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REVIEW ARTICLE

# Minimally invasive surgical techniques – robotic surgery

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Da Vinci robotic surgical platform is the result of many years of research of the military physicians from United States Army. This platform was initially intended to operate in close proximity to the battlefield, it was supposed to allow for complex surgeries without threatening medical personnel, but also to ensure a high survival rate among the wounded. Basically, after a soldier was wounded, he was supposed to be taken away from the front line, transported to the first sanitary structure which had this platform available and a surgical team from long distance, satellite connected, performed the surgery. The advantages of this course of action are related to the fact that the team is permanently safe and the injured person benefits from the experience of a well-trained surgical team.

Due to the large amount of information transmitted between platform components, which means millions of operations performed each second, and the impossibility to secure a channel for information dissemination, even more difficult in a hostile environment such as in the vicinity of the front line, and the long preparation of a patient to be subjected to a robotic surgery, the platform is not in current use of military doctors, the way it was originally intended. So far, only one surgery was performed in which the operator was far away from the patient. The two surgical platform elements were arranged one in the United States and one in France. During the surgery, the transfer of information was made by satellite, with great efforts to secure the information channel, as well as with the suspension of any satellite phone links between the two countries.

The advantages desired by military doctors have proved to be far from being put into practice, however, their research work led to the development of the best technology that allows for minimally invasive surgery. In 2015, worldwide, about 3,400 platforms daVinci were installed: 2295 in the United States of America, 573 in Europe and 7 in Romania.

Robotic surgical platform consists of several components which will be described below. Using the system is only possible if all three components are available, none of them is optional. Although there are three components, they are interconnected and have the same purpose: to allow for a minimally invasive surgery in maximum security conditions for the patient. The system combines technological advantages: high resolution three-dimensional image, video image stability and filtering of surgeons' hands unwanted movements, with the surgeons' experience and ability to make decisions in real time.

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Operator surgeon’s console consists of three parts. The video system allows viewing intracorporeal images in a tridimensional manner thanks to the two images submitted separately for each eye; here, there is also a number of sensors that detect the presence of the surgeon at the console, this thing is necessary as a safety measure to block chaotic motion of the device arms inside the body if the operator is absent. The second component of the console is represented by the console commands for each hand, called "master controls" and a series of commands for adjusting an ergonomic position. This component records the surgeon's hand movements allowing this information to go to the working forceps. The pedals system is the last component of the console, here it is possible to activate several functions for the working tools: electric coagulation or sectioning, handling video camera, change the working arm: the surgical system has three arms and it is necessary to change one tool with another for a certain hand. The whole assembly allows adjustment on more axes of all the components, depending on the preferences of the operator, the scope is to obtain an ergonomic position. If more surgeons use the equipment, the system stores each surgeon’s preference, and when the personal account is activated, it recreates the ergonomic position preferred by each surgeon.

**Figure 1.** The working console on which one can notice the three subcomponents from top to bottom: video playback system, master control, crank

Patient's charter is like a tower which has three working arms attached and a video camera arm. This charter, as its name implies, is beside the operating table. On each working arm, a certain tool is fixed and it is activated by a pulley system that allows movements in the seven degrees of freedom. Patient's charter only performs commands coming from the surgeon’s console, it has no autonomy to make decisions, it can not be programmed to execute movements without commands in real time. Fixing / replacing instruments is performed by a surgeon who is next to the patient, he is also the one who places all working cannula into the patient’s body. The working tools have a diameter of 8 mm and reproduce, in miniature, the instruments used in open surgery.

**Figure 2.** Patient's charter with the three working arms for tools and the video camera arm.

**Figure 3.** Working tools

The video system displays intracorporeal images on bidimensional monitors in the operating room. This system allows recording of images and setting of certain parameters. Here lies the source of light transmitted to the intracorporeal video camera through an optical fiber. All components described above are dependent on the presence of at least two surgeons, the system is not designed to fulfill the role of the surgeon but to support surgery by involving the present technological advantages.

**Figure 4.** Video tower and bidimensional monitor of high resolution

The three systems are interconnected by optical fiber since the information flow is very high.

Robotics is a minimally invasive technique, similar to laparoscopic surgery, in which working tools are inserted through small incisions of 5-15 mm in the peritoneal cavity through which cannula are introduced to work. Comparative studies between open surgery and robotic surgery have highlighted the following advantages in favor of robotic surgery: shorter stay in hospital, reduced bleeding, less postoperative pain, faster social reinsertion, small incisions that allow a much quicker recovery and lower risk of developing eventrations. Patients who have no indication for minimally invasive surgery, do not have indication for robotic surgery either.

