# Table of Contents

Abstract.............................................................................................................................................3

Introduction.......................................................................................................................................4

The Essence of Remote and Robotic Surgery....................................................................................4

Challenges of the Technology...........................................................................................................7
  Ethical Issues..................................................................................................................................8
  Technical Issues.............................................................................................................................9
  Legal issues....................................................................................................................................10

Recommendations............................................................................................................................12

Conclusion.........................................................................................................................................13

References.........................................................................................................................................15
Abstract

The paper argues with the prospective of the usage of remote and robotic surgery. It reviews recent cultural and technological state of the technology. Furthermore, it analyzes the benefits and the disadvantages of the remote and robotic surgery. The paper argues that despite the definite benefits of the reviewed technology for the patients and the surgeons, this technology has certain disadvantages. Furthermore, the disadvantages have ethical, technological, and legal peculiarities. Thus, people fear of the awkward machines performing precise actions because of the possible injuries. Furthermore, hardware and software glitches and malfunctions may emerge. Likewise, there is no appropriate legal strategy protecting the rights of the telesurgeons, patients, and the manufacturers.

Additionally, the investigation gives a comprehensive analysis of the presented evidence that supports both arguments. Furthermore, it provides a comprehensive strategy providing the solutions for the mentioned features.

The closing part of the paper provides the possible legal, ethical, and technological solutions. The study presumes that the rapid technological development is too fast for modern society. Thus, the subject requires further investigations to avoid various negative repercussions in the future.
Remote/Robotic Surgery

Introduction

Various technological improvements of the past decades have influenced many spheres of human activity. People use different electronic devices for distant communication, data processing, scientific investigations, and so on. Moreover, the changes led by the technology have entered the sphere of medicine. The reason for this is that surgeons and physicians are in a constant search of the new solutions improving the treatment conditions. Together with surgery video systems and machines for magnetic resonance imaging, many physicians practice remote and robotic surgery. Consequently, the mentioned technological methods and solutions in medicine anticipate negative impacts or potential controversies. Furthermore, possible disagreements include political and legal issues as well as moral ethical implications. Therefore, the paper argues with possible legal and ethical disagreements in the sphere of remote and robotic surgery. Moreover, one assumes that the discussed technology has been introduced for society too early. Thus, the subject requires additional analysis with the provision of the appropriate ethical and legal resolutions.

The Essence of Remote and Robotic Surgery

The term ‘robot’ originates from the Czech word ‘robota’ that means forced labor. The Czech playwright Karel Capek used this term in the meaning known now in 1921 in his play *Rossum’s Universal Robots*. According to the original meaning of the word, robots are autonomous machines capable of performing the programmed set of functions. The reason for the discussion of this topic is that there is evidence that the number of robotic surgery machines is growing. Thus, Pinkerton argues that “in 2000, there were only 1,000 robotic surgeries world-wide. That number surged to 360,000 in 2011 and 450,000 last year.” Current robotic surgery falls into three main categories: controlled systems, automatic and semi-automatic systems. The emergence of robotics opened the perspectives for the
application of robots in various spheres. Thus, the factories use the robotic machinery devices on automatic industrial and assembling lines. Furthermore, the perspectives of the highly precise and rapid performance turned the medical staff towards the usage of robots in surgery. For instance, they required extremely high precision of operations during the brain surgery. The scholars claim that the era of robots in surgery began in 1994 with the usage of AESOP robot as a voice controlled camera holder. However, the first recorder surgery performed with the assistance of a robotic device occurred on 11 April 1985. In this respect, Gomes claims that the surgeons used an industrial robot to assist a computerized tomography guided brain biopsy. The reason for this was “to use a sturdy mechanical structure … to reach a surgical target deep in the brain in a linear trajectory avoiding vital structures of the brain”. Thus, one of the benefits of this technology in surgery is precise targeting required particularly for neurosurgery. Moreover, robotic devices may assist in performing repetitive tasks or the tasks that require endurance. The last case is of vital importance because a surgeon with tired hands can lose the precision of movement, which might lead to negative consequences. Thus, the perspectives of the robot assisted operations “is often heralded as the new revolution… technology that is taking the surgical profession by storm”.

