



Nanorobots in Cancer Therapy

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ABSTRACT

Cancer is treated effectively by means of currently available medical knowledge and equipment for therapy. Still, earlier diagnosis of cancer is a crucial factor to determine the probabilities of a cancer patient for survival. Cancer must be identified at least before the stage of metastasis. Another significant aspect is the develop an efficient targeted drug delivery system, which can reduce the occurrence of side effects for achieving an effective patient therapy. Nanomedicine approach can be utilised for diagnosis, treatment and preventing various diseases by using molecular tools and molecular knowledge of human body. By using nano-structured materials and simple nanodevices which can be manufactured, nanomedicine can address various medical problems. Within few decades' technology assisted medicine and particularly robotics will have a significant impact. Surgeon's motor performance, diagnosis capability etc. can be augmented by robots. Nanorobots can navigate as blood borne devices and thus it has an extremely important role in treatment of cancer. For diagnosing of cancerous cell inside the patient's body at its earlier development stages, chemical biosensor embedded nanorobots can be used. To determine the E-cadherin signals intensity, integrated nanosensors may be utilized. The aim of the present article is to explore the future nanorobotic's use to fight cancer and, their designing and architecture.

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INTRODUCTION

Cancer is a most lethal and severe health problems in the current world. For cancer treatment traditional clinical methods such as chemotherapy, radiotherapy, and surgery were widely used (Tian, 2018; Juzenas *et al.*, 2008). Despite significant

developments in advanced medical sciences, cancer is remaining as a disease which is challenging for treating and becomes a prominent death cause worldwide (around 13% of all deaths). Recent years, the number of death due to cancer has remarkably increased and death due to other disease like cardiovascular diseases, cerebrovascular disease and diabetes has increased slightly. Nowadays, to get rid of solid tumours which are located deep within the organs or body, radiotherapy, and chemotherapy are principally used.

But conventional chemotherapeutic agents may affect both cancerous and normal cells as they get distributed widely, non-specifically throughout the body, thereby the dose available at the tumour site get reduced and can result in the suboptimal treatment because of the extreme toxicities. For example, paclitaxel and doxorubicin, the most common chemotherapeutic agents show anticancer activity by inducing programmed death of cells that divide

quickly. These may also cause the death of normal cells which are capable of fast division in ordinary conditions. One method to overcome the non-specificity of conventional chemotherapeutic agents is molecularly targeted therapy. However, the resistance developed by cancer cells can evade the cytotoxicity with these newer molecularly targeted therapeutics also (Morgillo and Lee, 2005).

Oncologists in the entire world are uncompromisingly carrying out research for the development of methodologies for the detection of cancer and exact localization of cancer therapeutics with minimal distribution and toxicity in healthy tissues. Nanotechnology can be described as the technology to developing or designing materials and structures of the size range from 1 to 1000 nm. The rapid growing research in nanotechnology has presented promising possibilities for achieving the dream of each oncologist since the previous decades (Huilgol and Hede, 2006). Nanotechnology can assure improved drug concentration in tumours while preventing accumulation in traditional cells by means of both passive and active targeting approaches (Maeda, 2001; Allen, 2002).

Advancements in the field of nanomedicine and nanotechnology has introduced the investigation of the use of robots in the scale of nanometer known as nanorobots. For the treatment of various fatal disease like cancer, for application in biomedical etc., advance researches are carried for developing use of nanorobotics (Freitas, 2000).

Nanorobots are likely to impart advancement in treatment with the miniaturization of microelectronics to Nano electronics (Cavalcanti et al., 2007).

With currently available medical technologies and tools for therapy, cancer can be successfully treated. As nanorobots are considered to navigate as blood borne devices, they have extremely important in cancer therapy like targeted drug delivery (Cavalcanti et al., 2007). Diagnosis of cancerous cell deep inside organs, during early stages can be done using nanorobots with embedded biosensors in it (Curtis et al., 2006; Hazan et al., 2000). For the determination of intensity of E-Cadherin signals, integrated nanosensors can be utilized (Sonnenberg et al., 1991).

