

Utilization of robotics in medical research



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1. Introduction/Objective

In the field of medical research, robotics has provided much assistance in the subfields of cancer research, biomedical research, and surgery in order to enhance the industry and to ultimately help all of those in need of medical assistance. Robots are currently very important, if not essential, to the medical research industry. Robotics has influenced and helped to progress medical research, especially in the three subfields previously mentioned. There are currently many institutions which lead the way in robotics in medical research such as University of Penn and the University of Texas. In cancer research, robots like nanorobots, apheresis machines, and cyclotrons are utilized to deter and destroy cancer tumors and cells. In biomedical research, robots like pacemakers, insulin pumps, and artificial organs are used. In surgery, the da Vinci Surgical System and PRECEYES robots are utilized. The objective of this paper will be to display all that robotics has done for the field of medical research by listing the robots and describing their specific tasks. This paper will mention all of the important robots which have aided the field of medical research that will also be utilized in the future.

2. 1 Cancer Research: History

Cancer has been a known disease since around 3000 BC with its discovery in Egypt. In the original texts, the disease was described as having no cure. The Egyptians also described using a tool to remove ulcers via cauterization with a ' fire drill'. This is the earliest depiction of cancer and tools utilized to attempt to cure/remove the disease. (Early History of Cancer)

2. 2 Cancer Research: University of Pennsylvania

One of the lead institutions in the field of cancer research is Penn Medicine. Ever since 1973 the Penn Medicine Abramson Cancer Center has been designated a Comprehensive Cancer Center by the National Cancer Institute (NCI). The Abramson Center has over 400 scientists who work there not only to help people beat cancer but to also run cancer clinical trials. Cancer clinical trials are “ combinations of medical, surgical, and radiation therapy” in order to improve treatment effectiveness and to improve the outcomes. Thanks to clinical trials, cancer has become far easier to diagnose, create more successful medications, and advance radiation and surgical techniques. All the strides the Abramson Center has made would not have occurred without the help of robotics. (Penn Medicine)

2. 3 Cancer Research: University of Texas

Another leader in the cancer research field is the University of Texas MD Anderson Cancer Center. The MD Anderson Cancer Center over the last 29 years has been one of the “ best hospitals in cancer care” according to the U. S. News and World Report. Like the Penn Abramson Center, the MD Anderson Center also uses clinical trials in order to help find treatments for cancer. First, the treatments are started in a lab, then the treatments are tested on animals, and lastly on people. Like UPenn, the massive strides by the MD Anderson Center would not have been so lengthy without the help of robotics. (University of Texas)

2. 4 Cancer Research: Nanorobots

One of the smallest robots that has had such a big impact is nanorobots when it comes to cancer research. Nanorobots are defined as microrobots that are smaller than or a little larger than a couple nanometers. One nanometer is the equivalent of 10^{-9} meters. Nanorobots are programmed with a specific task, and in the field of cancer research it is to kill tumors. The nanorobots are designed to seek out cancer tumors and destroy the tumor by cutting off blood supply to the target. At the University of Arizona, nanorobots are currently being tested. The robots are 60 nm by 90 nm and are coated by thrombin, a blood clotting enzyme. The nanorobots have the job of finding the tumors and transporting the thrombin. The robots themselves need to be programmed in order to specifically attack cancer tumors and to avoid healthy tissue. This is done by programming the robots to target the protein nucleolin, a protein found in high concentrations on tumor cells but not found on healthy cells. Yuliang Zhao, a professor at the National Center for Nanoscience Technology (NCNST), claims, "The nanorobot proved to be safe and immunologically inert for use in normal mice and, also in Bama miniature pigs, showing no detectable changes in normal blood coagulation or cell morphology," to portray the safety of the robots (Fully Autonomous). Within 24 hours, it has been shown that tumor blood supply has been blocked and the tumor tissue has been damaged without damage to healthy tissue. While this method was tested on mice, 3 out of 8 of the mice had the tumors completely destroyed and the median survival time rocketed from 20.5 days to 45 days. Those working with nanorobots are currently looking for clinical partners to help fund the project and continue the research. (Fully Autonomous)(Liu, Jason)(Shah, Agah)

