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ANTI- HIV USING NANOROBOTS

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Abstract: Nanorobots hold great promise in the treatment of HIV, offering the potential for more targeted and effective drug delivery and even gene editing. While there are no approved systems for the treatment of HIV using nanorobots yet, several promising studies have been conducted that demonstrate the feasibility of this approach. Nanorobots can be engineered to recognize specific markers on the surface of HIV-infected cells and deliver drugs directly to these cells, reducing the viral load in the patient's body and slowing the progression of the disease. Additionally, nanorobots can carry gene editing tools that could be used to remove the virus from infected cells. However, further research is needed to optimize these systems and evaluate their safety and efficacy in animal models and clinical trials. If successful, nanorobots could offer a game-changing approach to the treatment of HIV, providing more targeted and effective treatment options for patients.

***Index Terms* - Nanotechnology, HIV, WBC, Nanorobots, CD4 protein.**

I. INTRODUCTION

1.1 Nanorobots

There are several areas of robotic technology today. One of its subcategories is nanorobotics. In this area of robotics, teams of biotech and robotics experts are creating intricate, miniature robots. The ability to mimic human behavior is made possible by the components' nanoscale nature. Nano-robotics has made it possible to construct the various complex parts that make up robots.

A few authors started making predictions about the possible physical forms that future medical nanorobots might take in the 1980s and 1990s. A few people produced artistic renderings of their devices. Only the broadest analyses of the potential missions and capabilities have been made up to this point. Adriano Cavalcanti, a pioneer in nanorobot technology, created a model based on nanobioelectronics for the practical hardware architecture of nanorobots, which was used for applications in environmental monitoring, brain aneurysm, diabetes, cancer, cardiology, and AIDS.

1.2 HIV

HIV (Human Immunodeficiency Virus) is the name of the virus that causes the illness known as AIDS (Acquired Immunodeficiency Syndrome). When a person has AIDS, their body's unique defence mechanism against all infectious pathogens is no longer effective. Human Immunodeficiency Virus is referred to as HIV. HIV, like all viruses, is unable to develop or procreate on its own. It has to infect the cells of a living thing in order to reproduce.

HIV occurs as roughly spherical particles outside of human cells (sometimes called virions). Each particle's surface is covered in numerous tiny spikes. The diameter of an HIV particle ranges from 100 to 150 billionths of a metre. It is roughly equivalent to 0.1 microns. HIV particles are much too small to be seen under a standard microscope, unlike most microbes.

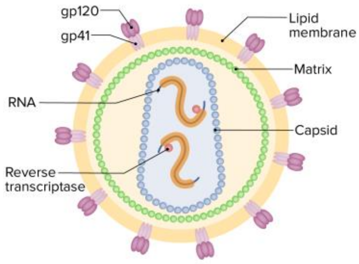

Fig-1: Structure of HIV Virus

1.3 Spreading of AIDS

AIDS is not a fatal illness by itself. The HIV virus, which has the ability to weaken the immune system, is what causes AIDS. As a result, the host system is susceptible to minor illnesses that could eventually become fatal but are not actually fatal. The WBCs are targeted by the HIV virus, which turns them into HIV. As a result, every WBC is turned into HIV, which causes the immune system to fail. This is what caused the patient to die.

1.3 Latest Drugs against HIV

The most recent medication used to treat AIDS is Zidovudine. DNA cannot be synthesized because this medication binds to the HIV genome (RNA molecule) before reverse transcriptase can do its job. Yet this medication's effectiveness can be lost at any time.

II. LITERATURE SURVEY

Dron P. Modi and others made a research on "Nanorobots: The Emerging tools in Medicinal Applications" and described that said that compared to other technologies, nanotechnology will have a more profound impact on human existence and health treatment. As a result, they will alter the industry's structure by expanding the contacts between the pharmaceutical, biotechnologies, diagnostic, and healthcare sectors in terms of product development and marketing.

