Title: ROBOTIC SURGERY

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ABSTRACT

The field of surgery is entering a time of great change, spurred on by remarkable recent advances in surgical and computer technology. Computer-controlled diagnostic instruments have been used in the operating room for years to help provide vital information through ultrasound, computer-aided tomography (CAT), and other imaging technologies. Only recently have robotic systems made their way into the operating room as dexterity-enhancing surgical assistants and surgical planners, in answer to surgeons' demands for ways to overcome the surgical limitations of minimally invasive laparoscopic surgery.

The Robotic surgical system enables surgeons to remove gallbladders and perform other general surgical procedures while seated at a computer console and 3-D video imaging system across the room from the patient. The surgeons operate controls with their hands and fingers to direct a robotically controlled laparoscope. At the end of the laparoscope are advanced, articulating surgical instruments and miniature cameras that allow surgeons to peer into the body and perform the procedures.
INTRODUCTION TO ROBOTIC SURGERY

Circa 1941: Second World War; D-day, Normandy.

A soldier in a far off battlefield with a life threatening injury, with no doctor in sight for hundreds of kilometres. The nearest hospital is thousand kilometres away. He needs to be operated upon right away. He dies.

Now Imagine: An army ranger is riddled with shrapnel deep behind enemy lines. Diagnostics from wearable sensors signal a physician at a nearby mobile army surgical hospital that his services are needed urgently. The ranger is loaded into an armored vehicle outfitted with a robotic surgery system. Within minutes, he is undergoing surgery performed by the physician, who is seated at a control console 100 kilometers out of harm's way. The patient is saved. This is the power that the amalgamation of technology and surgical sciences are offering Doctors.

Just as computers revolutionized the latter half of the 20th century, the field of robotics has the potential to equally alter how we live in the 21st century. We've already seen how robots have changed the manufacturing of cars and other consumer goods by streamlining and speeding up the assembly line. We even have robotic lawn mowers and robotic pets now. And robots have enabled us to see places that humans are not yet able to visit, such as other planets and the depths of the ocean. In the coming decades, we will see robots that have artificial intelligence, coming to resemble the humans that create them. They will eventually become self-aware and conscious, and be able to do anything that a human can. When we talk about robots doing the tasks of humans, we often talk about the future, but the future of Robotic surgery is already here.
WHAT IS ROBOTIC SURGERY?

Robotic surgery is the latest technological advancement that introduces the robotic technology in the field of surgery. Only recently have robotic systems made their way into the operating room as dexterity-enhancing surgical assistants and surgical planners, in answer to surgeons' demands for ways to overcome the surgical limitations of minimally invasive laparoscopic surgery.

This system enables surgeons to remove gallbladders and perform other general surgical procedures while being seated at a computer console and 3-D video imaging system across the room from the patient. The surgeons operate controls with their hands and fingers to direct a robotically controlled laparoscope. At the end of the laparoscope are advanced articulating surgical instruments and miniature cameras that allow surgeons to peer into the body and perform the procedures. This system and other robotic devices developed or under development have the potential to revolutionize surgery and the operating room. They provide surgeons with the precision and dexterity necessary to perform complex, minimally invasive surgical (MIS) procedures, such as beating-heart single- or double-vessel bypass and neurological, orthopedic, and plastic surgery, among many other future applications. Robotic surgery has broadened the scope and increased the effectiveness of minimally invasive surgery (MIS); improved patient outcomes; and created a safer, more efficient, and more cost-effective operating room. These Robotic systems will one day be applicable to all surgical specialties.
WHAT MAKES ROBOTIC SURGERY SO POWERFUL?