Historical Perspective

In the beginning of 20th century, the idea of robots emerged. Czech author Karel Cvapek was the first to introduce the word robot, in 1920s. He described it as mechanical labourers that work hard. Nevertheless, robot is a derived from a word that translates in English as work, in his native language (Dewdney,

1985).

The late Alfred Bernhard Nobel man of science Richard P. Feynman planned using machine tools to create smaller machines, which may be employed sequentially to build even smaller machines so on all the means right down to the nanoscale (Feynman, 1959). Richard P. Feynman was confident about the newer technology he proposed and its medical applications potentials. He aforesaid that his friend, Albert R. Hibbs recommended terribly attention-grabbing prospects of comparatively smaller machines. it'd be fascinating if a mechanical doctor will go within the blood vessels and goes into the targeted site and notice faulty one and slice it out mistreatment very little knife.

Feynman later in his historic lecture, thought-about the probabilities with biological cells, "that we will manufacture an object that manoeuvres at that level!". Later in 20 years Feynman's vision behind his remarks became a significant space of inquiry, once Eric Drexler printed a technical paper (Feynman, 1959). Paper suggests that it would be doable to construct nanodevices that might examine the cells of a living creature and persevere repairs among them. A decade later, Drexler's seminal technical book followed it, (Drexler and Göpel, 1992) that laid basis for the molecular manufacturing and molecular machine systems. and then, technical books by Freitas on medical nanorobotics followed the same (Freitas, 2005).

What Are Nanorobots?

Nanorobotics is an emerging technology that deals with the designing of machines or robots of nanometer size (10^{-9}) (Freitas, 2000). Nanorobots (or nanobots) are theoretical microscopic devices ranging in size from 0.1 to 10 μm and created of nanoscale or molecular parts. they remain as a theoretical thought as no biological nanorobots are created to date. When realized fully from hypothetical stage, to perform tasks in medical field and industries, they might work on the atomic, molecular and cellular levels. Nanomedicine's nanorobots will simply traverse the anatomy as they're so little.

As per scientist reports nanorobot's exteriors are possible to be created of carbon atoms in an exceedingly diamond structure owing to its inert characteristics and structure. Super smooth surfaces enable nanorobot to travel concerning their business unobstructed, because it lessens the probability of triggering the body's system. Natural body sugars or glucose may be reason for propulsion, and also the nanorobots can produce other molecular or biochemical components relying upon its tasks. Nanomachines are largely within the analysis and

development part however some earliest molecular machines are tested. the primary helpful applications of nanomachines was speculated to be in medical technology, where they may be utilized in the identification and destruction of cancerous cells.

Proposed Nanorobotics Theory

To carry out microscopic and megascopic tasks probably it'd be necessary for terribly massive numbers of nanorobots to work along as they're microscopic. This swarms of nanorobots includes those which are replication incapable and those that are at liberty replication capable in natural setting. The term "nanobot" ("nanite", "nanogene", or "nanoant" also) isn't a proper or uncomplimentary term used to refer engineering hypothesis of nanorobots. Within the prose context of significant engineering studies, the word nanorobot is the correct technical term. Nanorobots which are able to replicate outside of a restricted manufactory setting don't form an essential part of a reputed dynamic nanotechnology and that the self-replication method has to be ever developed, may be created essentially safe. Further they affirm that free-scavenging replicators are not present in their plans for developing and exploiting molecular manufacturing.

Nanorobots: Parts and Component

Nanobearings and Nanogears

It is compulsory to develop and analyse potential designs for nanoscale mechanical elements that can be manufactured so as to ascertain the feasibility of molecular production. As components cannot be physically built so easily, designers are compelled to depend upon ad-initio structural analysis and molecular dynamics stimulations.

The supreme expedient category of parts to design are possibly the molecular bearing as their structure, and operation is fair enough. One among the simple model is overlap repulsion bearing design by E. Drexler, that has 206-atoms of C, Si, O, and H. It is composed of a tiny low shaft that moves inside the ring sleeve. The shaft atoms are organized in a 6-folded symmetry, whereas the ring has 14-folded symmetry. This arrangement offers low energy barrier for the rotation of shaft. 2808-atom strained shell sleeve bearing design by E. Drexler and Merkle has 4.8 nm diameter bearing with an interlocking groove interface that developed from a reformed diamond surface. The shaft-ridges interlock with ridges on the sleeves, creating a really rigid assembly. Efforts to bob the shaft up or down, or rock it from facet to facet, or relocate it in any direction (except gyration, whereby displacement is very

smooth) encounter a really sturdy opposition.

