THE DA VINCI SURGICAL SYSTEM AND HOW IT IS USED FOR CORONARY ARTERY BYPASS SURGERY

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Abstract

This paper will explore in detail the technological innovation that is the da Vinci Surgical System. The da Vinci Surgical System has multiple components including a surgeon-operated control console, patient side mounted manipulator consisting of four controllable arms to perform surgical tasks, and a cart with a monitor and central computer. Our paper will go into detail about the robot, its ability to perform coronary artery bypass surgery, and how it is utilized to perform tasks that are impossible by hand. In order to provide greater detail on the surgical operation of the robot, we will specifically describe and evaluate the da Vinci Surgical System and its effectiveness to perform coronary artery bypass surgery. We will also be evaluating how the da Vinci Surgical System operates in comparison with a human surgeon to show how the use of the robot has revolutionized coronary artery bypass surgery along with many other surgeries. Overall, our team will describe and evaluate the da Vinci Surgical System and its efficiency in performing coronary artery bypass surgery, how it provides unparalleled safety, shortens recovery time, and how it improves upon traditional surgery.

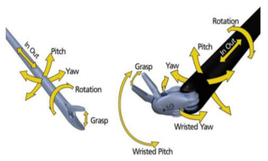
Mechanics and Ergonomics

Master Controller

- Located in the surgeon console, allows the surgeon to manipulate the four robotic arms
- Controlled by the surgeon's fingers, wrists, and arms
- Also controls EndoWrist tools, allowing additional movement with the arms

Arm Movement

- Arm movement can be scaled from the surgeon's inputs from precise to general movement
- Can switch out numerous tools at any point in time
- Each individual arm has seven axes of movement
- Arms can also support an endoscope



Ergonomics

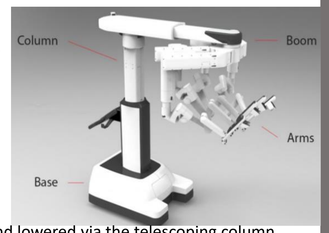
- Chair and console optimized for maximum comfort and control
- 3DHD Vision reduces eye and mental strain
- Large degree of customization to reduce fatigue and awkward positions
- Locks controls if surgeon leaves

Components

Surgeon Console

- Contains the Master Controllers which allow the operator to manipulate the arms
- 3DHD Vision allows the operator to view the target area with a 3D view
- Dedicated foot-pedals and touchpad controls to specifically control the endoscope mounted to the fourth arm
- Ergonomically positioned to provide the operator with the most comfortable position
- Allows controls to be locked if operator steps away from the console
- Contains emergency stop and power controls that allow the surgeon to have maximum control of the robot at all times
- A second console can be coupled with the first in order to perform more complicated surgeries that require use of all four arms at once
- Different modes can be selected to allow the surgeon's movements to become more precise

Patient Side Cart

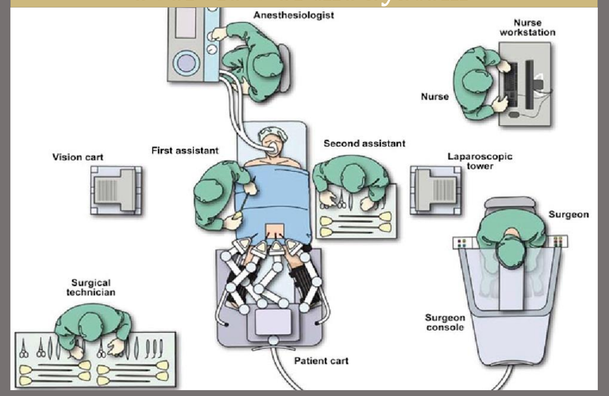


- A cart mounted at the side of the patient that contains a telescoping column, boom, and four controllable arms
- The initial position of the arms can be moved and locked in place by the setup joints and the boom to provide a stable base
- The whole boom can be raised and lowered via the telescoping column
- The four arms have a set of switchable tools that can be exchanged at any time during a surgery
- Tools can range from 8mm, to 5mm, to even a special tool called the EndoWrist that provides additional movement via the surgeon console
- The fourth arm can be mounted with an 8.5 mm 3D endoscope with fiber optic light that can be controlled via the foot pedals in the surgeon console
- The arms themselves have seven axes of movement and can move +/-90 degrees of articulation in the wrist

