

Review Article

Rise of robots in surgical territory

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ABSTRACT

Robotic surgery is a rapid advancement in the scientific strata of artificial intelligence and has evolved into a refined tool for the surgeons. Over the last 30 years, this field has evolved in leaps and bounds with wide applications in the field of surgery by improving the dexterity and accessibility for the surgeons in various array of major complicated cases. The surgical armamentarium has been strengthened by evolution of robotic surgery to an extent that man may be replaced by artificial intelligence-based robots in the operation theatre, thereby eliminating the possibility of human errors and limitations.

Keywords: Robotics, Surgery, Advantage, Future

INTRODUCTION

It has been an emerging technology that has taken the surgical profession into limitless possibilities. This domain demands high levels of skill in the psychomotor domain of competency.

Czech word *robot* refers to forced labour, evolved from meaning dumb machines that perform menial, repetitive tasks to the highly intelligent anthropomorphic robots of popular culture.¹ The progress in technology has driven robotic surgery to be the mainstay in the surgical field.

Today robot enhancements are being researched and developed. Schurr et al at Eberhard Karls University's section for minimally invasive surgery has developed a master-slave manipulator system named ARTEMIS.² Surgical robots are becoming a sign of prestige for centres involved in minimal invasive surgeries, as it is a major

addition to the surgical armamentarium for the operating hand of a surgeon.

The evolution of robotic surgery despite the issues of affordability and technicalities has been rapid, especially in the array of major complicated cases where the highest form of surgical skills is expected from the surgeon as part of their competency in the psychomotor skill domain. Therefore, robotic surgical devices seem to be the answer for better and precise surgeries which goes in synchrony with better patient care post operatively.

The aim of the study was to provide an unbiased evaluation of this evolving technology and to discuss pros and cons of Robotic surgery. In this article, the discussion was on the rapid development, evolution of robotic surgery in a century of extreme advancements in technology along with review of current trends of robotic surgery. And final focus was to highlight the future possibilities of robotics in the domain of surgical specialty which would definitely enhance quality of life of future generations.

HISTORY AND EVOLUTION OF ROBOTIC SURGERY

There cannot be any discussion started regard to history of robotic surgery by neglecting Czech play writer and his masterpiece 'Capek'. The term 'Robot' was first used in his play Rossum's Universal Robots.

The robota word has rapidly become corrupted to reflect a machine-orientated repetitive task with little. The play ends with not abiding with their masters will and taking forward their own destiny by the robots themselves. Though machines had intervened and being used with wide application in many sectors, its application is relatively slow in healthcare sector compared to other sectors.³ In a study, Puma 560, a robot was used in 1985 to perform neurosurgical biopsies with greater precision.³⁻⁹

During the year 1989, a high-tech medical device company- Computer motion was found with a goal to revolutionize surgical practices and to improve patient lives. In May 1992, Integrated Surgical Systems introduced RoboDoc for orthopedic surgery, specifically total hip arthroplasty. This robotic system allowed orthopedic surgeons to pre-plan their operations for performing more precised surgeries. Then by 07 November 1992, the first robot-assisted human hip replacements using Robodoc was initiated on 64-years old patient suffering from osteoarthritis. Later, ten more robot-assisted human hip replacements using Robodoc were performed at Sutter General Hospital, Sacramento under an Investigational device exemption (IDE) approved by FDA on 09 October 1992.

In December 1993, the Aesop™ 1000, a robotic system used for holding an endoscopic camera in minimal invasive laparoscopic surgery, produced by computer motion was approved by the FDA.¹⁰ Then on January 1995, Frederic Moll, M.D., Robert Younge and John Freund, M.D. formed Intuitive based on foundational robotic surgery technology developed at SRI International (formerly referred to as Stanford Research Institute). At June 1997, the da Vinci Surgical System manufactured by Intuitive Surgical Inc., became the first assisting surgical robot to get FDA approval to help surgeons better perform laparoscopic surgeries. During February 1997, Jacques Himpens and Guy Cardier in Brussels, Belgium used the da Vinci by Intuitive Surgical Inc. system to do the prime telesurgery gallbladder operation. In April 1997, Integrated Surgical Systems Inc. purchased Innovative Medical Machines Int., its Neuromate System and extended the field of robotic from orthopedics to neurosurgery.

