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Gene therapy for the cancer treatment

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Abstract
Gene therapy requires introduction of new genetic material into the tissue or cell to transform gene expression or alter the properties of cell for therapeutic purposes. Consequently, there is a need for the development of the safe and efficacious strategies like gene therapy to improve the survival rate and anticipation of life for cancer patients. The motto of gene therapy is to transfer a curative gene into the host cell to shown its remedial effect. The choice of delivery vehicle relies on the desired individuality of the gene therapy. The starting gene therapy trials used remedial genes driven by viral promoters like the CVM promoter, which effects peculiar toxicity in both normal cell and tissue, as well cancer cell to overcome this limitation, tumour specific promoter methods have been created to attack target cancer cells effectively. Gene therapy has the potential to revolutionize cancer treatment.

Keywords: Gene therapy, cancer, immunotherapy, Crispr, car t cell, cancer specific promoter

Introduction
Cancer is a medical state where certain cells in the body start growing in an uncontrolled manner, leading to the formation of abnormal tissue masses called tumor. If left untreated, these tumors can disperse to other organ of the body via the bloodstream or lymphatic system. [1]

Cancer is a vast term that refers to a group of diseases that can develop in various parts of the body. It is a serious health condition that can affect anyone, regardless of age, gender, or ethnicity. Unfortunately, cancer is one of the pre-eminent causes of worldwide deaths, with a approximate 9.6 million deaths in 2018 alone. This means that roughly one out of every six deaths were caused by cancer. The disease can be challenging to treat and manage, so it's essential to take preventative measures and look for medical attention if you notice any abnormal symptoms or changes in your body. [2]

Tumor is the abnormal mass of the cancers cell According to the site of the growing cancers cell there are more than 200 type of cancer, such as breast cancer, lungs cancer, brain cancer, etc.

Cancer can also be classified according to the type of cell they begin, there are 5 main groups. These are:

1. **Carcinoma:** This type of cancer starts in the skin or tissues that cover or line internal organs, like as the lungs, liver, and intestines. There are several subbranch of carcinoma, involving adenocarcinoma, squamous cell carcinoma, basal cell carcinoma, and transitional cell carcinoma.
2. **Sarcoma:** Sarcoma starts in supportive or connective tissues like as bone, cartilage, fat, muscle, or blood vessels. This type of cancer is relatively rare, accounting for less than 1% of all cancers.
3. **Leukaemia:** Leukaemia is cancer of white blood cells, which are important for attenuate infections. It begins in the bone marrow, where blood cells are made. There are several subtypes of leukaemia, including acute lymphoblastic leukaemia, acute myeloid leukaemia, chronic lymphocytic leukaemia, and chronic myeloid leukaemia.
4. **Lymphoma and Myeloma:** These cancers start in the cells of immune system, which help the body fight off infections and disease. Lymphoma affects the lymphatic system, which is part of the immune system, while myeloma infect plasma cells, which produce antibodies that help fight infection.
5. **Brain and Spinal Cord Cancers:** These cancers are collectively known as central nervous system cancers and can affect the brain, spinal cord, and other parts of the nervous system. Symptoms of these cancers can include headaches, seizures, and difficulty with movement or coordination. [3]

Types of treatment of cancer

1. **Chemotherapy-**treatment of the cancer by the medicine (Specific to type of the cancer)
2. **Radiotherapy –** treat the cancer by using the high dose of the radiation to kill the cancers cell
3. **Surgery -** Surgeon removes cancer from body.
4. **Hormone therapy-** in which stop or slow the growth of tumour by kill the cancers cell
5. **Immunotherapy -** Immunotherapy is a short of cancer treatment that helps your immune system diminish cancer.
6. **Stem cell transplant -** Stem cell transplant is a method used to restate blood-forming stem cells in patients who have undergone strong doses of chemotherapy or radiation therapy that destroyed their own stem cells. This treatment helps the body produce new, healthy blood cells.
7. **Targeted therapy -**Targeted therapy is another branch of cancer treatment that targets to specifically target proteins that restate how cancer cells grow, divide, and spread not like chemotherapy, which attacks both cancerous and healthy cells, and in this the cancer cells only get attack by design, reducing the risk of damage to healthy cells. This treatment is based on the genetic makeup of the cancer cells and may involve the use of drugs or other substances that specifically target cancer cells. Targeted therapy can be used alone or in combination with other cancer treatments, such as chemotherapy or radiation therapy, depending on the type and stage of cancer. [4]

1. Gene therapy

Gene therapy is used to fight the cancer.