Vision Cart

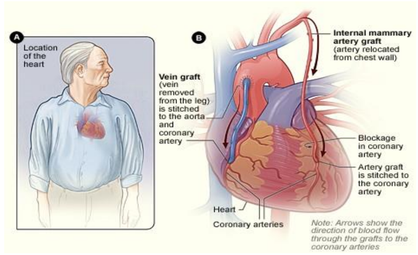
- The vision cart contains the main computer that translates the inputs from the surgeon console to the movement of the arms in the side cart
- The vision cart can also scale the movements down to be more precise or to tailor the operators needs
- The computer in the vision cart can correct slight accidental movements and larger unintentional actions that may harm the patient
- The vision cart also contains a 24-inch touch screen that relays the image from the 3D endoscope to allow surgeons and assistants to have the same view of the operator
- The screen also allows viewers to manipulate and zoom in and out on the image to give the most detailed view possible

Overview of the System



Coronary Artery Bypass

Coronary artery bypass graft surgery (CABG) is one method used to treat coronary artery disease, which is the clogging of the coronary arteries in the heart due to the build-up of plaque. The basic procedure of CABG is to bypass the clogged portion of the coronary artery with a piece of a healthy blood vessel elsewhere from your body. The image below helps visualize what the result of the surgery looks like.



Traditionally, surgeons perform this procedure through open heart surgery where they make a large incision in the chest and temporarily stop the heart. But, with the introduction of the da Vinci Surgical System, surgeons can use a method called minimally invasive direct coronary artery bypass surgery (MIDCAB). This procedure is first performed by making three-pencil sized incisions through the ribs in which the graft (i.e. the healthy blood vessel) is harvested and sutured to the heart vessel. The image below shows how MIDCAB is set up and how the incisions are made.

Benefits vs. Traditional Surgery

- **Faster Return to Normal Activities**
  - Healing time from receiving surgery from the da Vinci Surgical System is around three weeks while for open-heart surgery, healing time is several weeks.
- **Shorter Hospital Stay**
  - Time spent in hospital can be reduced by as much as 50 percent compared to conventional procedures.
- **Smaller Incisions**
  - Instead of a large incision down the center of the chest, the operation can be carried out through a few dime-size incisions using the da Vinci Surgical System.
- **Elimination of the Heart-Lung Bypass Machine (in most cases)**
  - In conventional open-heart surgery, a heart-lung bypass machine is used to temporarily stop the heart. But, this could lead to the patient developing neurological complications. However, the da Vinci Surgical System can be used to operate on a beating heart, removing the risk of the patient developing neurological problems.
- **Increased Agility and Precision of the Robotic Arms**
  - Allows the surgeon a greater range of motion than is possible with hand-manipulated moves in standard procedures.
- **Tiny Camera Attached to One of the Arms of the Robot**
  - Gives the surgeon a very detailed, three-dimensional view of the operating space in the chest.

Issues

- **Instrument Failure**
  - The main cause of these injuries and deaths are due to instrument failure or parts becoming detached inside the patient (25.1%) and electrical arcing (10.5%). This is caused primarily by hasty removal of the arms when the surgery is over and due to inexperience with the system.
- **Death Rate**
  - From 2000 to 2013, due to the complications of the da Vinci Surgical System, the death rate from receiving surgery from this robot was at 1.4%, and this was higher than the death rate of traditional surgery (which was 0.93%). However, due to the smaller sample size, it is unclear to say if the death rate due to the da Vinci Surgical System was significantly higher.
- **Unsustainable High cost**
  - The high additional costs of the da Vinci Surgical System prevent it from being implemented in many hospitals and from being a universal alternative to traditional surgery. This is because Intuitive sets the market standards for the robot, many instruments cannot be reused, the high initial and maintenance costs of the robot, and the high costs to pay OR personal.
- **Low Accessibility**
  - It has been found that Americans living in urban areas receive surgery from the da Vinci Surgical System more than those in who live in rural areas. Also, people living in the highest income zip codes and with private insurance are 28% more likely to be treated by the da Vinci Surgical System. The high cost of the surgery makes this robot unsustainable and limits its use to only wealthy individuals.