Ved Prakash Upadhyay, Mayank Sonawat and others in their journal "Nano Robots In Medicine" put into words that Sensitive new diagnostics will be used in healthcare in the future to improve individual risk assessment. The greatest impact can be anticipated if the major illnesses that place the greatest burden on the ageing population are addressed first: diabetes, cancer, musculoskeletal problems, neurological and psychiatric illnesses, cardiovascular diseases, and viral infections. Nano-medicine has the potential to improve follow-up care by enabling earlier diagnosis, better therapy, and more cost-effective treatments. Nano-medicine will enable offer a more tailored treatment for many ailments, using the in-depth understanding of diseases on a molecular level.

Lalit Kumar and others described in their article "Nanotechnology: A magic bullet for HIV AIDS treatment" that systems built on nanotechnology have the capacity to offer a logical strategy for HIV treatment. Studies on in vitro and animal in vivo systems based on nanotechnology show that these systems may enhance medication therapy in infected individuals. By lowering their toxicity and streamlining drug regimens, they were able to increase the anti-HIV activity of various medications. These techniques, which prolong medication levels in places that are known to be HIV reservoirs, can result in superior viral suppression. They might therefore resemble a magic bullet that only kills HIV. In addition to helping with the treatment of AIDS and other viral diseases, the development of drug delivery systems will hasten the development of systems for bacterial diseases, fungi, and mycobacteria. The viability of scaling up methods to quickly bring revolutionary therapeutics to market and the potential for getting multifunctional systems that will be able to satisfy the many biological and therapeutic needs are, thus, significant challenges for the future of drug delivery systems.

III. METHODOLOGY

3.1 Nanorobots Performing Operation on Blood Cells

HIV can be resisted by Zidovudine, however the virus cannot be eradicated. Nanorobots can be used to destroy viral genomes. A data converter, a container containing highly concentrated (say 20 u/microlitre) DNase and RNase enzymes, and a nanobiosensor created by nanoelectronics experts make up this type of nanorobot. By using a Nanorobot to change the AIDS-affected WBCs back into their original form, the patient is made to have a constant amount of immune system. The HIV process is reversed by the nanorobot.

3.2 Reason for Using Nanorobots

The majority of animal cells have a diameter of 10,000 to 20,000 nanometers. In order to interact with DNA and proteins, nanoscale devices (having at least one dimension less than 100 nanometers) can now enter cells and the organelles that reside inside them. With the help of nanotechnology, numerous diagnostic tests may be performed concurrently and with increased sensitivity. The development of nanotechnology may enable the detection of disease in very few cells or tissues. In general, nanotechnology may provide a quicker and more effective way for us to complete many of our current tasks.

3.3 Components of the Nanorobots

- Payload- A little amount of medication or a substance is stored in this empty space. The medicine might be released by the nanorobots as they go through the blood to the infection or injury location.
- Micro camera- A tiny camera might be incorporated into the nanorobot. When moving through the body manually, the operator can control the nanorobot. By harnessing the electrolytes in the blood, the electrode attached on the nanorobot may create a battery.
- Electrodes- By creating an electric current and heating the damaged cells to death, these projecting electrodes could likewise destroy the damaged cells.
- Swimming tail- As they move against the body's blood flow, nanorobots will need a means of propulsion to enter the body.

The nanorobot will contain manipulator arms or a mechanical leg for mobility in addition to motors for movement. Positional assembly and self-assembly are the two basic techniques used in nanorobot manufacturing. In self-assembly, the molecules are manually assembled using the arm of a tiny robot or a microscopic set. In positional assembly, researchers will group billions of molecules and then allow them to spontaneously assemble into the appropriate configuration based on their natural affinities. Software called Nanorobot Control Design was created to simulate how nanorobots will behave in a fluid environment where Brownian motion would predominate. The target molecules can be found by the nanorobots' chemical sensors. Swarm intelligence is offered to the nanorobots for decentralized action. Swarm intelligence algorithms are those created for nanorobot artificial intelligence in which work is completed collaboratively without centralized control.

