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NANOTECHNOLOGY'S ROLE IN CANCER TREATMENT A REVIEW

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Abstract-

The study, design, fabrication, synthesis, manufacture, and application of nanoscale materials, devices, and systems are known as nanotechnology. Nano is derived from the Greek word dwarf. One billionth of a meter, or 109 m, is a nanometer. Because of the prominence of particles in this range, they can have unique and better properties as compared to bigger materials. Nanomaterials are distinguished from ordinary materials by their increased surface area and quantum effects. It's still difficult to deliver anti-cancer medications to cancer cells specifically. Conventional therapy has failed to appropriately treat cancer due to drug availability, unfavorable side effects, and drug resistance. Nanotechnology holds a lot of promise for revolutionizing how doctors diagnose and treat cancer patients. Nanotechnology is already having a substantial impact on patient care, posing major future problems such as improving the design and engineering of cancer-targeting materials. One of the most terrible diseases of our day is cancer. A world in which millions of people are killed every year. cancer, uncontrolled apoptotic cell proliferation It frequently vanishes and necessitates a lengthy procedure. It demonstrates clinical variability and treatment resistance because of its genetic and phenotypic complexity. In recent years, a lot of work has been put in. Dedicated to creating nanotechnology to improve and decrease anticancer drug delivery to tumor tissue, as well as the distribution and toxicity of anticancer treatments in healthy tissues. Much has changed. Polymers Nanoparticles, liposomes, dendrimers, nanoshells, carbon Nanotubes, superparamagnetic nanoparticles, and nuclei Acid-based nanoparticles are examples of innovative nanotechnology platforms.

Index Terms **-** Nanotechnology, Chemotherapy, cancer, Nanomaterials, Tumor.

INTRODUCTION-

Nanotechnology is the research, design, manufacture, synthesis, manipulation, and application of materials, devices, and systems on the nanometer scale. The prefix nano comes from the Greek word dwarf. One nanometer is one-billionth of a meter or 109 m. The importance of particles in this range means that they can have different, improved properties compared to the same material of larger size. Increased surface area and quantum effects are the two main factors that distinguish nanomaterials from other materials.

These two factors can improve properties such as reactivity, strength, electrical properties, and in vivo behavior [1].

The definition of nanomedicine differs slightly between the National Nanotech Initiative in the United States and the European Science Foundation and European Technology Platform. The former refers to the nanoscale, while the latter does not. According to the National Nanotech Initiative in the United States, "Nanotechnology is the understanding and control of matter at dimensions of approximately 1 to 100 nanometers, a unique phenomenon that enables new applications. Nanotechnology is nanoscale. Includes science, engineering, and technology in, and includes imaging, measurement, modeling, and manipulation of substances on this length scale. Nanomedicines are the application of nanotechnology to medicine. [2]

However, the European Science Foundation describes nanotechnology as follows: "The field of nanomedicine is science and technology that uses molecular tools and molecular knowledge of the human body to diagnose, treat, prevent, relieve pain, and maintain and improve human health. Europeans. Nanomedicine technology the platform describes nanomedicine as follows: "Nanomedicine is defined as an application of nanotechnology to health. It is an improved and often new physical, the material on the nanometer scale. Utilizing chemical and biological properties, nanomedicines have potential impacts on disease prevention, early and reliable diagnosis and treatment. The main field of nanomedicine is drug delivery. In vitro, Vivo, in vivo diagnostics; regenerative medicine; and embedded devices including imaging. Nanomedicines have the potential to revolutionize our ability to study, diagnose and treat diseases ranging from cancer to cardiovascular disease to diabetes [3].

