

# Complications of Robotic Heart Surgery Compared with Traditional Open-Heart Surgery

Ch.Lochana<sup>1</sup>, A. Sravani<sup>2</sup>, D. Lavanya<sup>3</sup>, M. Sharmila<sup>4</sup>, M.Gayatri<sup>5</sup>

<sup>1</sup>Assistant Professor, Department of Pharmacology, Vijaya Institute of Pharmaceutical Sciences for Women, Vijayawada

<sup>2</sup>Pharm. D 4<sup>th</sup> Yr Student, Srinivasarao College of Pharmacy, Visakhapatnam

<sup>3</sup>Pharm. D 4<sup>th</sup> Yr Student, Srinivasarao College of Pharmacy, Visakhapatnam

<sup>4</sup>Pharm.D 4<sup>th</sup> Yr Student, Srinivasarao College of Pharmacy, Visakhapatnam

<sup>5</sup>Pharm. D, 4<sup>th</sup> Yr Student, Srinivasarao College of Pharmacy, Visakhapatnam

**Abstract:** *Complications of robotic heart surgery compared with traditional open heart surgery robotic heart surgery is a small invasive and fast recovery procedure while open heart surgery is large invasive and recovery time is more. Robotic heart surgery should be done in low time while open heart surgery takes place in nearly 3 hours. Heart is a fist -sized organ used for pumping of blood throughout the body. Nowadays heart problems are one of the causes of death globally. They can be overcome by intake of healthy diet and maintain good life styles such as regular exercise, controlling stress, avoiding alcohol and tobacco use. Many medications and surgical procedures are developed to treat heart problems such as arrhythmias, myocardial infarctions, angina, and atherosclerosis, left ventricular/articular disorders. Robotic /open heart surgery is one of the processes to treat valve diseases. In the following matter we discuss the differences between open heart and robotic heart surgeries and their complications.*

**Keywords:** Robotic heart surgery, traditional heart surgery, intramuscular damage, scar tissue, fist -sized organ, ST elevation, atherosclerosis, coronary artery disease

## 1. Introduction

Heart: The heart is shaped like an upside -down pear/a fist-sized organ. Heart is located between lungs in the middle of the chest, behind and slightly to the left of your breast bone (sternum). According to Gray's anatomy, the heart length, width and thickness are said to be 12cm, 8.5cm and 6cm respectively and the weight of the heart is 280-340 gms in males and 230-280gm in females. Heart is a muscular organ that pumps blood through the body with an intricate system of muscle layers, chambers, walls and nodes. It has 2 atria and 2 ventricles together four chambers. Deoxygenated blood returns to the right side of the heart through the venous circulation. It is pumped into the right ventricle and then into the lungs, where carbon dioxide is released and oxygen is absorbed. The oxygenated blood then travels back to the left side of the heart into the left atrium and then into the left ventricle from where it is pumped into the aorta and arterial circulation. The pressure in the arteries caused by the contraction of left ventricle is the systolic blood pressure. When the left ventricle has fully contracted, it begins to relax and refill with blood from the left atrium. The pressure in the arteries decreases as the ventricle fills up. This is the diastolic blood pressure. Pumps oxygenated blood to other body parts. Also pumps vital substances and hormones to different parts of the body. Receives deoxygenated blood and transports metabolic waste products from the body and pumps them to the lungs for oxygenation. Maintains the blood pressure.

There are many types of heart diseases and each one has its own symptoms and treatment. For some, lifestyle changes and medications can have a huge impact on improving your health. For others, you may need surgery to get the

typewriter working again. Lets learn about some most common types of heart disease and how to treat and prevent the heart diseases.

### Coronary Artery Disease (CAD)

CAD is the most common heart problem. CAD causes blockages in the coronary arteries which are the blood vessels that supply blood to your heart. This can lead to a decrease in blood flow to the heart muscle, which does not allow it to receive required oxygen. The disease occurs as a result of atherosclerosis (a condition of hardening of the arteries). Heart disease can cause chest pain, called angina or lead to a heart attack. Some things that can increase your risk of coronary heart disease include: age (For men, the risk of heart disease increases after age 55; for women, the risk rises sharply after menopause), being inactive, diabetes or metabolic syndrome, family history of coronary heart disease, genetics, high blood pressure, high levels of LDL ("bad" cholesterol) or low levels of HDL ("good" cholesterol), obesity, smoking, stress.