Another appropriate component system for molecular manufacturing design are molecular gears. For instance, 3557 atom planet gear design by E. Drexler and Merkle. Entire assembly of this design has 4.3nm diameter and 4.4nm length, 12 moving parts, with a relative molecular mass of 51009.844 Da and 33.458 nm³ molecular volume. The computer animation of stimulation indicates that the central shaft rotates rapidly, while the peripheral output shaft rotates slowly. The tiny planetary gears that are rotated round the central shaft are encircled by a ring gear (a strained silicon shell with sulfur atom termination) which hold the planets in proper place and confirms that every elements moves in an exceedingly correct manner. The planet gear resembles multi-hexasterane structures with 'O' instead of CH₂ bridges between the parallel rings, and also the planet carrier is customized from a Lomer dislocation array, connected to the planet gears by making use of C-C bonded bearings, designed by Merkle and L. Balasubramaniam, 2014.

Nano-motors and Power Sources

Gas-powered nanodevice is a class of theoretical nanodevice that has been built. It contains a pump and chamber wall fragment which in turn have 6165-atoms with 88,190.813 Da and 63.984nm³, molecular weight and molecular volume respectively. Neon gas atom pumping and conversion of neon gas pressure to rotary power can be done using these devices. The helical rotors have a cylindrical bearing surface which are grooved, at each end which supports the screw threaded cylindrical segment in the middle. While operating the rotating shafts moves the helical groove past longitudinal grooves inside the pump housing.

Enough area is there for the small gas molecules, only where it faces groove cross. As the shaft turns, the crossing points move from one side to the other which moves the neon atom along with it. Most of molecular nanotechnology for designing of nanorobots are constrained as theoretical concept and computer simulation. This can help in the designing and testing of Nano machines and gathering information for evolving libraries of molecular models ([Walsh et al., 2003](#)).

Montemagno and Bachand created the first artificial hybrid nanomotor by modifying a natural biomotor to incorporate non-biological parts. They added amino acid residue which can bind to metal, to ATPase, which is universal enzyme with moving part which is a central protein shaft, by using tools of genetic engineering. Electrochemical reactions with the three proton channels of molecule causes the

rotation of chemical shaft. Each of the motor protein molecules are firmly bonded to pedestals made up of nickel produced by e-beam lithography. Appropriately aligned motor molecules of diameter 12 nm were eventually connected to the nickel pedestals and a silicon nitride bar of length 100 nm, was bound to the rotor subunit of each motor molecule, all by self-assembly [Bachand et al. \(2001\)](#).

In microscopic videos it could be seen as dozens of bars spinning like a field of tiny propellers. The first integrated molecular motor of this group could work with 3-4 revolutions per second for 40 minutes while the succeeding motors have been operated continuously for hours by supplying additional ATP. Solar powered, bio molecular, motor-driven autonomous nanodevice, where the ATP produced from the conversion of light energy serves as a source of fuel for motor was a work of Montemagno. His plan was to make use of living cell sensory system to control implanted nanodevices inside the cells [\(Freitas, 2000\)](#). He speculates for targeted delivery to specific cells like tumors these nanofactories could be used, as they would synthesize and deliver chemotherapeutic agents [\(Rutgers, 2003\)](#).

Another researches on motor were rotating motor (78-atom) which are chemically driven developed by Kelly in 1999 [\(Kelly et al., 1999\)](#), a rotaxane - based linear chemically driven rotaxane motor by Stoddart's group, a catenane - based ring, UV driven motor by Wong and Leigh, [\(Leigh et al., 2003\)](#) and an artificial motor (58-atom) molecule that spins when irradiated by solar energy by Feringa [\(Koumura et al., 1999\)](#).