Cancer is one of the most deadly diseases of our time A world that kills millions of people each year. cancer, Uncontrolled proliferation of apoptotic cells It disappears a lot and requires a very complicated process. Due to its complexity at the genetic and phenotypic levels, it exhibits clinical diversity and therapeutic resistance. Much effort has been made in recent years Dedicated to developing nanotechnology to enhance and minimize the delivery of anticancer drugs to tumor tissue Distribution and toxicity in healthy tissues [4]. Much has evolved Innovative nanotechnology platforms such as polymers Nanoparticles, liposomes, dendrimers, nanoshells, carbon Nanotubes, superparamagnetic nanoparticles, and nuclei Acid-based nanoparticles [5]

NANOTECHNOLOGY & NANOMETER CONCEPT-

Nanotechnology is the creation of useful materials, devices, and systems used to manipulate substances. The incredibly small scale is between 1 and 100 nanometers. Nanometers are one billionth of the width of human hair or about 10 times the diameter of a hydrogen atom. Nanotechnology is also making rapid progress in terms of in vivo imaging and treatment. This advancement has the potential to have significant implications for the treatment of cancer patients shortly. Recent advances in nanoscale technology have led to the development of a variety of new and new nanodevices (quantum dots, nanoshells, gold nanoparticles, carbon nanotubes) currently being studied [6].

NEEDS OF NANOTECHNOLOGY/ NANOMEDICINE IN CANCER THERAPY-

Nanoscale devices can easily interact with biomolecules on the surface and inside the cell due to their small size. It can identify and treat disease since it has access to so many parts of the body. It contains a slew of novel cancer-treatment suggestions. This study focuses on the emerging role of these new platforms in cancer imaging and treatment. Nanoparticles have been targeted to tumor locations using two methods: active targeting and passive targeting. Linking ligands to tumor-specific nanoparticles are known as active targeting. The size of nanoparticles and the particular features of tumor vasculature allows passive targeting of nanoparticles [7]. A fundamental obstacle in cancer treatment is targeted localized delivery. Many anti-cancer drugs are often designed only to kill cancer cells semi-specifically, so there is a risk of severe side effects, so anti-cancer drugs for healthy organs and tissue distribution are particularly undesirable [8]. As a result, systemic use of these medications frequently results in major adverse effects in other tissues, limiting the drug's maximum permitted dose. Furthermore, quick clearance and widespread distribution to untargeted organs and tissues necessitate high therapeutic doses, which are typically unaffordable and compounded by non-specific toxicity. This A fundamental drawback of current cancer treatments is the vicious circle of high doses and related toxicity. Drug-toxic side effects are often reported to kill patients far faster than tumor loading [9].

THERE ARE SEVERAL NANOTECHNOLOGY SYSTEMS ACCESSIBLE FOR CANCER THERAPY-

Polymeric NPs, liposomes, dendrimers, nanoshells, carbon nanotubes, and superparamagnetic NPs are some of the most common nanotechnology platforms for cancer treatment. Due to their small size and diverse structural and physicochemical (EPR) properties, these nanotechnology platforms can penetrate tumor blood vessels with improved permeability and retention. Tumor cells can also be targeted using cancer-specific targeted moieties (antibodies, ligands, lectins, etc.) [10].

Carbon nanotubes-

Carbon nanotubes are the molecular morphology of carbon first discovered in the late 1980s [11]. Carbon nanotube applications are of great interest in many industries, as they are touted for being 100 times stronger than steel, only one-sixth the weight, and exhibiting excellent thermal properties and conductivity. [12] Carbon nanotubes, like the nanoshells described above, have been used primarily to deliver DNA payloads to cells and treat cancer for thermal ablation therapy [13].

Nanoshells –

Polymeric nanoshells (20–60 nm) of D-block copolymers can be assembled layer by layer as NPS Self-assembly of oppositely charged polymers to form a core/shell structure can be achieved [14]. Nanoshells with a silica core diameter of 120 nm and a 10 nm layer of the gold shell are the most beneficial because they absorb near-infrared (NIR) light at 800 nm and can generate tremendous heat that is fatal to cells. Because tissue chromophores do not absorb much energy in the NIR range, this NIR light can penetrate many centimeters of human tissue without causing injury [15]. The advantage of the nanoshell-mediated

technique is that the energy can pass through healthy tissue, leaving nearby cells unharmed while only killing tumor cells targeted by nanoshells [16].