Next, talking about the evolution of robots in surgery, one should note that the first robots were comparatively simple machines. The new technology required serious tests to assure its efficiency and safety. That is why the usage of robots as camera and tool holders was a perfect idea for pilot testing. However, contemporary automatic machines have such capabilities as 2-D vision, 3-D visualization, motion scaling, intuitive movements, visual immersion, and tremor filtration. Consequently, the results of the usage of robotics in surgery included the reduction of the invasiveness of the processes of treatment. Moreover, there has been a paradigm shift in medical procedures that “surgeons no longer directly touch or see the structures they operate”. Video imaging, new technological tools, and endoscope
technology led to the fact that many surgeries have transferred from open surgeries to endoscopic ones. That is why specialists tend to connect robotic surgery with the minimal invasive one.

One of the most widely-used robotic surgery technologies is a slave robot. It consists of two active robotic arms with the instrument manipulators and a presurgical adjustment system supporting the patient and the instrument manipulators.

![da Vinci surgical system](Figure 1. da Vinci surgical system)

The slave robot has a variety of cameras that enable the surgeon operator to manipulate with the toolkit successfully. Thus, the surgeon contacts with the patient-side slave telerobots with the help of joysticks or master manipulators. The essence of a slave robot surgery is that the robotic arms recreate the movements of the surgeon operator. Thus, the slave robot is a passive machine that captures the surgeon’s hand motions through manipulators and sends them to the patient-side robots. The medical practitioners call such machinery a telepresence surgical system, which means “actually being present”. Nowadays, one of the most widely used slave robots is the da Vinci surgical system (Figure 1). One of the peculiarities of this system is that its instruments (Figure 2) follow the orientation and linear motions of the hands of the surgeon. Furthermore, numerous practices with the da Vinci System, including simulated trainings, lead to the fact that modern remote surgery outperforms the classical one. For instance, one of the news of the 2015 was that telesurgeons from the Philippines had
removed a watermelon-sized, 2.7-kilo solid uterine mass from a morbidly obese, diabetic patient using only band-aid incisions. In addition to it, they claim that the application of the traditional surgery would have been more complicated with negative repercussions. Compared to band-aid incisions, the disadvantages of the traditional surgery would have included wound dehiscence, greater pain, higher infection rate, longer immobilization, and longer downtime.

Furthermore, the da Vinci system is capable of extremely precise movements, providing a high-resolution image and is 100% under the surgeon’s control. Additionally, to prove their arguments, the creators of the system present videos showing the system peeling a grape, painting, and folding origami (Figure 3).

**Figure 3. Demonstrating the capabilities of the da Vinci system**

**Challenges of the Technology**

Despite the advances of the machinery, it still has numerous challenges, particularly technical, ethical, and legal ones. The reason for this is that despite its gradual spreading, the robotics technology is new for the vast majority of institutions and surgeons. To assess the
prospective of this practice and predict its perspectives, one has to consider the possible problems in the mentioned spheres.

Ethical Issues

First, people wonder about the ethical applicability of the robotic surgery systems. Most of all they fear about the possible complete independence of the automatic systems. Despite the fact that modern surgery gives preference to the controlled and semi-automatic systems, researchers still develop the autonomous ones. Thus, society should assess possible risks that these surgery stations might include. In this respect, Moore offered the criteria for making the automatic surgery acceptable: they are sufficient laboratory intellectual and technical expertise and “institutional stability”. Such requirements would assure the safety of the technology in terms of programming, mechanics, and the absence of possible physical injuries. Consequently, one regards the ethical issues in the sphere of surgery to be coming from industrial robotics. The difference between the two spheres is that the assembly line workers are protected from the industrial robots with special safety cages. At the same time, a patient is directly exposed to the future artificial surgeon. Moreover, the industrial workers are still endangered by the autonomous machinery. For instance, Gander reports that a robot killed the 22-year old worker at the Volkswagen factory in Germany. Despite the robot was behind the safety cage, the worker appeared to be in the restricted area. Consequently, the robot grabbed him and crushed against a metal plate. Of course, industrial machinery bears significantly more power opposed to the surgical devices. However, the possible danger of the medical robots comes from their direct contact with vital organs. In this context, the sphere of neurosurgery is the most dangerous one as even the slightest mistake of the robot might damage the brain tissues. Additionally, the stories about the injuries from the robotic surgery scare the public. For instance, Pinkerton argues that they have been stories about “patients who have bled out after a robotic instrument inadvertently nicked a blood vessel.”
Furthermore, some of such stories mention those who have been injured having accidental punctures, tears, or burns.