Cancer is a disease that occurs when mutations in genes cause cells to grow uncontrollably, forming tumour. These trans mutations can be caused by a various factor such as smoking, environmental factors or inherited genes. If we were able to fix these mutations, we might be able to prevent cancer from developing. [5]

A significant advancement in gene therapy was the development of suicide gene therapy, which has helped to make cancer treatment safer and more effective. This approach involves introducing a therapeutic gene into cancer cells, which then causes the cells to self-destruct. By selectively targeting cancer cells, this therapy can potentially minimize damage to healthy cells and improve treatment outcomes. The success of this modality has been a major milestone in the sector of gene therapy, offering new expectation for treating cancer and other diseases at the genetic level.

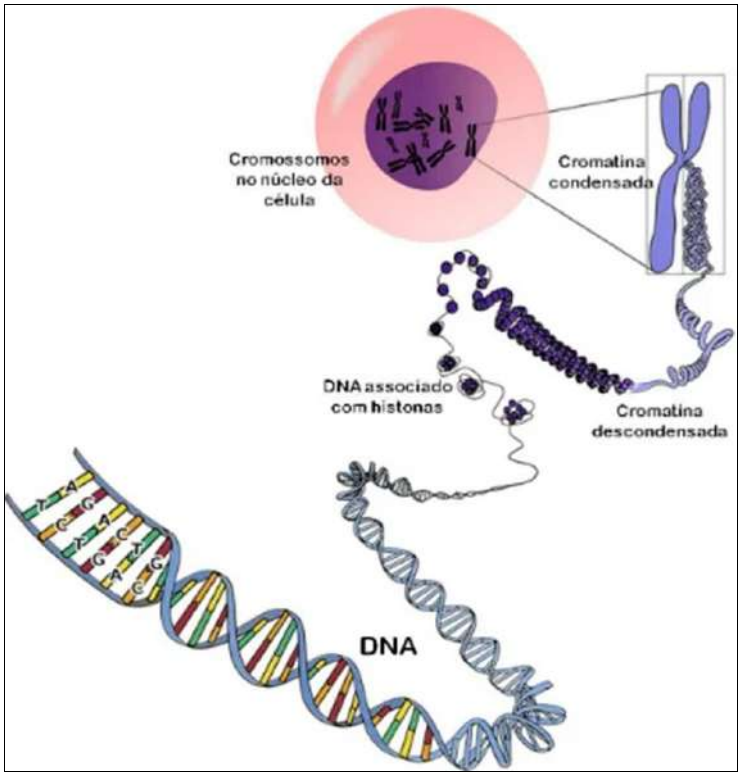

Fig 1: DNA, gene, and chromosome [6]

Base editing (gene therapy) allows the change the genetic coding and alter the structure of the gene.

In which doctor use donor heathy T cell to kill the cancers T cell by modifying the structure of the gene in the donor T cell.

Techniques used in gene therapy

The three steps of gene therapy are as follows:

1. Gene identification: This involves the identification of the gene of interest.
2. Gene duplication: This involves duplicating the gene of interest to be used for therapy.
3. Gene insertion: The duplicated gene of interest is inserted into the recipient.

1.1 Crispr

CRISPR/Cas is a genetic tool that allows scientists to edit genomes. It was originally discovered in bacteria as part of their immune system. The system consists of two main components: the CRISPR sequence, which acts as a

molecular memory bank, and the Cas enzyme, which acts as a molecular scissors that can cut DNA at particulars site. When combined, these components can be programmed to target and transform specific genes in an organism's DNA. This technology has reformed the area of genetics and has the power to be implementation for a wide range of applications, from curing genetic diseases to enhancing crop yields. [7]

CRISPR is the technology which used to the alter the gene sequencing of the DNA for change their genetic information of the cell. CRISPR made the gene editing cheap and easy.