Dendrimers-

Dendrimers, which are uniformly dispersed complex molecules with branched architecture, have been widely investigated nanocarriers. Because dendrimers have a hydrophobic core and a hydrophilic surface, they can transport both hydrophobic and hydrophilic medicines [17]. The generation number, chemical composition of the core and branches, as well as a surface functional group, all influence the size, shape, and pharmacokinetics of dendrimers. Dendrimer pharmacokinetics and biodistribution can also be considerably altered by chemical change. Solubility enhancement, photodynamic therapy, drug delivery, bioimaging, cancer treatment, and 3D nanoscale coreshell constructions are just a few of the applications for dendrimers. At the same time, multivalent dendrimers interact with several drug development targets. Dendrimers are spherical polymers, typically less than 5 nm in diameter. Their main useful feature is polymer branching, which provides a large surface area to which therapeutic agents and target molecules can be attached. A typical dendrimer begins with the core of ammonia (NH3), which reacts with acrylic acid to form triacid molecules. [18].

Polymeric Nanoparticles-

Natural or synthetic polymers are used to make polymer nanoparticles. To obtain the desired drug delivery efficacy and therapeutic impact, nanoparticles can be made from a range of biodegradable or non-biodegradable polymers. Biodegradable polymer nanoparticles, for example, have offered regulated, sustained, and targeted anti-cancer medication delivery. The most successful nanotechnology platform, polymer nanoparticles, has emerged as a versatile delivery mechanism for the targeted administration of anticancer drugs [19]. High molecular weight nanoparticles can deliver low molecular weight drugs and macromolecules such as genes and proteins. Poly (D, lactide coglycolide) nanoparticles, potent protease inhibitors (cystatins), and cytokeratin-specific systems. Monoclonal antibodies have been reported. It can neutralize the activity of excessive proteolysis to prevent the potential for metastatic and infiltrative breast tumor cells. Binding, grafting, and adsorption of hydrophilic polymers such as polyethylene glycol (PEG) are commonly used to stabilize the nanoparticle surface or to achieve active targeting. Copolymer regulation and folic acid conjugation can improve the stability of self-assembly in aqueous media and the in vivo tumor site selectivity of copolymers based on ring-opening metathesis polymerization [20].