The recommendations of robotic surgery are the surgeries that require access to limited spaces, inaccessible for open surgery and restricted by the small maneuverability of laparoscopy instruments. In urology, robotic prostatectomy is considered as the "gold standard". As a general idea, robotic surgery approach is indicated for the organs situated at the top and bottom pole of the peritoneal cavity, where limited space and difficult access are not impediments for daVinci surgical system instruments.

Complications can occur in robotic surgery just as it happens with any surgery, the maximum risk is death. Complications that may arise during surgery are: intraperitoneal organs injury, intraoperative bleeding, septic complications. Another factor to be taken into consideration is the human error, system failures or potential complications of anesthesia.

At this time, da Vinci surgical platform is the most advanced tool that allows a minimally invasive surgery. A very important element about the functioning of this system is that it can not "operate" independently; it cannot be programmed to carry out independent actions. It must be seen only as an extension of the arms of the surgical team members, executing commands coming from the surgeon at the working console, under the supervision of at least one surgeon.

**References:**

1. Park JS, et al. S052: a comparison of robot-assisted, laparoscopic, and open surgery in the treatment of rectal cancer. Surg Endosc. 2011 Jan;25(1):240-8. Epub 2010 Jun 15

2. Poston RS, et al. Comparison of economic and patient outcomes with minimally invasive versus traditional off-pump coronary artery bypass grafting techniques. Ann Surg. 2008 Oct;248(4):638-46

3. Health Information and Quality Authority (HIQA), reporting to the Minister of Health-Ireland. Health technology assessment of robot-assisted surgery in selected surgical procedures, 21 September 2011

4. Landeen LB, et al. Clinical and cost comparisons for hysterectomy via abdominal, standard laparoscopic, vaginal and robot-assisted approaches. S D Med. 2011 Jun;64(6):197-9, 201, 203 passim

5. de Souza AL, et al. A comparison of open and robotic total mesorectal excision for rectal adenocarcinoma. Dis Colon Rectum. 2011 Mar;54(3):275-82

6. Cerfolio RJ, et al. Initial consecutive experience of completely portal robotic pulmonary resection with 4 arms. J Thorac Cardiovasc Surg. 2011 Oct;142(4):740-6. Epub 2011 Aug 15

7. Shaligram A, et al. How does the robot affect outcomes?

A retrospective review of open, laparoscopic, and robotic Heller myotomy for achalasia. Surg Endosc. 2012 Apr;26(4):1047-50. doi: 10.1007/s00464-011-1994-5. Epub 2011 Oct 25

8. Lowe MP, et al. A comparison of robot-assisted and traditional radical hysterectomy for early-stage cervical cancer. Journal of Robotic Surgery 2009:1-5

9. Menon M, et al. Prospective comparison of radical retropubic prostatectomy and robot-assisted anatomic prostatectomy: the Vattikuti Urology Institute experience. Urology. 2002 Nov;60(5):864-8

10. Bell MC, et al. Comparison of outcomes and cost for endometrial cancer staging via traditional laparotomy, standard laparoscopy, and robotic techniques. Gynecologic Oncology III 2008:407-411

11. Miller J, et al. Prospective evaluation of short-term impact and recovery of health related quality of life in men undergoing robotic assisted laparoscopic radical prostatectomy versus open radical prostatectomy. J Urol. 2007 Sep;178(3 Pt 1):854-8; discussion 859. Epub 2007 Jul 16

12. Market share data on file at Intuitive Surgical

13. National Cancer Institute. NCI Cancer Bulletin. Tracking the Rise of Robotic Surgery for Prostate Cancer. Aug. 9, 2011 Vol. 8/Number 16; from www.cancer.gov, URL

14. da Vinci Surgery Facts Page 7 of 7 PN 1005811 rev A 5/14 http://www.cancer.gov/ncicancerbulletin/080911/page4. Sample. Eur Urol. 2012 Jun;61(6):1239-44. Epub 2012 Mar 30

15. Liu et. al., "Perioperative Outcomes for Laparoscopic and Robotic Compared with Open Prostatectomy Using the National Surgical Quality Improvement Program (NSQIP) Database," European Urology (2013), doi:10.1016/j.eurouro.2013.03.080

16. Kowalczyk et. al., "Temporal National Trends of Minimally Invasive and Retropubic Radical Prostatectomy Outcomes from2003 to 2007: Results from the 100% Medicare Sample," European Urology (2011), doi:10:1016/j.eurouro.2011.12.020

17. Lau et. al. "Outcomes and Cost Comparisons After Introducing a Robotics Program for Endometrial Cancer Surgery," Obstetrics & Gynecology (2012), DOI: 10.1097/AOG.ob013e31824c0956

18. Wright et. al. "Robotically Assisted vs. Laparoscopic Hysterectomy Among Women With Benign Gynecologic Disease," JAMA 2013;309(7):