**Technical Issues**

Furthermore, there is a category of people that doubts about the widespread prospective of the “artificial” surgeons. Thus, there are no long-time studies to prove the technological safety of the technology. Likewise, scholars mention such disadvantages as time, cost, efficiency, and compatibility with current systems. Unfortunately, because the technology is new, it is extremely expensive. For instance, despite the high cost of the da Vinci system, its basic construction requires the installation of the expensive small-force sensors. Consequently, this leads to the high prices for the patients. For example, at Brigham and Women's Hospital in Boston the prices are $49,526 for a robotic procedure and $43,622 for abdominal. Opinions differ regarding evaluation of the future costs of the robotic systems. Thus, one group of people claims the costs would be dropping because of the spread of the technology. Likewise, another group of people traces the connection with the IT sphere where the new devices and components are more expensive. Likewise, there might evolve a problem of the compatibility and upgrade of electronics. Thus, skeptics state that the rates and the costs of the upgrades in the future are unknown. Moreover, many people believe that to justify the purchase of such equipment they must gain widespread multidisciplinary use. Additionally, even the widespread da Vinci system has technological drawbacks. For instance, it requires several access ports and requires direct access to the surgical targets from the ports of entry. Consequently, it might involve arm collision and injuries. Furthermore, one of the major limitations of the robotic catheters is the lack of strength and stiffness at their tips. Thus, in some cases of the tissue manipulation, the constraints of the robotic catheters limit their applications. Apart from the direct surgical drawbacks, robotic machines have problems of logistics and space. Thus, researchers argue that the application of these
systems in overcrowded operating rooms might interfere with the surgeons’ dexterity. Apparently, the minimization of the robotic tools is possible in a long time perspective whereas the technology is popular today. Some surgeons claim that the discussed phenomenon is more popular because of the cultural and not medical reasons. For instance, Makary claims that this technology spreads too quickly and that society has a “culture that marvels at new technology”. That is why one can state that there is a collision between the practical reasonability and popularity of the technology. In this respect, there is an opinion that robotic equipment should be introduced in the spheres that lack qualified practical surgeons.

Additional public fears of the technology come from its dependence on electricity and possible software mistakes. For instance, an ordinary surgeon may work even with the candle light despite this being a difficult condition. Additionally, the lack of electricity for a robotic system would result in the rapid stop of the operation. Moreover, the instruments would stay within the body of the patient, and that might cause infections or injuries. In addition, some experts argue about the need in assurance of the compatibility and verification of the used software. For instance, some experts raise concerns about technical glitches that might occur during the surgery.

**Legal Issues**

Furthermore, the introduction and rapid development of the evolving technologies in surgery, the ethical and legal complications would increase exponentially. That is why countries require the development of the appropriate legal basis ensuring safety of the technology towards people. Despite the claims that robotic surgery is the future of humanity, society should prepare appropriate legal resolution for the global introduction of the said technology. For instance, the mentioned sphere requires special trainings and preparations assuring the appropriate skills of the surgeons. That is why there should be legal regulations
in the sphere of medical education providing high quality learning and assessment to reduce the mistakes at work. In this sense, Mavroforou, Michalodimitrakis, Hatzitheo-Filou, and Giannoukas claim that despite the fact that the legal basis for professional liability remains exactly the same, litigation with the use of robotic surgery may be complex. Moreover, courts may decline jurisdiction due to inconvenience to parties.

Thus, the countries’ laws should ensure the respect of the robotic surgery to ethical issues as well as the safety and reliability of the equipment. Furthermore, they should guarantee the provision of sufficient information as well as maintenance of confidentiality. Likewise, the legal resolutions should defend the patient’s rights in case of the undesirable outcome. Thus, if there is a medical mistake, one should evaluate the degree of the hospital’s, surgeon’s, and the manufacturer’s involvement into it. All the mentioned factors indicate that there is a strong need for the development of the separate legal regulations for the robotic surgery. Additionally, the regulations should protect the rights of the people that are restricted to the benefits offered by the applied technology.