### Heart Arrhythmias

If you have an arrhythmia, your heart rate irregular or with irregular beating pattern. Serious arrhythmias are often caused by other heart problem, but can also occur on their own.

### Heart Failure

In heart failure, the heart doesn't pump blood well enough to meet your body's needs. It is mainly caused by coronary artery disease, thyroid disease, high blood pressure, heart muscle disease (cardiomyopathy), or certain other conditions.

**Heart Valve Disease**

The heart has valves which open and close to direct blood flow between the heart's four chambers, the lungs, and the blood vessels. An abnormality makes it harder for a valve to open and close, when this happens, the blood may internally leak or the blood flows gets blocked. The valve of your heart may not open and close accurately. The causes of heart valve problems include high blood pressure, infections like rheumatic fever, congenital heart disease, coronary artery disease, even heart attacks.

Diseases of the heart valves include:

- Endocarditis. It is an infection which is usually caused by bacteria, which may enter the blood and reach your heart during illness, after surgery, or after using intravenous drugs. It often happens if you already have valve problems. Antibiotics can cure endocarditis as the disease is life-threatening without any treatment. If the heart valves are seriously damaged as a result of endocarditis, a valve replacement surgery is necessary.
- Rheumatic heart disease. This condition develops when the muscle of your heart and valves are damaged due to rheumatic fever, which causes strep throat and scarlet fever. Rheumatic heart disease was more common earlier in the 20th century, but the physicians can now prevent it by using antibiotics to treat the diseases. The symptoms might show up many years after the infection.

**Pericardial Disease**

Any disease of the pericardium, the sac that surrounds your heart is called a pericardial disease. One of the common diseases is pericarditis or inflammation of the pericardium.

It is mainly caused by an infection from virus, rheumatoid arthritis, or inflammatory diseases such as lupus or injury to your pericardium. Pericarditis often follows open heart surgery.

**Cardiomyopathy (Heart Muscle Disease)**

Cardiomyopathy is the disease to the myocardium of the heart or the heart muscle. It gets stretched, thickened, or stiff and the heart becomes weaker and doesn't pump well.

The causes of the disease, including genetic heart conditions, reactions against certain drugs or toxins (such as alcohol), and infections caused by a virus. Sometimes, chemotherapy causes cardiomyopathy. Sometimes the physician themselves can't find the exact cause.

**Congenital Heart Disease**

Congenital heart disease occurs when something goes wrong while the heart is still in the womb. Heart diseases sometimes causes problems right after birth, but sometimes there are no symptoms until adulthood.

Abnormalities to the septum are most common amongst the congenital heart problems. These are the holes in the wall that separate the left and right sides of your heart. A procedure involving patches to the holes in the walls can prevent the disease.

Another type of abnormality is called pulmonary stenosis. The narrowing of valve which causes decreased blood flow

to the lungs. A surgical procedure can be performed to open or replace the valve.

In some babies, a small blood vessel called the ductus arteriosus does not close properly at birth. When this happens, some blood leaks back into the pulmonary artery, putting strain on your heart. Doctors can treat it with surgery or a procedure, or sometimes with medication.

**Heart blocks:**

In most cases of heart block, the signals slow down but do not stop completely. Heart block is divided into first, second or third-degree:

- a) First-degree heart block is the least severe. As the electrical signals travel from atria to ventricles, they slow down. First-degree heart block doesn't require any kind of treatment.
- b) Second-degree heart block means, the electrical signals between the atria and ventricles intermittently fail to conduct. The second-degree heart block are of two types
  - Mobitz type I: The electrical signals get slower between beats. Eventually your heart skips a beat.
  - Mobitz type II: The electrical signals may or may not reach ventricles. There is no progressive reduction in flow of electrical signal. Third-degree heart blocks can often occur in this type.
- c) Third-degree heart block is the most severe. In this type the electrical signals don't travel from atria to ventricles. Electric conduction completely fails, this can cause fluctuations in pulse if back up heart rate is present.

