Robotic Surgery: When Technology Meets Surgical Precision

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Abstract

The objective of the following report is to represent a full & clear image of the latest technology in the field of surgery (Robotic Surgery) in a brief and easy way showing the advantages accompanied with this new type of surgery & the value it adds for both the patient & the surgeon.

BACKGROUND

OPEN SURGERY

The surgery first started with Open Surgery which implied making a large incision in the patient's body to allow the full exposure of the surgical site and to give enough space for the surgeon to introduce his hands to do surgery.

DISADVANTAGE

- Large incision resulted in more pain for the patient
- Patient needed to stay for long time in the hospital post operatively for wound healing.
- The big scar resulted from the surgery was annoying for patients specially females.

MINIMAL INVASIVE SURGERY

In the early 80's the Minimal Invasive Surgery was introduced. This type of Surgery was meant to avoid all the complications resulted from Open Surgery as it depended on small incisions for introducing the surgical Instruments to the field of Surgery. The Vision was acquired through a scope that displayed the image of the surgical site on a monitor display for the surgeon.

DISADVANTAGE

- The Surgical instruments were Rod-like having no wrist movement at the tip which required from the surgeon to move his arms in large scale movements outside the patients body for the instrument tip (internally) to get to the desired location.
- The movement of the instruments/scope were awkward (counter-intuitive) meaning that if the surgeon wants to move the instrument/scope to the left, he has to move to the right from outside.
- The scope displays only a 2D image on the display which has no depth perception. The surgeon needed to over/under shoot the target anatomy to be able to allocate it properly.
- The Surgeon gets tired because he is hanging his arms all the case time in an awkward position (Hand Tremors) & twisting his neck to be able to follow up the surgical site displayed on the monitor.
- A lot of miscommunication resulted from MIS due to opposite directions and fatigue.

ROBOTIC SURGERY: “DA VINCI” SURGICAL SYSTEM

HISTORY

- The Robotic Industry started with what so called “Industrial Robots” which depended mainly on a pre-installed program that carries a pre-defined tasks to be performed automatically i.e. Car assembling robots, Production lines machines..,etc. The main advantage was that the robots were much faster and accurate than human beings to perform such tasks but still, a disadvantage of having no human control on the machine – the machine was fully independent – limited the use of these robots

to tasks that needed only speed and mass production.

- A while after, a new kind of robots was invented "Tele-manipulated Robots". These robots were invented to carry tasks that were considered dangerous for human beings to perform i.e. Oil mines drilling, moon surface exploring, deep see/volcano studies... etc. These robots were sent to such missions being controlled by humans from a control base. They depended on "Computer Assisted Technology" for translating the human command to a robotic action.

THE "DA VINCI" SURGICAL SYSTEM

In the mid nineties and specifically in 1995, a new revolutionary type of Surgery appeared which relied on utilizing the latest technology in the field of Computer Assisted Surgery to control and manipulate electromechanical devices. This new type of Surgery was given the name "Robotic Surgery"

Robotic Surgery is performed in a similar way to Laparoscopic Surgery in the fact that it uses tiny incisions to introduce special types of instruments with the highest degrees of precision. The surgeon sitting comfortably on an operating console is able to view a very clear 3 Dimensional view of the surgical while controlling the arms of the robot which hold these special instruments together with the camera and scope. This ergonomic position for the surgeon has proved to relieve his stress and allowed him to focus more on providing a better quality of surgery.

ADVANTAGES OF USING ROBOTIC SURGERY

Robotic Surgery is with no doubt the "Surgery of the 21st Century" and it is regarded as the latest innovation in the field of Surgery.

Based on the latest medical studies, Robotics has added the following improvements to Surgery:

- A significant decrease in the blood loss & other potential complications which is usually encountered in surgery.
- Reducing the operative time which relieved the patient of all the risks accompanying prolonged stay under anesthesia.
- A relatively reduced post-operative hospitalization stay.
- Ability of the patient to resume his normal life in a period of only 24 to 48 hours after undergoing Robotic Surgery.
- Much better surgical efficacy which decreased the probability of surgical complications.
- Much lower risks of infection and healthier surgical outcomes.
- Ability to perform complicated surgeries with ease and with better results.
- More confidence & comfort to the surgeon in his surgical practice.
- Addition of more surgical operations that were not considered doable with older surgical techniques.

Based on Computer Assisted Technology, the "da Vinci" Surgical System was first developed by NASA to be used in Gulf War for performing surgeries for the American soldiers wounded in the battle field who needed surgery without the need of sending the surgeon himself to the zone of danger. From this idea aroused the thinking of "Tele-Surgery".

