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APPLICATION OF PACLITAXEL IN MODERN ONCOLOGY WITH NANOMEDICINE-BASED CANCER THERAPY

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Abstract: One popular anticancer medication is paclitaxel having a distinct mode of action. That's thought as among the most effective naturally occurring anti-cancer medications accessible. The article describes current developments in our knowledge of paclitaxel's genesis, anticancer activity, and production process. In light of the development of nanotechnology improvement in the innovative medication treatment. Recently paclitaxel assumes a significant role in the broad-spectrum cancer treatment.

Keyword- Paclitaxel, Nanotechnology, Nanomedicine

I. INTRODUCTION

The disease known as cancer is defined by the body's own cells proliferating and spreading abnormally. Cancer remains one of the world's greatest drivers of mortality, and during the past 10 years, much research has been conducted to find new treatments that could lessen the side effects of those that are now accessible. Therefore, developing accurate and effective treatments requires a thorough understanding of these intricate events. Different sorts of cells make up the body. In order to create the new cells needed to maintain the body's health, these cells divide and expand under control. Cells die and are replaced by new ones when they age or get damaged. It is an organized process, yet occasionally something goes wrong. Normal cell growth and division can be disrupted by damage to a cell's genetic code or DNA, leading to mutations. Typically, tumors are viewed as a whole cell population and cancer is treated as a single, universal disease. During cancer progression, tumors become highly heterogeneous, creating a mixed population of cells characterized by different molecular features and diverse responsivity to therapies. This heterogeneity can be appreciated both at spatial and temporal levels and is the key factor responsible for the development of resistant phenotypes promoted by a selective pressure upon treatment administration

[1]. Typically, tumors are viewed as a whole cell population and cancer is treated as a single, universal disease. Therefore, developing accurate and effective treatments requires a thorough understanding of these intricate events.

[2] In recent years, various cancer treatments have been created. Surgery and radiation therapy are the cornerstones of cancer treatment, and these are followed by a variety of specialized procedures such immunotherapy, hormone therapy, radiotherapy, chemotherapy, and specific therapy. [3].

Targeted medicines that offer many benefits are preferred to conventional therapy [4]. They specifically halt the proliferation and development of cancerous cells [5]. They achieve controlled release of the targeted agent, site-specific delivery, and accumulate in tumors sites, all of which are indicative of their selective targeting profile. More effective, focused treatments cause fewer systemic side responses because they lessen the need for large dosages of chemotherapy [3].

By enhancing the bioavailability and concentration of traditional chemotherapeutic medicines surrounding cancer tissues and modifying their release profile, nanomedicine provides a flexible platform of biocompatible and recyclable technologies that can be used to deliver these treatments in vivo [2]. One can use nanoparticles for a variety of purposes, from treatment to detection. [2]. Treatment outcomes for complex and lethal diseases have been greatly enhanced by using the technique of nanomedicine, or the fusion of nanotechnology and medicine, in disease diagnosis, monitoring, and treatment by maintaining the therapeutic dose at the target site.

For the treatment of lung cancer, breast cancer, and ovarian cancer, paclitaxel nano-formulations have shown effective in clinical settings thus far [6]. This narrative review article described the state of ongoing pharmaceutical research and the use of nanotechnology to enhance the pharmacokinetic and pharmacodynamic characteristics of paclitaxel as a chemotherapeutic drug. With an emphasis on their therapeutic usefulness in the targeted treatment of cancer cells in a variety of tumour types, this review highlights recent findings about the safety and toxicity of paclitaxel nanoparticles.

II. CANCER:

Malignant cells proliferate uncontrollably and irregularly in cancer, a disease that poses a serious threat to life. Uncontrollably growing cells have the ability to get inside healthy tissues and organs, leading to unfavorable reactions and eventual tissue destruction [7].

