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Conference report

Current and Future Robotic Surgery Platforms: Introduction of keynote speech at 2019 Mayo Clinic-SRRSH Global Robotic & Endoscopic Surgery Summit

1. Introduction

The 2019 Mayo Clinic-SRRSH Global Robotic & Endoscopic Surgery Summit was held on September 27 and September 28 at the Hangzhou International Expo Center. On the morning of September 28, plenary lectures from famous experts of the Mayo Clinic were held. These lectures covered a wide range of robotic and endoscopic surgery topics. Special focus was put on the application of robotic surgery platforms. Seven parallel sessions were held after plenary lectures including hepato-pancreato-biliary surgery, colorectal surgery, thoracic surgery, gastrointestinal surgery, gynecology, urology and nursing. Experts gave brilliant and impressive lectures to more than 1000 international attendees.

2. Keynote speech: Current and Future Robotic Surgery Platforms

On the morning of September 28, Prof. Sean P. Cleary who is the Vice Chair (Education) of the Department of Surgery and Associate Professor of the Hepatobiliary and Pancreatic Surgery Division at the Mayo Clinic gave a keynote speech titled “Current and Future Robotic Surgery Platforms” (Fig. 1). He gave his opinion and experience with robotic surgery accompanied by videos and pictures. This paper summarizes the core contents of his lecture and related literature to introduce the current status of and future of robotic surgery platforms.

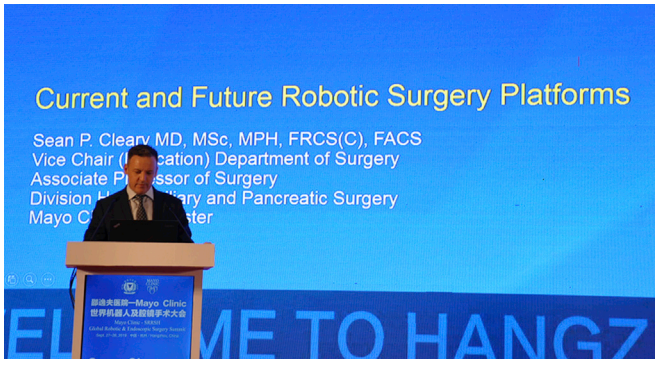

Fig. 1 Prof. Sean P. Cleary gave a lecture titled “Current and Future Robotic Surgery Platforms”.

2.1. Development of robotic surgery

With the development of society, the people's requirements for medication are increasing. Minimally invasive surgery (MIS) has become the preferred option for some surgical approaches. MIS provides an alternative to traditional surgery with less invasion, complications, postoperative pain, operation time and faster recovery. Despite major advances, MIS such as the laparoscopic and endoscopic approaches have some limitations. These include limited maneuverability of instruments, low quality 2-dimensional visualization, mobility impairment etc. In response to these natural and technological deficiencies, robotic surgery systems emerged.[1]

In 2000, the US Food and Drug Administration (FDA) approved the *da Vinci* surgical platform (Intuitive Surgical Inc.), which was the first surgical system for clinical application. For about two decades, there was a boom of innovation in the field of robotic surgery platforms. Nowadays, the *da Vinci* surgical platform is approved for a wide range of procedures across a variety of specialties, including hepato-pancreato-biliary surgery, colorectal surgery, gastrointestinal surgery, thoracic surgery, urology and pediatric surgery. Though robotic surgery is still in its infancy, it has shown great potential.

2.2. Current robotic surgery platforms

After the FDA approved the *da Vinci* surgical platform for use, many other robotic surgical platforms sprung up. With the development of robotic technology, the robotic surgery system evolved from a single purpose robot to a complex surgical instrument, which could perform numerous difficult operations. As we can see, the application of robotic surgery platforms is more and more extensive recently.

2.2.1. Advantages of robotic surgery

Robotic surgical systems were designed to address the inherent disadvantages of laparoscopic and endoscopic surgery. The advantages of the robotic surgical systems include three-dimensional vision, visual magnification, high-precision, and tremor suppression.[2] It reduces the surgeon's burden and improves the quality of surgery. With flexible robotic wrists and improved range of motion, surgeons could use robotic systems to perform delicate and precise dissection especially in narrow, deep and inaccessible areas which, laparoscopy can not reach.[3] For example, robots overcome the

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limitations of laparoscopy in performing hepatectomy, including depth perception, rigid instruments and the difficulty of suturing and accessing the posterosuperior segments of the liver.[2] Additionally, it integrates medicine and computer technology which provides a platform for surgeons to apply artificial intelligence and image guiding in the future.[4]

2.2.2. Utilization status

In recent years, the utilization of robotic surgery platform is more and more extensive. Robotic surgery platforms have become staples of the healthcare system in the USA.[5] More than 2800 American hospitals invested in *da Vinci* surgery platforms by 2017.[6] According to some studies, the market size of image-guided and robot-assisted surgical procedures is increasing.[7] This not only apply to the USA, the increased utilization of robotic surgery platforms is all over the world. According to a report of Intuitive Surgical Inc., 3471 global hospitals or medical institutions have utilized the *da Vinci* surgery systems by 2015.[6] In addition, more than 15,000 scientific papers on this technology were published by 2017.[6] Robotic surgery platform is developing rapidly.