In 2003, the Zettl group [\(Fennimore et al., 2003\)](#) made a nanomotor of 550 nm width which is driven electrically. It was built by the deposition of nanotubes on flat silicon oxide surface of a silicon wafer. Then gold rotor, opposing stators and nanotube anchors was patterned around chosen nanotubes using electron beam lithography and later to nanotube, rotor was annealed. Its surface was selectively etched which provides enough clearance for the rotor. When 50V of direct current is alternately applied to the stators, the gold rotor rocked to and fro to 20°, which makes a torsional oscillator.

The gold rotor rock to and fro up to 20°, producing a torsional oscillator, when the stators are alternately charged with 50V of DC. A sturdy electrical jolt to the stators shook the rotor which causes the breakdown of the outer wall of the nested nanotubes which allow the outer nanotube and attached rotor to spin freely around the inner nanotubes as a frictionless bearing [\(Cumings, 2000\)](#). The oscillating rotor can be used for generating microwave frequency oscillations

feasibly up to a few gigahertz, or the spinning rotor can be used for mixing liquids in microfluidic devices.

Nano computers

For the efficient monitoring and controlling the work of medical nanorobots by physician it should be equipped with an onboard computer. Molecular switches in nanoscale memories, which can completely reverse room temperature are first demonstrated in laboratory by UCLA and Hewlett Packard, in 2000 [\(Collier, 2000\)](#). These molecular switches used catenanes, which are mechanically interlinked ring molecules. Earlier molecular electronic devices like memories are followed by numerous companies. By using self-assembly technique various computational parts of nano-computers are also used by companies. Even there is chances for biological based low speed digital nano-computers.

The Design of Nanorobot

The designing of nanorobot is based on mainly criteria such as navigation means of nanorobot and the way it attaches to the tumor cells. The main consideration during the nanorobot designing is the way it moves in a liquid environment. For the navigation in the bloodstream, device must have smooth trajectory path and should be non-destructive to the normal cells. To capture the cancer cells in time after its detection, the tentacles have to move forward. In order to achieve faster action of tentacles it should have high responsive rate. Also, to provide a "brain" to the nanorobots, it might need a microcomputer consisting of a miniature processor [\(Senanayake, 2007\)](#).

Carbon nanotubes can be used for constructing body of nanorobots due to its inherent properties. It tends them to absorb near IR radiations, which may pass harmlessly through human cells. Around the body of the nanorobots ultrasonic sensors are attached for collision avoidance purposes. This can prevent the knocking of nanorobots each other. For attracting the nanorobots to the cancerous cell, folate materials can be employed, this can also be called as folate-receptor cells. Rather than coating with the folate material, it is modelled as an object connected to nanorobots.

Thus the observer can get better treatment process. The navigation of nanorobot in the blood stream is better supported by flagella. A series of rotary motor (known as flagella motor) provides the power for the generation of remarkable force, which can drive the thin helical filament (flagella). Depending upon the variation in nutrients concentration in the external medium, these flagella motor helps the nanobots

to decide which way to go (Senanayake, 2007).

Modulation of rotary motor imparted to flagella is necessary so as to assure that nanorobots traverse in proper direction. A wave away from the cell body is created by helical flagella when rotated by motor in an anti-clockwise direction. Later the nearby flagella, like propulsive corkscrew manner get intertwined and drive the nanorobots. When flagella are rotated in a clockwise direction by the motor, it moves apart. This helps nanorobot to change its direction. A movement with speed of $25 \mu\text{m/s}$ and 1/s direction reversals are provided by the flagella motor. The size range of assembled nanobot is about 0.5μ to 0.8μ and the capillary size was found to be approximately $5\text{-}10 \mu\text{m}$ in diameter. For the nanorobot to navigate through blood vessels, it should of size within the range of capillary size (Senanayake, 2007).

Manufacturing Technology

Smaller the size of robot, harder is to design it. Firstly, it is difficult to apply mechanical engineering for designing as components are in the nanometer size range. Rods, nuts, bolts cannot be used to keep things together and real time imaging to receive immediate feedback on the system status is very rare. Secondly, the problem we face is of because of large number of components (Hess, 2011).