**Causes of heart blocks:** Coronary artery disease, with or without a heart attack, is one of the most common causes of heart block. Wire damage can be caused due to weakened heart muscles due to cardiomyopathies. Diseases such as sarcoidosis which infiltrate the heart and few cancers or any disease causing heart inflammation such as autoimmune disease or infections can result in heart block. Wire failure can also result from high potassium levels. If you are born with congenital heart block or have a heart block. This condition is caused either by an illness during a mother's pregnancy or by congenital heart problems. Most people develop heart block as they age because the wires connecting the top and bottom of the heart can develop fibrosis and eventually fail. Sometimes this can happen with age. Any process that can damage these heart wires can lead to heart block. You have an overactive vagus nerve (causes the heart to slow down). You take medications that slow the conduction of the heart's electrical impulses including some heart medications (beta blockers, digoxin, CCBs), antihypertensive drugs, dysrhythmics; muscle relaxants, antidepressants, antipsychotics, sedatives, diuretics and lithium, etc. Ask the physician to review your previously used medications.

Treatment for heart block: Treatment depends on the type of heart block you have:

- Treatment is not needed for first-degree heart block.
- A pacemaker is needed if symptoms are present or if Mobitz II heart block is seen in second-degree heart block.

- A pacemaker is most likely needed in third-degree heart block.

In addition, your medical team may make changes in any medicines you're taking. Doctors sometimes administer atropine, an anticholinergic drug, intravenously to people who experience heart block. Atropine acts on the heart's atrioventricular (AV) node which carries electrical impulses from the atria, down the ventricles. This medication is not always as effective in treating third-degree heart block as it is in treating first or second – degree heart block. But in some cases, it can help to get back normal electrical patterns. The bacterial infection that causes Lyme disease can also trigger third-degree heart block, though this is an uncommon complication. A 2021 report notes that injections of the antibiotic ceftriaxone helped fight the infection and began to restore healthy heart function. It was followed by the use of the oral antibiotic doxycycline, which results in complete reversal of third-degree heart block and eliminated the need for a pacemaker.

- **Angioplasty or balloon angioplasty.** To start the treatment, the physician will pass a balloon through a tube that is threaded into your coronary arteries. The balloon is then inflated in the areas of blocked arteries. This procedure is usually done with a stent that opens the arteries further. This non-surgical heart block treatment can last thirty minutes to several hours. Sometimes this is done in an emergency, such as during a heart attack.
- **Stent Placement.** A procedure in which the medical team takes a wire mesh tube and places permanently in the artery. This is done in conjunction with angioplasty. Coronary artery blockages and deposits can also occur after stent placement. These are called "restenosis." Stents hold the artery open, direct blood flow to the heart muscle, and reduce the chest pain.

% of blockage for heart surgery: when 50% or more blockage in their left main vessel or 70% or more blockage in branch coronary arteries.

Because of the severity and complexity of the blockages, angioplasty, a less invasive procedure, was either unsuccessful or not recommended by a provider.

**Diagnosis:** Diagnosis of heart disease is based on many different tests including blood tests, chest x-rays, ECG or EKG, Holter monitoring, Echocardiogram, cardiac catheterization, heart CT scan and MRI- scan. Main diagnosis is done by ECG. ECG is also called ELECTROCARDIOGRAM. Is often done to diagnose the function of the heart. It is a painless non-invasive way to help diagnosis. It diagnoses irregular heart rhythms (Arrhythmias), coronary artery diseases such as blocked or narrowed arteries in the heart. ECG is suggested when you experience chest pain, dizziness, lightheadedness, confusion, heart palpitations, rapid pulse, shortness of breath, weakness, fatigue, or delay in ability to exercise. An acute blockage can be revealed by typical changes to ST wave. P wave shows contraction of the heart's atria, which refers to the two upper chambers. The QRS complex shows electrical activity running through the heart to the ventricles, which are the two lower chambers. T wave shows the electrical reset of the heart in preparation for its next cardiac cycle. ST

segment shows the end of contraction of the heart's ventricles and the beginning of repolarization.