Globally, cancer is the cause of over 3.4 million deaths [8]. Several established factors are linked to an increased risk of cancer, including smoking (which can cause lung, breast, and ovarian cancers), being overweight or obese (which can lead to 13 different cancer types, including breast, kidney, womb, and bowel cancers), consuming processed meat, radiation exposure (which can cause skin cancer), family history, stress, environmental factors, and random chance [14].Through blood arteries and lymphatic channels, cancer cells can travel throughout the human body and metastasize, or create a second tumor [15]. Patients are usually given anticancer medicines to kill cancer cells. These medications function in two ways: they either cause the cancer cells to undergo apoptosis, or suicide, by treating them directly to the chemical agent [16]. It may be possible to increase efficacy while lowering the harmful side effects of drugs used for chemotherapy by using nanomedicine pharmaceuticals and liposomal drug compositions. The pharmacokinetics and distribution in tissues of the integrated anticancer drug may potentially be affected. They are alternative DDSs that have been employed to lower the harmful effect of anticancer drugs on normal cells and increase the therapeutic index.

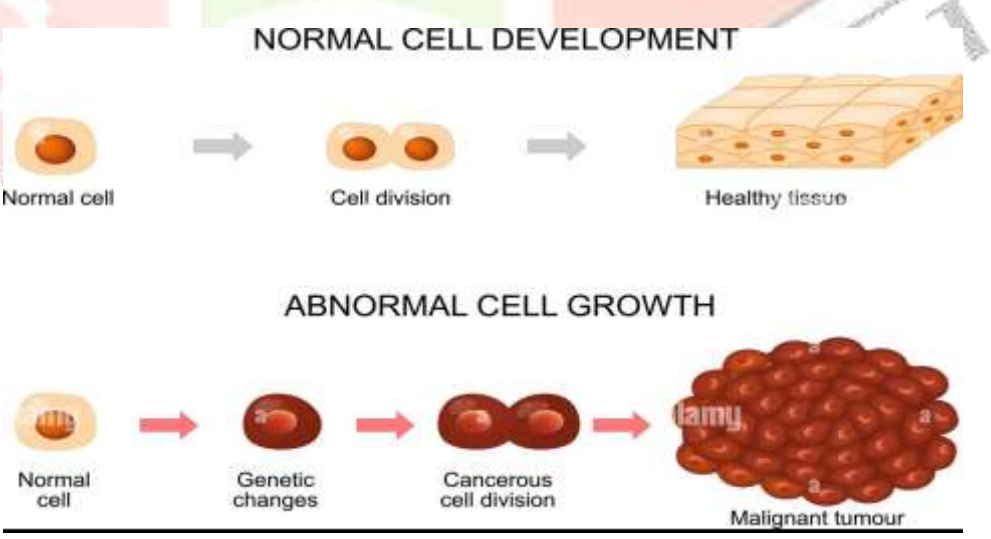

Fig. 01: Diagrammatic representation of Normal Cell growth and Abnormal cell growth.

III. PACLITAXEL AN ANTI-CANCER AGENT:

Paclitaxel is occurring in the form of White to off-white color crystalline powder. It is a plant derived and most commonly used anticancer drug in chemotherapy. Paclitaxel (trade name Taxol) is a tricyclic diterpenoid compound naturally produced in the bark and needles of Taxus brevifolia commonly known as "Pacific Yew". Its molecular formula is $C_{47}H_{51}NO_{14}$, and its chemical structure is shown in Fig. 2. Because of its unique anticancer mechanism, it is already one of the most successful and widely used natural anticancer drugs [17]. Unlike other tubulin-binding anticancer drugs, which prevent the assembly of tubulin into microtubules, paclitaxel promotes the assembly of tubulin into microtubules and prevents the dissociation of microtubules, blocking cell cycle progression, preventing mitosis, and inhibiting the growth of cancer cells [18]. It is also used in coronary heart disease, skin disorders, renal and hepatic fibrosis, inflammation, and axon regeneration, and clinical trials are being conducted for degenerative brain diseases [19].