The Tele-Surgery was examined in a live case between New York and Paris and found to be very expensive due to the need of very fast communication lines between the sender and receiver & was also accompanied by a factor of delay mainly due to the fact of the communications technology being not up to that level for the time being.

Accordingly, The Robotic Surgery was directed only for direct surgeries being done at the same location the robot is installed in, however, Tele-Surgery is still under Research & Development studies.

Figure 1

Figure 2

Figure 3

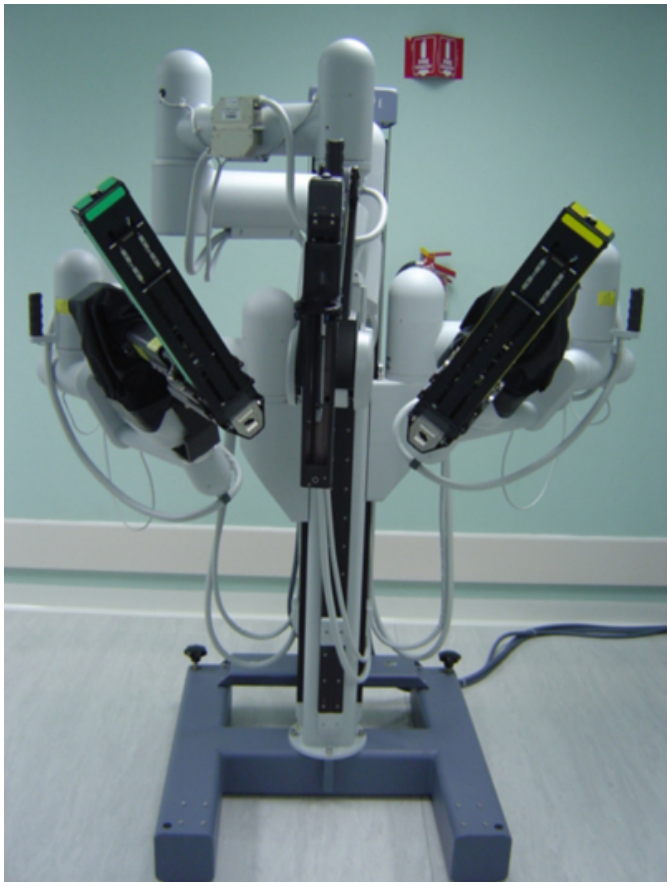
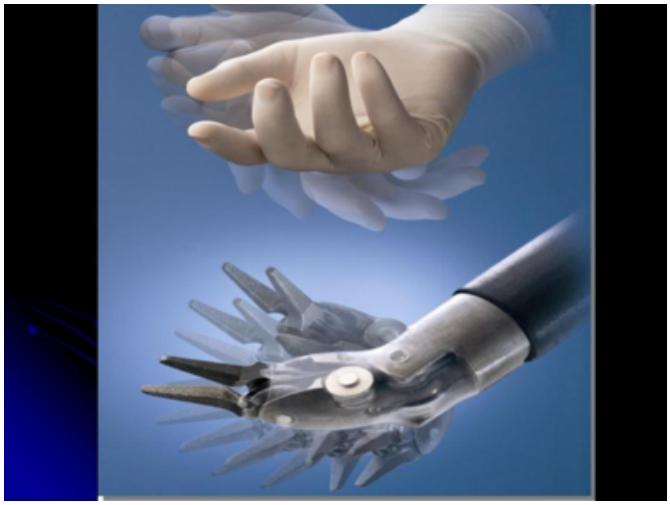


Figure 4



INTUITIVE SURGICAL INC.

Intuitive Surgical Inc. is an American Surgical Robots manufacturing company based in Sunnyvale, California and was founded by a Surgeon & an Engineer (Fred Moll & Rob Young) who invented the first Surgical Robot (Monaliza) in 1995 which passes through a series of developments & updating until it reached the version nowadays named “The

da Vinci Surgical System".

The Robotic Surgery aimed to eliminate all the disadvantages resulted from both Open & Minimal Invasive Surgeries & at the same time combine all the benefits of the two types of surgery for both the surgeon and the patient.

The Robotic Surgery can be named as an "Open Surgery technique on a Minimal Invasive Platform" How?