- ST segment depression
- ST segment elevation- myocarditis, pericarditis, stress cardiomyopathy, acute vasospasms, benign early repolarization, left bundle branch block and electrolyte abnormalities. (>0.1mV in the precordial leads).
- Flattening of the T waves- when the wave varies from -1.0 mm to +1.0mm in height indicates underlying cardiac diseases, low K<sup>+</sup>, LV dysfunction, CAD, also caused by digitalis therapy.
- Inverted T waves- it is associated with myocardial ischemia, as well as cardiovascular and total mortality. Right ventricular overload causes T-wave inversion indicates acute or chronic pulmonary embolism.
- Q waves- Abnormal Q-waves in ECG commonly describe underlying myocardial infarction. (Abnormal wide > 0.2 sec. or abnormal deep >5 mm). which indicates the initial phase of ventricular depolarisation abnormalities.

- Epidemiology:** Globally heart diseases are the leading cause of death. In 2019 an estimate of 17.9 million people died from cardiac diseases representing 32% of global deaths.
- Etiology:** The cardiovascular diseases can vary depending on the specific type. For example, atherosclerosis, peripheral artery diseases. Scarring of heart muscles genetic problems, medications can cause arrhythmias, aging, infections and rheumatic diseases can cause valve diseases.
- Signs & symptoms:** Chest pain (angina), heaviness, discomfort, shortness of breath, dizziness, fatigue, leg sores, swelling of legs, numbness in face or limbs, weakness.
- Risk factors:** High blood pressure, hyperlipidemia (high cholesterol), tobacco use, type -2 DM family history of heart diseases, obesity, high intake of sugar and fats, over use of alcohol, kidney disease, chronic inflammation and autoimmune conditions, age, lifestyle.
- Treatment:** Treatment of cardiac disorders include medications, surgery, pacemakers, ablation, stents. Drugs: statins (HMG-CoA reductase inhibitors) Angiotensin converting enzyme (ACE) inhibitors and angiotensin ii receptors blockers (ARBs). Calcium channel blockers Beta blockers Nitrates Anti platelets Anti coagulants Surgery: A procedure to remove or repair a part of the body and tissues
- Open- heart surgery:** Open-heart surgery is a general term for surgical procedures performed to treat heart problems by directly accessing the heart through an opening the chest. During open-heart surgery, the surgeon performs sternotomy and spreads the ribs to access the heart.

Add the procedure for open heart surgery

#### **Preoperative Preparation:**

**Patient Evaluation:** The patient undergoes a thorough evaluation, including medical history, physical examination, and diagnostic tests like echocardiography, angiography, and blood tests to assess the heart condition.

Anesthesia: Before surgery, the patient is administered general anesthesia to ensure they are unconscious and do not feel pain during the procedure.

- **Surgical Steps: Incision:** The surgeon makes an incision in the chest. The type and location of the incision may vary depending on the specific procedure being performed.
- **Sternotomy:** In most cases, the surgeon will cut through the breastbone (sternum) to access the heart. This is called a sternotomy.
- **Cardiopulmonary Bypass:** The patient's blood is rerouted through a heart-lung machine (cardiopulmonary bypass machine) to take over the heart's pumping function. This allows the surgeon to work on a still, bloodless heart.
- **Cardiac Arrest:** The surgeon induces cardiac arrest by infusing a cold solution into the coronary arteries, stopping the heart temporarily. This provides a motionless field for the surgery.
- **Repair or Replacement:** The surgeon performs the necessary repairs or replacements depending on the patient's condition. Common procedures include coronary artery bypass grafting (CABG), valve repair or replacement, and repairing congenital heart defects.
- **Weaning from Bypass:** After the repairs are complete, the heart is gradually rewarmed, and the patient's own heart is restarted. The cardiopulmonary bypass machine is slowly discontinued.
- **Monitoring:** The patient is closely monitored during and after the procedure for vital signs, oxygen levels, and heart function.
- **Closing the Chest: Chest Closure:** Once the surgeon is satisfied with the heart's function and the repairs made, they close the chest using sutures or wires to secure the sternum.
- **Closing Incisions:** The skin incision is closed using stitches or staples. Sometimes, a temporary drainage tube may be placed to remove excess fluids.