3.3.1 Onboard computers of Nanorobot

- Power System- The human body's glucose molecules serve as the nanorobots' power source.

- Nano Logic Processor- It addresses the fundamentals for operating medical devices by including the primary sensing, actuation, data transmission, uploading of remote controls, and connecting power supply subsystem.

- Sensors- Nanorobots will be equipped with molecular recognition sites, gravity, position/orientation sensors, electromagnetic, magnetic, and optical sensors. The nanorobots will additionally be equipped with DNA sensors.

- DNA Sensor- The cantilever style DNA sensor is used. The actual sample is inserted in one arm, and the WBC sample is placed in the other. It can be identified even if there is only one base difference between the samples. NTNFETs (carbon nanotube network field-effect transistors) serve as specialized DNA immobilization and hybridization detectors.

- Antenna Interface- A transponder device attached to the object is part of a system for tracking an object in space. A transponder circuit receives an RF (radio frequency) signal through one or more transponder antennas on the transponder device. The transponder device produces an RF response for transmission through the transponder antenna by adding a known delay to the RF signal. This aids in positioning control for nanorobots.

- RNA Converter- It modifies the HIV virus's RNA.

- Actuator- It is a tool that pumps fluids at the nanoscale and opens and closes valves. It is employed in this model primarily to give the nanorobot translational mobility.

3.4 Approaches

There are two approaches used to create nanorobots.

- Top Down Approach
- Bottom Up Approach

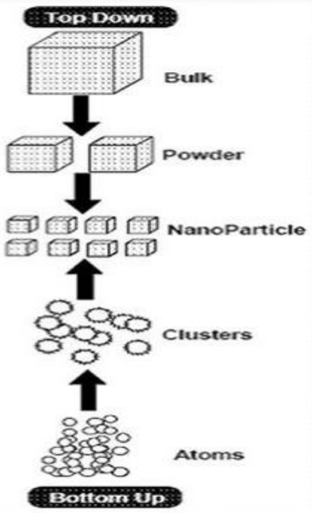

Fig-1: Different approaches for building of nanorobot

The bottom-up technique is the one that is most frequently used while making anti-HIV nanorobots. It entails putting together structures that will be helpful in producing the devices, atom by atom or molecule by molecule.

3.5 Introduce the Device into the Body

The nanorobots must be introduced into the body and given access to the operation location without inflicting too much collateral damage. We have already decided to enter through the circulatory system, but there are still a few things to take into account.

The size of the nanorobots should first determine the smallest blood vessel that it can pass through. It shouldn't harm the blood vessel's walls and shouldn't be overly blocked, since this could hinder efforts to prevent the condition we're trying to treat in the first place by either causing a clot to form or simply slowing or stopping blood flow. Naturally, this implies that the better Nano-machine is one that is smaller. This must be weighed against the fact that a larger Nano-machine can be more adaptable and efficient. This is crucial since using numerous machines, even if they don't interfere with one another, greatly increases the difficulty of external control difficulties.

Second, we can introduce it into the body without causing too much initial damage. In order to access the majority of the body's parts quickly, we need to obtain access to a large diameter, easily traversable artery. The femoral artery in the leg is the obvious contender. It will work well for our objectives because this is the typical point of access to the circulatory system for procedures requiring bloodstream access for catheters, dye injections, etc.