2. 5 Cancer Research: Chimeric Antigen Receptor T Cells

Another newer cancer treatment is CAR-T cell therapy. T cells are cells that are necessary in the body's immune system. When someone has cancer, the body often fails to immediately recognize the tumor thus delaying the deployment of T cells. Once the cells are deployed, the attack is ineffective due to the delay. The idea behind CAR-T cell therapy is to train the T cells to easier detect cancer at an appropriate, earlier time. The major robot used in this process is the apheresis machine. The apheresis machine is programmed to take blood from the patient and to then isolate out the white blood cells and T cells from normal blood cells. The T cells and white blood cells are then taken to a lab while the machine returns the blood to the patient. The isolated T cells are then sent to a laboratory which they become genetically altered into CAR-T cells which is an abbreviation for Chimeric Antigen Receptor T Cells. The CAR's are proteins which are attracted to the cancer cells giving the T cells guidance to seek and destroy the tumor. The CAR-T cells are then infused back into the patient and have the ability to remain in the body months after infusion even after the tumor has been eliminated. CAR-T therapy is a new, robust system that requires the apheresis machine in order to operate. Without the apheresis machine, this treatment would not exist. (CAR T Cells)

2. 6 Cancer Research: Proton Therapy

Another revolutionary, renowned treatment for cancer is proton therapy. Proton therapy uses the emission of protons to penetrate cancer tumors. The protons pass by the atoms in a cell and rip the electrons from their

atoms causing ionization. This ionization causes damage to cancer cells thus destroying cancerous tumors. Proton therapy is the most technologically advanced form of cancer treatment and is far superior to X-ray or gamma treatment. Proton therapy uses a beam of protons to pinpoint a tumor and to avoid dealing damage to other tissue such as the heart, lungs, and bones. X-rays, on the other hand, have the potential to damage large swaths of bodily tissue due to the spread of the rays. Due to the nature of the protons, the proton beam penetrates the tumor and ceases to travel past. X-rays, however, penetrate the tumor and continue to pass through the body, causing secondary tumors and causing damage. The step from primitive X-ray therapy to the advanced proton therapy would not have occurred without the assistance of robotics. The cyclotron is the main robot utilized in proton beam therapy. The cyclotron has the task of accelerating particles via the use to electromagnetic waves. In the case of protons, a stream of them is fed into the device and voltage is then applied to attract or repel the particles, thus causing them to accelerate. The protons travel in a circular path and as they accelerate they come closer and closer to approaching the speed of light. In cancer treatment, the protons are then emitted from the machine and focused into cancer tissue. (Proton Therapy)

2. 7 Cancer Research: Stereotactic Radiosurgery

A large problem in cancer treatment is when tumors are formed in the brain. The brain is a sensitive are which is also had to penetrate due to the skull. This was the basis to the formation of Stereotactic Radiosurgery (SRS). Stereotactic Radiosurgery is non-surgical radiation therapy used to treat tumors especially in the brain. The tools/robots utilized for such a feat are <https://assignbuster.com/utilization-of-robotics-in-medical-research/>

the Gamma Knife and the linear accelerator. The Gamma Knife is a machine which focuses up to 192 beam of radiation which penetrate into tumors in the brain without destroying any of the neighboring, healthy tissue. The Gamma Knife has extreme precision and is non-invasive whatsoever. Much like a cyclotron, the linear accelerator uses waves to accelerate subatomic particles. The differences are the medium which accelerates the particles and the particles themselves. The linear accelerator uses microwaves to accelerate electrons which then collide with heavy metals such as lead to produce X-Rays. X-ray radiation can pose a potential problem when it comes to damaging healthy tissue, but as the X-rays leave the machine they are formed to conform to the patient's tumor shape. The beam is shaped via a "multileaf collimator that is incorporated into the head of the machine" (Cyclotron). The machine is mobile and therefor has the ability to rotate around the patient to achieve the optimal angle for radiation. (Cyclotron) (Elektra)

2. 8 Cancer Research: Conclusion

Robotics has proved to become a staple part of medical research due to its assistance with cancer research. Cancer, seemingly a death sentence, has become more and more curable over the years due to the robots previously mentioned. Robots have aided this field because they have provided many different ways and procedures to treat cancer. With robots, doctors are able to treat cancer without even physically touching the patient. The machines have reduced the possibility of major, catastrophic errors that humans make. Ultimately, robots have helped to lead to the creation of newer, safer ways to mitigate or treat cancer.

