Robotic surgery

Information Technology in Medicine: Should patients trust robotic surgery

1 Introduction to the topic

Robots are ubiquitous today. They are found in our cars, in our houses, in our industries inside buildings and to places we neglect to notice. We trust robots to do everyday chores for us either by knowing directly or indirectly. Robots are becoming part of our lives and we have all accepted it.

Today technology has advanced so that it allows for innovative robotic systems to be inserted in the medical field. New materials, ideas and technological advancements bring robotics into medicine. Robotics in medicine entails many advantages and benefits for both the doctors and the patients. But there are also some limitations in robotic surgery that cause doubt and uncertainty to people.

However, as it happens with every new technological development, people need time to become familiar with it, to accept it and finally trust it. So the question is if the world is ready to accept and trust robots in health and more specifically in surgery. There will be people who are pioneers and enjoy trying something new, people who are skeptical and need to know everything about it before agreeing and people who will be afraid no matter how much proof they’re given. There cannot be an abrupt transition from classical surgeries without robots to surgeries all aided with robots. Gradually, the surgeries aided with robots will increase as people’s experience and trust increases.

2 IT Background

2. 1 History of robotics

Most of us when we hear the word “ robot” we think of science fiction movies showing robots of the future, performing outstanding tasks. In fact, most of these robots seen are now everyday reality making our lives more convenient.

One definition that could be given to a robot is “ a reprogrammable multi-functional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks.[1]

Robotics is the engineering science and technology of robots, their design, manufacturing, and applications. It is related to electronics, mechanics, and software.

ht_2bunimate_080415_sshRobots could not be manufactured until the 1960’s when transistors and integrated circuits were invented. Compact, reliable electronics and a growing computer industry added intellect to the power of already existing machines. In 1959, researchers demonstrated the possibility of robotic manufacturing when they disclosed a computer-controlled milling machine.[2]

The first digitally operated and programmable robot, the Unimate, was installed in 1961 to lift hot pieces of metal from a die casting machine and pile them.[3]

Commercial and industrial robots are ubiquitous in performing jobs better, cheaper, more accurately and reliably than humans. They are also found in jobs that are too hazardous, dirty or tedious for humans.[4]

2. 2 Robotics in surgery[5]

Robotics in medicine is a fairly new, yet advancing field. It is now introduced in medicine, in the field of surgery as it allows for exceptional control and precision of surgical devices in minimally invasive procedures. Robotic surgery has as its main goal to design robots that will be able to be used in performing closed-chest, beating-heart surgery in collaboration with the surgeons.

Munich_OR_415Today numerous surgical robots have been adopted by many operating rooms all over the world. Surgical robots are not actually autonomous “ surgeons” capable of performing assignments on their own, but a helping assistant of the surgeons.

A number of commercial corporations have been founded in order to create surgical robotic systems. Computer Motion, Inc. developed the AESOP Endoscope Positioner: a voice-activated robotic system for endoscopic surgery.

In January 1999, Intuitive launched the DaVinci Surgical System, which is classified as a master-slave surgical system as it uses true 3-D visualization.

In 2001 Computer Motion, Inc built the SOCRATES Robotic Telecollaboration System as well. It includes integrated telecommunication equipment along with the robotic devices in order to provide remote surgical telecollaboration.

Computer Motion merged with Intuitive Surgical, Inc., in June of 2003.

They introduced the ZEUS Surgical System.

3 Robotic Surgery Systems

Robotic surgery systems are divided into three types: supervisory-controlled systems, shared-control systems and telesurgical systems. These systems differ in the sense that in each case there is a different degree of involvement of the surgeon. In some cases, the operation is carried out by the robotic system with a minimal intervention of the doctor. In other cases, the surgery is performed by the doctor with the help of the robotic system.

3. 1 Supervisory-controlled systems [6]

supervisorySupervisory-controlled systems are the most automated systems of all. But they still need the guidance of the surgeon and an extensive preparation before the initiation of the surgery. The surgeon inputs information and programs the robotic system to follow certain instructions. However, once these robots have been programmed, and start operating there is no option for adjustments and that’s why the surgeon must keep a close watch of the surgery in the need of intervention.

