Medical Robots

Healing and Helping

Monika and Wen
Index

- Definition
- My definition
- For what?
- History
- Other facts
- C' Arm
- Telediagnosis
- MRI
- Robitom
- Nursery
- Robotic Surgery
- Telesurgery
- Advantages & Disadvantages
- Conclusion
- Thanks & Q/A
Medical Robots, also robot-assisted medicine is a term for various technological developments that currently are developed to support a range of medical procedures.
My definition

1. intelligent medical systems which can replace doctor's and nurser's labor, technology and experience

2. communication and diagnose media between the doctors and patients

3. base on the last two points to achieve medical globalisation
For what?

To make medicine fast and convenient
To achieve the higher medical level
To improve the medical treatment and therapy
To help more people in the wider area of the world
The world's first surgical robot was the "Arthrobot", which was developed and used for the first time in Vancouver, BC, Canada in 1983.

In related projects at that time, other medical robots were developed, including a robotic arm that performed eye surgery, and another that acted as an operating assistant, and handed the surgeon instruments in response to voice commands.
History

1985 a robot, the PUMA 560, was used to place a needle for a brain biopsy using CT guidance.

In 1988, the PROBOT, developed at Imperial College London, was used to perform prostatic surgery.

The ROBODOC from Integrated Surgical Systems was introduced in 1992 to mill out precise fittings in the femur for hip replacement.

Further development of robotic systems was carried out by Intuitive Surgical with the introduction of the da Vinci Surgical System and Computer Motion with the AESOP and the ZEUS robotic surgical system.

In September 2010, the Eindhoven University of Technology announced the development of the Sofie surgical system, the first surgical robot to employ force feedback.
Other facts

• In May 1998, Dr. Friedrich-Wilhelm Mohr using the *Da Vinci surgical robot* performed the first robotically assisted heart bypass at the Leipzig Heart Centre in Germany.

• In 2001, Prof. Marescaux, while in New York, used the "Zeus" robot to remotely perform *gall bladder surgery* on a patient who was in Strasbour, France.

• In September 2001, Dr. Michel Gagner, while in New York, used the Zeus robotic system to remotely perform a *cholecystectomy* on a woman who was in Strasbourg, France.

• In January 2009, Dr. Todd Tillmanns reported the results of the largest multi-institutional study on the use of the *da-Vinci robotic surgical system* in gynecologic oncology and included learning curves for current and new users as a method to assess their acquisition of skills using the device.

• In January 2009, the first all-robotic-assisted *kidney transplant* was performed at Saint Barnabas Medical Center in Livingston, New Jersey by Dr. Stuart Geffner. The same team performed eight more fully robotic-assisted *kidney transplants* over the next six months.[10]
The Surgeon's Third Hand

X-Raying: The C'Arm

Why?

- Costs an time in OR utilization become more important
- Human become weaken by monotonous work
C'Arm

Idea

• Long time ago
• Invasive tasks: active tools for manipulation systems

Definition

− Robotic assistance system to integrate new features such as enhanced positioning modes or guided imaging while keeping the familiar means of operation and improving workflow → a robot?
C'Arm

Advantages

- Not necessary to move patients
- C'Arm is mobile
C'Arm

Construction:

- One end is a transmitter other end the receiver
- „C“ because of shape
- C'Arm connected with the mobile carriage
- Patient on daybed between the „C“
- The „C“ horizontal movable
C'Arm: Use and more advantages

- Surgical intervention: flexibility
- For small OR
- For planning and orientation
- Takes many pictures of all perspectives
- Movable: patient can be orbited
C'Arm: the future

Camera augmented mobile C'Arm

- Digital camera for less radiation
- Pictures are shown on monitor
- Important: Software needed to guarantee the congruence of the pictures (x-rays and digital)
C'Arm: the future

Improvement and realization

- Second camera
- Position of tools is actionable
- Target: only one x-ray picture required
- Advantage: faster, saver less radiation for all
- Work on a study; simple upgrade
The InTouch Health flagship product is the RP-7, a mobile robotic platform that enables the physician to be remotely present. Through the integration of key technologies, the Remote Presence Robotic System can remove time and distance barriers and effectively extend the physician's reach to manage patient care. The Robot's panoramic Virtually There visualization system, combined with the Holonomic Drive System, the SenseArray System 360, and the easy-to-use control interface, affords physicians, patients and hospital staff a safe and effective interactive experience.

http://www.youtube.com/watch?v=cR4Bicgjk_g
Combination with Rescue Robots

USF professor Robin Murphy, with one of her many robots, is director of CRASAR, the Center for Robot Assisted Search and Rescue.

