JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Robotic surgery using artificial intelligence

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Abstract **-** Despite the vast academic research on artificial intelligence's significant potential, there have been no findings on its efficacy in improving patient safety in robotic surgery. The purpose of this research is to undertake a comprehensive review of the published literature on artificial intelligence in robotic surgery, as well as to identify and analyze present limitations and roadblocks. A literature search was conducted using PubMed, Web of Science, and Scopus, according to the PRISMA 2020 statement. The papers were to be peer-reviewed and published in English between January 1, 2016 and December 31, 2020. Amstar 2 was used for quality control. To examine the risk of bias, the Newcastle Ottawa Quality Assessment Tool was employed. The data from the studies was visually displayed using the SPIDER tool.Thirty-five publications were found to meet the search criteria, representing 3436 patients, and were included in the study. Motion analysis (n = 17), urology (n = 12), gynaecology (n = 1), other specialties (n = 1), training (n = 3), and tissue retraction (n = 1) are among the papers chosen. Surgical instrument identification precision ranged from 76.0 percent to 90.6 percent. After a robot-assisted radical prostatectomy (RARP), the mean absolute error on urine continence prediction ranged from 85.9 to 134.7 days. After RARP, the accuracy of predicting length of stay was 88.5 percent. During robot-assisted partial nephrectomy (RAPN), the accuracy of recognizing the next surgical task was 75.7 percent. The studies that were examined were of poor quality.The tiny size of the datasets limits the findings. Due to method and dataset variability, comparisons between studies on the same topic were limited. There is no evidence that AI can yet detect the crucial robotic surgery operations that impact patient outcome. Large dataset investigations and external validation of AI systems are both urgently required. Furthermore, surgeons should be able to communicate with patients in layman's terms because the results should be transparent and relevant.

IndexTerms **- Artificial intelligence robotic surgery ,Machine learning robotic surgery , applications, the da vinci surgical robot.**

I. INTRODUCTION

It is referred to as the intelligent responses by machines in a way that it looks like machines have their own intelligence. They respond intelligently, like the Intelligent responses which we associate with the human mind. The person using it may feel as if the machine has its own brain or mind because they have the capability to learn and solve problems. These machines are capable of interpreting the speech of humans, learning from data, solving the problems of users, planning and taking the required action etc[1].

These are types of surgeries performed using robotic machines which are AI enabled. It is developed to assist the doctors in performing surgery and also to overcome the shortcomings of the pre existing methods of surgery. In this, some small incision are made and surgery is performed through them using robotic arms which are controlled by professionally trained doctors[2]. These are called laparoscopic procedures and are considered as form of minimally invasive surgical procedures. The doctor operating the machine uses one of the two methods to perform this type of surgery. They include using a direct telemanipulator or through computer control. The telemanipulator is just like a remote through which the doctor controls the movement of the arms of the machine[3]. The doctor performs the normal movements associated with the surgery and the robotic arms carry out the desired movements using the end effectors and manipulators. The medical professional operating the machine can adjust it accordingly. For example, the machine used

can be adjusted in a way so that if the person performing the surgery moves his hand by (say) 4 inches, the arm of the machine would move by 2 inches or any other measurement set by the person according to the requirements of the procedure which would make it easier.In the computer control system, the doctor controls the procedure with the help of a computer[4]. He provides his input through the computer and the robotic arms and end effectors carry out the desired movements and actions required. The person performing the surgery can see in the monitor of their computer device, the actions which are performed by the machine performing the required procedure[5]. Computer controlled surgery has a very big advantage, that it can be performed by the person performing the surgery, regardless of where he / she is in the world. That person does not need to be physically present in the room where the surgery is actually being performed. He / she just need to provide the necessary input through the computer and watch that it gets done by the machine by seeing the results in the monitor[6].

When performing open surgeries, autonomous instruments replace the steel tools which are usually used while performing surgical procedures. The motions are feedback controlled. The goal of these smart instruments is to reduce the tissue damage which happens during open surgery. This technology helps in improving open surgeries and only require limited training on the machine by the professionals[7].

