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REVIEW ARTICLE

The Camera-holding Robotic Device in Laparoscopy Surgery

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ABSTRACT

Background: The inconvenience of laparoscopic operations lies mainly in the difficulties in mutual understanding between the surgeon and the camera assistant who maneuvers the laparoscope according to the surgeon's instructions. Another problem arises when the operation has to be performed for many hours. In this case, the camera image tends to become unsteady due to fatigue of the camera assistant. The self camera-control by the surgeon gives more stability of the laparoscopic image. A robotic camera assistant, directly under surgeon's control, can help the surgeon control the view better. This review is limited only in the robotic camera holder to replace the assistant camera holder in laparoscopy surgery.

Materials and methods: Several types of the camera-holding robotic devices, such as the AESOP, EndoAssist, PMAT and PARAMIS were reviewed respectively.

Discussion: Most of the camera-holding robotic devices have the advantages, such as elimination of the fatigue of the assistant who holds the camera, elimination of fine motor tremor and small inaccurate movements, delivery of a steady and tremor-free image, nondependency on camera operator, reduced cost of surgery and reduced number of highly skilled staff. Some of them have additional advantages and disadvantages depend on their uniqueness.

Conclusion: There is no fundamental difference between the operation performed with and without the devices, but the machines do contribute to certain aspects of the operations and may help to overcome some of the difficulties encountered in these complex laparoscopy procedures. Unavailability and variability in quality of human camera-holders should not be an obstacle to performing satisfactory laparoscopic surgery. Therefore, some form of standardization of assistance is required and laparoscope-holding systems are a first step in this direction.

Keywords: Camera-holding robotic device, Robotic camera assistant, Camera holder, Laparoscopy surgery, AESOP, EndoAssist, PMAT, PARAMIS.

BACKGROUND

Robotic surgical devices have developed beyond the investigational stage and are now routinely used in minimally invasive general surgery, pediatric surgery, gynecology, urology, cardiothoracic surgery and otorhinolaryngology. Robotic devices continue to evolve and as they become less expensive and more widely disseminated.[1] But not every country, especially, the developing countries ready for this. In the developing countries, the conventional laparoscopy surgery is just about to grow.

The term 'robot' was coined by the Czech playright Karel Capek in 1921 at Rossom's Universal Robots. The word 'robot' is from the 'Czech' word robota which means forced labor. The era of robots in surgery began in 1994 when the first AESOP (voice, controlled camera-holder) prototype robot was used clinically in 1993 and then marketed as the first surgical robot ever in 1994 by the US FDA. Since then, many robot prototypes like the EndoAssist (Armstrong Healthcare Ltd, High Wycombe, Buck, UK), FIPS endoarm (Karlsruhe Research Center, Karlsruhe, Germany) have been developed to add to the functions of the robot and try and increase its utility. Integrated surgical systems (now Intuitive Surgery, Inc.) redesigned the SRI Green Telepresence Surgery System and created the daVinci Surgical System® classified as a master-slave surgical system. It uses true 3D visualization and EndoWrist®. It was approved by FDA in July 2000 for general laparoscopic surgery, in November 2002 for mitral valve repair surgery. The da Vinci robot is currently being used in various fields, such as urology, general surgery, gynecology, cardiothoracic, pediatric and ENT surgery. It provides several advantages to conventional laparoscopy, such as 3D vision, motion scaling, intuitive movements, visual immersion and tremor filtration. The advent of robotics has increased the use of minimally invasive surgery among laparoscopically naïve surgeons and expanded the repertoire of experienced surgeons to include more advanced and complex reconstructions.[2]

Manipulation of instruments is what makes the difference between laparoscope holders and fully operational robots, such as the da Vinci®. These robots allow the surgeon to perform meticulous dissections and microsutures in restricted and difficult-to-reach areas. However, their exorbitant price, their volume, their technological complexity and long setup time mean they have not yet entirely won over the surgical community and their cost-effectiveness still needs to be evaluated. It should be made perfectly clear that the rationale for fully operational robots and laparoscope holders is different; robots are not meant to address economic concerns or lack of assistance in the operating room (OR); therefore, they are probably not for every general hospital.[3]