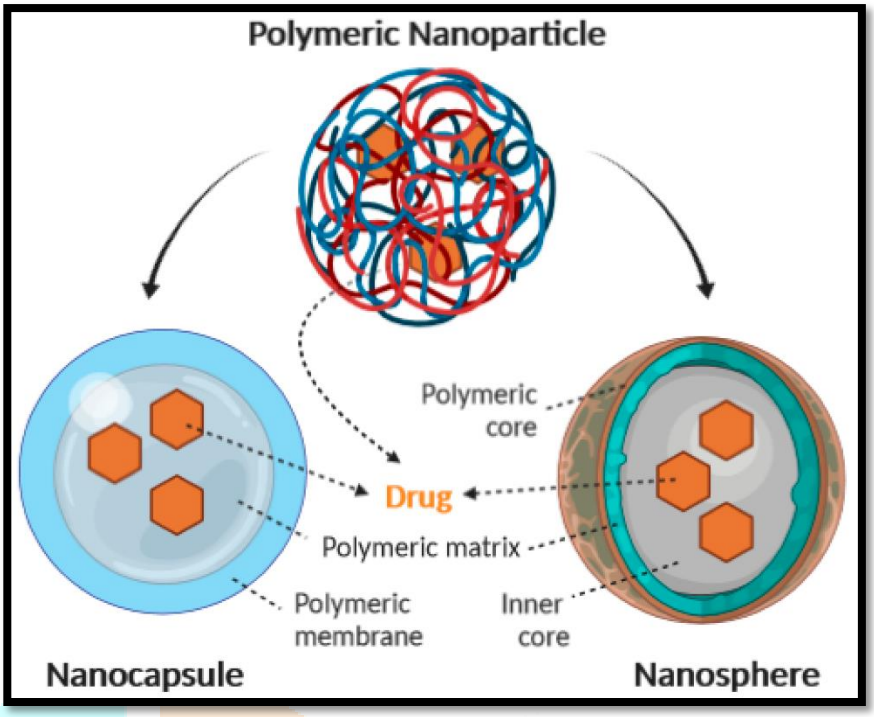

Fig no 1- Diagrammatic representation of nanoparticles

Liposomes-

As closed round vesicles, liposomes include a lipid bilayer that encapsulates an aqueous section to keep drugs. With the size (90150 nm) that is barely larger than the traditional definition (≤one hundred nm), liposomes do now no longer represent novel nanotechnology, however, a huge part of them are related to nanotechnology research. Forming lipid bilayers via hydrophobic interaction, liposomes are taken into consideration terrific structures for the shipping of hydrophobic and hydrophilic drugs. In particular, liposomes gift sizable endurance withinside the blood [21]. It facilitates efficient drug delivery to the target tissue. Different lipids have different fatty acid chain lengths, headgroups, and melting temperatures. Therefore, temperature 46 or pH-sensitive liposomes can be constructed by manipulating the formulation. We evaluated the efficacy of 1-methylxanthine (1MTX) as a radiosensitizer and the in vivo efficacy of temperature-sensitive liposome 1-methylxanthine (tslMTX) in combination with topical hyperthermia and ionizing radiation [22]. Intraperitoneal injection of use MTX suppressed tumor growth in a mouse xenograft tumor model. In addition, the combination of tslMTX with local hyperthermia and ionizing radiation suppressed tumor growth. To target leukemic cells, pH-sensitive immunoliposomes (ILs) containing terminal-alkylated N-isopropyl acrylamide (NIPAM) in the bilayer have recently been bound to anti-CD33 monoclonal antibodies [23].

pH-sensitive ILsCD33 immunoliposomes are highly cytotoxic to HL60 cells, suggesting that pH-sensitive immunoliposomes may be beneficial in the treatment of acute myeloid leukemia (Fig. 1). Commercially available liposomes have already been approved by the US FDA. A good example is a liposome-encapsulated in doxorubicin (doxorubicin), which exhibits potent antitumor activity against a variety of cancers [24].

