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Editorial

Nanorobots: Changing Face of Healthcare System

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Abstract

Nowadays medical science is more and more improving with the blessings of new scientific discoveries. Nanotechnology is such a field which is changing vision of medical science. Nanorobot is an excellent tool for future medicine. Nanorobotics is the technology of creating machines or robots at or close to the microscopic scale of a nanometer (10^{-9} meters). More specifically, nanorobotics refers to the still largely hypothetical nanotechnology engineering discipline of designing and building nanorobots, devices ranging in size from 0.1-10 micrometers and constructed of nanoscale or molecular components. Nanobots moves around their environment consuming molecules to attain energy. Nanobots direct themselves towards certain cells by their glycolipid structures. This idea would help physicians to treat diseases effectively without any adverse side-effects; actually the idea is to repair organs such as the brain, or the heart. The most valuable feature is that without any invasive surgery all of this can be done.

Keywords: Nanotechnology; Robots; Nanorobot

Minimally invasive medicine is the current buzz word. Scientists are looking for effective ways of diagnosing ailments, detecting diseases and analyzing changes in the body without having to physically cut open and observe the subject. Since Karel Capek first used the word “robot” in print in a 1920 play, a vast array of autonomous electromechanical systems have emerged from research labs, making their way onto production lines for industrial tasks, into toy stores for entertainment, and even into homes to perform simple household jobs. Films like *Fantastic Voyage* (1966) and *Innerspace* (1987) have long conjured fictional images of microscopic submarines or machinery that can travel inside the human body to cure ailments. Nanorobot swarms, both those which are incapable of replication (as in utility fog) and those which are capable of unconstrained replication in the natural environment (as in grey goo and its less common variants), are found in many science fiction stories, such as the Borg nanoprobes in *Star Trek*. Greater advances in robotics technology are now closing the gap between humans and robots. Robots are now able to help and interact with disabled people, as well as the elderly.

A *nanorobot* is a system able to modify the surrounding in a controlled and predictable fashion, with size at the molecular or even atomic scale. Medical nanorobots will be the size of bacteria, composed of thousands of molecule-sized mechanical parts perhaps resembling gears, bearings and ratchets. They may be composed of a strong, diamond-like material. A nanorobot will need motors to make things move, and manipulator arms or mechanical legs. It will need a power supply, sensors to guide it, and an onboard computer to control its behaviour. But unlike a regular robot, a nanorobot will be smaller than our red blood cells and able to squeeze through our body’s narrowest capillaries.

When fully realized from the hypothetical stage, they would work at the atomic, molecular and cellular level to perform tasks in both the medical and industrial fields. Nanorobots are so tiny that they can easily traverse the human body. A viable nanorobot has to be small and agile enough to navigate through the human circulatory system, an incredibly complex network of veins and arteries. The robot should carry medication or miniature tools. Assuming the nanorobot isn’t meant to stay in the patient forever, it also has to be able to make its way out of the host. Building nanorobots involves sensors, actuators, control, power, communications and interfacing across spatial scales and between organic/inorganic as well as biotic/abiotic systems. One convenient shortcut to nanorobotics is to engineer natural nanomachine systems microscale biological viruses and bacteria to create new, artificial biological devices. For biomedical application, temperature, concentration of chemicals in blood, electromagnetic signatures, acoustic signals, velocity of nanorobot and fluid are some of the parameters which are required to be considered for the nanorobot architecture.

In practice, a *nanorobot* is either a passive or active structure able to detect, signal and elaborate information. The very limited size of the devices implies limited capabilities and reduced computation resources; therefore it is necessary to make devices collaborate by applying design techniques such as *Swarm Intelligence* in order to realize complex systems through the interaction and the cooperation of very simple agents. The challenge is to control large collectives of nanorobots interacting in complex tumor environments and towards the improvement of treatment outcomes. Swarm behaviors of interest include amplification, optimization, mapping, structure assembly, collective motion, synchronization and decision making.