CRISPR-cas9 is a genome editing system that was originally found in bacteria. When bacteria are invaded by viruses, they capture snippets of viral DNA and use them to create CRISPR arrays, which allow the bacteria to recall the virus. If the virus invades again, the bacteria produce RNA segments from the CRISPR arrays to aim the virus's DNA. Cas9 or similar enzymes are used to cut the DNA, which disables the virus. CRISPR can be used to find specific bits of DNA in cells and modify them, as well as turning genes on or off without changing their sequence. The key to CRISPR is the many different types of "Cas" proteins found in bacteria, with Cas9 being the most commonly used by scientists. Cas9 can be organized to find and bind to almost any appropriate target sequence by giving it a piece of RNA to steer it in its search. [8]

The steps involved in CRISPR gene editing are as follows:

1. First, specific sequence of genes causing the problem must be identified.
2. An RNA molecule is then programmed to locate the faulty sequence on the DNA strand, much like the "find" or "search" function on a computer.
3. Next, a specialized protein called cas9 is used to break the DNA strand at a specific site and remove the unwanted, problematic sequence.
4. During the natural repair process, the correct sequence of genetic codes is introduced, which attaches to broken DNA strand and replaces the faulty sequence. This way, the problematic gene is edited and corrected.

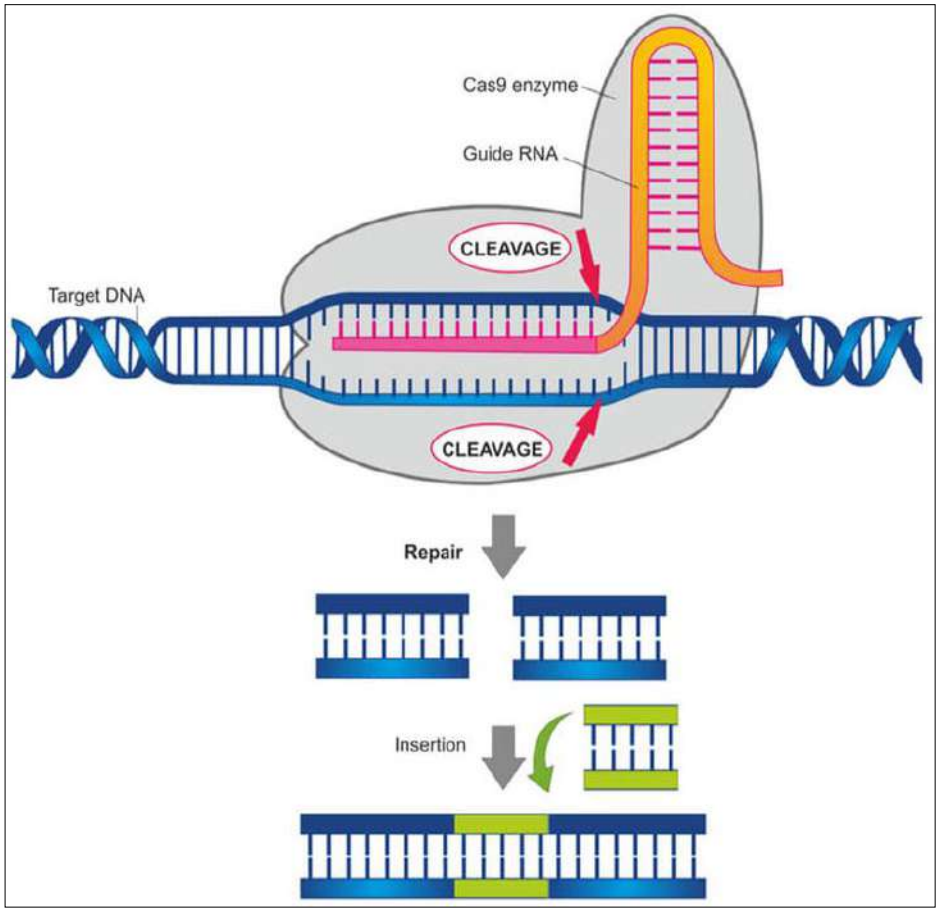

Fig 2: CRISPR-Cas9: The Gene Editing Tool [9]

There are two primary ways to use CRISPR as a therapy. The first approach, known as ex vivo gene editing, involves extracting human cells, modifying them in a lab, and then returning them to the patient's body. While similar to existing gene therapies, this approach can be costly as each patient requires their own personalized manufacturing process.