Not only for supplying water but also can carry medicine, give injection or function of telediagnosis, test heart rate, blood sugar, blood pressure and so on.

With such functions we can make a first aid robot in the future.
Robotic System for MR Image-guided Interventions

MRI
- Excellent soft-tissue contrast
- Functional information: sensing temperature changes, blood-flow measurements, 3D modality
- Biopsies and therapeutic interventions
Robitom

- Diagnosis and therapy of breast cancer
- Used in magnetic resonante tomograph
- Biopsy of localized possibly cancer with monitoring
- If positive, cancer destroyed per kryoblation, minimally invasive
Robitom

- Three steps in tomograph
- No psychological strain, no uncertainty
- Operation is spared
- First MR-compatible robot, tested 2004
Innomotion

- consists of imaging system, Innomotion robotic arm, 3-DoF valve delivery module and user interfaces
- can precisely and repeatably deliver aortic valve prostheses
- physician can remain in the loop and adjust the orientation and position using real-
Innomotion

- 3-DoF valve delivery module can deploy both balloon-expandable and self-expanding stented prostheses

- New compact fiducial can be placed close to volume of interest; requires single image plane for image based robot registration

- Preliminary results in ex-vivo experimentation suggest: robotic system can be translated into animal and clinical models
Robodoc

- surgical system
- pre-operative planner
- Orthodoc
- surgical tool RoboDoc
- developed by Integrated Surgical Systems in the 1980s
- currently used in hospitals in Europe
- first used in total hip replacements
- now extended to revision hip replacement and total knee replacement
Robodoc

Use
• robot is controlled via a hand-held terminal, manually guided to desired location
• cuts bone automatically
• surgeon can see inside the bone and monitor the robotic cutter’s position within the bone through “real time monitor”

Advantages
• Robot fits hips without cement („pressfit“)
• most implant is immediately loadable
• femoral pocket is more accurately formed
• pre-operative planning with CT-scan data allows optimize implant size and placement for each patient
Robodoc disadvantages

- registration process requires use of registration pins on bone surface; traumatic pin-placing procedure and slow pin-finding registration process are required
- complex and time-consuming method is used to fix femur to base of the robot
Robodoc

- system is still awaiting FDA approval in the US, but used in more than 35 hospitals in Europe
- takes three weeks to three months for doctors to feel comfortable with the system
- patients are positive
- The cases involving RoboDoc result in one-third less hospital staying time.
- costs USD 600,000 or 700 more than conventional surgery because of time
helping robots

- Robot takes the washing and bring it to desired place
- Other tasks: distribute food, dispose the garbage, clean the OR's and distribute medicine
- Nevertheless, one person is „on call“
- Less risk of infection (robots for clean and dirty tasks)

http://www.youtube.com/watch?v=p-37v345DyYtp
nursery

- Robot remind patient to take medicine and bring it to him
- If patient refuses, robot calls the staff

http://www.youtube.com/watch?v=PbtaFPpiF08
Nursery: Care-o-bot

- „riman“ can carry persons up to 70kg (green one)
- Still testing
- Now: care-o-robot brings drinks
- Should help seniors in the future
Rehabilitation robots - Locomat

**Targets:**

- increase range of motion
- increase strength („training“)
- combination of both
- Cobots („Cooperating Robots“)
- Less staff is needed, more patients can be treated
- No problem with own weight
Robot-assisted surgery was developed to overcome limitations of minimally invasive surgery. Instead of directly moving the instruments, the surgeon uses a computer console to manipulate the instruments attached to multiple robot arms. The computer translates the surgeon’s movements, which are then carried out on the patient by the robot.
RS Applications

General surgery
Cardiothoracic surgery
Cardiology and electrophysiology
Gastrointestinal surgery
Gynecology
Neurosurgery
Orthopedics
Pediatrics
Radiosurgery
Urology
ZEUS robotic surgical system

ZEUS is a minimally invasive robotic surgery system. ZEUS can be known as an RSS alternatively. ZEUS is known widely since it was used in a tele-surgery operation where the surgeon was in New York and the patient was in France on September 7, 2001.