New approaches in construction, computation, transducers, and manipulation aids in the ability to manufacture nanorobots. For the diagnostic purposes, different temperature gradients, chemicals concentration in the blood and electromagnetic signals are some of the important parameters (Hogg and Kuekes, 2006). Complementary metal oxide semiconductor (CMOS), very large scale integration systems design which uses deep UV lithography provided high precision and a profitable method for manufacturing of primary nanodevices and nanoelectronics systems. Joint use of Nano photonic and nanotubes with CMOS can effectively lead to find a pathway for assembly process which essential for nanorobot manufacturing, which also accelerate the actual levels of resolution ranging from 248 nm to 157 nm devices (Bogaerts et al., 2005).

Propulsion

A variety of innovative approaches are developed by natural system for movement in its environment. The direct movement of mammalian cells in blood vessels is not possible because of the high flow rate ($2\text{-}14 \text{ ml/s}$) of blood (Berger and Jou, 2000). It is more difficult to travel outside the vessel as it have to move between smooth muscle cells (Paulsson et al., 2012).

However, several eukaryotic parasites and bacteria have the ability to move inside the vessels by the use of variety of strategies. Earlier researches have reported that inability of chemotherapeutics reduces the delivery efficiency. So it is necessary to establish an actively moving therapeutic (Toley and Forbes, 2012). Thus, active movement is essential for the proposed nanorobot. Approaches typically employed by swimming microorganisms were explored for the determination of how a better propulsion system can be developed.

Generally, microorganism move using motile structures like flagella, cilia and pseudopodia. Flagella are found in round prokaryotes which rotates and in eukaryotes of planar or sinusoidal structure. Power supply for flagella is provided by chemical energy supplied by ATP. Cilia are found only in eukaryotes and in these propulsive force is provided by beating using power. These allows the rapid movement of ciliated organisms. The pseudopodia help in crawling along the surfaces by using extensions of cytoplasm, which are projected from the cell body. This crawling motion caused by pseudopodia is relatively slower than propulsion caused by cilia and flagella. Multi flagellated microorganism uses multiple beating patterns to attain extremely controlled movement (Lenaghan et al., 2011). By inspired from motile structures used by the microorganism researches started engineering structures similar to Reynolds's number swimmers.

To move in 3-D, robots with artificial bacterial flagella (ABF) have been developed experimentally. ABF are designed from helical nanobelts with soft magnetic heads made of Chromium/gold/Nickel, this permits the rotation of nanobelts under external magnetic field (Zhang et al., 2009). A fluid motion similar to it can be generated by fabricating ABF with biological flagella. But metals used their construction can lead to severe toxicities and reduce nanorobot's biocompatibility. Microrobots with ABF are able to move both to and fro as bacterial cells.

Robots with microscale flexible paddles, similar to eukaryotic flagella have been used in several studies. This can move millimetre sized robots. Currently, living bacteria attached to microspheres are used for bioengineered propulsion of microrobots. Chemical gradients can control the navigation of bacteria-driven microrobots to destination. Magneto tactic bacteria (MTB) is another alternative for chemical gradients. These are controlled by magnetic field externally applied to gather microstructures and it assists in directed treatment of tumour (Martel and Mohammadi, 2010).

By development of an effective propulsion system, retention time of nanorobots in the body can be increased and also slower the renal clearance rate. This will improve the bioavailability of drug for extended traditional therapy

Chemical Sensing

To monitor E-cadherin gradients, chemical sensor is embedded in nanorobots. Thus detailed screening of the patient body is possible with nanorobots programmed for such tasks. Mobile phones are applied to retrieve information about patient conditions in various medical nanorobotics architecture. For commanding and detection of location of nanorobots within the patient can be accessed by the help of electromagnetic waves (Ahuja and Myers, 2006; Hanada et al., 2000).

Chemical Signals Within the Body

An important aspect to describe the nanorobot application in cancer therapy is the interaction of chemical signals within the body with the blood. The nanobots are architecture to sense the variations of E-cadherin signal. Instead of floating in the blood, these are maintained near the vessel wall in order to improve the responses and bio sensing capabilities. In chemical signalling an important option is the measurement of time and determination of threshold at which signal is to be received.