#### Postoperative Care:

- **Recovery:** The patient is transferred to a recovery area and then to an intensive care unit (ICU) for close monitoring. Ventilation must be continued for a period of time.
- **Medication:** Medications are administered to manage pain, prevent infection, and regulate blood pressure and heart rate.
- **Rehabilitation:** Physical therapy and cardiac rehabilitation programs may be recommended to aid in the patient's recovery.
- **Hospital Stay:** The length of the hospital stay varies but is usually several days to a week or longer, depending on the complexity of the surgery and the patient's recovery.
- **Follow-up:** After discharge, the patient will have regular follow-up appointments with their cardiac surgeon and cardiologist to monitor their progress and adjust medications if necessary.
- It's important to note that open heart surgery is a highly specialized procedure, and the specific steps and techniques used can vary depending on the patient's condition and the surgeon's preferences. Patients should discuss their surgery in detail with their medical team to understand the risks, benefits, and expected outcomes.

The success rate for open heart surgery :The success rate for open heart surgery varies depending on the specific procedure and patient factors but is generally high, with many procedures achieving success rates of 90% or higher.

#### Benefits

The benefits of beating heart surgery include:

- A lower risk of stroke
- Few memory loss and thinking skills problems.
- Lower death rate – especially among women and "high risk" patients
- Less need for transfusion
- Reduced injury to the heart
- Shorter hospital stay
- Fewer heart rhythm problems

#### Risks

In the United States Coronary artery bypass surgery is one of the most common surgical procedures. The risk of death is usually low, but like any other surgery there are risks involved. Off-pump cardiac bypass surgery carries no more risks than traditional bypass surgery. These risks can include but are not limited to: Bleeding, Infection, Stroke, Kidney failure, Lung complications, Death (Rare cases based on severity and also on the patient).

#### Safety Measurements

That should be taken during & after open heart surgeries:

- The procedure should be done under specialized heart surgeons.
- Avoid exercises and lifting heavy weights, that strains your chest muscles and causes pain.
- Avoid driving during the initial 6 weeks (about 1 and a half months) after the operation, as twisting movements are the operation, as twisting movements are needed to turn the steering wheel.
- One should follow the discharge medication and diet changes like limiting high- saturated fats, salt, and sodium and others which are suggested by the surgeon .
- Instead of long showers the wound should be gently washed with mild soap and Lukewarm water.
- Avoid using oils, creams, and perfumes on the body in the chest region.
- The procedure should be done in sterile condition and the instruments used should be sterile.
- Sex enhancing medications should not be used and restrict sex activity during the initial recovery phase.
- Patients who are using anti coagulation drugs like warfarin and acitrom should avoid food containing lots of vitamin k such as liver, broccoli, Brussel sprouts, mustard green, parsley.
- Regular prothrombin check-ups needed as suggested by the doctor.
- One should consult a doctor if one is experiencing pain, swelling, redness, itching and discharge from incision site, fever, headache, dizziness, blood in urine or stools, difficulty in breathing, any changes in pulse rate less than 60 pr more than 100.
- Avoid sports after discharge if the doctor doesn't allow.



### Robotic Heart Surgery

Robotic cardiac surgery is heart surgery performed through small incisions in the chest. By using robot-controlled tools and tiny instruments, surgeons do heart surgery in less invasive way than open-heart surgery. The procedure is also known as da Vinci surgery because that is the name of the manufacturer of the robot which is used for this procedure. The specialized technology enables enhanced magnification and precise movements. The technology consists of:

- Surgical arms having tiny instruments with wrists at the tip.
- A specialized camera which provides enhanced magnified 3D views of the surgical area.
- Surgical console where the surgeon controls the instrument and camera's every move. Robotic surgeries are useful in different heart-related procedures, like valve surgery, coronary artery bypass, cardiac tissue ablation, heart defect repair, and tumor removal, etc.

Add the success rate for robotic heart surgery

### Procedure

- First, your surgeon makes one or more small incisions.
- Thin tubes (ports) are placed through these incisions by the surgeon. The instruments needed and the robot is attached to these ports and placed through them.
- One of the ports is used to insert an endoscope (a long thin camera). The camera provides 3D high-definition images during the surgery.
- The other ports are used to insert surgical instruments, enabling the physician to perform the procedure
- Your surgeon controls the robotic arm while sitting at a console a few feet away from you. An assistant is required aside to help the surgeon by changing the instruments.

### Advantages

- The main advantages of this procedure is, it enables surgery through smaller incisions. Other advantages of robotic surgery include:
- Greater precision: The robotic arms are more accurate than a human hand. The arms have ability to rotate instruments in tight spaces in ways.
- Better visualization: High definition, magnified views of surgical area is provided by a camera additionally it can image in 3D.
- Ability to do surgery inside the body: Traditionally, surgeons would have needed to make larger incision to complete that portion of the process outside of your body, but now by using smaller instruments, surgeons get to perform steps of the operation inside your body.

