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Replacement of Heart Bypass Surgery Using Nanorobots: A Review

[1]S. Lukeman Hakkim, [2]A. Ranjitha

Department of Electronics and Instrumentation, Sri Ramakrishna Engineering College, Coimbatore, India

***Abstract*: When we enter the enchanting world of electronics we have pleasant routes. The path we have chosen is the union of robotics & medicine. The integration of nanotechnology into medicine is likely to bring some new challenges in medical treatment. Let us peep inside the real world of NANO TECHNOLOGY. Nanorobot is a wonderful vision of medicine in the future. The most advanced nanomedicine involves the use of nanorobots as miniature surgeons. Advancement in nanotechnology may allow us to build artificial red blood cells called Respirocytes capable of carrying oxygen and carbon dioxide molecules (i.e., functions of natural blood cells). Respirocytes are nanorobots, tiny mechanical devices designed to operate on the molecular level. Respirocytes can provide a temporary replacement for natural blood cells in the case of an emergency. Thus respirocytes will literally change the treatment of heart disease.**

***Keywords:* Asphyxia, Erythrocytes, Haemoglobin, Plaque, Respirocytes, Ventilators.**

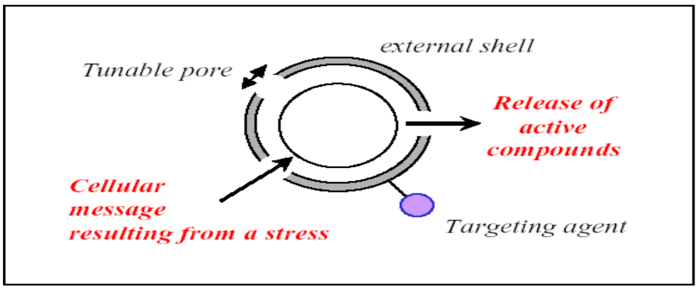
I. INTRODUCTION

Robot, computer-controlled machine that is programmed to move, manipulates objects, and accomplishes work while interacting with its environment. Robots are able to perform repetitive tasks more quickly, cheaply, and accurately than humans. The term robot originates from the Czech word robot, meaning “compulsory labour.” It was first used in the 1921 play R.U.R. (Rossum's Universal Robots) by the Czech novelist and playwright Karel Capek. The word robot has been used since to refer to a machine that performs work to assist people or work that humans find difficult or undesirable.

A nanorobot can be defined as an artificially fabricated object able to freely diffuse in the human body and interact with specific cell at the molecular level. The figure shows a schematic representation of a nanorobot that can be activated by the cell itself when it is needed. Nanorobots will be able to analyze each cell types surface antigens to recognize if the cell is healthy, what the parent organ is, as well as almost all information about the cell, and using chemo tactic sensors, certain molecules and cells could be identified and easily targeted for action.

II. THE ERA OF NANOROBOTS

Stress induced by disease or infectious attack generally leads to changes in the chemical content of the cell which in turn trigger the nanorobots.



Nanobots

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Nanorobots can be coated with different agent depending on their application or tissue destination. The external shell is a crucial point because it has to be recognized as a part of the body (inert coating) and be able to release different size molecules (tunable porosity). A rigid shell like silica is an ideal matrix that it is not toxic at the nanometer level. The pore size can be tuned permitting release of different size molecules. The surface is easily functionalizable with simple chemical methods but most important is that the silica is not biodegradable permitting a long-term activity in the body.

A 1 cm^3 injection of nanorobots would be able to deliver selectively into cells at least 0.5 cm^3 of chemical agent, and the sensors could test levels of the chemical to guard against an accidental overdose. Self-Assembly and Nano manipulation are two main ways for the production of nanorobots.

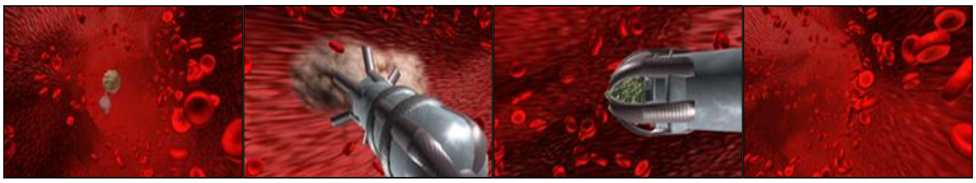
2.1 EXPLORING THE INCREDIBLY SMALL MEDICAL NANOROBOTS:

The artificial respirocytes is a hollow, spherical nanomedical device 1 micron in diameter. This would serve as a super efficient red blood cell, by providing oxygen or carbon dioxide molecules. It will act like mini scuba tanks within the blood allowing a person to hold their breath for more than an hour. It would be a moving thin celled tank with a brain and sensors.