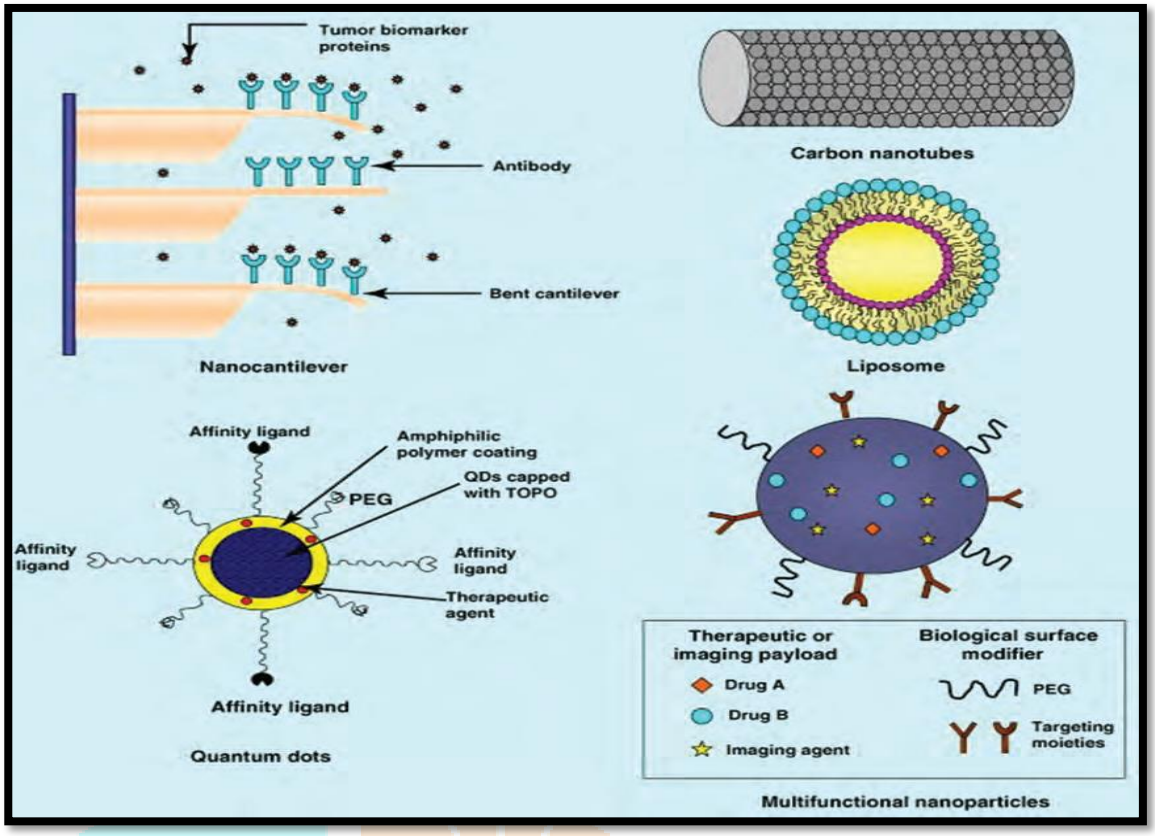

Fig no 2- liposome treat the cancer tumor [25]

Novel Cancer Therapy-

Cancer treatment that targets only cancer cells while sparing healthy cells is gaining popularity. Nanotechnology has brought in more precise cancer therapy materials and techniques. Advanced cancer therapy methods based on nanotechnology, such as photodynamic therapy (PDT), irradiation, and radiofrequency therapy, as well as agnostics, are allowing for the novel, noninvasive cancer therapeutic strategies that were previously unavailable (Fig. 2). Cancer cells can now be targeted while healthy cells remain unaffected by these new technologies. As a result, cancer cells die, while healthy cells live. [6].

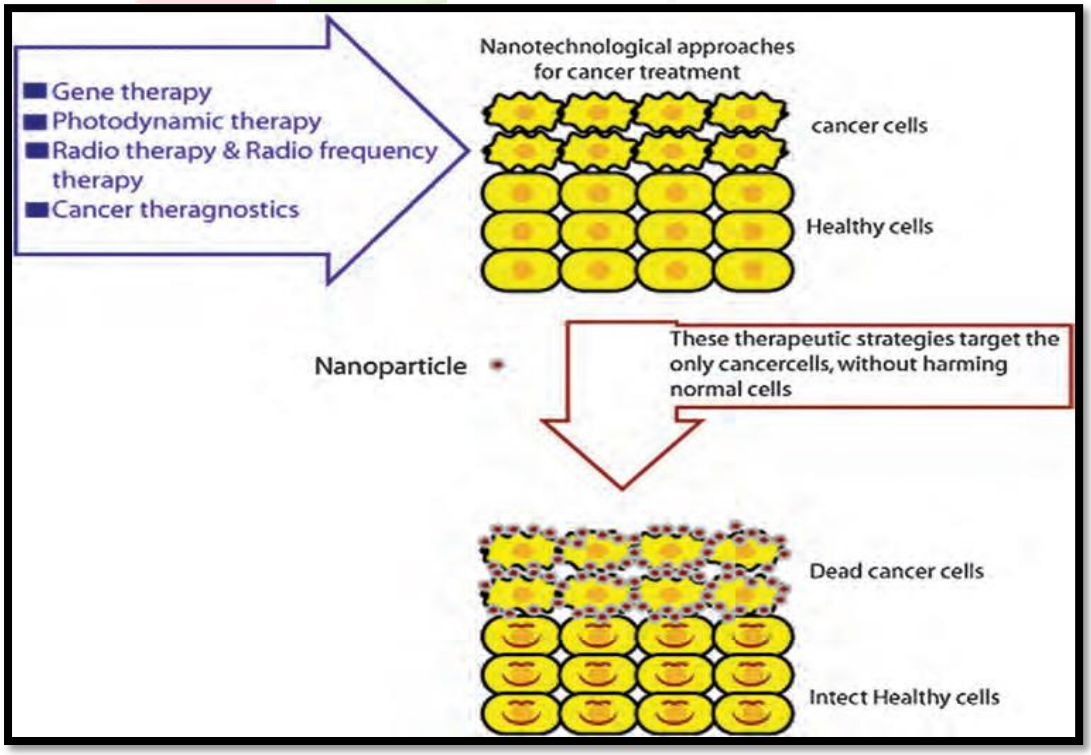

Fig no 3- The flow of Novel Cancer Therapy.