As it is known, not all people have the same body structure and so it is not possible to have standard instructions for the robot to follow.

This is done in three stages: planning, registration and navigation.

In the planning stage, the surgeon captures images of the patient’s body. As soon as the surgeon has imaged the patient, he must determine the path that the robot will take to operate.

The next stage is registration, in which the surgeon links the images obtained before with points on the patient’s body. In order for the surgery to be completed successfully, the points must be positioned precisely according to the patient’s body.

The final stage is navigation, which is the actual surgery. In this stage the surgeon places the patient and the robot so as the movements of the robotic system to follow the programmed instructions. When all preparations are complete, the robot is activated and the surgery is carried out.

3. 2 Shared-control robotic systems[7]

Shared-control robotic systems are a helping hand for the surgeons. The operation is carried out only by the surgeon who uses the robotic system manually in order to have greater efficiency. The robotic system monitors the surgeon’s actions during the operation and provides support and stability by “ active constraint”. 7

“ Active constraint” is the process of labelling regions of the patient’s body with one of the four possibilities: safe, close, boundary and forbidden. Surgeons label safe regions the regions that are appropriate for the robot to be and to operate. For instance, a close region can be found in orthopaedic surgery in orthopaedic surgery, near the soft tissues. Many orthopaedic surgery tools can damage the soft tissue and so the robot limits the area that the surgery is safe to take place.

This is done using “ haptic” technology[8], which is the science and physiology of the sense of touch. This means that as the surgeon approaches the boundary region he will start feeling a resistive force and as he proceeds

to the forbidden region the force is getting larger and once he enters the forbidden region the robotic system stops operating immediately.

But in order for the robotic system to know which are those regions, the surgeon must program it first as it is done with the supervisory controlled systems.

3. 3 Telesurgical systems [9]

Telesurgery is a field of telemedicine that was developed in recent years and holds great interest. Today it can be seen as a two way transmission of picture and sound, allowing the communication between surgeons of little experience and surgeons of great experience to cooperate no matter the distance separating them.

Also it is understood, this technology needs highly advanced software in order for the simulation to be feasible in the remote surgery room. For this purpose, systems of virtual reality are required that allow the surgeons that are in a different room or city or country to have an actual image of the operating room and of the procedure. Robots with camera will provide a better quality of the images as they will be in colour and enlarged.

3. 3. 1 Da Vinci Surgical System [10]

The Da Vinci Robot is probably one of the most well-known robotic surgery systems in the world. It is a robotic system that is used in minimally invasive surgery, which means that the robot makes a petite aperture in the patient’s body that brings many positive results.

DaVinci-Robot During the surgery, the surgeon sits in a console inside the operating room and handles the surgical tools of the robot. After the patient

has been anaesthetized, three apertures are made on the patient’s body allowing the rods to enter. On the screen the surgeon observes the 3D image that the camera is transmitting through the patient’s body and which is handled by joysticks. The camera sees every movement of the robot and can be activated or deactivated any time from a button.[11] Every surgical arm is connected with a surgical tool and there is camera in the end of the main arm. One of the rods has a camera on it while the others have surgical tools able to cut, remove or stitch the tissues. The robotic system uses the same stitches and materials used in the traditional surgery.

The surgeon can bend and rotate the arms like the human wrist guaranteeing increased percentage of success and important benefits much for the patient as for the surgeon.

The Da Vinci robotic system includes a lenses system of three-dimensional view, which can make the surgical field as 15 times larger. Also, the camera allows the surgeon to go closer at the point of surgery than the human vision can and so the surgeon can perform the operation in a smaller scale than the conventional surgery allows.

3. 3. 2 Zeus Robotic Surgical System[12]

The robotic surgical system Zeus was the first system to be used in 1999 to perform the first full endoscopic robotic surgery bypass with a beating heart.