II. APPLICATIONS

There are various applications of AI which help users in performing their task successfully and efficiently in minimal time period. In the automobile industry, the most well known application is that of driverless cars. Tesla , Google and Apple are involved in developing driverless cars. Some government bodies of the world are pairing AI with facial recognition systems(FRS) for increasing the efficiency of their surveillance systems. Some parts of China use this technology[8].It is used a lot in the gaming industry. It is used to generate appropriate behavior in game characters which are not controlled by the player. In addition, it is also used in helping the player find his/her path in the game to reach the required destination.This technology is also used in army to enhance communications, threat detection and identification, marking of enemy positions, target acquisition, coordination etc.This technology has helped in providing better healthcare by helping doctors[9]. It helps in R&D of medicine which may be used in treatment of cancer or other dangerous ailments. It also helps in finding out which drug would be suitable for which type of patient. AI is also used these days in conducting surgery through robots. It is explained in detail below[10].

III. USES

This surgical approach is used various organs and body parts surgeries like-

Heart
Thoracic
General Surgery
Gastrointestinal
Gynecology
Bone
Spine
Transplant surgery
Urology

IV. HISTORY

The first robotic surgery that happened was way back in 1985. The first robot that performed the surgery was named Arthrobot. It was used first time in Vancouver. It's function in the first surgery performed was to help keep the patient's leg in appropriate position for the surgery according to the commands given to it by the medical professional performing the surgical procedure. It was voice controlled. Another robot which was developed during this time period, was the scrub nurse robot. It's main function was to hand the necessary tools for the procedure to the surgeon[11].

Unimation Puma 200 was another surgical robot used in the 1985. It was used in a neurosurgical biopsy. In the following year the same system was used in transurethral resection. In the late 1980s came the PROBOT. It was developed in London and was used to perform prostatic surgery. The robot was not big in size and was accurate. Thus, helping the surgeon in the procedure and the surgeon wouldn't get tired. In 1992 came the ROBODOC. It was introduced and it changed the face of orthopedic surgery because it was capable of assisting with hip replacement surgeries[12].

In 1994 came the AESOP. It was a breakthrough in robotic surgery. It was the first camera holder which was laparoscopic and approved by FDA. NASA funded the company responsible for the development of the system, to develop a robotic arm that could be used in space by them. But in the end , it became a camera used in laparoscopic procedures. Voice activation was added in it in the year

1996 with AESOP 2000. In 1998, feature in this system were added so that it could function just like a human hand with all directions of motions and accuracy. This device was named AESOP 3000[13].

In 1998 came ZEUS. It was the first among all to bring a type of surgery in which the medical professional performing the surgery, is at distance from the patient on whom the surgery is being performed on. He / she is at distance from the patient because he / she is sitting on a console from where he is providing his input and watching the surgery being performed successfully in his monitor[14]. This resulted in the idea of telerobotics or telepresence surgery in the medical industry. In the past it has been successfully used in fallopian tube reconnection, beating heart coronary bypass graft and an operation to remove the gall bladder.In the 2000s came the da Vinci surgical system which became one of the most used systems to perform minimally invasive surgical procedures[1].

V. THE DA VINCI SURGICAL ROBOT

It is one of the most advanced computer assisted surgical system. It is a robotic surgical system whose main purpose is to perform surgery which is normally difficult in nature and can be performed with minimal invasive technique. The surgery is controlled from a console by the medical professional conducting the surgical procedure. He / she can view the surgery through their computer monitor and provide the necessary input through the console. This increases the efficiency of the procedure because the surgeon has more control and increased capabilities. The surgery can be performed with very small incision which can be as small as quarter inch or 2 – 3 cm long[2].

