IOSR Journal Of Pharmacy *www.iosrphr.org*
(e)-ISSN: 2250-3013, (p)-ISSN: 2319-4219
Volume 9, Issue 6 Series. II (June 2019), PP. 59-62

Robotics: A New Approach for Surgery

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Abstract: Robotic surgery is a new innovation in healthcare technology towards improved clinical outcomes. Robotic technology is enhancing surgery through improved precision, stability and capability. There are five generations of robotic surgical platforms including stereotactic, endoscopic, bioinspired, microbots and the future development of autonomous systems. Recently robotic system is a way into the operating room as surgical assistants and surgical planners, in order to answer various demands to overcome the surgical limitations and to avoid various problems. Surgical robots are controlled by the methods of remote control and voice activation. In image-guided procedures, robots use magnetic resonance and computed tomography image data to guide instruments to the treatment site. Robotic surgery is minimally invasive procedure. It uses remotely controlled robots that allow the surgeon to work inside the patient's body without making large incisions. Robotics is being introduce to medicine because they provide help for exclusive control and precision of surgical instruments in various invasive procedures. The main objective of the robotic surgery field is to design a robot that can be used to perform closed-chest, beating-heart surgery.

Date of Submission: 22-06-2019 Date of acceptance: 10-07-2019

I. INTRODUCTION

The birth of robotic surgery took place at a time where there is an increasing demand for greater surgical precision and safer operations and in aperiod where surgeons are increasingly accepting minimal invasive surgical (MIS) technologies to enhance their outcomes[1]. In April 1991, it was the first time in the world that a special-purpose robot has been device and clinically practical to independently remove tissue from a human patient[2]. In 2007 it was estimated that 68% of radical prostatectomy's in the USA were performed using robotic help. The most commonly use system is the da Vinci® Surgical System (dVSS) which is consists of two main components; master console and a slave robot. A surgeon provides input through manipulation of the master console which, in turn, controls a slave robot to perform the necessary motions on the patient[3].

The benefits of these minimally invasive approaches include:

(i) Reduce wound access trauma
(ii) Shorter hospital stays
(iii) Improved visualization
(iv) Less postoperative wound complications
(v) Less chances of scar
(vi) Increased cost-efficacy.

There are several types of robotic surgeries available. Some of them robotic gynaecologic surgery, robotic arm system for partial knee replacement surgery, robotic cardiovascular surgery, robotic urologic surgery, robotic head and neck surgery, robotic abdominal surgery and colon and rectal surgery.

Humans must provide detail commands, using preoperative planning systems or by providing explicit move-by-move instructions. Even in the most sophisticated systems, robots are specializing to specific tasks within procedures; humans must prepare the patient, make many of the incisions and sutures, and perform many other functions. Robotic systems are best described as ''extending human capabilities'' rather than ''replacing human surgeons''[4].

By this system surgeons can perform complex surgeries with more precision, accuracy and flexibility.To understand the advantages of using robots in surgery, it is helpful to consider the differences in human and machine characteristics.

Table 1: Strength and limitations of human and robotic system[2, 4, 5]

Humans system	Robots system
Strengths	**Strengths**
Strong hand-eye coordination	Good geometric accuracy
Dexterous (at human scale)	Stable and untiring
Flexible and adaptable	Can be designed for a wide range of scales

Can integrate extensive and diverse information Able to use qualitative information Good judgment Easy to instruct and debrief	May be sterilized Resistant to radiation and infection Can use diverse sensors (chemical, force, acoustic, etc.) In control
Limitations Limited dexterity outside natural scale Prone to tremor and fatigue Limited geometric accuracy information Large operating room space requirement Limited sterility Susceptible to radiation and infection	**Limitations** Poor judgment Limited dexterity and hand-eye coordination Limited to relatively simple procedures Expensive Technology in flux Difficult to construct and debug

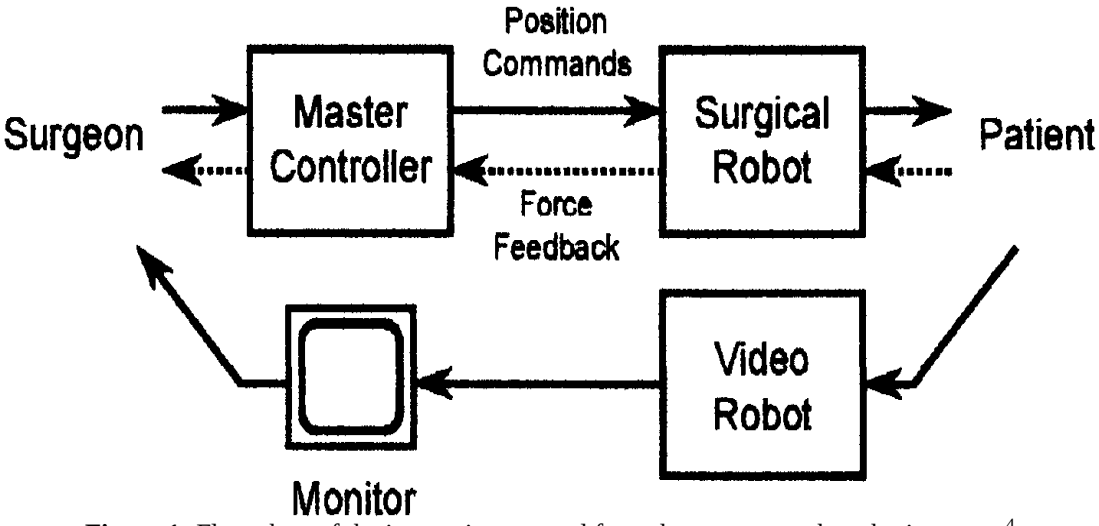

Figure 1: Flow chart of the instructions passed from the surgeon to the robotic system[4]