GENE THERAPY USING NANOTECHNOLOGY-

Gene therapy is based on the concept that certain exogenous genes can be integrated into the genome of tumor cells to achieve a tumor-killing effect. It is one of the fastest-growing areas of preclinical and clinical cancer research [26]. Viral vectors, traditionally the primary means used to deliver genes to target cells, pose a serious immune and inflammatory response risk to the host. Problems related to viral vectors are toxicity, immune and inflammatory responses, genetic regulation, and targeting. Also, there is always a risk that the virus will recover and become ill. To overcome this, there is great interest in non-virus-mediated gene transfer technology. The advantage of using a non-viral vector is that it is non-toxic and can be repeated at a very low cost with a low immune response [27].

Liposomal-mediated cationic polymers and nanoparticles are the most commonly used non-viral vectors. Physical properties such as nanoparticle shape, size, charge density, and colloidal stability are important factors in determining its overall effectiveness as a non-viral gene delivery medium. Jere et al. Succeeded in delivering a biodegradable nanopolymer carrier loaded with small interfering Akt1 RNA to cancer cells, resulting in the silence of the Akt1 protein and reduced cancer cell viability, proliferation, malignancy, and metastasis [28].

RADIOFREQUENCY THERAPY AND NANOTECHNOLOGY-BASED RADIOTHERAPY

Increased radiation doses from high atomic number (Z) materials have long been of interest. It has been reported that loading a high Z material into a tumor result in greater photoelectric absorption within the tumor than in the surrounding tissue, which may increase the dose applied to the tumor during radiation therapy. To be clinically useful, radiosensitizers and/or dose enhancers should significantly increase the therapeutic ratio, be readily available, easy to use, and non-toxic. Gold (Au; Z = 79) Or nanogold (gold nanoparticles) have shown dose-increasing effects in cell experiments and mouse models [29]. Gold nanoparticles have been actively studied in a variety of biomedical applications due to their biocompatibility and easy binding to biomolecules. Investigation of dose-increasing effect and lethality of gold nanoparticles in combination with a single-dose electron beam in B16F10 melanoma-bearing mice. Although radiofrequency ablation has been used in the treatment of cancer, cardiac conduction abnormalities, and nerve damage, it is the most commonly used in cancer therapies. letter [30]. Unresectable malignant liver damage is the most common tumor treated with this procedure. A radiofrequency ablation is an established approach to destroying tumors that traditionally involves the insertion of probes into the tumor; however, nanotechnology allows the development of non-invasive radiofrequency ablation methods. In vitro and in vivo studies have revealed that gold nanoparticles improve cancer cell death in non-invasive radiofrequency fields. Gold nanoparticles could be used to target cancer cells specifically. The heated tissue and cancer cells in vitro and in vivo using novel non-invasive radiofrequency equipment and gold nanoparticle-enhanced solutions [31].

Nucleic Acid-Based Nanoparticles-

Gene therapy is the direct delivery and expression of DNA into diseased cells for therapeutic purposes. (DNA, RNAi, and ASO) The chlorotoxin peptide (CTX) is bound to DNA complexing polyethyleneimine (PEI) in the nanoparticles and then functionalized with the Alexa- Fluor 647 near-infrared mover to yield a neutral nanocarrier ligand space [32]. In vitro and in vivo gene delivery to colon and liver cancer cells was confirmed using mixed nanoparticles consisting of 4th generation poly(amidoamine) (PAMAM) dendrimers and 4th generation poly(amidoamine) dendrimers (PAMAM). 5 and plasmid DNA [33]. RNAi and ASO therapy use oligonucleotides to block the expression of target genes to treat the disease. Poly (propylene imine) (PPI) dendrimers were first used to generate RNA nanoparticles.