The second method is known as in vivo gene editing, which include transporting the CRISPR-Cas9 system directly inside the patient's body to to modify the DNA within the cells. This could be achieved by encoding the CRISPR system into DNA or delivering it in nanoparticles that can be cleared from the body once the editing process is complete. While this approach has started human testing in 2020, there is a menace of CRISPR preparing unintended alterations, which raises some concerns. [10]

1.2 Car- t cell therapy

T cells are type of white blood cell that plays a important role in the immune complex. They are now being used in the fight against cancer by modifying them in a laboratory to enable them to indentify and destroy cancer cells. This

process is known as CAR T-cell therapy and can be considered a form of cell-based gene therapy since it includes modification of genes within T cells to support them knock down cancer cells. By enhancing the T cells' skill to identify and destroy cancer cells, this therapy offers an auspicious approach to cancer treatment. [11]

T cells are a kind of white blood cell that function as part of the immune complex to target and eliminate infectious or cancerous cells in the body. Cancer cells are admited to evade the normal immune system, but with CAR T cell treatment, scientists can enhance T cells' skill to locate and kill cancer cells. CAR T-cell treatment is a form of immunotherapy that alters the patient's immune complex to make it help full for identifying and attacking cancer cells. By equipping T cells with chimeric antigen receptors (CARs), which are engineered to recognize and bind to cancer cells, this therapy offers a powerful tool for fighting cancer at production of CAR T cells, a specific protein is added to the external surface of the T cells to enhance their ability to target cancer cells. This protein is known as a chimeric antigen receptor (CAR) and is composed of three distinct proteins. The first protein within the CAR recognizes antigens present on the surface of cancer cells, while the other two proteins within the CAR trigger the T cell to become activated once the first protein binds to an antigen on the cancer cell. By incorporating this CAR protein, CAR T cell therapy can effectively reprogram T cells to target and attack cancer cells in a highly targeted and effective manner.

Since cancer cells can have different types of antigens, each chimeric antigen receptor (CAR) is designed to target a specific antigen that is present on the cancer cell surface. This means that CAR T cell therapies must be specifically tailored to each patient's cancer based on the specific antigen profile of their cancer cells. For instance, certain types of leukaemia or lymphoma may express an antigen called CD19. In this case, the CAR T-cell therapy is designed to recognize and attach to the CD19 antigen, which is unique to cancer cells with this antigen expression. However, this therapy would not be effective for other cancers that do not express the CD19 antigen. Therefore, each CAR T cell therapy must be designed and customized based on the unique characteristics of each individual patient's cancer.

When a CAR T cell recognizes and attaches to an antigen on a cancer cell, it triggers a chain reaction. The activated CAR T cell undergoes cell division and produces cytokines, which are signalling proteins that activate other immune cells to join the attack on the cancer cell. This process leads to an inflammatory response that focuses on the cancer cell, causing its death. This may result in the temporary or permanent disappearance of the cancer. The ability of CAR T cells to activate and coordinate the immune system makes them a promising therapy for certain types of cancer. [12]

CAR (chimeric antigen receptor) is a type of protein used in CAR T-cell therapy to help T cells recognize and attack cancer cells. It is called "chimeric" because it is made up of parts from different types of immune cells - the antigen-binding site of the B cell receptor and an intracellular TCR activation domain. The CAR protein consists of three domains - the extracellular domain, which is made up of cancer-specific epitopes (SCFV region) that target the antigen (such as CD19), the transmembrane domain, which spans the cell membrane, and the intracellular TCR-derived stimulatory domains that activate the T cell when it identifies the targeted antigen on the cancer cell. [13]

T CELL + CAR = CAR T CELL

The procedure for car- t cell therapy

The process for CAR T-cell therapy starts by collecting the patient's white blood cells, including T cells, through leukapheresis. During this procedure, blood is taken out from the body by one IV line, and the white blood cells are separated out. The blood is then infused to the body through another IV line. This process can take 2 to 3 hours and may cause a drop in calcium levels, which can be treated by replacing the calcium.

Once the T cells are collected, they are genetically modified to produce CAR receptors, which takes several weeks. After the CAR T cells are produced in the required quantity, they are infused back into the patient's blood. Before the infusion, the patient may be given chemotherapy to lower the number of other immune cells, giving the CAR T cells a great possibility to kill the cancer.