Generations of robotic surgery

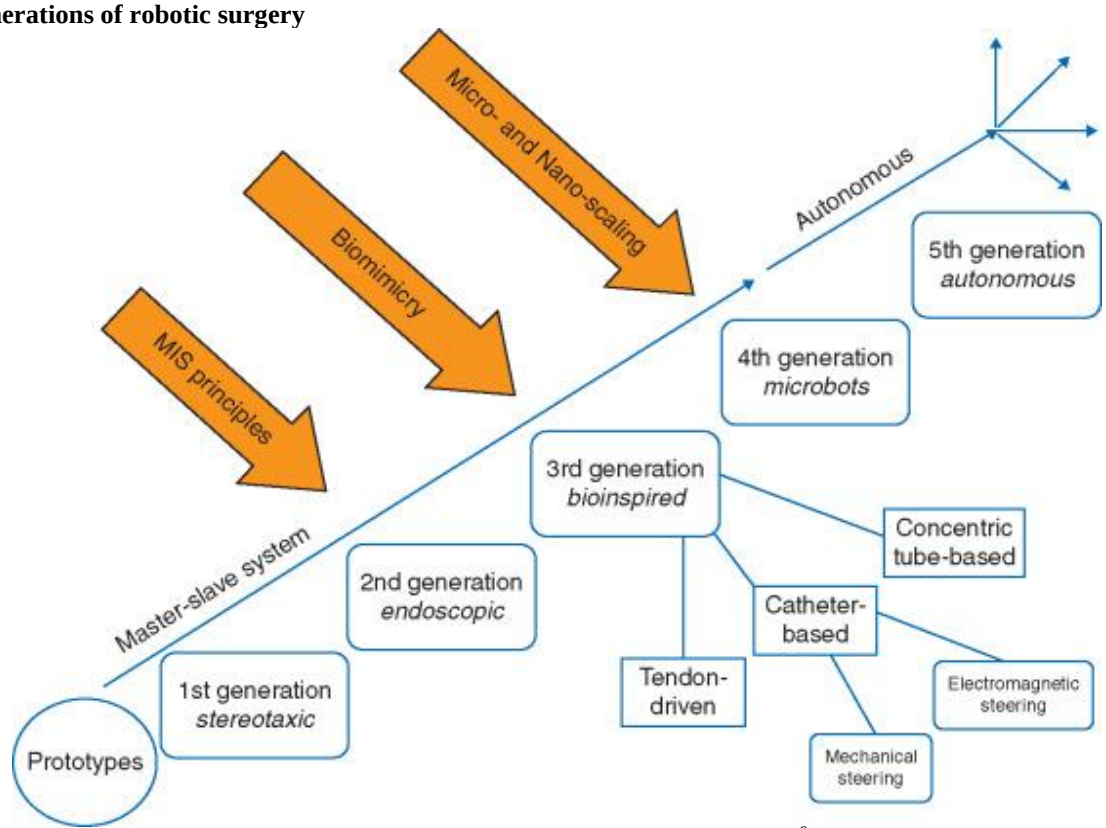

Figure 2: Five generations of robotic surgery[6]

II. CLASSIFICATION[7]

As we know all surgical robots are not equal. There are three different kinds of robotic surgery systems:

- Supervisory-controlled systems
- Tele surgical systems
- Shared-control systems.

There is a main difference between each system that is how human surgeon is involve in performing a surgical procedure. we can see that on one side of the spectrum, robots perform surgical techniques without the direct interference of a surgeon. On the other end, doctors are performing surgeries with the help of a robot, but in both the cases doctor is doing the majority of the work.

2.1 Supervisory-controlled robotic surgery systems: Among the above three categories, supervisory-controlled systems are the most automated. But that doesn't mean these robots can perform surgery without any human guidance. In fact, surgeons need to do extensive work with surgery patients before they allow the robot to operate. Because supervisory-controlled systems follow a specific set of instructions when performing a surgery. The human surgeon must input data into the robot, which then initiates a series of controlled motions and then completes the surgery.

1.2 Tele surgical systems: On the basis of the skill experience in open surgery relies on the almost unlimited wrist, elbow and shoulder's degree of freedom. The degree of freedom in laparoscopic surgery is in limit because instruments need to be long and are manipulate through fixed ports. The surgeon has to move around these fixed ports. In order to solve these limitations tools have been designed that have an articulation at the tip, which increases the degrees of freedom and provides a great help.

III. APPLICATIONS OF ROBOTIC SURGERY[7,8]

3.1 Orthopedic surgery[4]

- Total hip arthroplasty: femur preparation
- Total hip arthroplasty: acetabular cup placement
- Knee surgery
- Spine surgery

3.2 Neurosurgery[8]

- Complement image-guided-surgery
- Radio surgery

3.3 Gynecologic surgery[9]

- Tubal re-anastomosis
- Hysterectomies
- Ovary resection

3.4 Cardiothoracic surgery[10,11]

- Mammary artery harvest
- Coronary artery bypass grafting (CABG)
- Mitral valve repair

3.5 Urology[12]

- Radical prostatectomy
- Ureter repair
- Nephrectomy

3.6 General surgery[13]

- Cholecystectomy
- Nissen fundoplication
- Heller myotomy
- Gastric bypass
- Adrenalectomy
- Bowel resection
- Esophagectomy

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Ruchi Shukla. "Robotics: A New Approach for Surgery." IOSR Journal of Pharmacy (IOSRPHR), vol. 9, no. 6, 2019, pp. 59-62