Dakota Edwards
IT103-DL2
Robot-Assisted Surgery
George Mason University

"By placing this statement on my webpage, I certify that I have read and understand the GMU Honor Code on http://oai.gmu.edu/honor-code/. I am fully aware of the following sections of the Honor Code: Extent of the Honor Code, Responsibility of the Student and Penalty. In addition, I have received permission from the copyright holder for any copyrighted material that is displayed on my site. This includes quoting extensive amounts of text, any material copied directly from a web page and graphics/pictures that are copyrighted. This project or subject material has not been used in another class by me or any other student. Finally, I certify that this site is not for commercial purposes, which is a violation of the George Mason Responsible Use of Computing (RUC) Policy posted on http://universitypolicy.gmu.edu/1301gen.html web site."
Robot-assisted surgery uses robotic hands with human-like movements to help complete the work normally done by a sole doctor. This creates many great advantages for physicians, giving them the ability to perform minimally invasive surgeries quickly and efficiently, with little error. In essence, the robot simply becomes an extension of the doctor, moving and performing on a patient the same way he would.

Currently, there are two main types of robotic-assistance machines being used. The first, a “passive” robot is completely controlled by a physician nearly six feet away from the patient. The doctor is able to view the entire procedure and make decisions for the machine. Using this type of robot typically renders the surgery safe, because the machine is not attempting anything a doctor would not be able to do. The second, an “active” robot is controlled solely by a computer, with minimal human direction. It comes with the capability to perform unsafe acts during surgery and is able to make decisions on its own (Gerhardus, 2003, p. 242). An advanced machine capable of switching from a passive mode to an active one, and vice versa, is also an option for hospitals and medical centers.

At present, there are two key robot systems that are being utilized in medical centers, the da Vinci robot and the Zeus robot. Both systems are FDA approved through clinical trials; the da Vinci is approved to cut, dissect, and suture, while Zeus is approved to grasp, hold, and move tissue during procedures (Gerhardus, 2003, p. 242).

These machines are vital in the performing of minimally invasive surgery (MIS). Minimally invasive surgeries are procedures in which the surgeon minimizes the invasiveness of the surgery in order to reduce trauma to the surrounding tissue. During these procedures, surgeons no longer “directly touch or see the structures on which they operate. (Gerhardus, 2003,
MIS procedures are made easier by the use of robot-assisted technology. The surgeon will sit at a console approximately six to seven feet away from the patient and control the instruments on the robotic arm. A separate computer filters out any hand tremors the surgeon might have and then transmits the surgeon’s every movement to the robotic arms in real-time (Gerhardus, 2003, p. 243). This increases the efficiency and accuracy of MIS procedures, as well as decreases the rehabilitation time for patients.

Dr. Douglas Boyd, who operates out of London, Ontario, describes robot-assisted surgery as “The holy grail of surgery,” stating that “The computer digitizes our motion at the console in very precise movements that are performed by robotic hands inside.” He admits that most of the work is done by the robot, adding that “Zeus gave us dexterity and precision. It enabled us to use the same big motions used during conventional surgery, where you can change angles and maneuver to the right position” (Azam, 1999 Oct. 15). Because of the increased precision and reduction of a surgeon’s large hand movements, doctors are able to use their natural hand movements, just as they would in an open surgery.

There are still disadvantages to this new technology. For physicians, there is an intensive learning curve requires before a surgeon is even able to operate using robot assistance. It is required that they take 40 hours of course training, but also operate on 12-18 patients to feel comfortable and be considered familiar with the machines (Gerhardus, 2003, p. 245). Even with those standards, a doctor may be unable to complete an operation within the “standard time,” until he is fully comprehensive on the machine.

An important part of a surgeon’s ability is tactile feedback. When operating with these robot-assistants, there is reduced tactile feedback. The surgeons are not feeling things the way they normally would during surgery, forcing them to change their state of mind from a “hands
on” surgery, to a hands on surgery with little tactile feedback (Gerhardus, 2003, p. 242).

Patients have experienced less pain, a faster recovery, and a decreased chance of morbidity overall (Gerhardus, 2003, p. 243). The use of these robots for MIS procedures also reduces the rate of bacterial infections and the need for blood transfusions. But for patients there is more to consider beyond the success of these procedures.

The use of robots for assisting surgery poses many ethical dilemmas for patients. They must receive very comprehensive information on the treatment, including consideration of risk, what will be done in case of technical failure, and they also must be convinced and reassured that contingency plans will be in place to ensure the operation runs safely and effectively (Mavroforou, 2010, p. 76). The biggest concern among patients is the loss of human connection normally received by a surgeon. “A human is able to explain what he is doing and why he is making certain decisions,” but a computer is not (Harryson, 2002, p. 4). These robots are not capable of handling human emotions and connections. They are not able to provide sympathy or care the way a doctor would. This can easily scare people. Patients look to their surgeons or physicians for comfort, as well as treatment. While a robot can provide the treatment, it can’t reproduce the feeling of comfort. Trust is a serious dilemma for many patients. While they are aware doctors make mistakes, a machine malfunctioning has a more drastic undertone to it. Will doctors be able to confidently tell patients that a malfunction with the robot will not lead to their death or the further damage of what was being operated on?