Even background concentration can cause the detection without any target signals. Once the diagnosis of a tumour is done, nanorobots are programmed to get attached on it. Nanorobots can attract a defined number of other nanobots to the site for chemotherapeutic action and also it is architecture to allow wireless communication for sending the precise location of tumour to the doctors (Howard and Berg, 1993).

Energy Supply

The energy needed for the nanorobot to operate as long as it needed for operation can be secured by using CMOS for supply of power and telemetry. Using this same technique digital bit encoded data can be transferred from within the body (Mohseni et al., 2005). Many operations with multiple tasks can be operated with few or no energy loss can be done using nanocircuits, which is having resonant electric characteristics. Nano circuits can supply 1.7 mA at 3.3 V for power through electromagnetic energy (Sauer et al., 2005).

Telemetry (based on radiofrequency) method have shown very good results in monitoring of patient and transmission of power by using inductive coupling. Nanorobots can save about 1 μ V of received energy. It becomes active only when it is require to

do so by signal patterns otherwise it remains in inactive mode (Ricciardi et al., 2003).

Data Transmission

The continuous medical monitoring can be greatly benefitted by the application of sensors and devices implanted within the body to transmit health related data of patients. Recently, radiofrequency identification, for application in collection and transmission of in-vivo data were successfully tested for EEG (electroencephalograms) (Sauer et al., 2005). Depending upon the application, sound, light, radiofrequency and chemical signals can be regarded as best possible option used for data transmission and communication in liquid workspaces (Cavalcanti and Freitas, 2015).

Communication between adjacent nanorobots for coordination can achieved by chemical signalling (Cavalcanti et al., 2007). Read and written data from devices implanted can be better understood by the use of integrated sensors, which is data transfer.

Nanorobot teams can be armed with single chip RFID-CMOS based sensors (Panis et al., 2004). For reducing the power consumption by the nanorobots which communicate long distance through an acoustic sensor, CMOS with submicron SoC (System on Chip) design can be used. The active sonar communication frequencies for the nanorobots might extend equal to 20 μ W 8 Hz at resonance rates with supply of 3 V.

System Implementation

The design of nanorobots comprise of integrated nanoelectronics (Cavalcanti et al., 2007). Nanorobotics includes the use of cell phones. For example., earlier detection of E-cadherin level for drug delivery for chemotherapy and identification of new cancer tumour for cancer therapy (Ahuja and Myers, 2006).

For *in vivo* positioning, nanorobots make use of a RFID-CMOS transponder system (Freitas, 1999; Ricciardi et al., 2003). This can identify the information regarding the position of nanorobot using well established communication protocols (Ahuja and Myers, 2006).

This information obtained can help in the early detection of malignant tissues. The outer structure of nanorobot consist of diamond material, which is in turn attached to an artificial glycocalyx surface. This can reduce absorption and bioactivity of fibrinogen which ensure adequate biocompatibility to avoid attack by immune system. By using a set of chemotactic biosensors having binding sites (with specific affinity for different molecules), vari-

ous types of molecules can be differentiated (Freitas, 1999).

Even obstacles can be detected by these sensors using new strategic planning (Cavalcanti, 2003). Various types of sensors are possible. For instance, chemical sensing which can be very specific, example for distinguishing different types of cells by markers. Another possibility are acoustic sensors, which uses diverse frequencies to get a wavelength equivalent to the size of object of interest (Panis et al., 2004).

Controlling of Nanorobots

The sensors and motors interconnected by the controller. In both system mechanics and chemical reaction networks, control algorithms were encoded in biological nanorobots. Sensing, actuation and control are extremely integrated. The methods that are evolved to offer biological system robustness, adaptability, and high performance are active region of research. To accomplish a bigger task, nanorobots have to communicate each other and work together, and that is the largest challenge regarding them.

Probably the solutions lie in swarm behaviour. Engineers of Harvard University have already built swarming kilobots (51) at nanoscale. Kilobots are robot of thousands of centimetre size that functions under a decentralized system. They can effectively understand how to solve various problems and build enormous shapes by working together through local neighbours interactions. The decentralised control methodology on nanoscale in swarms are capable of completing elaborate tasks, where a single nanorobot would fail.