It consists of three basic parts:

1. 1zeusconsoleAn ergonomic control console

2. the central control computer

3. Robotic arms, which move with the movement of the surgeon’s hand.

The surgeon sits comfortably in the surgical seat and handles the tools that are placed inside the patient. After the surgeon’s movements have been digitalized they are filtered, thinned and transmitted to the computer’s control station, which transfers those movements through an electromechanical interface to the robotic arms and to the tools.

In addition, Zeus robotic system enhances the optical field of the surgery by enlarging it and also with the help of AESOP robotic system the surgeon’s hands are free to handle the surgical tools.

3. 3. 3 AESOP Robotic Surgical System [13]

AESOP Robotic surgical system was developed by Computer Motion Inc. The period when it first came out, the surgeon could control the robotic arm remotely, manually or with a foot pedal but the most recent edition of AESOP 3000 is controlled with voice commands.

The robotic arm contains and moves a camera which is used in MIS surgeries for the observation of the surgical field. The camera is placed at the edge of the robotic arm and is inserted in the patient’s body through an aperture of about 2cm. The robotic system AESOP is the surgeon’s third arm. By using simple commands such as “ AESOP, move up” or “ AESOP, move left”, the surgeon tells the robot to move the camera as he wishes. Every surgeon records his voice and has a voice card that is inserted into the system whenever he operates, in order for the robot to identify the commands. Usually the system works well. The robot may sometimes not recognize the tone of the voice of the surgeon is different from the recorded voice. But

there is a support system with which the surgeon can handle manually if something like this happens.

3. 3. 4 SOCRATES Telecollaboration System [14]

Socrates telecollaboration system was the first system to be approved (October 2001) for the new-founded category “ telesurgery robotic systems”. It consists of advanced telecommunication equipment that is connected with medical devices and robotic systems. The system gives the surgeon who is at a remote location the opportunity to work with another surgeon who may be in an operating room across the globe. The system provides real time view of the surgery. In collaboration with Zeus robotic system, Socrates is the first fundamental step that marks the start of minimally invasive telesurgery. In 2001 Socrates robot along with Zeus robotic system performed the first translantic surgery. On September 7th, 2001 a group of surgeons in New York performed a cholecystectomy surgery on a patient located in France with the help of doctors that were there. The console and the robot were connected with fiber optic wires. This surgery was first tested on six pigs. That was the first complete telesurgical process that was performed by surgeons 7000 away from their patient. The patient left the hospital 48 hours after the operation and returned to his social activities a week later.

4 Advantages and Limitations [15]

4. 1 Advantages

The advantages of robotic surgery are listed below:

1. Tinniest incisions result in:

* Faster recovery

* Shorter hospital stay and reduced costs

* Less pain and fear

* Less blood loss

* Cosmetic benefit

* Reduced risk of infection or complications

* Less anesthesia required

2. Better sterilization

3. Robot immune to radiation and infections.

4. No muscle tremor or fatigue.

5. Elimination of need for personnel resulting in lower costs for the hospitals.

6. Shorter return to everyday activities(1-2 weeks)

7. Telesurgery: The ability to perform surgery from a different operating room.

8. A 3D camera provides an enhanced view.

9. Robots reach places that surgeons alone couldn’t before.

10. Can be designed for a wide range of scales.

11. Surgeons don’t get tired quickly as they’re seated and have less eye strain and they have the ability to control their natural flinching or nerves more effectively.

4. 2 Limitations

However some of its disadvantages and concerns are:

1. Robotic systems have highly complex software and it is very difficult to program and debug them.

2. Costs including the robotic systems ($750. 000-$1 million), the maintenance and the training of surgeons are considerably high.

3. Since the need of personnel will be minimized, some surgeons will be left unemployed.

4. Telesurgery is based by a large percentage on the transmission of information between two locations. The more the distance between the two locations the more the time delay is inserted. This increased the period between the action and the result and after a certain point this makes surgery impossible in real time.

5. Synchronization during telesurgery is very critical and is not easy to attain.

6. Telesurgery is highly dependent on the security and reliability of the network.

5 Robotic Surgery in Greece [16]

The first robotic navigation system used in a surgery procedure in Greece is the Vector Vision II system in “ Ygeia” (see www. ygeia. gr) hospital in Athens.

