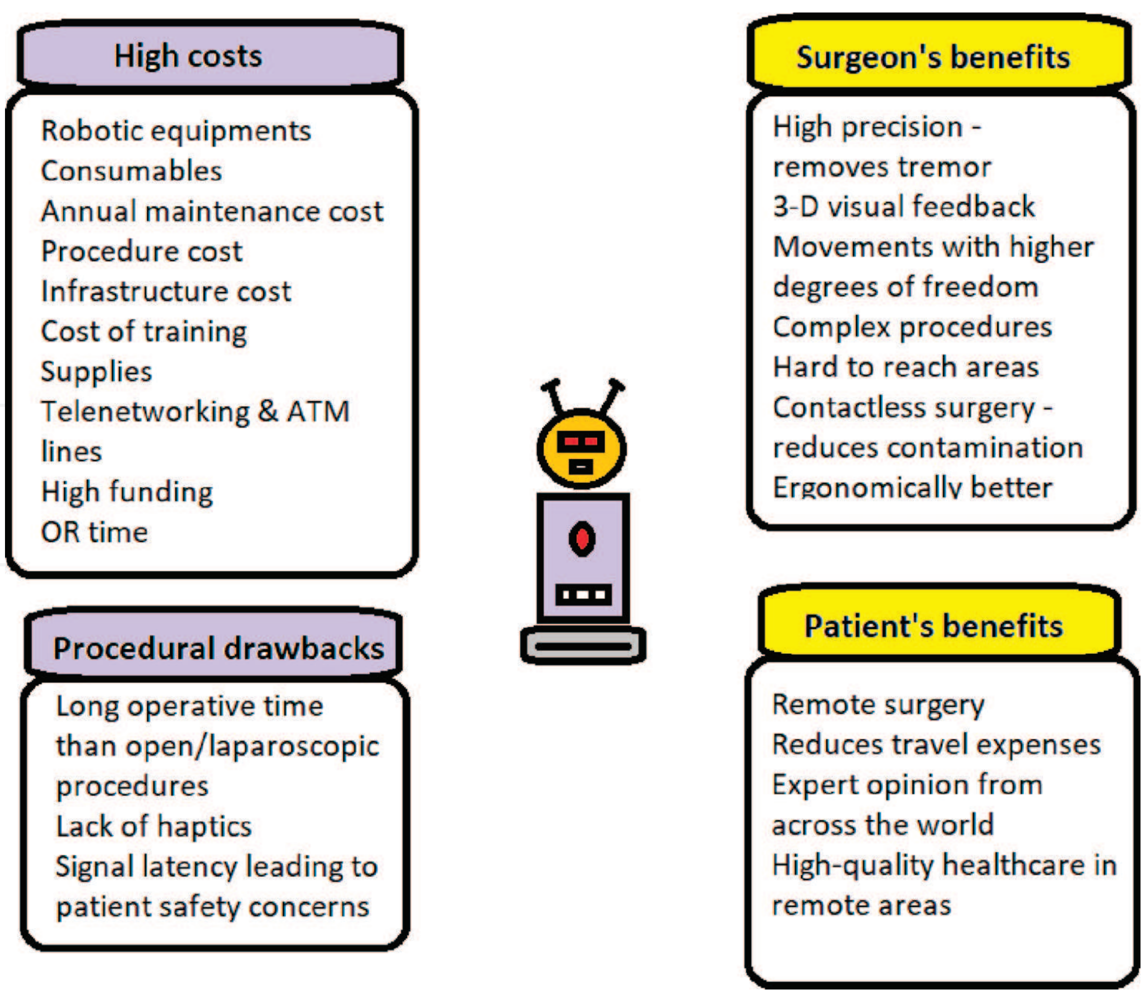

Figure 1.
Cost-benefit analysis.

The annual maintenance cost of these robotic systems is also very high. US hospitals spend $ 1000–4000 more per robot-assisted case than in endoscopic or minimal access and open procedures [31, 32]. Apart from the recently launched “Senhance” surgical system, companies such as Stryker Corporation, Hansen Medical, Verb Surgical, and Mazor Robotics are the leading companies in the robotic-assisted telesurgery market, which challenges the monopoly of Intuitive Surgical. It is believed that this competition will significantly decrease the cost of robotic systems, equipment, disposables, and maintenance in the near future.

Despite the high cost, it has been assumed that robotic surgery would be cost-effective in the long term by reducing postoperative recovery and hospital stays. Until now, most studies evaluating the cost-benefit analysis of robotic surgery are only observational studies. Concrete evidence from well-designed randomized clinical trials is needed in confirming the cost-effectiveness of robotic surgery vis-a-vis laparoscopic or open surgery.

Establishing a high-speed and quality telecommunication service is another area of high investment in telesurgery. It will be determined by the distance between the telelinked centers. In Operation Lindbergh, the estimated cost for 1-year availability of the ATM lines ranged between $100,000 and $200,000. [33] With advancements in communication technology, its cost is also expected to decrease with time, making telesurgery and robotics available to a larger population.

Apart from the technological expenses, there is an added expense for training the surgical staff. Procedural cost, cost of additional supplies, anesthesia, and medicines required for surgery are the additional costs. It is not easy to justify these costs based only on the clinical outcome and shorter recovery time. Currently, on an objective assessment, the cost factor overwhelms the benefits associated with telesurgery. But if analyzed based on healthcare and patient outcomes, the benefits certainly outweigh the costs. The future looks promising in terms of overall cost reduction, which will make telesurgery acceptable throughout the world (**Figure 1**).

10. Conclusion

In the coming era, the goal of providing health facilities to all will be fulfilled by incorporating telemedicine and telesurgery facility into the health care system. In providing telehealthcare, setting up the facility for telesurgery requires a comparatively more robust network channel and affordable surgical robots. Apart from taking care of the scarcity of expert surgeons in remote places, it will also give freedom to choose the desired surgeon for the patient. Telesurgery may save time and money of patients and their families while improving health outcomes. Treating injured soldiers in the combat zone and astronauts in space are the added benefits of telesurgery. This technology would also allow trainee surgeons to perform surgery under the supervision of expert surgeons without jeopardizing the patient’s safety. With future advancements in robotic technology, including haptic and visual feedback coupled with a 5G network, telesurgery could revolutionize health care and surgical treatment around the globe.

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Conflict of interest

The authors report no conflict of interest.

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