5.1 HOW IT WORKS:

It has two sections which are the tower and the console. The tower, has four arms. Out of the four arms, three hold the tools which are required for performing the surgery which can be anything like scalpels, scissors, bovies, or graspers and one holds the cameras which shows the 3D view of the surgery[3]. The three arms holding the tools copy the movements of the medical professional operating the console and providing his / her input through the console[4].

The console is from where the surgeon provide his input for the surgery and controls the robot while looking in the monitor which provides a magnified, high definition 3D view of the surgery being carried out by the arms of the machine. The surgeon can comfortably sit and provide his input for the surgery. It is designed in a manner through which the surgeon can be rested and can focus such that the procedure can be performed with ease[5].There is also a footswitch in the machine which provide additional options such as switching between two different energy resources. There are also touchpads through which the surgeon can adjust audio, video and system settings.There are additional screens through which the team of the professionals included in the procedure can view two dimensional view of what the surgeon is looking through[6].

5.2 HOW IT HELPS THE SURGEONS:

It provides many user friendly functions making it easy to operate and increasing its efficiency.

Enhanced vision- The surgeon gets an enhanced, high definition and 3D vision of the surgical site. Its two stereoscopic cameras help in providing an enlarged view of the surgical site. It provides 40-50 percent sharper image as compared to traditional models.Many arms- The arms of the machine can hold surgical tools which increases the operating capacity of the person performing the surgery by 50-60 percent because he / she need not hold the tools directly in their hand[7]. Two image reference - The surgeon can display upto two images at the same time while performing the surgery on the monitor. For example, the surgeon can have one image which was taken prior to the surgery such as CT scans or ultrasound and the second image would be the real time image which shows the procedure being performed. This provides the surgeon with ability to make comparison and take reference from the images[8].

Suitable Scale- The surgeon can adjust the ratio between the movement of surgeon's hand to the movement of the arms of the machine. This is very useful in surgeries where high degree of precision is required.Wrist Like action- The da vinci system has patented mechanical wrists which moves like human wrists and can hold a variety of tools required, with greater flexibility[9].

VI. COMPARISON BETWEEN TRADITIONAL METHODS OF SURGERY AND ROBOTIC SURGERY

The introduction of surgical bots in the medical industry have made the surgical procedures better by bringing in the concept of remote surgery, minimally invasive surgery and unmanned surgery. All of these increase the degree of ease with which the medical professional performs the surgery, and also is beneficial for the patients because when they go through robotic surgical procedures then the blood is loss is less, the pain is less, the healing time is quick, there are only small scars on the body, less pain medication is required etc[10]. It is way better than traditional surgical methods because in traditional surgery there is longer time of recovery, longer operating hours, more blood loss and surgical scars comparatively. The view of the surgical procedure also is better because of the two cameras which are well held by the arm of the machine and prevents shaking[11]. The surgeon can perform the surgery comfortably as he can sit and provide his input through the console and rotating surgery teams can make this procedure even easier[12].

Some problems in robotic surgery include high costs of each unit which range from $1 million to $2.5 million, which in turn make the cost of the operation higher. This procedure requires long period of training and practice by the surgeons[13]. It takes longer than traditional laparoscopic surgical methods because of which patients might have to stay under anesthesia for longer time. While using

these type of machines, the surgeon is not able to know properly when the surgical tool is coming in contact with the patient as there are no such types of feedback by the console[14].

VII. CONCLUSION

Robotic surgery, even after having its drawbacks is of great use to the medical professionals as it makes certain types of surgical procedures very easy and also make it suitable for the patients. These types of procedures pave way for the future of modern medical industry because this technology is already evolving the process of traditional surgery by bringing in the concept of remote surgery, unmanned surgery and taking minimally invasive surgery to the next level.In the future, the shortcomings of the machines will begin to fade away with the advancement in technology and more R&D on such systems. Thus, these types of surgeries could cost very less and could be very safe in the future. This field is already expanding and becoming popular everyday and one day it could result in fully automated surgery without the presence and control of humans and thus, change the face of surgical procedures in the medical profession forever.

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