Then, May 1998 Carpentier et al performed the first mitral valve repair using an early prototype of the da Vinci articulated intracardiac 'wrist' robotic device. At June 1998- Dr. Frank Damiano performed the first procedure in the United States having a reanastomosis of a fallopian tube by using Zeus system.

In 24 September 1999, Dr. Boyd based in London Health Sciences Centre's (LHSC) university performed the world's first robotically-assisted closed-chest beating heart cardiac bypass operation on 60-year-old dairy farmer John Penner using the Zeus system. On 22 November 1999, the very first closed-chest beating heart cardiac hybrid revascularization procedure was performed at the LHSC. Dr. Douglas Boyd used Zeus to conduct an endoscopic, single-vessel heart bypass surgery on a 55 years-old male patient's left anterior descending artery. At 09 December 1999- Dr. Ralph Damiano, in the Milton S. Hershey Clinic at Penn State College of drugs in Hershey performed the very first robotic assisted beating heart bypass in the United States using the Zeus Robotical Surgical System.¹¹

At July 11 2000, Intuitive Surgical Inc. received clearance from the FDA to market the da Vinci Surgical System in the United States to be used in laparoscopic surgical procedures. On 13 March 2000, Dr. Francois Laborde of L'Institut Mutualiste Montsouris Chiosy performed the very first time pediatric cardiac procedures using Computer Motion's Zeus robotic assistance to perform seven fully endoscopic closures from the Patent ductus arteriosus (PDA). In 09 October 2001 ZEUS Robotic Surgical System from Computer Motion got FDA regulatory clearance using the FDA decision for U.S. surgeons to use a number of instruments to carry out a number of robotically assisted laparoscopic and thoracic procedures.

During August 2001, the Cyber Knife, became the first image-guided robotic technology to get the FDA clearance for non-invasive cancer surgery to provide radio-surgery for lesions indicated with radiation treatment. At 07 September 2001, ZEUS robotic system produced by Computer Motion was adopted in the trans-Atlantic operation. A doctor in New York removed the diseased gallbladder of the 68-year-old patient in Strasbourg, France. In 01 October 2001- FDA cleared the marketing from the Cyber Knife with Dynamic Tracking Software (DTS) developed by Accuray Incorporated to supply radiosurgery for lesions, tumors and conditions where radiation treatment is indicated. During March 2000, two leading medical robotic companies- Intuitive Surgical Inc. and Computer Motion Inc. announced the merge agreement, combining the companies products for operative surgical robots, telesurgery and operating room integration.¹²

During July 2004, FDA cleared the marketing of the robotic-like system to assist in coronary artery by-pass surgery enabling the surgeon to do heart surgery while seated at a console with a computer and video monitor. At 09 April 2005, Surgeons in the University of Illinois Clinic at Chicago successfully performed a laparoscopic right hepatectomy, removing approximately 60 percent of patients liver, and also the tumor using the da Vinci Surgical System.¹³

TYPES

There are three main types of robotic systems currently in use in the surgical arena. They can be classified as active, semi-active and master-slave systems. Active systems essentially work autonomously (while remaining under the control of the operative surgeon) and undertake pre-programmed tasks. The PROBOT and ROBODOC platforms described later are good examples of this. Semi-active systems allow for a surgeon-driven element to complement the pre-programmed element of these robot systems. Formal master-slave systems (of which the da Vinci and ZEUS platforms were the forerunners) lack any of the pre-programmed or autonomous elements of other systems. They are entirely dependent on surgeon activity. Surgeon hand movements are transmitted to laparoscopic surgical instruments, which faithfully reproduce surgeon hand activity- but intracorporeally.³