2.2.3. Applications in specialties

At present, the *da Vinci* surgical platforms are approved for a wide range of procedures across a variety of specialties, including hepato-pancreato-biliary surgery, gastrointestinal surgery, thoracic surgery, colorectal surgery, gynecology, urology and pediatric surgery. Especially in urology and hepatobiliary surgery, the progress of robotic surgery has been astounding in the last five years.

One research based on a mathematical model declared that robotic surgery was the better choice for lung lobectomies and prostatectomies when compared to laparoscopic surgery.[8] One large observational cohort study indicated that robotic prostatectomy had shorter hospital stay (2.0 days vs 3.0 days), lower rate of blood transfusion (2.7% vs 20.8%), less complication when compared to the open radical prostatectomy.[9] Furthermore, some studies reported that rectal cancer patients who underwent robot-assisted surgery have lower recurrence rates and lower morbidity.[10,11] With the help of big data and artificial intelligence, the application of robotic surgery platforms will be widened and deepened, which will catch more people's attention.

2.2.4. Current challenges

Many studies demonstrate that robotic surgery leads to faster patient recovery, less bleeding and postoperative pain when compared to the traditional open surgery.[2,4] But there are no clear studies showing significant long-term benefits of robotic surgery over laparoscopic surgery. Which is better, robotic or laparoscopic surgery? The debate on surgical procedure selection has never stopped. Further research is necessary to demonstrate the benefits of robotic surgery compare to the conventional minimally invasive approaches.

Some surgeons have noted weaknesses and deficiencies of the current robotic surgery platforms, such as no setup, haptic feedback, hardly precise positioning, prolonged operative time and high costs.[2,12–15] Furthermore, scientists are faced with technological difficulties, such as data integration, imaging integration, reduced operating room footprint.[4] In sum, unsatisfactory curative effects, technological limitations and cost are the key challenges that we are now faced with.

2.3. The future of robotic surgery platforms

Robotic surgery platform is shifting to meet the need of surgeons and patients from innovation at the technology level to integration of medicine and computer techniques. Robotic systems will have the ability to reproduce surgical steps by self-learning based on the information of patients and procedures.[16] Surgeons could perform remote surgery for patients by robotic surgery systems in near future. Also, with the help of virtual reality-based curriculum, young surgeons could simulate surgery and operate robotic system skillfully.

As more and more medical enterprises and researchers devote themselves to the field of robotic surgery platforms, we believe the future is promising. There is no doubt that robot will play a huge role in the future of surgery.

2.3.1. Novel and developmental platforms

Senhance surgical system (TransEnterix Surgical Inc.) is a multi-port robotic platform which includes multiple robotic arms, 3-dimensional high-definition (3D-HD) vision and haptic feedback. The unique and special feature of this system is that a surgeon can control the camera by eye movements. Controlling this system is similar to performing laparoscopic operations, but it is opposed to the *da Vinci* system.[4]

Versius robot (CMR Surgical) consists of a set of independent arms, which are small, lightweight and portable. Just like its name “versius”, light and flexible are the most distinguished features of this platform. Surgeons could move the robot around the operating table during surgery or between operating rooms at any time.[4]

2.3.2. Single-port surgery platform

The aim of single-port surgery is to improve the benefits of conventional multi-port robotic surgery by decreasing the number of surgical incisions. It will improve cosmesis by decreasing postoperative incisional herniation, reducing recovery time, postoperative pain, blood loss and costs.[17]

da Vinci SP 1098 surgical system (Intuitive Surgical Inc.) includes a 25 mm single-port, three 6 mm articulated arms, articulating 3D-HD camera and a single-arm platform compatible with the *da Vinci Xi side cart*.[18] Two human pre-clinical trials are underway now.[19]

The single-port orifice robotic technology surgical system (SPORT, Titan Medical Inc.) can be controlled by surgeons using hand controls, foot pedals and a touchscreen. The most unique feature of this system is the disposable end effectors, which may reduce cost.[19] In February 2018, the pre-clinical trials of this system have begun in single-port prostatectomy.[20]

Apart from what is outlined above, there are several promising robots for surgery, such as *Master* (Endomaster Pte Ltd) and *Avicenna Roboflex* (Medical Microinstruments).[19] These surgical robots enter the body through a natural orifice, instead of an incision. Human trials are underway.[21,22] There is no doubt that this is the next wave in surgical robots.

3. Conclusions

In under 30 years, robotic surgery platforms have shifted from scientific research to clinical applications. After the FDA approved the *da Vinci* surgical platform for use, many other surgical platforms arose. More and more hospitals and scientific institutions invested in this technology all over the world and the application field has expanded. Though the current robotic surgery platforms have some limitations and challenges, more and more medical enterprises and researchers have devoted themselves to the field of robotic surgery. The future is now for those who can see it. Not only scientists and surgeons, but also patients are confident in robotic surgery platforms.

Conflict of interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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