The infusion process takes about 30 to 90 minutes, but the visit may take up to six hours to allow for care before and after the infusion. After the infusion, the patient will be closely monitored for many weeks. When the CAR T cells come in contact with cancer cells, they activate and begin to multiply, signalling to other components of the immune system to approach towards the site of the cancer cell. The activated CAR T cells then attack and destroy the cancer cells. [14]

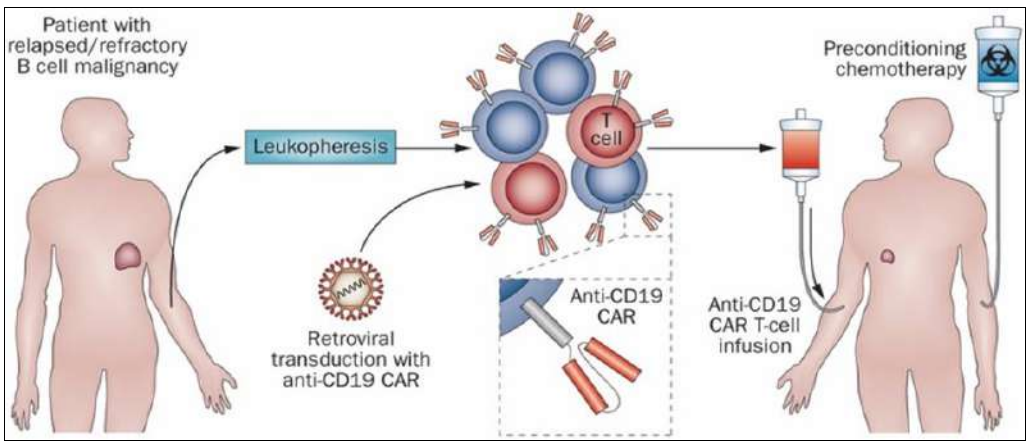

Fig 3: The process of CAR T cell therapy

1.3 Suicide gene therapy

Suicide gene therapy is a treatment approach that involves introducing genes that can trigger the death of tumor cells. This therapy can work in two ways: directly or indirectly. In direct suicide gene therapy, a gene is introduced that encodes for a protein that is toxic to the tumor cells, and its expression within the tumor cells leads to their death. The aim of this therapy is to induce the death of cancer cells that can benefit to slow down or stop the progression of cancer. [15, 16]

Suicide gene therapy, or gene-directed enzyme prodrug therapy (GDEPT), is frequently used for treating solid tumours. This approach involves introducing specific genes into the target cells, which can then activate inactive prodrugs and convert them into toxic substances. This results in the death of the host cells, which can help to eliminate the tumor [17].

The strategy in suicide gene therapy is to transduce cells with a gene that can convert an inert prodrug into a toxic agent. One system that has been extensively investigated is the combination of the herpes simplex virus (HSV) thymidine kinase gene with ganciclovir.

Suicide gene therapy has led to tumor growth delays and some outright cures in animal models, but it has been less successful in clinical trials. Because of the minimal efficacy of gene delivery, suicide gene therapy has to be merge with conventional radiation therapy [18].

The GDEPT approach Is similar to chemotherapy, but it targets cancer cells from within and is generally less harmful to healthy cells. The therapy involves introducing genes into cancer cells that encode enzymes capable of transforming a non-toxic prodrug into a toxic compound. This toxic compound can kill the host cell and can also spread to nearby cells, causing their death as well. This phenomenon is known as the bystander effect and can enhance the effectiveness of GDEPT [19].

Cancer is a common disease that conventional treatments may not be able to fully cure. In suicide gene therapy, a non-toxic prodrug is metabolized into a toxic drug by transgene products, leading to the death of cancer cells. The combination of herpes simplex virus-TK/ganciclovir or E. coli cytosine deaminase/5-fluorocytosine with adenoviral vectors has been used for this treatment. The adenoviral vectors are delivered directly to the tumor site, which converts the prodrug to the toxic form only within the tumor, providing a less toxic form of chemotherapy. This approach has been found to be effective in murine models of established tumors [20].