Medical Nanobots

In an emergency situation they can be injected directly into the bloodstream of the endangered individual. They do not move by their own power, but are carried along in the bloodstream like natural erythrocytes. Once the respirocytes have dispersed they begin releasing oxygen and collecting carbon dioxide. . If an individual has lost access to a natural oxygen supply due to drowning, choking, or any other form of asphyxia, respirocytes can release oxygen throughout the bloodstream until the danger has been removed.

Respirocytes make it possible to breathe in oxygen-poor environments, or in situations where normal breathing is physically impossible. Prompt injection with a therapeutic dose, or advance infusion with an augmentation dose, could greatly reduce the number of choking deaths and reduce the use of emergency tracheostomies, artificial respiration in first aid, and mechanical ventilators. The device would provide an excellent prophylactic treatment for most forms of asphyxia, especially those involving drowning. Respirocytes could be employed as a long-duration perfusant to preserve living tissue, especially at low temperature, for grafts (kidney, marrow, liver and skin) and for organ transplantation. It could also serve as a universal blood substitute.



Nanobots working in Blood Stream

Respirocytes will literally change the treatment of heart disease. Therapeutic doses injected into a person at risk for heart disease would give that person enough time after a heart attack to call their doctor, report their heart has stopped and get

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to the emergency room where they will likely be okay, as long as they are helped within an hour. It could permit the achievement of major new sports records.

2.2 NANOROBOTS IN THE BLOODSTREAM:

Respirocytes have the ability to swim through the blood, or crawl through body tissue. They would have different types of robotic manipulators, shapes, colours, and surface textures, sensor arrays. Each medical nanodevice could be designed to do a particular job, and would have a unique shape and behaviour. This image shows reciprocytes and red blood cells flowing through a blood vessel.

There are many useful power sources for the nanodevices readily available in the human body and many different ways to communicate with the machines as they do their work. Each nanorobot would have its own computer and sensor to receive the physician's messages and compute and implement the appropriate response. And a navigational network could be installed in the patient's body, with station keeping navigational elements providing high positional accuracy to all passing nanorobots that interrogate them. It could be programmed to seek the areas that need oxygen and arrive very rapidly.

Once there, it could administer much larger quantities than a single red blood cell could. The reason for this is that it would be pressurized. The average male human body has 28.5 trillion red blood cells, each containing 270 million haemoglobin molecules binding four O2 molecules per haemoglobin By contrast, each respirocytes stores up to 1.51 billion oxygen molecules, 100% of which are accessible to the tissues. To fully duplicate human blood active capacity, we have to deploy 5.36-trillion devices. If respirocytes are administered via hypodermal injection or transfusion in a 50% aqueous colloidal suspension, this requires a standard ~5.61 cm^3 therapeutic dose of activated suspension, taking only seconds to inject at, say, an accident scene. But one of the potential benefits of nanomedical devices is their ability to extend natural human capabilities.

III. STEPS INVOLVED IN CABG SURGERY

This paper proposes the use of nanorobot based on the nanotechnology that will be used for replacing the existing coronary artery bypass grafting (CABG) surgery that involves so many risks to the patient. However, no matter how highly trained the specialists may be, surgery can still be dangerous. So nanorobot is not only the safe but also fast and better technique to remove the plaque deposited on the internal walls of arteries. The heart bypass surgery reroutes the blood supply around clogged arteries to improve blood flow and oxygen to the heart. The arteries that bring blood to the heart muscle (coronary arteries) become clogged by plaque (a buildup of fat, cholesterol and other substances). This can slow or stop blood flow through the heart's blood vessels, leading to chest pain or a heart attack. Increasing blood flow to the heart muscle can relieve chest pain and reduce the risk of heart attack. So the surgeons go for this surgery by taking a segment of a healthy blood vessel from another part of the body usually from leg and make a detour around the blocked part of the coronary artery. The surgery involves an incision in the middle of the chest and separation of the breastbone and after detouring, the breastbone is joined using wire and the incision is sewed.