3. 1 Biomedical Robotics: Introduction/History

Robotics have granted a great benefit to the field of biomedicine. Biomedical robots are robots used to aid humans or even other animals in their lives. These robots main purpose is to work as an assistance to those who have disabilities and issues that need hands on and constant help. These robots are as simple as a prosthetic leg and are as complicated as a device that monitors a humans vital signs. They all are included in the field of biomedical robots. Devices such as prosthetics have been put into use in the world for thousands of years back to the egyptians. They had a great fear for amputation because they believed that if a person was not whole on Earth they would not be whole in the after life. They developed prosthetic limbs to give to their people to use and also to be buried with. Other more sophisticated biomedical robots were created later on with devices like the first implantable pacemaker which was designed in 1958. Created by Wilson Greatbatch the implantable cardiac pacemaker opened the door for many more biomedical robots to be created and implanted to serve all living beings. (AABE), (EMBS), (Techoarget)

3. 2 Biomedical Robotics: The Heart Lander Robot

The leading institution in biomedical robotics is Carnegie Mellon University. They have conducted many projects in this field that have been used to aid the human body. Cam Riviere, a researcher at Carnegie Mellon University, created the Heart Lander. This device is used to offer a minimal therapy to the surface of the heart. The Heart Lander is a mobile robot that works autonomously to find the specified area of the heart that needs the therapy.

It is inserted into the chest just below the sternum. There it will navigate itself to the correct part of the epicardial surface of the heart. The main goal that this robot is designed to achieve is to stabilize the interaction that the surface of the heart will have when it is beating. (Carnegie Mellon)

3. 3 Biomedical Robotics: Magnetically Actuated Soft Capsule Endoscope

Carnegie Mellon University has many important projects that have been pushing the field of biomedical robotics. Metin Sitti, who is a researcher at Carnegie Mellon University, worked in the Nanorobotics Lab to create the Magnetically Actuated Soft Capsule Endoscope. This robot is the size of a pill and is used to take active images when placed in the patients gastrointestinal tract. The MASCE is the size of a coin and its purpose for being so small is that it will be able to pass through the system smoothly. What is impressive about this robot is that it is remote controlled and positioned. This robot is used to run advanced diagnostics, drug delivery, biopsy, and methods of therapy in the gastrointestinal tract. MASCE's use external permanent magnets which is what makes it more accurate. The way that it moves inside the gastrointestinal tract is through a surface based locomotion system. These robots are not yet used for personal and professional use because of doubts on locomotion and safety. These problems are being solved by making the capsules smaller and by making their shape deform and recover after insertion. (Carnegie Mellon)

3. 4 Biomedical Robotics: The Modular Prosthetic Limb

Prosthetics are a very vital part of medical robotics. Prosthetics range from replacing arms and legs to replacing heart valves. Michael McLoughlin, who <https://assignbuster.com/utilization-of-robotics-in-medical-research/>

is the chief engineer of research and exploratory development at John Hopkins' Applied Physics Laboratory, has been leading a team to develop The Modular Prosthetic Limb. In 2005 their development began when the Defense Advanced Research Projects Agency requested a robotic arm that would serve as a close replacement for a real functioning arm to be made for those who lost theirs serving their country. The Modular Prosthetic Limb has been designed to fully replace any arm or leg. It has been made with over 100 sensors that are used for position and movement sensing. The angles, velocity, and torque are measured through the sensors that are placed at the joints of the arm. There are sensors that are placed on the fingertips of the arm and they play a key role to the robotic arm. The fingertip sensors are used to measure vibration, temperature, force, contact, and heat fluctuation. The arm is able to run by the power of a motor. The arm is controlled and powered by a large motor which works as a circuit to give power to the four joints located at the upper part of the arm and also the three joints located at the wrist part of the arm. This main motor is called the large motor controller, or LMC, and is the driving force of powering the robotic arm. The fact that the entire arm is controlled by one motor allows the LMC to monitor other factors of the arm like the joint temperature, rotor position, torque, and sensors for motor communication. While these arms are still in development the researchers and developers involved hope that they will soon help people do both simple and complex tasks with The Modular Prosthetic Limb. (Staff, RBR)

3. 5 Biomedical Robotics: The Pacemaker

The pacemaker may be the most common biomedical robot there is. This is a robot that is inserted into the chest and of the patient, and unlike some of the other robots, stays inside the person's chest and works twenty four hours a day non stop. The job of pacemakers can vary due to different conditions but for the most part they produce a pulse to the heart which is usually between 0.5 and 25 milliseconds wide producing around 0.1 to 15 volts from 30 to 300 times a minute. This alters based of the patient's heart and what type of pacemaker they are receiving. Implantable pacemakers are the one previously discussed where the device is implanted into the chest for long stay of pacemaking. External pacemakers are temporary forms of stimulating the heart and giving it a pulse. The most commonly used type of external pacemakers are defibrillators. They are used to temporarily stabilize the heart and most used used in emergency situations. Pacemakers are a great tool in the medical field and provide a great service to all living beings. (MedMuseum)

3.6 Biomedical Robotics: Conclusion

The field of biomedical robotics has granted so many benefits to patients over the years. The advancement of biomedical robotics has progressed at an exponential rate due to the technological advances scientists and doctors have made over the years. These robots are so crucial because of their ability to change someone's life completely. Biomedical robots have the power to save a life, whether it be keeping a heart beating in someone chest, or detecting a life threatening disease. These magnificent robots have life altering abilities. Biomedical robots give a person missing a leg the chance to stand or someone missing an arm the ability to shake another person's

hand. The future is very bright for the field of biomedical robotics and new developments are made everyday to grant more people with medical issues a better life.