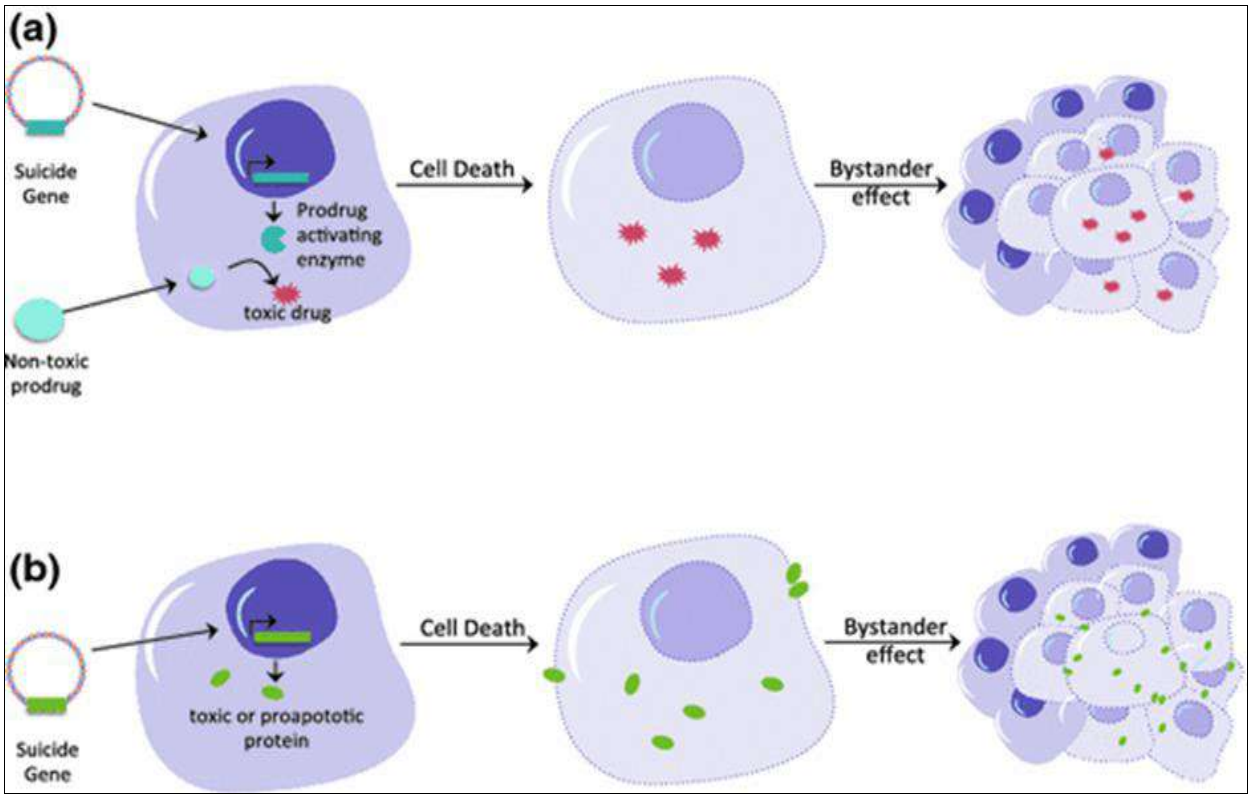

Fig 4: suicide gene therapy

1.4] Immuntherapy

Immunotherapy for cancer is a type of treatment that involves using the body's own immune system to knock down cancer. This approach aims to enhance and activate the immune system's natural defences against cancer cells, helping to identify and attack them more effectively. By boosting the immune system's response to cancer, immunotherapy can potentially offer a more targeted and less toxic alternative to traditional cancer treatments like chemotherapy and radiation therapy. [21]

For more than a century, scientists have been trying to use immunotherapy to increase the immune system's ability to kill cancer cells. But traditional immunotherapy has had limited success due to cancer cells' ability to evade the immune system. To address this challenge, a range of gene therapy methods are now being used to develop more effective immunotherapies. [22]

Immunotherapy is a treatment approach that involves boosting the immune system's ability to identify cancer cells as harmful cells, despite their ability to disguise themselves as normal cells. This has been a challenge for traditional cancer treatments, as cancer cells have developed mechanisms to evade detection by the immune system. By training the immune system to identify cancer cells,

immunotherapy can help shrink or eliminate tumors, potentially leading to a more effective treatment for cancer [23].

Immunotherapy drugs can be very effective in treating certain types of cancer, but they don't work for everyone. In fact, only about 15 to 20% of patients will see a positive response to the treatment. While these drugs can be life-changing for some, it's important to understand that they are not a guaranteed solution for all cancers. [24]

- Some immune therapy drug helps the immune system work harder and smarter to find and kill the cancer cell.
- Immunotherapy boost or create a strong immune response that can kill the cancer cell, but does not harm the healthy cells. chemotherapy can kill the cancer cells but also harm the normal cells.