Scientists report the exterior of a nanorobot will likely be constructed of carbon atoms in a diamondoid structure because of its inert properties and strength. Super-smooth surfaces will lessen the likelihood of triggering the body’s immune system, allowing the nanorobots to go about their business unimpeded. The nanorobot navigation in a liquid environment is the main consideration during the path planning inside the body. It is important that the device is having a smooth trajectory path while navigating in the blood environment and at the same time does not cause any damage to the

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other cells.

Route of administration is determined by size of the nanorobot. Not only do we want to avoid damaging the walls of whatever blood vessel the device is in, we also do not want to block it too much. We have to get it into the body without being too destructive in the first place. The obvious candidate is the femoral artery in the leg.

Nanorobots will get to desired site by either passive or active propulsion. Passive prolusion means by way of blood flow which has problems like blood flow should be uninterrupted and it would be difficult to remain at the site without some means of maintaining position, either by means of an anchoring technique, or by actively moving against the current. Means available for active propulsion are Propeller, Cilia/flagellae, Electromagnetic pump, Jet Pump, Membrane propulsion and by Crawl along surface.

Ideally nanorobot must be able to move at a practical speed against the flow of blood and when blood is pooling rather than flowing steadily. And should not get stuck in heart and be able to maintain position, or anchor itself to the body so as to remain unmoving while operating.

Three behavioral control techniques have been considered to control the nanorobots' motions. First approach used nanorobots' small Brownian motions to find the target by random search. In second approach, nanorobot monitors for chemical concentration intensity for E cadherin signals. After detecting the signal, the nanorobot estimates the concentration gradient and moves toward higher concentrations until it reaches the target. In third approach, nanorobots at the target release another chemical, which others use as an additional guiding signal to find the target.

Navigation can be done by long or short range sensors. Long-range sensors will be used to allow us to navigate to the site of the unwanted tissue. Short-range sensors would be used during actual operations, to allow the device to distinguish between healthy and unwanted tissue.

We can either generate an ultrasonic signal and track that, or generate enough infrared or heat within the structure of nanorobot and track that. Of the two, the infrared technique is more practical, since there is far less problem of reflections and multi-path problems with infrared than with ultrasonic's.

The tracking of nanorobots can be done by internal or external method. Tracking of nanorobot can be done by external means such as Ultrasonic, NMR/MRI, and Radioactive dye, X-ray or Radio/Microwave/Heat. Internal sensor can be Chemical, Spectroscopic, TV camera, UHF sonar for resolution, texture. When the device is within a short distance of the operation site, these sensors will be used to help it find the rest of the path, beyond what the external sensors can do. Best choice for short-range sensors is the spectroscopic technique.

We have to be able to get sufficient power to the nanorobot to allow it to perform all of its required operations. There are two possible paths we can take for this. The first is to obtain the power from a source within the body, either by having a self-contained power supply, or by getting power from the bloodstream. The second possibility is to have power supplied from a source external to the body. Sources in body include body heat and power from blood stream or Carry the full amount of energy required directly onboard. Second is to get power from outside body with or without physical connection. Physical connection requires wire which has many problems such as length, navigation, flexibility and most of all should not cause trauma to body. Power can be transmitted by electricity or light. Without physical connection ie no wire the power source can be Microwave, Ultrasonic or Induced magnetic power.

Various methods of treatment include application of heat, physical removal, physical trauma, chemical means, and microwave or radiofrequency. Heat can be generated by Microwave, Ultrasonic, Electrical resistance heating, Laser and radiofrequency methods.

Finally to summarize we need to know where to go, Need to know the route, Need to be able to correct if drawn off course, Need to be able to apply treatment effectively, Need to be able to reach outlet from body, Need to compensate for the unexpected. If we had thousands or millions of nanorobots in the bloodstream, this would be a serious obstacle. However, with only a very few microrobots to control at once, we can actually have a person controlling the nanorobot directly.