Nanorobot Simulation

Nanorobots, due to the advancement of nanoelectronics, is also considered as a new effective technology to assist with new approach for drugs. Real time 3D visualisation of red corpuscle is possible with nanorobots, which are within the vessels. For the healthy working of human body, glucose which are carried through the blood is very important.

Complementary Metal Oxide Semiconductor (CMOS) bioelectronics is embedded in the prototype model of simulated nanorobot. Nanorobotics computations can be performed through nanosensors, embedded for persistent computation.

Their performance needs very low energy intake. Due to biocompatibility, the nanorobots are not attacked by the white corpuscles. The significant data obtained can be transmitted to the cell phone automatically, in medical nanorobot.

Cancer Diagnosis and Therapy Using Nanorobots

The advance of nanorobotics will offer significant progresses for the cancer identification and treatment. Nanoparticles will show a very important role in evolving new methodologies for cancer diagnosis. Cancer detection throughout primary stage could be a crucial step in improvising cancer medical care. Wide-ranging nanoparticles used are cantilever, nano-pores, nano-tubes and quantum-dots. These are being concisely outlined here in this article.

Cantilever

Cancerous cells secrete molecular product and the antibody coated fingers of cantilever specifically binds to those proteins secreted. The cantilever's physical characteristics alters with period. They supply data regarding the presence and concentration of various molecular expressions.

Nano pore

Nanopores are another vital device. Advanced strategies for the genetic code reading will facilitate the scientists in the identification of errors in genes codes which will results in cancer generation. Nanopores contains a small hole, which permits the passage of a DNA at a time. This makes deoxyribonucleic acid sequencing further efficient.

Nano tubes

A multi-disciplinary team (MIT, Cambridge, USA), has developed CNT (carbon nano-tubes) which may be used as cancer medication detectors and for sensing other deoxyribonucleic acid destructive agents within living cells. Carbon rods of nanotubes are of half the diameter of a deoxyribonucleic acid (DNA) molecule. This could will find the presence of altered genes and additionally, it can precisely locate the altered region or base pairs.

Quantum Dots

These are small crystals that produce radiance once stimulated by ultraviolet ray. They might drift around until come across with cancerous tissue, when injected into the body. Onto the special coating on the radiant dots, the deadly cells will attach. These light particles can help doctors to indicate where the disease has spread by serving as a beacon. Nanorobots can be very helpful, as nowadays treatments like chemotherapy, and radiation therapy most frequently results in destructing normal cells instead of tumour cells. The nanorobots can differentiate cancerous cell from traditional cells by checking their surface antigens, using chemotactic sensors connected with the particular antigens on

the targeted cells. These will be automated to identify E-cadherin and β -catenin levels in primary and metastatic phases by making use of chemical sensors. So nanorobots destroy solely the cancerous cells (53). Current attempts are to create micro electrochemical System [MES]- based nanorobots for use in *in-vivo*. The "MR-Sub" project done by Ecole Polytechnique, Montreal nanorobotics laboratory is an example.

They used MRI technology as a method of micro-robot propulsion within the blood vessels. The first generation epitome may be applied for the release of drug at targeted site, the further opening of arteries that are blocked, or taking samples for biopsies. The project was to gather the required data and design a miniature form of the system and to develop a robot created from nanometre elements. This makes it doable to hold out procedures within the blood vessels that are inaccessible. Gordon's cluster at the University of Manitoba have projected 'cytobots' and karyobots' which are magnetically controlled for acting wireless intracellular and intranuclear surgery respectively. The nanorobots that are loaded with therapeutic chemicals can deliver drug and can avoid further advancing of cancer. For drug delivery dendrimers and nanoshells, liposomes, NPs, micelles are used.

Dendrimers

Dendrimers are extremely branched, spherical, artificial macromolecules with modifiable dimension and shape. A dendrimer can convey a molecule which will recognize the neoplastic cell, a drug to destroy these cells, and a molecule which will identify the necrobiosis signals. Dendrimer nanoparticles have the ability to target cancer cells with larger doses of anti-neoplastic drugs.