The current average cost of a ZEUS robotic surgery system is approximately $975,000. It is only $25,000 less than the Intuitive Surgical Da Vinci system. In 2003 Computer Motion Inc. was acquired by Intuitive Surgical. The ZEUS system is now completely owned and maintained by Intuitive Surgical and is no longer sold.
The da Vinci Surgical System

Three components:
- a surgeon’s console
- a patient-side robotic cart with 4 arms manipulated by the surgeon
- and a high-definition 3D vision system.

And also:

Articulating surgical instruments are mounted on the robotic arms which are introduced into the body through cannulas.

http://www.youtube.com/watch?v=C17-bGquljl&feature=youtube_gdata_player
The da Vinci Surgical System

The first robotic surgery took place at The Ohio State University Medical Center in Columbus, Ohio under the direction of Dr. Robert E. Michler, Professor and Chief, Cardiothoracic Surgery.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Open Surgery</th>
<th>Laparoscopic</th>
<th>daVinci®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>100</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Average blood loss, millimeters</td>
<td>900</td>
<td>380</td>
<td>&lt;100</td>
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<tr>
<td>Cases with complications</td>
<td>15</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Average days with catheter afterwards</td>
<td>15</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Average days hospitalized</td>
<td>3.5</td>
<td>1.3</td>
<td>1.2</td>
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The da Vinci Surgical System

<table>
<thead>
<tr>
<th>Maintenance/year Physician Training</th>
<th>$1 million $100,000 $250,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of one inpatient hospital day</td>
<td>$2,000</td>
</tr>
<tr>
<td>Reduced inpatient hospital days for heart procedures</td>
<td>4.5 days</td>
</tr>
<tr>
<td>Cost saving per heart procedure due to reduced hospital stay</td>
<td>$9,000 per heart valve</td>
</tr>
<tr>
<td>Extra procedure cost</td>
<td>$2000 more per operation</td>
</tr>
<tr>
<td>Surgical assistance</td>
<td>$175,000 for fourth arm (Compared to $80,610 per year for extra OR nurse)</td>
</tr>
</tbody>
</table>

The da Vinci System was used in 48,000 procedures in 2006 and sells for about $1.2 million. The new da Vinci HD SI released in April, 2009 currently sells for $1.75 million.
Neuromaster

The surgical procedure:

1) Surgical planning: CT or MRI images

2) Registration: Four markers fixed with patient head

3) Insertion: move automatically to the location

http://www.youtube.com/watch?v=UtB1CVIyoQc
Telesurgery enables the surgeon to remotely operate on the patient under the help of medical telerobot. It frees the surgeon from the operating room, protects the surgeon from the radiation of X ray or radical medicine, and provides rescue for patient in remote rural area, ship at sea, battlefield, or spacecraft.
Teleneurosurgery

The remote stereo-tactic neurosurgery system is client/server based.

Two parts:
surgeon site and surgery site.
Advantages and disadvantages

major advantages: precision, miniaturization, smaller incisions, decreased blood loss, less pain, and quicker healing time

Further advantages: articulation beyond normal manipulation and three-dimensional magnification, resulting in improved ergonomics

Also: reduced duration of hospital stays, blood loss, transfusions, and use of pain medication

For short, the robotic system does not come cheap and has a learning curve.

1, The question is whether it is really worth a hospital’s while to purchase such a system and opinions differ dramatically

2, although the manufacturers of the systems provide training on this new technology, the learning phase is intensive and surgeons must operate on twelve to eighteen patients before they feel comfortable with the system. During the training phase, minimally invasive operations can take up to twice as long as traditional surgery, which ties up operating room and surgical staff time and keeps patients under anesthesia longer.
Conclusion

- Reduce costs, time and pain
- Improves precision and create new modalities → new possibilities

Think about...

- Acceptation (patient and doctors)
- Unemployment
- Socialisation
Thanks for listening!
Q/A

Now shoot!