After a series of clinical trials, the US Food and Drug Administration (FDA) approved paclitaxel for the treatment of advanced ovarian cancer in 1992 [20]. Since then, paclitaxel has been widely used in the treatment of breast cancer, colorectal cancer, and squamous cell carcinoma of urinary bladder. Furthermore, it has been used in the treatment of diseases such as head and neck cancers, small-cell and non-small-cell lung cancers (NSCLCs), and AIDS [21].

T. brevifolia is where paclitaxel was first isolated. However, because paclitaxel is contained in relatively small amounts in the plant, it is quite costly [22, 23]. Consequently, a number of other methods for obtaining paclitaxel have been devised, such as T. brevifolia artificial growth, chemical or semi-synthesis of the drug, and biotechnological synthesis. In particular, paclitaxel may be extracted from genetically modified endophytic fungus, and this method has shown to be successful in getting the medication.

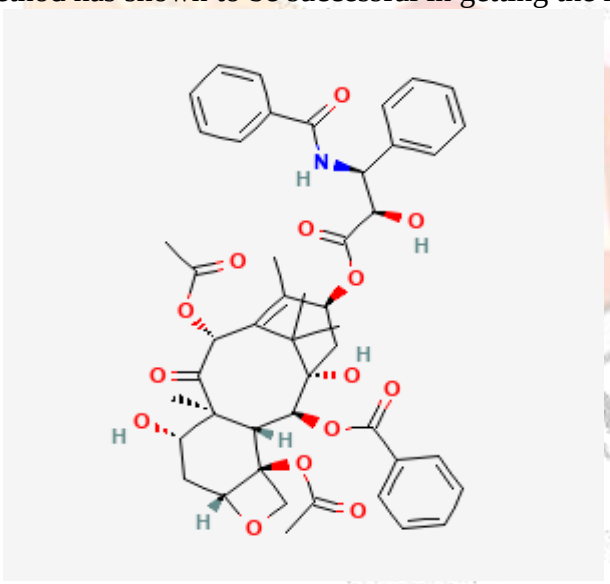

Fig. 02: Chemical structure of Paclitaxel

IV. MECHANISM OF PACLITAXEL AT CELLULAR LEVEL:

This was recently established that the anticancer drug paclitaxel may have an effect on microtubules. Natural cylindrical hollow bodies with diameters ranging from 25 to 30 nm are called microtubules. They are composed of many tubulin polymers in dynamic equilibrium and tubulin heterodimers, which include beta- and alpha-constituents of the protein components. [24, 25].

During the prophase and G2 phases of mitosis, tubulin was synthesized and microtubules were gathered. According to several reports, microtubules exhibit dynamic stability, especially when head-to-tail arrangement of component tubulins such as β and α is observed. The plus ends usually move faster compared to the reduced by finishes, which are slower at the opposite end. Moreover, it has been demonstrated that the length of the microtubule remains constant under steady-state conditions

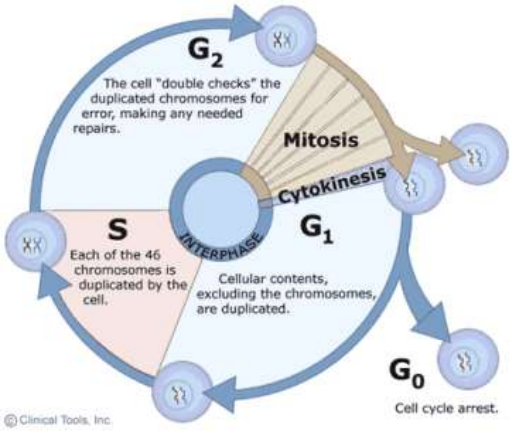

Fig. 03: Diagrammatic representation of Cell Division

It was revealed in 1979 that paclitaxel facilitates the formation of microtubules, which are structures made up of repeated subunits made of monomers of α/β tubulin. Paclitaxel raises the fraction of assembled filament subunits and lowers the critical concentration of tubulin subunits [18]. Microtubules create a spindle to drag the chromosomes towards the poles during the prophase. They depolymerize and the spindle structure disintegrates in subsequent phases. Microtubule depolymerization is triggered by exposure to calcium ions as well as cold temperatures. Microtubules attached to paclitaxel are stabilised and unable to depolymerize, even when exposed to calcium ions or extremely cold temperatures. As a result, paclitaxel therapy inhibits the progression of mitosis and encourages tubulin polymerization. [26, 27]. This is how the paclitaxel reduces the rapid and malignant cells generation in body.

