ADVANCED ROBOTIC TECHNOLOGY IS THE FUTURE OF SURGERY

LA TECNOLOGÍA ROBÓTICA AVANZADA ES EL FUTURO DE LA CIRUGÍA

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Currently, we live in a new era of minimally invasive surgery. Operations are more like video games than traditional open surgeries. The old-fashioned expression that "a good surgery requires a large incision" has been completely abandoned in countries where medical technology and research are well structured. Within the modern minimally invasive surgeries over the last 30 years, laparoscopic surgery is the most well established and recognized approach. However, with development of advanced technologies and intense research, robotic surgery has emerged in the last decade as an attractive alternative to laparoscopic surgery.

Nowadays, robotic technology plays an important role in our daily life beginning with its use in industries until its adaptation for the medical field. The history of robots begins in science fiction books and movies, where sometimes the robots were seen as an independent and even with some complicities with humans, as in the movie of George Lucas, "Star Wars" where robots were friends with humans, but in other cases with conflict, as in movie "Terminator" that robots were enemies against the human race. Furthermore, in today's industry there are many applications of robots. On the other hand, in medicine, this technology has been introduced successfully even though it is still difficult to think that a robot can perform surgery independently without human monitoring.

Robotic technology in surgery initially was introduced in areas where a high level of precision and fine movements are required such as in Neurosurgery or when repeated actions are needed as in Urology. Currently, robotic surgery is performed in different surgical specialties including gynecological[1], pancreatic[2], bariatric[3], colon surgery[4], etc. Essentially, robots can replicate the movements of a surgeon with high precision, reducing any type of errors. Robotic surgery has many advantages over the well-established laparoscopic surgery. One of the major disadvantages of laparoscopic surgery includes the mismatch between the vision space and instruments, vision is usually 2D in laparoscopic surgery causing the surgeon to lose the prospect of depth, as well as the limitation of rotational movements and imperfect coordination of the eye and hand since the camera is controlled by an assistant.

However, in robotic surgery, these limitations have been exceeded. First, there is a 3D high resolution visualization. Second, hand movements are coordinated perfectly by the camera; essentially, visual fields follow simultaneously to the hand movements without need of an assistant to manipulate the camera as in laparoscopic surgery. Third, robots reduce the tremor of the human hand, improving precision and operational dexterity and with new endo-wrist technology, surgeons using the robot can suture with more rotational degrees. Finally, haptic feedback which is touch feedback (kinesthetic (force) and cutaneous (tactile) feedback) has improved significantly with new technology systems with multimodal haptic feedback programs[5].

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Citar como: Raul Sebastian. Advanced robotic technology is the future of surgery. [Editorial]. Rev. Fac. Med. Hum. 2017;17(3):7-9. DOI 10.25176/RFMH.v17.n3.1067

Journal home page: http://revistas.urp.edu.pe/index.php/RFMH

Another important point is the ergonomics of the surgeon, which is much better with robots since surgeons perform surgeries sitting comfortably at the console, reducing operational fatigue, thus increasing the possibility of performing more operations[6].

However, there are some limitations of this robotic technology such as low adaptability, high cost and longer operative times. All of these are arguments against robotic surgery. With respect to low adaptability, it is a phenomenon similar to what occurred with laparoscopic surgery. In the beginning, it was difficult to convince surgeons that a laparoscopic approach was better than open surgery in some pathologies, and it was a slow adaptation but now a laparoscopic approach is the standard for most of surgical pathologies.

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Regarding the high cost, it is a natural phenomenon of technology. As the first cellphone was $1000 30 years ago, and then gradually decreased. With respect to the operative time, with the subsequent technological advances, the robotic arms can decrease in size making it easy to manipulate resulting in a decreased docking time which is the interval from port placements to docking of the robot, thus reducing operative time.

In the last decade, minimally invasive surgery led to new approaches such as Single incision laparoscopic surgery (SILS) and Natural orifice transluminal endoscopic surgery (NOTES)

These 2 new approaches associated with robots could be an excellent combination in the near future. Thereby making the combination of a Robotic approach and SILS or NOTES would be the next step in the surgical research field[7-9].