### Disadvantages

- It is only available in centers that can afford the technology and have specially trained surgeons.
- If any complications occur the surgeon may need to convert to an open procedure with larger incisions, which causes scar tissue from previous surgeries that make it difficult for robotic technology to complete the procedure.
- Risk of nerve damage and compression.
- Robotic malfunction, which is extremely rare.

Comparative Complications: Robotic heart surgeries are not applicable to patients with earlier surgeries on their chest or where multiple valve/vessel surgery is needed. This is due to scar tissue from past surgery which causes difficulty in completing procedures using robotic technology and this may also cause intermuscular damage. This robotic heart surgery may result in nerve damage and compression due to malfunction of robotic arms, binocular lens, controller, camera, other instruments etc. Patients with severe illness or trauma cannot be advised with robotic surgery. In conventional surgeries risk is caused by human errors but in robotic assisted surgeries along with human errors mechanical failure and malfunction is included. If there is any complication during the surgery, surgeons need to convert to an open surgery with large incisions which increases the procedure time resulting in comorbidities. Optical system problems, software issues or console defects cause complications. Robotic assisted surgeries require machinery and technical requirements for the procedure of robotic surgery. specialized skilled, trained surgeons only can conduct the procedure. In some cases, robotic heart surgeries result in internal hemorrhage, unwanted punctures of vessels, loss of large amounts of blood, possible inadvertent cuts, tears, burns or other injuries to organs, tissues, major blood vessels or nerves. Humans might face economic problems if the use of robots gets increased. Robots can only do what they are told or programmed to do they cannot improvise. Whatever the procedure, robotic or conventional safety procedures should be taken. Some other complications included are bleeding, infection, stroke, arrhythmias, or irregular heartbeat. Robotic heart surgery requires centers that can afford the technology and specially trained surgeons. Robotic heart surgery is expensive when compared with other conventional heart surgeries. Robotic heart surgery is costly when compared with other conventional heart surgeries. Another great issue with robotic surgery lies around movement latency. This refers to the time taken to carry out the Surgeon's commands. Normally a computer needs a few moments to communicate with robotic arms. This issue is not seen in routine surgery but seen in surgeries where quick response is needed. The skills and training to adopt such systems might be too long and to perform the procedure the surgeon must need experience and skills to avoid severe complications Safety procedures that should be taken during Robotic heart surgeries:

- The procedure must only be done by skilled trained surgeons. Before doing robotic assisted surgeries, surgeons should check the patient's condition and his /her comorbidities completely and check eligibility of the patient to undergo robotic heart surgery.
- Not prescribing robotic heart surgery to patients who already underwent surgeries on chest or in thoracic region is one of the safety precautions of robotic heart surgeries.
- Do not soak the incision in water until your doctor says ok to it.
- Should take a good balanced diet.
- Many of the complications are associated with patient condition and technical issues. Knowing the complete condition of the patient before surgery is the best step to control some of the complications of robotic heart surgeries.

- Another step is to maintain superior quality of equipment, technology, surgeons, and staff to avoid malfunction and potential mechanical and technical errors. Developing better technology to perform the procedure.

## 2. Conclusion

Robotic surgery is considered minimally invasive surgery because it allows doctors to make small incisions, when compared to traditional open-heart surgery. Recovery time is greatly reduced in robotic heart surgery, but traditional open-heart surgery is widely used in treating cardiac disorders when compared to robotic heart surgery because Robotic heart surgery is only application when it is the first surgery in chest region and where there highly specialized instruments and surgeons and it is expensive when compared to traditional heart surgeries due to the above reasons traditional heart surgery is prefers more than robotic heart surgery. Worldwide, an estimated 44 out of 100,000 have a bypass surgery. In the United States, 79 out of 100,000 people have this surgery. With reference to success rate and acceptability of patients and also robotic surgery is not most common in india . it is common in other countries like U.S.A and U.K Where technology is much developed. What ever the surgery type after open heart and robotic surgeries patients needs counselling about lifestyle modifications and food habits. The patient must be careful and always taken care by some one.

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