NANOTECHNOLOGY AS A TOOL FOR COMBINATION THERAPEUTICS-

Chemotherapy resistance is an important clinical problem that limits the effectiveness of drug cancer treatments. Due to microenvironmental selective pressure, tumor cells can induce multidrug resistance (MDR). The MDR of cancer cells refers to their ability to recover against drugs that are functionally and structurally independent. Mechanisms of MDR include sequencing, increased drug efflux, decreased drug efflux, altered binding site, activation of detoxifying enzymes, blockade of apoptotic signaling, and DNA repair.108 To overcome MDR, Nanotechnology for combination therapies has attracted increasing attention in recent years. . Drug delivery combines various modulations (eg, regulation of drug outflow, apoptotic threshold, and intracellular pH) and energy therapies (eg, ultrasound, hyperthermia, and photodynamic therapy) has shown great promise in improving the treatment of multidrug-resistant cancers [34].

Table no 1- Nanomedicine for anti-cancer therapy

Sr. NO	Trade name	Compound Nanocarrier	Nanocarrier	Reference
1	Abraxane	Paclitaxel	Albumin bound paclitaxel	[35]
2	Daunoxome	Daunorubicin	Pegylated Liposome	[36]
3	Doxil	Doxorubicin	Pegylated Liposome	[37]
4	Bexxar	Anti-CD20 conjugated to idodine131	Radioimmunoconjugate	[38]
5	Zevalin	Anti-CD 20 conjugated to yttrium-90	Radioimmunoconjugate	[39]
6	Zoladex	Goserelin	Acetate Polymer rods	[40]
7	Most	Doxorubicin	Non-pegylated liposome	[41]

CHALLENGES OF NANOTECHNOLOGY IN CANCER TREATMENT-

Nanotechnology has many advantages in cancer treatment. With its small size, the nanotechnology platform can penetrate the tumor's blood vessels through EPR. In addition, functionalization with hydrophilic polymers/oligomers can provide long cyclic half-lives and prolong exposure of tumor tissue to antineoplastic agents; While the introduction of tissue-recognizing residues, such as antibodies, lectins, and cancer cell-specific ligands, can help nanotechnology platforms achieve tumor cell targeting. To overcome cancer cell MDR, a major challenge, cancer therapies are ineffective, and combinations of multifunctional nanotechnology platforms and other therapies have been developed and achieved considerable success. However, the development and application of nanotechnology platforms in cancer treatment still face many challenges such as limited knowledge of cancer cell physiology, diverse and poorly functional medical nanomaterials. ability, lack of clinical evaluation criteria. However, with new advances in functionalization based on a profound understanding of the physiology of cancer cells, nanotechnology platforms hold the promise of fundamentally changing cancer practice, allowing Simple and effective targeted therapy [42].

CONCLUSION-

Delivering anti-cancer drugs specifically to cancer cells remains a major challenge. Due to drug availability, undesirable side effects, and drug resistance. Nanotechnology has great potential in radically improving current methods of diagnosing and treating patients with various types of cancer. Nanotechnology is already beginning to have a significant impact on the treatment of patients by raising major challenges for the future, including optimizing the design and engineering of cancer-targeting materials. To realize the potential of nanoparticle strategies, a better understanding of tumor-specific, tumor-site, and host-specific factors influencing the delivery of nanomaterials specifically to sites is needed. cancer cell. Because of their appropriate size and surface chemistry, which allows conjugation with bioactive molecules, several NPSs are being investigated to provide more effective targeted chemotherapeutic agents. Liposomal and protein-based nanomedicine formulations are already in clinical use, and many new formulations are in phase 2 and phase 3 evaluations. The future of nanomedicine will undoubtedly provide innovative platforms. for cancer treatment, and the research presented here may improve the overall reception of cancer treatment with NPS.

CONFLICTS OF INTEREST-

There are no conflicts of interest and disclosures regarding the manuscript.

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