On the other hand, robotic surgery was visualized at NASA by Scott Fisher, Ph.D. and Joe Rosen, MD in telemedicine field[10]. They imagined devices that could rescue injured people in the battle field and having the surgeon control the robot at a console within a reasonable, safe distance from the battle. Similarly, although more futuristic is the Telesurgery, to operate from a place to another far away location by robotic approach[11,12].

There are many robot systems, such as Zeus robotic systems consisting of 3 robotic arms; one for the camera and another 2 arms to perform operations[13]. The most popular robotic system, currently known for its versatility, is the Da Vinci system. The system consists of 3 components, of 1 or 2 consoles (Figure 1) for surgeons with 3 or 4 robotics arms (Figure 2) and a 3D visual system similar to endoscopic. The Da Vinci has 2 high resolution cameras with dual lenses with 3 chip technologies each one recording an operative field at different angles. Since the hand/eye coordination is almost perfect due to how the cameras follow the operative field simultaneously with the hand movements as in open surgery, this offers a feeling of surgical field presence (immersion phenomenon). It is these attributes that make the Da Vinci the most important system at the present moment[14].

There are many types of robot classifications in surgery, an interesting classification proposed by Camarillo et al.[15] emphasizes the autonomy of robots from passive to active. This classification would lead us to develop more robotic independence. However, nowadays it is unlikely to think that a robot can realize a cholecystectomy independently.

The future of this robotic technology is the miniaturization of robotic tools specifically the arms that are associated with flexible technology which is already in the robotic fields will make the robotic approach insuperable for any type of surgery[16-18]. Also, the fictitious concept of octopus' surgeon having more than 2 arms with high coordination is a fascinating challenge.

Recently, there are new proposal to create minirobots which can have tactile, chemical pressures, ultrasound sensors that provides adequate information to perform surgeries. Finally, the proposals of Nano robots to be injected or swallowed and act at the cellular level for injury repair or gene modifications are an attractive and fascinating potential applications for the future.

In conclusion, robotic surgery is definitively the future of surgery, and eventually this advanced technology will be the standard approach for almost all surgical pathologies. Presently, we are living in an explosive technological era in which our imagination is the limit to develop more sophisticated surgical equipment to improve human quality of life.

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Figura 1. Surgeon Console in the da Vinci system.

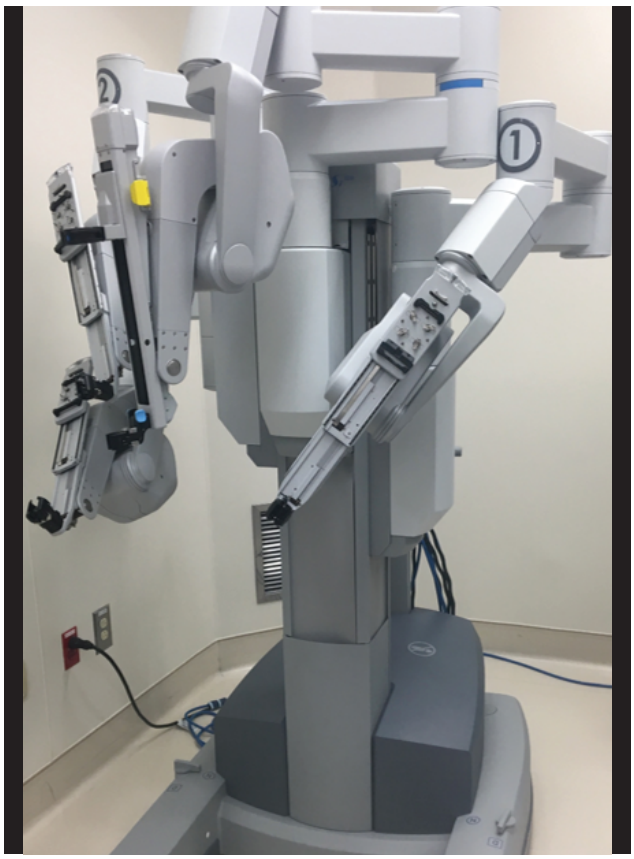

Figura 2. Robotic arms in the da Vinci syste.

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