Nano robotics for Advanced Biomedicine

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Abstract

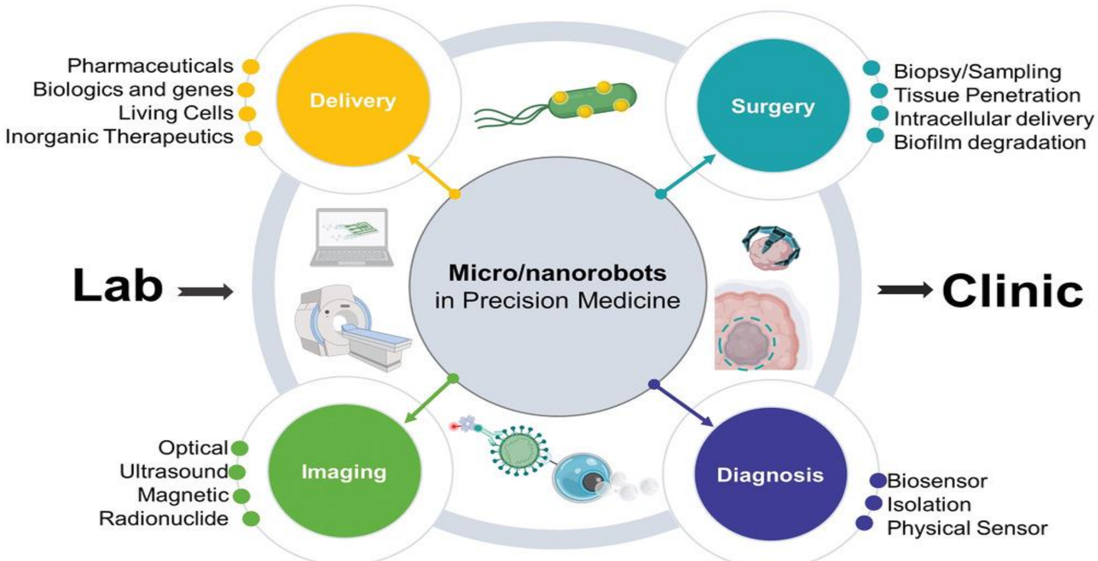
This study explores the remarkable advancements in the field of medical nanorobots, which have the potential to revolutionize healthcare. It discusses the components and types of nanorobots, including their power supply, payload, micro cameras, electrodes, lasers, swimming tails, and various novel designs. The applications of these nanorobots in healthcare are diverse, ranging from continuous glucose monitoring for diabetes patients to the detection and treatment of cancer. The study also highlights the use of biohybrid micro/nanorobots for drug delivery and precision surgery, showcasing their potential for minimally invasive procedures. Furthermore, it mentions the emerging role of nanorobots in dentistry. Overall, the research aims to shed light on the current trends in medical nanorobots and their potential for precision medicine."

Keywords: *Nanorobots, drug delivery, medicine, nanoparticles, Biomedicine.*

INTRODUCTION:

Robotic systems have significantly increased human ability to sense, interact with, manipulate, and change the environment. In particular, the convergence of several technologies has made it possible for a revolution in robotic medical applications that will enhance healthcare. Medical robotic devices are created for wholly different surroundings and operations relevant to the diagnosis, treatment, and prevention of diseases, in contrast to industrial robots, which were developed largely to automate repetitive and risky macroscale manufacturing jobs. Therefore, medical robots need miniature components and intelligent materials for complex and accurate activities as well as mating with the human body, unlike conventional or "old" robots that are constructed with big mechanical systems. Several technological developments in the fields of motors, control theory, materials, and medical devices have contributed to the rapid expansion of medical robotics. For instance, robotic surgical you, like the da Vinci system, enable the surgeon to translate hand movements into more minute, exact movements of tiny instruments inside the patient's body. Although robotic systems for minimally invasive surgery are frequently used, there are still significant technological obstacles and problems. In example, to reach and treat big, previously inaccessible areas of the human body, the mechanical components of current medical robotic systems are still rather massive and inflexible. By creating highly adaptable, miniature robots with dimensions of a few micrometers or smaller, the whole human body may be explored. (1-2) Robotic platform downsizing offers the potential to advance patient diagnosis and medical care. We may access difficult-to-reach areas of the body with these small robotic surgeons and carry out a variety of medical treatments. Medical micro/Nanorobots development has advanced over the past ten years, but one of the field's unmet requirements and biggest obstacles is getting these devices into more clinical settings. This study intends to demonstrate current developments in micro/Nano robotic research in this regard, with an emphasis on their application in precision medicine for the transfer to the clinic. (3) (Figure 1).