By design, nanobots can be loaded with molecules that are released in a controlled fashion, or coated with molecules that allow them to interact with their environment. Certain molecules can serve as a signature to uniquely identify and internalize in cancer cells. Current macroscopic robots are being programmed and tested with what is known as "swarm intelligence", in which they share information available to each one of them, pool it together, and take collective decisions. Robot assisted surgery is already in successful use, as we can see from the *Da Vinci* surgical robot. DNA nanorobots," are short hexagonal tubes made of interwoven DNA that can open along their length like a clamshell. At one end is a DNA "hinge," and at the other, a pair of twisted DNA fragments that act as "latches" to hold the device shut. Scientists have inserted DNA-based nanobots into a living cockroach, which are able to perform logical operations. These DNA machines (or origami robots, so-called since they can unfold and deliver drugs stored within) carry fluorescent markers, allowing researchers to tell where in the roach's body they are traveling and what they are doing. Incredibly, the "accuracy of delivery and control of the nanobots is equivalent to a computer system In their new study, Israeli and American researchers successfully deployed DNA nanorobots in living cockroaches and used those nanobots to release an antibody that recognizes the insect's hemocytes, which are analogous to human white blood cells.

"The Bacteriobot has a sensing function to diagnose the cancer and it's attacking the cancer as it uses the bacteria's brain while moving toward the tumor." At the moment, the Bacteriobot can only detect solid cancerous tumors like those in the breast and colon. A rapidly vibrating (100 Hz) micropipette with a <1 micron tip diameter has been used to completely cut dendrites from single neurons without damaging cell viability. Axotomy of roundworm neurons was performed by femtosecond laser surgery, after which the axons functionally regenerated. A femtolaser acts like a pair of "nano-scissors" by vaporizing tissue locally while leaving adjacent tissue unharmed.

Medical nanorobots could also perform surgery on individual cells. A surgical nanorobot, programmed or guided by a human surgeon, could act as a semiautonomous on-site surgeon inside the human body. Such a device could perform various functions such as searching for pathology and then diagnosing and correcting lesions by nanomanipulation, coordinated by an on-board computer while maintaining contact with the supervising surgeon via coded ultrasound signals. Surgical nanorobots could be introduced into the body through the vascular system or at the ends of catheters into various vessels and other cavities in the human body. A surgeon-controlled nanorobot called a “chromallocyte” would extract all the chromosomes from a diseased cell and insert new ones in their place. In some cases, chromosomal replacement therapy is more efficient than in cytorepair. Replacement helper-T cells in a weakened immune system. The new chromosomes would have been manufactured outside the patient’s body using a desktop nanofactory. After injection, each nanorobot would travel to its target cell, enter the nucleus and replace the chromosomes, then exit the cell and leave the body. If the patient chooses, inherited defective genes could be replaced with non-defective base-pair. Nanorobots can be of great importance in easy and accurate correction of genetic defects, and help to ensure a greatly expanded health span. More controversially, medical nanorobots might be used to enhance natural human capabilities.

Nanorobots can be used to remove microscopic particles of cholesterol or cancer, and to rebuild individual molecules to create a new tissue layer. They can be used to remove sialoliths from salivary gland system and kidney stones. In cases where a bone has been broken researchers have already created a “nanobone” which has all the properties of natural bone but is also much stronger and more flexible. Eating away dead flesh at a wound site to actually re-growing tissue so that it heals cleanly and quickly without leaving a nasty scar. Produce synthetic clotting material for their wound sites in order to stop the bleeding. Closing a split vein or a gash at the same time. Micro surgery of the eye as well as surgeries of the retina and surrounding membranes could soon be performed using nanobots. In addition, instead of injecting directly into the eye, nanobots could be injected elsewhere in the body and guided to the eye to deliver drugs. Similarly, other difficult surgeries will also benefit from advances in nanorobotics. Foetal surgery, risky even today due to high mortality rate of either the baby or the mother, could soon have a 100% success rate, due to the fact that nanobots can provide better access to the required area inducing minimal trauma.

The major advantages this technology provides are Minimal or no tissue trauma, less recovery time, less post-treatment care required, Continuous monitoring and diagnosis from the inside and Rapid response to a sudden change. The end goal with this technology is to be able to prevent disease in the first place and cure whenever possible with return of both functional and esthetic function.

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