Nano shells

It has an inner core made of silica and a metallic outer cover. Scientist have designed beads to absorb radiation close to IR region, which may produce an intense heat which can be deadly to cancer cells. This is achieved by adjusting the thickness of outer layer. The phenomenon, enhanced permeation retention can lead to the physical selectivity to cancer lesion site (52).

Liposomes

Since it is a simple preparation with acceptable toxicity and biodegradability profiles, liposomes are mostly preferred drug carrier system. Loading of drug in liposomes can be done by various means like:

1. vesicle formation in a saturated aqueous solu-

tion with soluble drug

2. the employing organic solvents and solvent exchange mechanisms
3. the employment of oleophilic drugs
4. by using method which uses pH gradient.

Polymeric NPs

These are good choice as carrier of cancer medications for treatment and, are made from biodegradable polymers. Polymeric NPs are carriers with 10 to 1000 nm diameter size range and are generally biodegradable usually prepared of natural or synthetic polymers. Medications can be encapsulated, dissolved, adsorbed, entrapped or covalently linked via a simple -COO-R or -CO-NH- bond (which may be hydrolysed *in-vivo* by pH) to the polymer backbone. These are generally more stable than liposomes when administered systemically. However, these are very much limited by their poor Reticulo-Endothelial System (RES) uptake. To increase the pharmacokinetics liposomes can be coated with nanoparticles on their surface or can be intercalated into their structure. This can even enable targeted delivery of therapeutic drugs and imaging purposes (Bajpai *et al.*, 2008).

Micelle

These are spherical nanocarriers with size range of 10-200 nm and are generally biodegradable in nature. Micelles can be considered as best option as drug delivery vehicle as they have many advantages. To carry therapeutic drugs specifically lipophilic drugs, the hydrophobic core can be used. Lipophilic drugs entrapped in the inner hydrophobic core will be highly solubilised and the micelles will have high loading capacity. These can deliver more than one therapeutic drug simultaneously, and drugs are released in a regulated fashion. The release of drugs encapsulated are by biodegradable polymer erosion, drug diffusion through polymer matrix, or drug diffusion following swelling of polymer. The drug release from micelles can also be affected by the external conditions like changes in pH and temperature. For targeted delivery of drugs, using ligands (antibodies, peptides etc.) modification of micelles can be done. Uptake of these nanocarriers can thereby reduce toxicity and can improve their specificity and efficacy (Oerlemans *et al.*, 2010). Pictorial representation of the various drug delivery systems in cancer detection and therapy (Satyanarayana and Rai, 2011). Though nanorobots may prove to be a boon to developing medical technology but at the same time there are certain disadvantages associated with it.

Disadvantages

1. Designing of nanorobot is very costly and complicated
2. Stray field might be created from electrical systems which can trigger bioelectric based molecular recognition system in biology
3. Electrical nanorobots remain vulnerable to electrical interference from other sources like radiofrequency or electric fields, electromagnetic pulse and stray fields from other in-vivo electronic devices.
4. Nanorobots are difficult to design, and customise
5. These are capable of molecular level destruction of human body thus it can cause terrible effect in terrorism field. Terrorist may make usage of nanorobots as a tool for torturing opponent community
6. Other possible threat associated with nanorobots is privacy issue. As it dealt with designing of miniature form of devices, there are risks for snooping than that exist already.

CONCLUSION

Over past decades, nanotechnology based cancer therapeutics and diagnostics has developed from drug particles of nanosize to well-designed nanomaterials that are able to deliver heat, radiations, and therapeutic agents. Nanorobots are the merely feasible nanotechnology inventions in terms of advanced treatment and cost-effectiveness. The study and implementation of nanorobots have numerous advantages in targeted therapy in cancer and diagnosis of cancer cells even in the initial stages. They can provide individualised treatments with enhanced efficacy and fewer side effects, as nanorobots can distinguish the cancerous cells from the healthy cells. The introduction of MNT will expand immensely the efficacy, ease, and rapidity of upcoming medical treatments. They can significantly reduce the threats, charge, and tactlessness in the treatment. Nanorobotics has strong ability to reform health-care, to treat and identify disease in future. It introduces new means for infinite, copious research work in cancer therapy.

Conflict of Interest

None.

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