3.6 Process

The biosensor's job is to recognize a certain substance. In this instance, a specific antibody will be present in the biosensor. The cell membrane of an infected cell has two distinct HIV envelope proteins called gp41 and gp120. The appropriate signal will be provided by the antigen (the proteins gp41 and gp120) and antibody response. Because those viral proteins are only present in the cell membrane of infected cells, this response will only occur in the case of infected cells. After the nanorobot receives the positive signal, it will inject its nanotube into the infected cell's nucleus and release the DNase and RNase enzymes. The viral genome is present throughout the entire genomic DNA, which the DNase enzyme will break into single nucleotides because it is not sequence-specific. The viral genome loses its sequence when it loses its ability to replicate, and after the entire genomic DNA has been digested, the cell goes through a natural process of programmed cell death known as apoptosis. As a result, the diseased body's infected cells can be eliminated in order to complete the viral genome there.

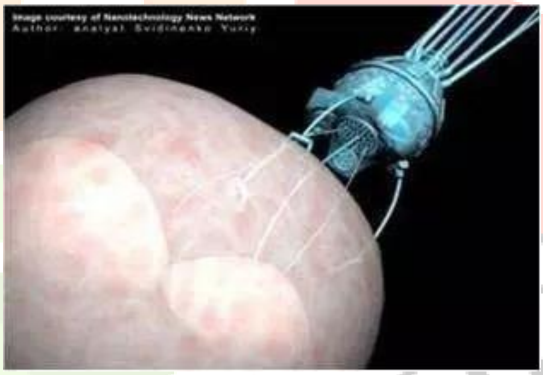

Fig-2: Blood cell manipulation via a nanorobot

3.7 Challenges faced by Nanorobots

There should be a greater grasp of how matter interacts on this small a scale while creating nanoscale nonorobots. On the nanoscale, matter behaves differently than it does at higher scales. Thus, it is important to watch how the nanorobots behave so they do not harm humans both within and outside of the body.

3.8 Structure

Two slots in the structure of the nanorobot will be:

- Interior: It will be a sealed, vacuum environment, and outside liquids won't often be able to get in unless it's necessary for a chemical analysis.
- Exterior: In our body, it will be exposed to several chemical solutions.

3.9 Requirements of the Nanorobot

- It should be extremely tiny to prevent interference with blood capillary flow.
- The WBC shouldn't have an impact on it.
- It should only be able to detect WBC that is HIV-positive, and it should only act on those WBC.
- It should work on the RNA to convert it back to the WBC's original DNA by appropriately replacing the nucleotides like adenine and guanine.
- It should quickly transform the contaminated WBC back into the original WBC.
- It should be made of more affordable materials so that the patient may easily afford it.

IV. System Analysis

4.1 Existing System

There isn't yet a system for treating HIV with nanorobots that has been given the green light for clinical use. Nanorobots, however, might be a promising approach for the treatment of HIV, according to some encouraging investigations and experiments.

A 2018 study that appeared in the journal Nature Communications described the creation of a nanorobot that could recognize and eliminate HIV-positive cells in vitro. A gold nanorod coated with a peptide that binds to the CD4 receptor on the surface of HIV-infected cells served as the basis for the nanorobot. Near-infrared light was utilized to activate the nanorobot once it had adhered to the diseased cell, which heated up the gold nanorod and killed the cell.

Another study that was presented in the 2019 issue of the journal ACS Applied Materials & Interfaces described the creation of a nanorobot that could transport a medication cocktail directly to HIV-positive cells. The magnetic core of the nanorobot was covered in a coating of silica, which was then covered in a layer of chitosan. The medications were enclosed in the chitosan layer and released in reaction to adjustments in the pH levels of the HIV-infected cells.

Despite the fact that these studies show the potential of nanorobots for the treatment of HIV, further study is required to improve these systems, assess their security and effectiveness in animal models, and finally, conduct clinical trials. Also, before these technologies could be deployed in the treatment of HIV patients, regulatory approval from health organizations would be necessary.

4.2 Proposed System

Targeted drug delivery and gene editing may be combined in a system for treating HIV that uses nanorobots. The system would consist of nanorobots with the specific objective of locating and eliminating HIV-infected cells while safeguarding healthy cells.