During minimal access surgery, an assistant is controlling the laparoscope and surgeon should be free to manipulate instruments. Although the advantages of laparoscopic surgery are well-documented, one disadvantage is that, for optimum performance, an experienced camera driver is required who can provide the necessary views for the operating surgeon. There are many drawbacks in human camera operator, especially, if they are not trained.[4] The inconvenience of laparoscopic operations lies mainly in the difficulties in mutual understanding between the surgeon and the camera assistant who maneuvers the laparoscope according to the surgeon's instructions. Another problem arises when the operation has to be performed for many hours. In this case, the camera image tends to become unsteady due to fatigue of the camera assistant. The self camera-control by the surgeon gives more stability of the laparoscopic image. A robotic camera assistant, directly under surgeon's control, can help the surgeon control the view better.[5] This review is limited only in the robotic camera-holder to replace the assistant camera-holder in laparoscopy surgery. In this review, 'Camera-holding robotic device' term is used. Camera-holding robotic device is a robotic device that replaces the human assistant and ensures steady visualization of the operative field and a view which can be controlled by the surgeon (Fig. 1).[6]

MATERIALS AND METHODS

Several types of the camera-hoding robotic devices were reviewed. The first of camera-holding robotic device is AESOP. AESOP is an acronym for automated endoscopic system for optimal positioning. This computerized robotic assistant for laparoscopic surgery was created by Yulun Wang, PhD, and a team of robotic expert. They had a research grant from the National Air and Space Administration and initially were charged with the development of a robotic arm for use in the US space program. This arm was later modified to hold a laparoscope and to replace the human laparoscopic camera holder. AESOP 1000, the first generation AESOP, was based on this development. The surgeon controlled AESOP with either a footswitch or hand control. AESOP 2000 was marketed in 1996 (Fig. 2) with improvements in design and function, including voice control. Voice activation allowed the surgeon to control the laparoscope with simple spoken commands. AESOP 3000 system became available in 1998. It had additional joint, functioning as a second 'elbow', on the robotic arm, and made it possible to apply the robot in a broader range of procedures. The fourth generation system, the AESOP HR (Hermes Ready), enables the surgeon to control AESOP as well as other peripheral devices, such as the operating table and room lights by voice command. By the end of the year 2002, over 8000 AESOP units had been sold and used in over 175,000 procedures in over 600 hospitals around the world.[7]

The other device is EndoAssist (Fig. 3). EndoAssist is programmed to detect and follow the movements of the surgeon's head. The surgeon wears a lightweight headband fitted with an infrared emitter. The head position of the surgeon is detected by a receiver unit and converted into motion of the robot, so to move the view left, the surgeon simply glances to the left of the monitor and the camera pans round. To move the view up, the surgeon looks to the top of the monitor and the camera follows. Movement only occurs if the surgeon is simultaneously pressing a footswitch, thus allowing unrestricted head movements at all other times.[6]

Another camera-holder device was invented by Prof Mishra, India, in collaboration with Mexican engineers. 'PMAT', the name of his invention, is mechatronic assistant wih three degrees of freedom, which is made of aluminium and weighs 2.5 kg (Fig. 4), including laparoscope and camera. This system consists of a harness that is placed over the surgeon's shoulders. The active degree of freedom is moved in both ways using two switches. To make mixed movements, the surgeon moves his/ her body through visual perception. This invention was helping the laparoscopic instrument companies to make ideal camera holder.[4]

PARAMIS (parallel robot for minimally invasive surgery) was invented in Romania, which is used for laparoscope camera positioning. The system has been built in such a way that it has the possibility to transform it in a multiarm robot controlled from the console. The control input allows the user to give command in a large area for the positioning of the laparoscope using different interfaces: Joystick, microphone, keyboard, mouse and haptic device.[8]

DISCUSSION

Based on robotic system's classification, such devices function as endoscopic holders that can be directed by commands from the surgeon are classified under 'Intern replacement' surgical robots. These robots are an intermediate class between the 'precise path systems' surgical robots and the 'master-slave' device. They substitute the surgical assistant to perform tasks that require dexterity without tiring.[9]

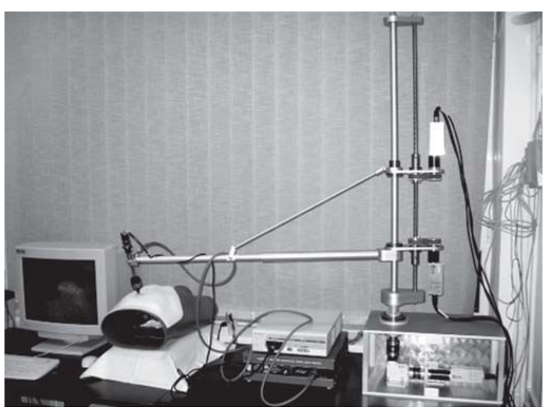

Fig. 1: Laparoscopic primitive camera-holder

Most of the camera-holding robotic devices have the advantages, such as elimination of the fatigue of the assistant who holds the camera, elimination of fine motor tremor and small inaccurate movements, delivery of a steady and tremor-free image, nondependency on camera operator, reduced cost of surgery and reduced number of highly skilled staff.[4]