- EndoWrist Instruments/scope are introduced through small incisions as in MIS. (Benefit for the Patient) Accordingly, The patient's post-operative stay was reduced as in MIS.
- The Endowrist instruments/scope is held by Robotic Arms all the time. This reflected on decreasing the number of staff in the OR as the surgeon himself is the one who is controlling all the Robotics Arms and their correspondences.
- The movement of the Endowrist Instruments/scope is controlled by the surgeon sitting comfortably on a console then, are scaled & translated by the robot to minimal movements inside the patients body. (Benefit for the surgeon).
- The movement of the EndoWrist Instruments/scope is an intuitive movement (when the surgeon moves his arm to any direction, the robot moves the instrument tip to the same direction). No miss-communication.
- The robotic arms have filters to eliminate hand tremors. (Benefit for the surgeon).
- The robot doesn't get tired & is available at all times.
- The EndoWrist Instruments introduced a new wrist movement to the former Endoscopic Instruments which massively increased the surgical capabilities of the surgeon. (benefit for the surgeon)
- The Robot provided the surgeon with a true 3D vision of the surgical site having depth perception just as the normal vision with a much better magnification & image quality.
- The robot allowed surgeons to do more complicated cases that were difficult and sometimes rather impossible to be done under Endoscopic Surgery.

THE "DA VINCI" SYSTEM COMPONENTS

The "da Vinci" system consists of four main parts:

1. SURGEON'S CONSOLE

This is the place where the surgeon sits comfortably and via hand manipulators controls the EndoWrist Instruments movements at the surgical site. The console is provided by a "Stereo Viewer" that translates the image of the surgical site acquired by the Endoscope and displays it in front of the surgeon's eyes (surgical immersion). It is also considered the control unit for the rest of the parts.

2. THE SURGICAL CART

This part is considered the actual robot that is based beside the patient bed. It has 3 arms mounted on, 2 Instruments arms & 1 Camera arm for holding the EndoWrist Instruments & scope. It receives the commands from the surgeon at the console and mimics them into minor instrument/scope tip movements inside the patient's body.

3. THE VISION TOWER (INSITE VISION SYSTEM)

This tower looks like any regular MIS vision tower except for having extra equipment used mainly for handling the 2-channeled image acquired by the robotic scope. (See Vision System parts).

4. THE ENDOWRIST INSTRUMENTS (8MM & 5MM)

These are special instruments used in combination with the "da Vinci" Surgical System. They have got extra degrees of freedom than normal Endoscopic instruments (Wrist Movement) which massively increased the surgeon's hand capabilities. The EndoWrist instruments come in a big range to cover all possible cases in all surgical disciplines.

VISION SYSTEM PARTS

The Vision System consists of the following parts:

1. DUAL CHANNEL ENDOSCOPE

The robotic scope is a dual channel scope (having separate channel for each eye lens). It gets a right & left images of the surgical site that are transmitted through a series of lenses in each scope channel embedded in the scope shaft to the Camera Head. The scopes come in 2 angles at the tip (0 & 30 Degree).

2. THE CAMERA HEAD

The Camera Head consists actually of 2 camera head embedded in one box, one for each scope channel. Its function is to transfer the photons of the image acquired by the scope into an analog signal then, sending it to the Camera Control Units (CCU). It also performs mechanical focus on the image.

3. THE CAMERA CONTROL UNITS (CCU)

The Vision Tower has 2 CCUs for both left and right images. The CCUs gives multiple video signal outputs for the image i.e. S-Video, Composite & RGB. They also apply gain factor and control brightness, White & black balances and electronic shutter speed.

4. THE SYNCHRONIZERS

The CCUs send the 2 images to two synchronizers that transforms the image into the digital format and adjust edge definition & image sharpness.

5. THE CONSOLE BACK PLANE (VSD BOARD)

The images are then sent to the back plane of the console where they are sent to a Video Signal Distribution board (VSD). The VSD board is responsible of applying text overlay on the image and sending it to the two Barco monitors in the console Stereo Viewer & to the Assistant monitor mounted on the Vision Tower.

6. ILLUMINATION

The Tower is accompanied by a Xenon Illumination System that is responsible of emitting light through fiber optic light guide cables to illuminate the surgical site and to heat the scope's tip to prevent anti-fogging.

FUTURE OF ROBOTIC SURGERY

As mentioned before, the Tele-Robotic surgery is still under Research & Development. Of course, it will be considered a breakthrough in surgery when launched but, up till now, there is no date known for its release.

It is also expected that the future will carry out smaller size robots which would be easier in function & cheaper in price.

The International Journal of Medical Robotics + Computer Assisted Surgery CAS

References

- Intuitive Surgical Inc. website (http://www.intusurg.com)

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