The nanorobots might be programmed to detect particular markers, such the CD4 receptor or the HIV envelope protein, on the surface of cells that have contracted HIV. A payload of medications that are hazardous to the virus or the infected cell itself may be released by the nanorobot once it has bound to the infected cell. This would aid in lowering the patient's body's viral load and controlling the disease's progression.

The nanorobots could be utilized to deliver gene editing tools to HIV-infected cells in addition to drugs. CRISPR/Cas9 and other gene-editing techniques can be utilized to eradicate the HIV virus from infected cells. These gene editing tools might be designed to be carried by the nanorobots and delivered right to the infected cells, where they could be utilized to eradicate the virus.

Before clinical trials could start, substantial research in animal models would be required to ensure the safety and efficacy of this suggested technology. In order to properly target and eliminate HIV-infected cells without damaging healthy cells or having unfavorable side effects, the system would also need to be adjusted. Prior to being employed in the treatment of HIV patients, this system would also need regulatory approval from health organizations.

4.3 Scope of Future Research

While being in its early phases, research on the application of nanorobots to the treatment of HIV has produced some encouraging findings. Future research on anti-HIV nanorobots may focus on a number of topics, including:

- Creation of nanorobot platforms: A variety of nanorobots are available that can administer medications or target particular cells in the body. The development of nanorobots that are intended to target and combat HIV may be the main area of study.

- Enhancing drug delivery: The ability to target nanorobots for drug administration to particular cells or tissues is one of their key benefits. The efficacy of drug delivery to HIV-infected cells could be improved while the toxicity to healthy cells is reduced, according to research.

- Increasing specificity: HIV-infected cells could be the only cells that nanorobots target, omitting healthy cells. Researchers could lower the possibility of side effects and improve treatment outcomes by increasing specificity.
- Creating novel therapeutic approaches: Researchers could investigate novel therapeutic approaches that nanorobots might be used to deliver. For instance, they could look into the possibility of using gene editing instruments to eradicate the HIV virus from affected cells.

Thorough safety and efficacy testing must be completed before any anti-HIV nanorobots are authorized for clinical usage. To assess the efficacy and safety of these new medicines, researchers might design standardized testing techniques.In general; there is still a lot to learn about using nanorobots to treat HIV. Yet, further study in this area might result in the creation of fresh, more potent treatments for HIV patients.

V. ADVANTAGES

- This terrifying illness affects more than million people worldwide. There isn't right now.
- There is a permanent vaccine or treatment for the illness. Currently accessible medications can.
- The creation of this nanorobot will shorten the patients' lives to just a few years, causing them to recover from their illness.
- There are no adverse effects because the nanorobot does not produce any hazardous activity. It only functions at a specified location.
- Even if the initial cost of development is high, producing in batches lowers that cost.

VI. DISADVANTAGES

- If the nanorobot is not extremely exact, hazardous impacts could result.
- The price of the initial design is relatively costly.
- This nanorobot's design is extremely intricate.

VII. CONCLUSION

The study merely provides a theoretical defense. Yet, new developments in nanotechnology raise the possibility of using this technology successfully in the medical sector. We could anticipate future advancements in the Nano period, such as an AIDS treatment employing nanotechnology.

In conclusion, the use of nanorobots in the fight against HIV has shown promising results. Nanorobots are capable of delivering drugs directly to infected cells, thereby increasing the effectiveness of treatment and reducing side effects. Moreover, the use of nanorobots can help to overcome the limitations of current antiretroviral therapy, such as drug resistance and poor drug distribution.

Several types of nanorobots have been developed for HIV treatment, including liposomes, dendrimers, and carbon nanotubes. Each type of nanorobot has unique advantages and limitations, and further research is needed to optimize their design and efficacy.

Overall, the use of nanorobots in HIV treatment is a rapidly evolving field, and holds great promise for improving the lives of millions of people affected by this devastating disease. Further research and development in this area is crucial for realizing the full potential of nanorobots in HIV treatment.

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