A second major issue is that the use and efficacy of this technology is not well established yet (Mavroforou, 2010, p. 76). There have been no records of long-term follow up with patients. Many procedures also have to be redesigned to optimize the use of the robotic arms and increase efficiency, which requires consent from the patient.
In regards to the security of this technology, confidentiality and doctor-patient relationships come into question. Care must be taken to ensure that people who are not directly involved in the patients care, such as intermediaries, do not disclose the patient’s information. They must only observe what is happening in the operating room (OR) (Mavroforou, 2010, p. 76). All decisions are made between the doctor and the patient, keeping the information private. The confidentiality of the patient is put at risk because the doctor is not directly in the OR during the procedure.

The current cost of this technology is extremely expensive. For Zeus alone, the market price is $975,000. This does not include the yearly maintenance fee of $100,000 or the physician training which costs nearly $250,000. The total cost for implementing Zeus in a medical institution totals around $1.325 million. The total cost of implementing da Vinci is upwards of that number, totaling $1.35 million (Gerhardus, 2003, p. 242). A small hospital, Memorial Hospital, in Converse County, Wyoming, purchased the da Vinci surgical system for $2.2 million. The facility expected to do about 100 robot-assisted surgeries a year. According to Dr. Martin Makary, surgical director at Johns Hopkins, that falls far below the minimum standard requirement to produce a viable financial return within six years of the investment (Lee, 2014 Apr. 19, p. 75). In order to make the purchase worth it, hospitals should be performing at least 150-300 surgeries a year for six years.

The cost of this technology is likely to remain high. As the technology becomes more complex, the cost will continue to rise (Harrysson, 2002, p. 4). There are concerns about how much upgrading the systems will costs, which creates the ethical concern that if the system cost goes up, will the cost of the procedure for the patient also increase?

Research is currently being conducted on several imperative robots, all attempting to make “noninvasive” surgery a reality. NeuroArm is a two-armed, MRI-guided neurosurgical robot
actuated via piezoelectric motors. It is accurate to tens of micrometers. MrBot, another like NeuroArm, has a parallel linkage arm designed for MRI-guided access of the prostate gland, actuated by pneumatic stepper motors for reduced MR interference. The most impressive of the robots are TraumaPod and HeartLander. TraumaPod is a semi-automatic telerobotic surgical system designed to be rapidly deployed. It is a surgical cell which consists of features such as, a surgical robot, a scrub nurse subsystem, a tool rack system, patient imaging system, and supply dispensing system. HeartLander is a minimally invasive robot capable of using suction to crawl around the surface of the heart (Azam, 1999, Oct. 15). It is mainly designed for procedures such as drug delivery and cell transplantation. These machines give an idea of what is to come from robot-assisted technology in the future and will continue to change to fit medical needs.

Although there are many different social, ethical, and healthcare aspects to consider when discussing these robot-assistance machines, they will only improve as time goes on. Dr. Boyd asserts that “The opportunities for robot-assisted, computer enhanced surgery are limitless. This can be used in pediatric surgery. It has the potential to chance medicine; it’s one thing to cut things out, but the dexterity, the precision required to be able to connect minute vessels and tissues, can lead to all kinds of possibilities.” As this technology continues to be researched, more knowledge will be gained and more extensions will be made in an effort to advance it. With any hope, robot technology will become a dominant part of the medical field.
Bibliography


Dr. Douglas Boyd talks about his experience with robot-assisted surgery through the use of Zeus. He contends that this technology is the holy grail for surgery and continually makes statements in the support of its use. He specifically discusses his work with bypass surgeries and the difference the use of robotic assistance machines has made. He compares and contrasts the conventional method of performing a bypass surgery to performing a bypass surgery with the help of this technology. The last thing he discusses is the training in Canada versus the United States, claiming the many more


The author of this article discusses how medical robots have been used since surfacing and where they plan on going in the near, and also distant future. He gives a unique perspective in the future of these robots, only looking towards advancement. He describes several types of robots that are currently in use or currently being researched and gives an explanation of each. The
article also talks about the different types of procedures in which these robots are and can be used. This article is good for its detail in presenting the different types of robotic structures. The author made it easy to understand.


This article discusses the way robotic technology is currently being used. It describes the benefits for patients, doctors, and hospitals, but it also talks about the disadvantages doctors will face. The author then goes on to talk about the costs of implementing such technology and the future outlook on its continued use. The article describes potential ways of using the technology in the future and what changes can be made to improve its use. The author provides great insight to how the technology can potentially be used and make a vast difference in the medical field.


The above article directly talks about the use of robot-assistance during surgery and its relevance to trust. The main type of surgery that is discussed throughout the article is orthoscopic knee surgeries. The author also discusses the possible cons of robotic-assistance, including safety, accuracy and control of these machines. She also goes on to speak about patient concerns
and some of the ethics behind using this technology. This article will serve as importance because she hits many of the major points in discussing robots in relation to human trust.


This article directly discusses the problems facing small hospitals who are implementing this technology into their institution. It talks about the standard surgical rate for making a viable return on investment and the minimum amount of time these machines should be implemented for this cost and return to be true. It also discusses how clinical use is not the only reason for purchase, but that they can also be used for marketing purposes, plus to keep surgeons interesting in employment.


This article talks about ethical and legal issues regarding robot-assisted technology in the medical field. The author talks about the ethical concerns of patients and surgeons. She talks about the requirements for a doctor to obtain the skills necessary for utilization of the machines and how it impacts the hospital in regards to implementation costs. She also discusses the issue of doctors losing out to these machines, and thus their skills becoming unnecessary in the field.
The article concludes that surgical robots will have a significant impact on surgical practice, but it will present many ethical and legal challenges.