APPLICATION OF ROBOTIC SURGERY

Robotic surgery is at the cutting edge of precision and miniaturization in the realm of surgery. The possible applications are as extensive as the uses of minimally invasive surgery. Robotic surgery has already become a successful option in neurological, urological, gynecological, cardiothoracic and numerous general surgical procedures. Intuitive Surgical, makers of the Da Vinci robotic surgery system, have released upgrades in the number of operating arms, eliminating the need for one surgical assistant, which may expand its clinical applications.¹⁴

Robotic surgery procedures performed in Europe, particularly those done by German surgeons, have advanced the field of robotic medicine greatly. Smith and Nephews, in conjunction with URS Orthopedic Systems, have created software to be used with robotic surgical systems such as da Vinci and is exploring its orthopedic applications in hospital clinical tests throughout Germany.¹³

Table 1: Depicting advantages of robotic surgery.

Advantages
Better 3D vision
Digital camera zoom
Camera stability
Greater df
Improved dexterity
Elimination of fulcrum effect
Better ergonomics for surgeon
Motion scaling
Elimination of psychological tremor
Telesurgery possible
Telemonitoring possible

Table 2: Depicting disadvantages of robotic surgery.

Disadvantages
High cost of robotic system
High cost of maintenance
High cost of setup
Bulky size of the robotic surgery
Sometimes difficult access to patient
Separation surgeon from the operating field
No tactile feedback
Chance of breakdown
Use of mm ports
Monopoly of single market leader

THE FUTURE OF ROBOTIC SURGERY

Prosperity in robotic surgery will definitely add for better advancement in delicate procedures for modern medicine. The current merits of robotic surgery systems will be expanded upon in the next generation of medical robotics. Robotic surgery systems capable of functioning at greater distances between surgeons control console and the patient side table robotics would assure dilemma related to accessibility of patients. Necessary precautions should be taken for patients intending on reducing or eliminating the intra operative infection. The days are not far away for next-generation medical robotics and robotic surgery to conduct surgical prep work remotely as well.

The surgeon experience during invasive traditional procedures would be elevated with the advancements in making robotic surgery systems capable of replicating the tactile feel and sensation. The landmark of the technology is that, without losing the sensory information helpful in making judgment calls during robotic surgery, the surgeon would gain the precision and advantages of minimally invasive procedures.¹⁵

As robotic surgery is in its infancy stage many obstacles and disadvantages will be resolved in time and definitely new queries will pop up. Questions related to malpractice liability, credentialing, training requirement and interstate licensing for tele-surgeons are some to point out.⁶ The vibe of technology complementing the process of publishing data with help of efficient surgical centres helps in analytics of the trend. Many studies report that robotic surgery is the future and will remain the mainstay of the surgical advancements for next decades. The negative comments propagated are regarding affordability and controversial ethical issues of robotics surgery overtaking and replacing human resource in the healthcare sector, which can lead to design the role of surgeon as a base level programmer of the robots.¹⁵

There are more interventions to be done for accomplishing the dream of maximum utilization of the technology. Although these systems have greatly improved dexterity, they have yet to develop the full potential in instrumentation or to incorporate the full range of sensory

input. More standard mechanical tools and more energy directed tools need to be developed. Some authors also believe that robotic surgery can be extended into the realm of advanced diagnostic testing with the development and use of ultrasonography, near infrared, and confocal microscopy equipment.¹⁶

CONCLUSION

Robotic surgery is in a phase of evolution beyond comprehension with limitless possibilities in well-defined niches of surgery with its current applications in major advanced surgeries. Searching to decades back, it is evident there were lot of wild imaginations regard to robots, depicted in literature and cinemas. There were thoughts about robots ruling the coming future and imaginations have no cost per se. And this is the sole reason laboratories are working on improving current methods and developing new devices to fulfil goal of such imaginations. Nowadays when most people think about robotics, specifically thought process leads to automation. There are exciting and controversial possibility of automating tasks. Ability of a surgeon to program the surgery and merely supervise as the robot performs most of the tasks will be definitely the future. And let's hope for a good tomorrow with advancements in robotic surgery for mankind betterment.

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