The Laparoscopic surgery—in which instruments are inserted through small incisions—has been used by surgeons whenever possible. Patients are less traumatized, require shorter hospital stays, and heal faster than with conventional surgery. Laparoscopic instruments are mainly limited to scissors and staplers to close incisions or attach blood vessels. It also has graspers to manipulate tissue. The instruments enter the body through a long tube; a video image from a tiny camera called an endoscope poked through another incision guides the surgeon. For a relatively simple procedure like gallbladder removal, the tools work well enough. But surgeons can't use the instruments to perform complicated tasks like suturing and knot tying. Because of these limitations, most operations can't be performed endoscopically.

Robotic surgery uses laparoscopic tools—including miniature robotic hands with the dexterity to tie knots. The reason the surgeons have to cut a person open is to get their hands in there. The surgeons like to get their hands around the organs, to palpate them. Robotic surgery provides with little instruments in there that let the surgeons feel as if they are working with their hands in a normal procedure, and hence avoiding a bigger incision.

The Robotic surgical system consists of a pencil-size joystick (one each for the surgeon’s right and left hands), a computer, and right-hand and left-hand end effectors—the robotic instruments that snake into the body to perform the actual surgery. Each hydraulically powered end effector consists of a single digit, three to four inches long and less
The surgery is completely anthropomorphic. If the hand moves in, the instrument moves in; if the hand moves to the right, the instrument moves to the right.

The system also has force feedback, which relays to doctors the response of muscles and other tissues to their actions. The feedback makes the procedure feel more like normal surgery. The system also has tactile sensors that will transmit the feel of tissue to the surgeon’s fingertips.

Surgery now uses robotic and image processing systems in order to interactively assist the medical team, both in planning the surgical intervention, and in its execution. This new technique enhances the quality of surgical procedures by minimizing their side effects (smaller incisions, lesser trauma, and more precision...), thus increasing patient benefit while decreasing the surgical cost. These techniques are being successfully introduced in several areas of surgery: neurosurgery, orthopedics, micro-surgery, cardiovascular and general surgery etc.
STEPS INVOLVED IN CONDUCTING SURGERY.

There are two main steps in a general robotic surgery intervention:

**1: Data acquisition and subsequent planning:** In the pre-operative phase, a patient dependent model of the rigid, e.g. bones, and de-formable, e.g. the heart anatomical entities involved in the surgical act have to be built. For this, several medical imagery techniques, MRI, Scanner, Ultrasonic, etc. are used, where the anatomical structures are detected, located and modelled. In the same time, the mechanical model of the robotic system is fused in an overall geometric model. This will be used to describe and simulate the different potential problems that may occur during the intervention.

**2: Intra-operative assistance:** The results obtained in the planning phase are then calibrated and put in correspondence with patient in intra-operative situation. As a consequence, the robotic system is able to provide interactive assistance/guidance, and to constrain the movements of the surgeon in order to perform, with the desired precision, the possibly pre-defined procedure, e.g. neuro-surgical biopsy. In some cases, the robot may have an autonomous behaviour in order to realize a dedicated and fixed part of the procedure, e.g. thighbone drilling for artificial hip installation.

This is an illustration of a local robotic surgery unit.
**Surgeon console**- A high definition 3-dimensional image of the area to be operated upon is projected on to a screen. Mechanical controls for operating the robotic arm is handled by the surgeon in the console.

![Surgeon console diagram](image)

**Image processing equipment**- This consists of optical sensors and a Digital signal processor for getting enhanced images.

**Surgical arm cart**- This acts as a platform for the entire Robotic arm and is used for controlling the linear movements of the arm.

**Hi-resolution 3-D Endoscope**- This consists of an optical fibre and a reflector arrangement. It is an optical instrument used for visual inspection or photography of internal parts of the human body. The insertion of the endoscope into the body is done either through the natural openings or through a small incision in the skin.
So far, these machines have been used to position an endoscope, perform gallbladder surgery and correct gastroesophageal reflux and heartburn. The ultimate goal of the robotic surgery field is to design a robot that can be used to perform closed-chest, beating-heart surgery. According to one manufacturer, robotic devices could be used in more than 3.5 million medical procedures per year in the United States alone.
WHERE CAN ROBOTIC SURGERY BE USED?