The example of the mentioned legal resolutions might be the EU Council Directive 93/42/EEC of 14 June 1993 and the 90/385/EEC. These legal measures preserve the safety issues. They achieve such an effect through the evaluation of such factors as manufacturing of the robotic devices as well as their selling and handling. For instance, they regulate the cases that might happen only in the future such as criminal activity during the telesurgery and so on. However, Graur et al. claim that they view such documents as preliminary legal measures that require further development of the issue. For instance, it is argued that the manufacturers might attempt to escape the strict legal framework by the production of non-medical devices.

Additional problems may arise with the certification of the surgeons and their practice afterwards. For instance, the “initial concern is whether a practitioner licensed only in
jurisdiction A who treats a patient in jurisdiction B violates B's laws”. Further concerns might involve the actions of the surgeon when he or she might commit a crime in the cases of malpractice due to the undefined liability. Furthermore, the legal disagreements between the manufacturing companies may arise. One example of such case is the lawsuit between Computer Motion and Intuitive Surgical. The two companies merged in 2003 and Computer Motion’s produces were discontinued in favor of the Intuitive’s ones. That is why the surgical and technological problems followed by the ethical and legal repercussions can restrain the technological evolution. Furthermore, the manufacturing of the new devices might stop because of the mentioned disagreements. Additional problems might evolve because of the emergence of the biased reviews and articles in favor of the products that tend to monopolize the market. In this sense, the manufacturers of such devices should share the objective reviews of their products with the public.

**Recommendations**

Consequently, one can see that the “wow” effect of the robotic surgery in the mass culture clashes with the problems of the reality. Thus, in order to provide the ethical solutions, society needs more adequate and comprehensive studies. Such studies should assess the degree of the applicability of the robotic surgery in various medical fields. Furthermore, additional studies should stimulate the provision of adequate information to the public. Likewise, the manufacturers should establish a unified safety standard assuring the safety of the software and hardware. More to say, the institutions that are willing to install robotic equipment should obtain a special license from the state and the manufacturer. Such institutions should have extra power supply facilities as well as large operating rooms. Furthermore, there is a need for the manufacturer to provide special courses increasing the efficiency of the surgeon operators. Such courses should go along with the legal regulations of the sphere of robotic surgery. Thus, the facilities should instruct the telesurgeons of their
legal responsibility and the possible consequences of their actions. Additionally, the companies should introduce a developed and easy to comprehend system of licensing. Such a system would allow surgeons to perform the operations strictly in their field. These measures would protect both the patients and the surgeons from the negative physical and legal outcomes accordingly in case of the surgeon’s mistake. Furthermore, society should define the spheres where the telesurgery might be especially helpful. For instance, the arctic and the space stations would definitely benefit from such technology. At the same time, remote surgery should not be preferred for the institutions that already have skilled surgeons. Further researches should focus on the delivery of the therapeutic modalities through natural orifices in which examination is under distant control and navigation. Thus, society can definitely benefit from remote and robotic surgery. However, this could be possible in case in case of the wide range of scientific investigation and legal measures raising the standards of the technology.

**Conclusion**

Analyzing contemporary remote and robotic surgery, one comes to the conclusion that this technology is prospective only in the future. Among its benefits, one can name less blood loss and rapid recovery time for the patient and the ability of performing operations in distant locations. As for surgeons, they get the availability of more precise actions and reduction of the tiresomeness. However, the scholars claim that this technology is more culturally than scientifically driven. Thus, despite the lack of a comprehensive field of practical studies, the rates of the installation of the equipment have been constantly growing. Consequently, scholars argue about the possible ethical, legal, and technological issues. For instance, people still fear of the possible physical damage done by the artificial surgeon because of the hardware or software mistake. Moreover, not all surgeons have the appropriate knowledge and skills. Furthermore, they are not aware of their legal liabilities. At the same time, the
legal resolutions provided by some countries might aggravate the conditions, which is opposite of their aims. Thus, modern society is not ready for the rapid spread of robotic surgery. Consequently, this technology will benefit in case of additional comprehensive studies. Likewise, it will benefit from a comprehensive legal program provided by the states’ and local regulators.