Some of them have additional advantages and disadvantages depend on their uniqueness. There are mechanical, nonrobotic table-mounted clamps, but these require manual adjustment. Another robotic device is the AESOP which is table-mounted and, therefore, has the advantage of moving with the table, if the table position is changed. The EndoAssist, being floor-mounted, has to be brought to the operating table once the optimal position has been decided and has to be reset if the table position is changed. The AESOP device is voice-activated and needs to be set to recognize each individual operator, whereas the EndoAssist is activated by the infrared head device and the surgeon's head movements and this is transferable between individuals according to who wears the head controller.[6] Two robotic laparoscopic camera-holders, EndoAssist and AESOP 3000 are compared from a system design viewpoint measuring the time taken to perform certain tasks by the operator. The results showed the EndoAssist robot to be significantly quicker for most of the tasks studied. This was attributed to increased accuracy of movement in EndoAssist in comparison to the voice recognition errors evident while operating AESOP.[10]

On the other device, the surgeons were slightly felt fatigue with use of the PMAT for laparoscopic procedures which took more time and prompting for motion adjustment was required repeatedly for the cases studied.[4] PARAMIS robot has some advantages that could be emphasized: Rapid returning in key-positions, open architecture allowing a simple and fast introduction of new commands or modification of the existing ones, direct control over a smooth, precise, stable view of the internal surgical field for the surgeon, no fatigue, save three anatomical positions and return to them by a single voice command.[8]

Fig. 2: AESOP

Fig. 3: EndoAssist

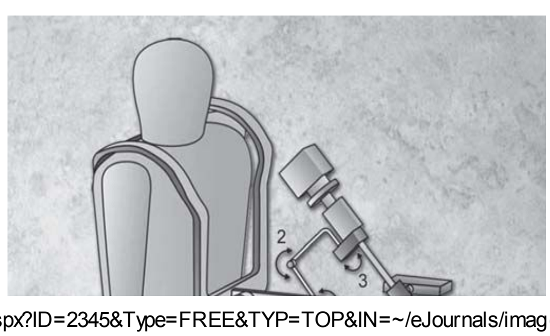

Fig. 4: PMAT

CONCLUSION

There is no fundamental difference between the operation performed with and without the devices, but the machines do contribute to certain aspects of the operations and may help to overcome some of the difficulties encountered in these complex laparoscopy procedures.

Unavailability and variability in quality of human camera holders should not be an obstacle to performing satisfactory laparoscopic surgery. Therefore, some form of standardization of assistance is required and laparoscope-holding systems are a first step in this direction.

REFERENCES

- Herron MD, et al. A consensus document on robotic surgery 2007, cited from http://www.sages.org/publication/id/ROBOT/

- Palep JH. Robotic assisted minimally invasive surgery. J Minim Access Surg Jan 2009;5(1):1-7.
- Polet R, Donnez J. Using a laparoscope manipulator (LAPMAN)in laparoscopic gynecological surgery, 1998, cited from http://www.surgicaltechnology.com/17-187-GY-Abstract.html
- Mishra RK, et al. Comparison of PMAT camera holder withhuman camera control. World Journal of Laparoscopy SurgeryMay-Aug 2008;1(2):1-5.
- Shirwalkar V, et al. Robotic camera assistant for laparoscopicsurgery, cited from http://www.scribd.com/doc/45776626/Robotic-Camera-Assistant.
- Gilbert JM. The EndoAssist robotic camera holder as an aid tothe introduction of laparoscopic colorectal surgery. Ann R CollSurg Engl July 2009;91(5):389-93.
- Ballantyne GH, et al. Primer of robotic and telerobotic surgery.Lippincott Williams and Wilkins 2004;35.
- Pisla D, et al. PARAMIS parallel robot for laparoscopic surgery.Chirurgia Sep 2010;105(5):677-83.
- Otero JL, et al. History, evolution and application of roboticsurgery in urology. Arch Es Urol 2007;60(4):335-41.
- Nebot PB, et al. Comparison of task performance of the cameraholderrobots EndoAssist and AESOP Oct 2003;13(5):334-38.