Our society is constantly progressing on a day to day basis. We constantly improve our ways of life by finding new ways to accomplish tasks, one of which is the way surgery is performed. The first documented robot-assisted surgery dates all the way back to 1985 when the PUMA 560 was implemented during a delicate neurosurgical biopsy. The device was successful in the surgery and demonstrated how devices such as itself can be useful in minimally invasive surgery. In 1990, the AESOP system became the first system to be approved by the FDA for its endoscopic surgical procedure.

The AESOP system was implemented into the ZEUS robotic system (ZRSS), a three arm robotic system which was remote controlled. Although AESOP was cleared by the FDA back in 1995, the ZEUS robotic system was not cleared until 2001. The AESOP system was used in the first arm of the ZRSS system as a voice activated endoscope which allowed surgeons to get a more in depth look inside the patient's body. The other two arms mimicked the movements of the surgeon to make precise cuts and extractions. This system did not last long and ultimately discontinued in 2003 due to the merge of its development company.

The new company, Intuitive Surgical, worked in favor of developing the Da Vinci surgical system which is still used all across the country to this day. What made the Da Vinci system stand out from its predecessors was the

more advanced technology that was used, making surgery more precise and convenient. With the predecessors of the Da Vinci system, surgeons heavily relied on endoscopes and multiple assistants to perform the surgery. With the Da Vinci system, a three-dimensional screen allows surgeons to see the operative area in high resolution. Aside from improved display, the Da Vinci system utilizes one-centimeter diameter arms which are significantly smaller than the large arms of the PUMA system. Not only does this make surgery easier, it also removes the need to leverage the sides of incision walls. This allows for less contact between the surgical device and exposed tissue, greatly reducing the risk for infection as well.

Robotics in the surgical field have definitely evolved for the better over the years. However, no system is perfect and there is still plenty of room for improvement. Dr. Mona Orady, a robotic surgeon since 2007, addresses some of the things that could be improved as well as the future for robotics in the surgical field. In an interview with medgadget. com, she says, “ Without question I wish for smaller instruments. Eight millimeters is still pretty big, especially since I perform Microlaparoscopical and Minilaparoscopical surgery. I use 3 millimeters instruments in traditional laparoscopic procedures. Jumping from 3 millimeters - almost a scarless incision - to 8 millimeters incision is what sometimes steers me more down the laparoscopy route rather than the robotic-assisted route. The second thing that I wish I had is a dedicated and trained team. A dedicated robotic team is one of the most important things for efficiency in a robotic-assisted procedure. The robot is different than other traditional surgical procedures. It's a computer-based product, there is a lot of troubleshooting going on, and

you have to be able to work through and fix error messages efficiently.

Therefore, to optimize the function of the robot, you need someone who is really savvy in adjusting things perfectly and quickly.” One thing that Dr. Orady addressed was the need for proper training. This is essential for a surgical machine due to the fact that someone’s life could be at risk if the machine is used incorrectly.

When asked if Intuitive Surgical, Da Vinci’s developer, will have any competitors in the future, she responded with, “ It definitely will change. It cannot stay like that forever. The da Vinci robot has been around since 1999, so almost 20 years. New robotic companies have been working on their robots for maybe 10 years or more; although, none of them have been FDA approved yet but some are very close.” Intuitive Surgical has essentially monopolized the robotical surgery industry, but they will more than likely be challenged by other companies who will be willing to make improved systems for cheaper prices to compete. In conclusion, robotics in surgery has made the lives of surgeons a lot easier in terms of certain types of surgery. Although there is still room for improvement, it is definitely heading in the right direction.

Overall, robotics has led to many great advancements in medical research. In cancer research, devices such as nanorobots and apheresis machines have contributed heavily to our understanding of cancer and how to effectively, safely have it treated. In biomedicine, the prosthetic limb and the pacemaker have become staple devices in the live of those who have heart problems or lack a limb. In surgery, robots like the AESOP system and the DaVinci surgical system have revolutionized what surgery is due to the

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precision and accuracy of these devices. Not only have these robots helped to define what medical research is in the modern day, but the robots in the field have ultimately become crucial in the preservation of human life. These robots have saved people countless hours of suffering and have saved countless lives. Without these robots, the medical field would not even be half of what it has become today.

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