In February 2003 the robotic surgical system “ Aesop 1000” was used to perform the first laparoscopic operation in the General Hospital of Crete, Greece.

“ Aesop 1000” is being improved in the labs of University of Crete and will be released as “ Aesop 2000” and “ Aesop 3000” and soon is expected to be used in more complex operations and surgeries.

In addition, the school of medicine in the University of Athens offers advanced courses on robotic surgery. The course aims to teach basic robotic surgery skills such as instrument manipulation, camera control among others. This is done using the Da Vinci surgical system.[17]

1stdayIn November 8th, 2006 the opening day of the Da Vinci robotic system took place in the Athens Medical Center Hospital.

The president of the Hellenic Scientific Robotic Surgical Association Prof. K. Konstantinidis explained the fundamental principles of the Da Vinci robot to Greek ministers and the establishment of the Hellenic Scientific Society of Robotic Surgery.

The first total hysterectomy in Greece was successfully carried out with the latest-generation Da Vinci Robotic Surgery System at the Diagnostic and Therapeutic Centre of Athens – HYGEIA. the operation was broadcasted in

real time during the daily conference held at the Hospital on Tuesday, July 1st 2008, titled “ Robotic Surgery in Gynaecology”.[18]

5. 1 Survey analysis

A survey was conducted during October and November 2009 in Athens about robotic surgery, in which 73 people answered (ages 14-50). The survey included a questionnaire and it was distributed by email. Robotic surgery in Greece is in its infancy so it is quite reasonable to see that 72% of the people asked knew nothing about robotic surgery.

6 Social Concerns

6. 1 Safety

Safety is the prime concern of patients and doctors. People today have trouble trusting robotic devices in general and in the case of their healthcare the issue of trust is intensified.

First of all, there is always the possibility of errors happening as total safety is a fallacy. Robots are programmed by humans who in turn are not infallible and are prone to make mistakes. In the case of robotic surgery a fault could have serious health injuries or death. Thus, the probability of errors must be kept at a very low level and in the case of a malfunction the system must be programmed to shut down immediately. Afterwards, the surgeon will have to take over complete the operation manually. So, it is obvious that the presence of a human doctor is mandatory and critical.

There are many things that can go wrong which experts must take under serious consideration. Some problems resulting in system failures can be flawed design of the system, malfunction of software and hardware[19]or

misinterpretation and inadequate specification. In order to eliminate the possibility of errors, mechanics must undergo “ heavy” testing and reasoning about infinite scenarios. Also surgeons must prepare the robotic system cautiously so as not to forget anything which can backfire. They also need to have contingency plans like converting the robotic surgery to open surgery. [20]

The increased testing and reasoning is time-consuming and usually involves high costs.

Even though safety is a big issue, 41% of the people asked would go through a robotic surgery.

This can be considered a good percentage as 65% of the people asked believed that robotic surgery is safe and reliable.

6. 2 Reliability and knowledge

Nowadays most people don’t trust robots very easily. The reason for this is the lack of information and the fear that these robots/machines can harm them in a physical level or in a professional level.

As it can be seen from the above 88% of the people asked have heard of robotic surgery but 56% of the people asked claimed to know very little about it.

As it is stressed in a website about robotic surgery, and prostate cancer surgery in particular, most people worry about the side effects it could have on them such as sexual dysfunction and impotence.[21] Another concern was the fear of the robotic system and the probability of errors, but most

people do a little research before resorting to robotic surgery. This way they minimize their worries and concerns. However, there still are people who despite the evidence don’t trust robots with their health.

Therefore, robotic surgery needs time to become known and trusted by the people. This percentage of 56% must be minimized and increase the percentage of knowledge. In the future, as robotic surgery will start being implemented into hospitals, there will be many surgeries done, successful or not, which will enhance robotic surgery by correcting the errors, the failures and any problem that may arise. This way, patients who had successful operations will spread the word and people will become more aware and acquainted with this new technological development.

7. Elevating concerns, resolving problems

Robotics in surgery is a great helping tool, which holds many benefits and advantages for the surgeons and the patients. However, since it is still at an early stage of development there are problems in need for resolutions.