Robots have often been thought of as machines that replace humans. These machines have been used in manufacturing, space exploration, and other areas. However, they can also be used as surgical tools. Many people think of these tools as devices used to replace the physician. However, they are used to complement human surgeons. Surgical robots are technical components in an overall system that allows the joining of information and action. "Surgical Robotics" refers to the application of "robotic" technologies, including sensing, manipulation, modeling and geometric analysis, and human-interfaces to increase human physicians’ ability to carry out varied medical procedures.

There are increasing numbers of medical specialties that are using these technologies to extend and enhance human capabilities. Neurosurgery, orthopaedics, ophthalmology, dentistry, urology, general surgery, gynecology, radiation oncology, and many more fields are relying on robotics for a wide range of uses. This wide range of roles includes, "intern replacements", which perform such tasks as instrument holding, and limb positioning; "navigational aids", which help the clinician relate the "virtual" reality of presurgical images, models, and plans with the actual reality of surgery; "telesurgical systems", which extend the reach of the surgeon over great distances or into confined spaces; "precise positioning systems" which accurately place a needle, radiation beam, or other instrument onto selected targets, and "precise path systems", which move an instrument through a defined path.

The field of robotics provides an enhancement of human performance, the ability to project surgical expertise to remote and distant places, and recreation of a patient in a "virtual" form. Robotics takes the surgeon’s motions and changes them into electronic signals which through a computer can be enhanced. The result is performing a procedure with greater accuracy and
precision. Robotics allows doctors to perform the most delicate of operations with little risk and postoperative discomfort.

Robotic surgery has been used in many delicate procedures including heart surgery. The first coronary bypass surgery in a human patient using robotic arms manipulated by the surgeon was performed by Dr. Ralph Damiano, at the Milton S. Hershey Medical Center at Penn State College of Medicine in Hershey, Pennsylvania. The device, called the Zeus Robotic Surgical System, consists of three robotic arms that are used to manipulate instruments inserted into the chest through pencil-sized incisions. Normally, coronary bypass surgery requires a 12 to 15 inch incision in the chest, and patients are hospitalized for 5 to 6 days. This procedure may lead to the elimination of the large incision and to much faster recovery time. If robotic surgery continues to be safe and successful, it could mean that doctors many need to cut across the chest and crack the rib cage to perform open-heart surgery only in rare cases.

Because robotic instruments and controls are linked electronically via cable or satellite link, a surgeon can operate on patients located in remote areas. In order to perform a remote surgery operation, the system requires two functioning worksites: one for the surgeon and one for the robotic devices actually operating on the patient. Remote surgery is based on a master-slave robotics model, in which a controller manipulates the robot from a distance by using two joysticks that control the tracking of the robotic devices. The worksite on the patient’s end contains the robotic devices, which perform the surgical procedures. Despite certain difficulties, many experts believe remote surgery will be a reality in a few years.

By providing the use of a variety of technologies to enhance the capabilities of human surgeons, robotics will become an increasingly vital component in the medical world. Doctors of the next century must learn to use this information to complement their capabilities in order to provide better patient care.
CONCLUSION

The field of surgery has grown in amazing leaps and bounds since anesthesia was first developed and the first surgeries were performed, more than 100 years ago. Now, surgeons, through Robots are finding new ways to get inside the patient, rather than the standard large incision. The robotics revolution requires a different skill set and advanced instrumentation that can perform the functions of the human hand, but at a microsurgical scale. With the emergence of the first completely robotic surgery system, we are crossing the threshold into an amazing new future.

Surgical robotics systems mark the beginning of a potentially huge wave of surgical applications for robotic technology. With the assistance of surgical robots, surgeons can’t extend their healing skills to places within the body that are currently out of reach. The continuing evolution of this technology holds the promise of immense benefits in healing that cannot yet be imagined.
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