The entire surgery can take 4-6 hours. After the surgery, the patient is taken to the Intensive Care Unit. For a few days after the surgery, the patient is connected to monitors and tubes.

After release from the hospital, the patient may experience side effects such as:

- Loss of appetite, constipation.
- Swelling in the area from which the segment of blood vessel was removed
- Fatigue, mood swings, feelings of depression, difficulty sleeping
- Muscle pain or tightness in the shoulders and upper back.

The incision in the chest or the graft site (if the graft was from the leg or arm) can be itchy, sore, numb, or bruised. The surgery may also lead to loss of memory and mental clarity. To overcome all these problems that are involved in the bypass surgery, we are going for nanorobot, which can replace this techniques efficiently and effectively. These nanorobots will remove the clot without any surgical procedure. Just a small incision is made into the femoral artery to

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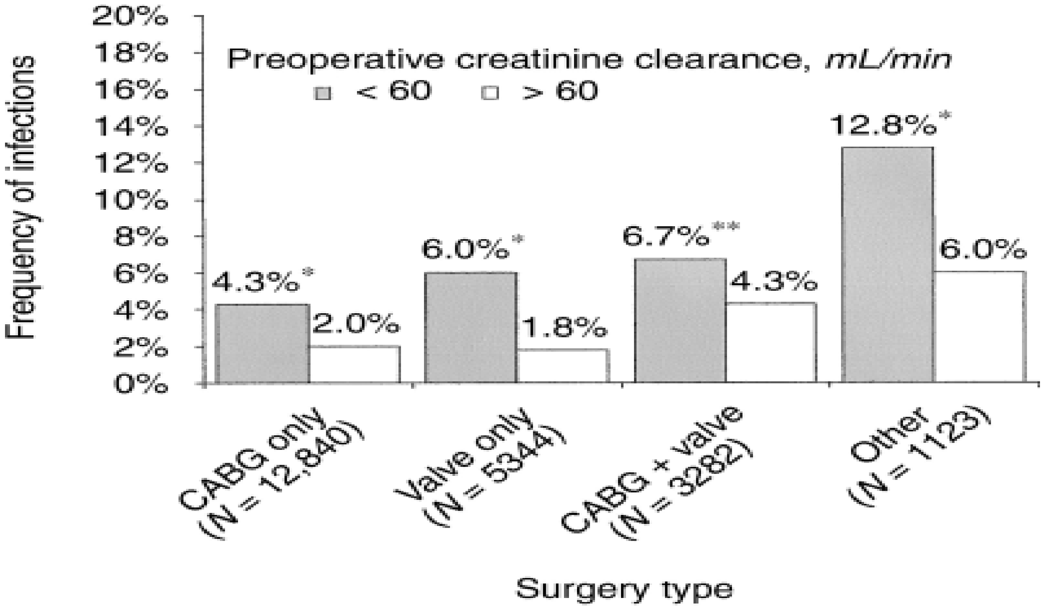
insert this nanorobot, from where it is moved to the site of the plaque by the use of its nano components that are attached to it.

The frequency of infections with each category type of open heart surgery compared according to preoperative creatinine clearance is given below:



IV. SURGERY USING NANOROBOTS

4.1. PROPERTIES OF THIS NANOROBOT:

The nanorobots structure will have two spaces that will consist of an interior and exterior. The exterior of the nanorobot will be subjected to the various chemical liquids in our bodies but the interior of the nanorobot will be a closed, vacuum environment into which liquids from the outside cannot enter. A nanorobot will prevent itself, from being attacked by the immune system by having a passive, diamond exterior. The diamond exterior will have to be smooth and flawless to prevent Leukocytes activities since the exterior is chemically inert and have low bioactivity.

4.2. COMPONENTS IN NANOROBOTS:

An electric motor is attached to this nanorobot for its propagation inside the circulatory system in the blood vessels. The microprocessor, artery thermometer, camera, rotating needle are also incorporated in this nano machine, which perform the vital role of the nanorobot. The microprocessor control the overall operation of this nanorobot .The radioactive material is impregnated and is made as a part of the exterior surface, which helps us to trace the nanorobot at any period of time. The magnetic switch is also provided.

4.3. INTRODUCTION OF THIS NANOROBOT INTO THE BODY:

This nanorobot gets access into the body through a large diameter artery so that it may be without being too destructive in the first place. This artery should be traversed easily to gain access to most areas of the body in minimal time. The obvious candidate is the femoral artery in the leg. This is in fact the normal access point to the circulatory system for operations that require access to the bloodstream for catheters, dye injections, etc., so it will suit our purposes nicely.