Figure 2. Components of Nanorobots (4)



1)Power supply:

Supplier of energy for the device operation and function.

2)Payload:

A little amount of medication or a substance is stored in this empty space. The nanorobots might move through the blood and release the medication at the illness or injury location. (5)

3) Micro Camera:

A tiny camera might be incorporated into the nanorobot. When moving manually through the body, the user can control the Nanorobots. (6)

4) Electrodes:

By harnessing the electrolytes in the blood, the electrode attached on the nanorobot may create a battery. By creating an electric current and heating the cancer cells to death, these projecting electrodes could also destroy the cancer cells. (5)

5) Lasers:

These lasers have the ability to destroy dangerous substances like cancer cells, blood clots, and arterial plaque. (7)

6) Swimming tail:

As they move against the body's blood flow**,** nanorobots will need a means of propulsion to enter the body**.** (5)

Types of Micro/Nanorobots used:

1) **Smallest engine ever created**:
Most compact engine ever made: The tiniest engine ever built from only one atom was just produced by a group of scientists from the University of Mainz in Germany. Like every alternative engine, it transforms energy into movement, but on a smaller scale. Then has ever been seen. A highly conical electromagnetic energy field surrounds the atom, and lasers are square. When you utilize the usual heating and cooling cycles, the atom inside moves back and forth. Similar to an engine piston, the cone. (8)
2) **Deoxyribonucleic acid-based 3D-motion nanomachines**:
They were created by mechanical engineers at Ohio State University using DNA origami, demonstrating that the same fundamental design concepts that apply to ordinary full-size machine components also apply to

advanced nanoscale mechanical components. Even DNA at this point — and could create sophisticated, programmable components for upcoming nanorobots. (9)

3) **Nanoswimmers:**
Researchers from Technion and ETH Zurich have created elastic "Nanoswimmers" polypyrrole (Ppy) nanowires that are around 15 micrometers (millionths of a meter) long and 200 nanometers thick and can travel through biological fluid environments at nearly the speed of sound. A speed of fifteen microseconds. It is possible to functionalize the Nanoswimmers to deliver drugs and as an illustration, magnetically directed to swim through the blood to concentrate on cancer cells. (10)

4) **Ant-like nanoengine with 100 X force/ unit weight:**
A tiny engine that can exert a force per unit of weight roughly 100 times greater than any motor or muscle was created by researchers at the University of Cambridge. With the development of new nanoengines, nanorobots that may infiltrate living cells and treat diseases or Illness, the researchers claim. Cavendish Laboratory professor Jeremy Baumberg, who led Actuating nanotransducers (ANTs) is the name given to the devices by the research. Similar to real ants, they Create powerful forces that are heavy for them. (11)

5) **Sperm – inspired Microrobots:**
Researchers from the German University in Cairo and the University of Twente in the Netherlands have developed sperm-inspired microrobots that can be manipulated by intermittent mild magnetic fields. They are utilized in targeted and advanced micro-manipulation. (12)

6) **Bacteria – powered robots:**
Drexel University engineers have created a method for harnessing electrical fields to assist minute bacteria-powered robots in detecting and avoiding obstacles in their environment. Using stem cells to direct the delivery of drugs is another application. (13)

7) **Nano rockets:**
Recently, numerous research teams developed a high-speed, pilotless nanoscale rocket by fusing biological molecules with nanoparticles. The goal of the researchers is to create a rocket that can be used anywhere, for instance to deliver Administering medicine to a specific bodily part. (14)

Medical Application of Nanorobots:

Figure 3. Illustration showing various other applications of nanotechnology in medicine. (15)

1)Nanorobots for Diabetes:

Diabetes patients today are required to check their blood sugar levels frequently throughout the day using tiny blood samples. These procedures are unpleasant and quite inconvenient. The body's sugar levels must be reduced to address this issue. It can be seen by using medical nanorobotics for continuous glucose monitoring. This crucial information could aid in monitoring and enhancing care for medical professionals. This Nanorobots based procedure could be more practical and secure, making it possible to implement an autonomous data system. It may potentially prevent infection as well as regular punctures to gather blood samples, potential data loss and even prevent patient from forgetting to take part of their glucose samples during a busy week. (16-17)

2) Treatment and Diagnosis of Cancer:

•Detection:

Nanorobots are capable for detection of malignant cells by checking their surface antigens as they are different for each type of cell. (18)

•Treatment:

Nanorobots could tag target cells with biochemical natural defensive or scavenging system a strategy called "phagocytic flagging". (19)