One great concern is the reliability and safety in delicate surgical procedures. We cannot deny that machines are made from humans, who are not infallible and thus tend to make mistakes. Whether the surgery is done by a plethora of surgeons or by a single surgeon and a robot there is definitely the possibility of error.

As with every new technology, people need time to get familiar with it and to start trusting it. Thus robotic-aided surgery just needs time to advance and to become more well-known. People who go through robotic surgery procedures will spread the good news. The media will start making more

coverage of the issue as they learn about more cases. As mentioned by many patients in the Da Vinci website, they were very pleased with the surgery and the recovery time which proved to be shorter than expected. [22]

Furthermore, the training of surgeons may take a while but it does not compare having to do a 6-hour surgery above the patient, getting tired and stressed with a 4-hour surgery sitting in the robotic device some metres away from the patient. The surgeon will tire less and will finish the surgery in less time.

As far as the costs are concerned, patients in the Da Vince website did not worry about the costs so much because they were dealings with their health. And most people will do anything for their well-being.[23]

8. Future

Robotic surgery has made quite a progress and development but it still has a long way to go. Many obstacles will be dealt with time and undoubtedly some new concerns may appear. Questions such as malpractice liability, credentialing, training requirements and license granting will have to be resolved in the future.

Most people on the survey (49% to be exact) answered that robots could have negative implications on employment as robots will do most of the work that humans currently do and many of related jobs will be reduced.

However, as mentioned in the advantages chapter, new fields are inserted into robotic surgery such as telemedicine, which shows that new needs for personnel emerge.

Also it is quite interesting to note how the people asked are divided into three groups based on their answers concerning robotic surgeries in the future:

There is a 64% of the people asked who have a positive outlook on robotic surgeries in the future and a 36% who are quite intimidated and afraid of this potential change. Part of this comes from the lack of information about robotic surgery and from the fact that it is still in an early stage.

As far as robotic surgery is concerned, there is much to be done until it can reach its full potential. Even though, these robotic systems have enhanced dexterity significantly, they still need to advance the full potential in instrumentation or to integrate the full range of sensory input.

Most people when hear about robotics, they think of automation. The possibility of automating some tasks is both exciting and controversial. Future systems might entail the ability for a surgeon to program the surgery and merely supervise as the robot performs most of the tasks. The possibilities for improvement and advancement are only limited by imagination and cost.

9. Conclusion

Robotic surgery may be at an early stage, but that does not mean that it has not demonstrated its potential and significance, particularly in areas

previously inaccessible by traditional procedures. However, it still remains to be seen if robotic surgery will replace completely conventional instruments in less technically demanding procedures.

Robotic technology will bring major changes in surgery by enhancing and expanding laparoscopic procedures, advancing surgical technology and thus bringing surgery into the digital age. Not to mention, it possesses the potential to expand surgical treatment beyond the limits of human ability. The benefits of robotic surgery outweigh the costs.

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11. Appendix

11. 1 Robotic surgery Questionnaire

1. Have you heard about robotic surgery?

a) Yes

b) No

2. How much do you know about robotic surgery?

a) A lot

b) Very little

c) Almost nothing

3. Do you know anything about robotic surgery in Greece?

a) I know quite a few things

b) I know very little

c) I know nothing

4. Have you heard of any of the following robotic systems?

a) Da Vinci

b) Zeus

c) AESOP

d) Socrates Robotic System

e) None of them

5. Do you think robots can perform surgery better than humans?

a) Yes

b) No

c) I’m not sure

d) Maybe in the future

6. Do you think that robots could have negative implications on employment?

a) Yes

b) No

c) I’m not sure

7. Would you undergo a surgery aided with a robotic system?

a) Yes

b) No

c) I’m not sure

d) If absolutely necessary

8. Do you think that robotic surgery is safe and reliable?

a) Yes

b) No

9. Would you avoid a robotic surgery due to costs?

a) Yes

b) No

10. How would you describe a future where all surgeries are done by robots?

a) Very appealing

b) Very useful and time-saving

c) Not so happy about it.

d) Quite frightening.

6

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