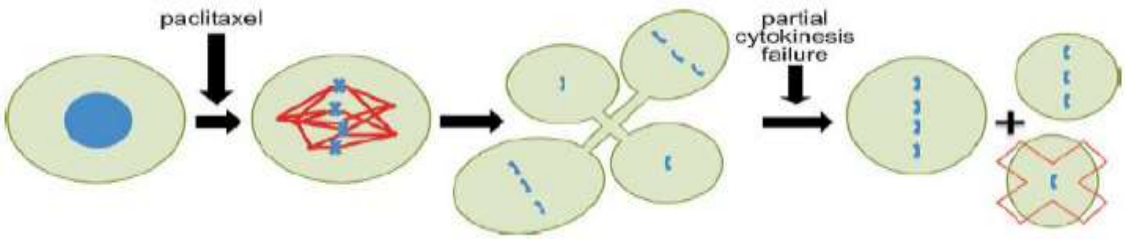

Fig. 04: Diagrammatic representation of Mechanism Action of Paclitaxel (Taxol)

V. NANOMEDICINE AS A DRUG DELIVERY TECHNOLOGY:

The application of nano-medicine, particularly in the medical profession, for the diagnosis and treatment of serious illnesses like cancer is useful. By reducing the negative effects associated with conventional therapies, the use of nano-medicine enhances the efficacy of the medications administered and provides a more exact and accurate detection.

Nano-medicine is worked as a "Magic Bullet" in the body. When nano-medicine contained drug is absorbed into the body, travels to the location of action, and acts on the area that is impacted.

Particles with a size ranging from 10 to 1000 nm, solid colloidal particles are called nanoparticles. They are made up of micromolecular components in which the medicine or physiologically active chemical is either dissolved, encapsulated, adsorbed, or connected. The medication is disseminated or adsorbed onto the surface of [28] nanoparticles, which are encased in a monolithic type framework (matrix). This medication contains a vesicular structure that allows it to either dissolve internally or adsorb outside. The benefits of using nanoparticles include less toxicity, increased drug bioavailability, and protection against drug degradation.

The process by which nanoscale structures containing API are created is known as nanotechnology. It can range in size from between 1 and 100 nm. Treating the condition as effectively and without side effects as possible is the aim of nanotechnology. Drug delivery systems benefit greatly from nanotechnology.

Cancer is another condition for which lipid nanoparticles are exploited. Liposomal drug delivery presents an opportunity to both decrease the harmful side effects of the medication and increase its efficacy. The pharmacokinetics and pharmacodynamics of anticancer compounds are also affected. Based on the number of layers, liposomal vesicles can be divided based on their dimension, which ranges from 0.025 µm to 2.5 µm. both multi- and uniflagellar.[29]

Using nanotechnology, the drug paclitaxel is a broad-spectrum anticancer agent that can be used to treat different types of cancer and cure them without causing significant side effects.

VI. CONCLUSION:

The cancer is the world's second-leading cause of mortality, behind diabetes and cardiovascular disease. Tumour is the uncontrolled, abnormal cell proliferation that has the potential to be fatal. Its effectiveness versus lung, breast, and ovarian cancers has been confirmed by research. Paclitaxel's chemical makeup, practical application issues, or potential toxicity of various nanoparticles containing paclitaxel were the main topics of discussion in the review. The fact that medications like paclitaxel are safer, more potent, and less toxic due to their improved ability to reach malignant cells and tissues has been demonstrated to be the reason behind the increased importance of nanomedicine in cancer treatment.
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VII. References:00000

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