3) Nanorobots for Drug delivery:

Biohybrid micro- and nanorobots are functioning micro- and nanorobots made of both natural and artificial components, such as inorganic or polymer particles, as well as biological elements (such as DNA, enzymes, cytomembranes, and cells). Their biological characteristics, built-in actuation, and sensing skills can be inherited from their parents. The goal of medical microrobotics is to create and deploy a large number of micro/nanomachines (capable of physical, chemical, or biological propulsion, programmability, and reconfigurability) to perform a variety of medical tasks (such as delivering medications in situ, inducing localized heat, focusing on diseased cells, and performing cell microsurgery) inside the complex body environments. (24)

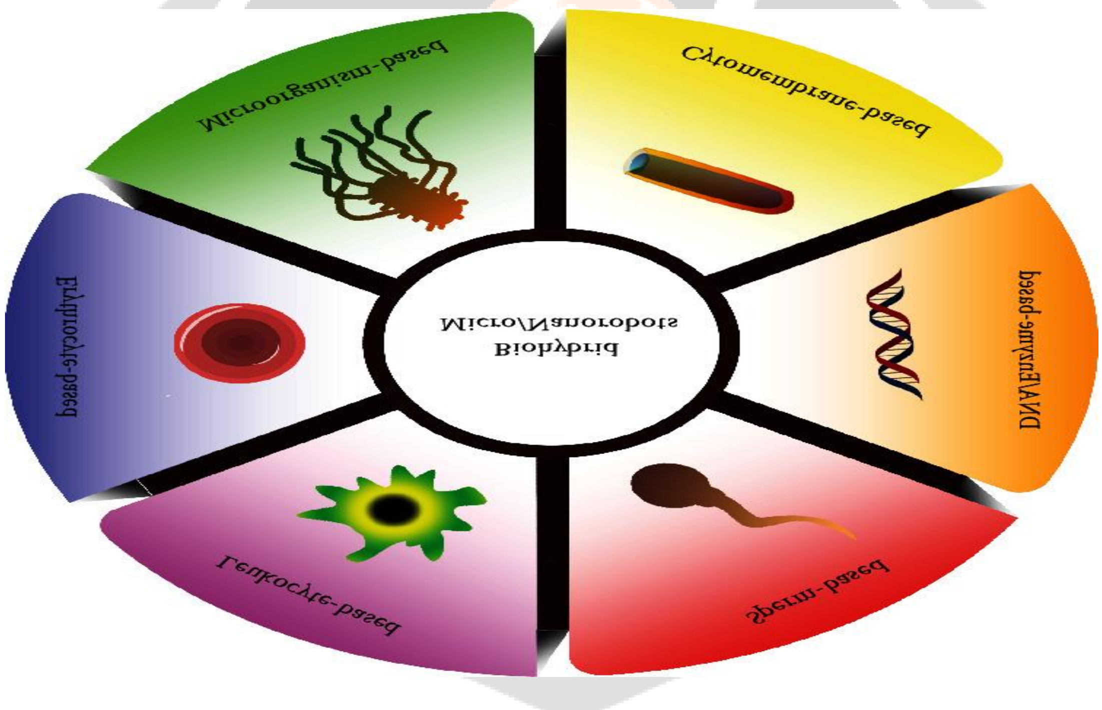


Figure 4: Summary of various biohybrid micro- and nanorobots. (25)

4)Nanorobots in surgery:

The usage of surgical robots has increased recently, and they have just recently been used in clinical settings. Nanorobots are still in their infancy and heavily rely on novel, multifunctional biomaterials. (26) Nanodrillers, micro-grippers, and microbullets are only a few examples of the untethered micro/nanorobotic tools that offer special capabilities for minimally invasive surgery. Micro/nanorobots offer significant advantages for very precise minimally invasive surgery because their dimensions are compatible with those of the tiny biological entities they need to treat.

The mobile micro/nanorobots with nanoscale surgical components can directly access or retrieve cellular tissues for precise surgery and are powered by a variety of energy sources. These tiny robots, as opposed to their larger robotic counterparts, are able to operate at the cellular level and can pass through the body's smallest capillaries. (27)

5)Nanorobots in Dentistry:

By utilizing a computer to control these small workers in their activities, dental nanorobots might be created to eliminate caries-causing bacteria or to mend tooth flaws where decay has already begun. Dental nanorobots can be designed to employ distinct motility mechanisms for precise navigation through human tissue, energy acquisition, environmental sensing and manipulation, safe cytopenetration, and a wide range of real-time nerve-impulse traffic monitoring, interruption, and modification in individual nerve cells. (33-34)

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