4.4. MOVEMENT OF NANOROBOT IN THE BODY:

We will use the circulatory system to allow our device to move about. But to get access to the site of operation of the nanorobot, it must have active propeller. So for that purpose we will be using an electric motor which will be having shrouded blade design so as to avoid damage to the surrounding tissues (and to the propellers) during the inevitable collisions.

4.5. DRIVING OF NANOROBOT TO THE SITE OF PLAQUE:

Long-range sensors will be used to allow us to navigate to the site of the plaque closely enough so that the use of short-range sensors is practical. These would be used during actual operations, to allow the device to distinguish between healthy and unwanted tissue.

- **Long-range sensor:** Radioactive dye
- **Short-range sensor:** Arterial thermometer
- **Device for monitoring the whole operation:** TV camera

A radioactive fluid is introduced into the circulatory system and its progress throughout the body is tracked by means of a fluoroscope or some other radiation-sensitive imaging system. The major advantage of this radioactive dye technique is that it follows the exact same path that our nanorobot would take to reach the operations site. By sufficiently increasing the resolution of the imaging system, and obtaining enough data to generate a three dimensional map of the route, it would provide valuable guidance information for the nanorobot.

A small amount of radioactive substance is impregnated as part of the micro robot. This would allow its position to be tracked throughout the body at all times. After reaching the site of location the internal sensor is used to find out the exact location of the plaque and also by using TV camera the plaque can be more precisely located. The area where the temperature exceeds than the maximum limit set in the nanorobot, will be operated on by the nanorobot i.e. that part will be cut by the rotatory needle attached to the nanorobot.

A TV camera in the device helps in transmitting the picture outside the body to a remote control station, allowing the people operating the device to steer it and also to view the internal environment of the circulatory system.

4.6. TREATMENT OF THE PLAQUE:

As soon as the nanorobot detects the site of plaque using camera and thermometer, it will activate the rotating needle and the diamond–chipped burr grinds the plaque into micro particles, which then travel harmlessly through the circulatory system and are eventually eliminated by the body. Cutting procedure is monitored using the camera and care is taken that it will not cut the surrounding tissue.

4.7. SOURCE OF POWER FOR THE NANOROBOT:

The nuclear power is carried onboard to supply required amount of energy for the operation of the device. This would be relatively easy to shield given the amount of fuel involved, and it has other advantages as well. The same radioactive material could be used for power and tracking, since the casing must be hotter than body temperature to produce power and there would be no worries about running out of power, or insufficient power to get the job done. At the micro scale, shielding and power conversion are relatively easy, making this method extremely practical.

4.8. MEANS OF RECOVERY FROM THE BODY:

After the nanorobot has removed the plaque, and its function is over, it has to be removed from the body. This can be made possible by guiding the nanorobot to anchor a blood vessel that is easily accessible from outside, and perform a small surgical operation is performed to remove it.

4.9. INCASE OF ANY EMERGENCY:

In case of some unanticipated situations where we want to switch off the nanorobot immediately, can be done by a magnetic switch that has been provided in it. Once the nanorobot has been inserted into the body, it starts operational only when a bar magnet is moved over it. This movement of magnet in one direction only makes the magnetic switch in on condition, and the nanorobot becomes active. So if anyhow in between the task of removing the plaque , we encounter any problem where shutting off the nanorobot is the only solution so we go for making the magnetic switch off by moving the bar magnet again that will terminate all the running functions of this nanomachine.

4.10. ASSUMPTIONS:

- The nanorobot to be designed must be biocompatible.

- The size of the nanorobot should not be more than 3 micron so as, not to block any capillary.
- The nanorobot should resist the corrosive environment of the blood vessels.
- The nano particles that are attached to this nanorobot should be held tightly and must be durable.

V. CONCLUSION

Nanomedicine will eliminate virtually all common diseases of the 20th century, virtually all medical pain and suffering, and allow the extension of human capabilities, most especially our mental abilities. It is an idea that can be made practical by the exiting engineering technology. Once this task for designing a nanorobot is accomplished, it will enable us to get rid of hard plaque in the arteries without any surgical procedure involved that may be very complex and tedious. The practical implementation of this technique will mark a great achievement in the history of mankind.

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