1.4.1] Stem cell transplants and CAR T-cell therapy:

This therapy involves replacing or genetically modifying the immune system. In addition, medications and vaccines can be used to help a patient's immune system excellent identification and kill cancer cells. Bone marrow transplants have been used since 1968 to effectively treat diseases like leukaemia's, lymphomas, aplastic anaemia, immune deficiency disorders, and some types of solid tumor cancers. These various immunotherapy techniques offer hope for improved cancer treatment options and outcomes. [25, 26]

1.4.2 Precision or personalized medicine

Precision medicine is an approach to healthcare that tailor's medical treatment to the specific needs of an individual patient. By analysing a patient's genetic makeup, proteins, and other biological markers, healthcare providers can design personalized treatment plans that are more effective and have fewer side effects than traditional one-size-fits-all treatments. This approach is also known as personalized medicine or personalized care, and it represents a promising new frontier in healthcare. Precision medicine has the potential to change the way we prevent, diagnose, and treat diseases, leading to better health outcomes and a higher quality of life for patients [27].

1.4.3 Hormone therapy

Hormone therapy is a type of cancer treatment that is used to target cancers that rely on hormones to grow, such as certain types of breast and prostate cancers. This therapy works by slowing down or even halting the growth of cancer cells that rely on hormones for their growth. Hormone therapy is also referred to as hormonal therapy, hormone treatment, or endocrine therapy. By blocking or suppressing the production of hormones in the body, hormone therapy can help to control the spread of cancer and improve a patient's quality of life. This type of treatment is often used in conjunction with other cancer therapies, such as chemotherapy or radiation therapy, to provide the most effective treatment plan for the patient [28].

1.4.4] Biosimilar drug:

A biosimilar drug is a medication that is highly similar in both structure and function to a biologic drug. Biologic drugs are medicines that are produced using living organisms such as bacteria, yeast, or animal cells. These drugs are often used in the treatment of cancer and can work in a variety of ways to target cancer cells. Biosimilar drugs are designed to be interchangeable with their biologic counterparts and must meet rigorous standards of safety and efficacy before they can be approved for use. By providing a more affordable alternative to biologic drugs, biosimilars can help to increase access to life-saving cancer treatments for patients who might otherwise not be able to afford them [29].

1.4.5 Tumor-agnostic drug

A tumor-agnostic drug or therapy is a type of targeted therapy that uses the same drug to treat different types of cancer that share a specific genetic mutation or biomarker. It is not limited to a particular type of tissue and can be effective in treating cancers with the same genetic mutation or biomarker, regardless of their location in the body. Therefore, it can potentially broaden treatment options for patients with cancer. [30]

1.4.6 Hyperthermia to treat cancer

Hyperthermia is a cancer treatment method that involves heating body tissues to temperatures as high as 113 °F, with the aim of damaging and killing cancer cells while minimizing harm to normal cells. This approach is sometimes referred to as thermal therapy, thermal ablation, or thermotherapy. By applying heat to the affected area, hyperthermia can help to enhance the effectiveness of other cancer treatments, such as radiation therapy and chemotherapy. It is a non-invasive treatment option and may be used to treat a variety of cancers. [31]

Recent research studies have shown that the use of hyperthermia in combination with cancer immunotherapy can be an effective approach. These studies have produced evidence, both in preclinical and clinical settings, indicating that the addition of mild hyperthermia to cancer immunotherapy can result in improved antitumor immune responses. This suggests that hyperthermia can potentially enhance the effectiveness of cancer immunotherapy by helping to stimulate the body's immune system to precious target and kill cancer cells.

1.4.7 Blood transfusion and donation

also called cell therapy. Cell therapy is a type of immunotherapy that involves the removal of immune cells from a patient's body, which are then genetically altered to enhance their ability to fight cancer. These modified cells are then multiplied in a laboratory setting before being reintroduced to the patient's body via a transfusion-like procedure. This form of therapy aims to enhance the immune system's ability to identify and kill cancer cells more effectively. By altering and multiplying the patient's immune cells outside the body, cell therapy may provide a more targeted and personalized treatment approach to cancer [32].

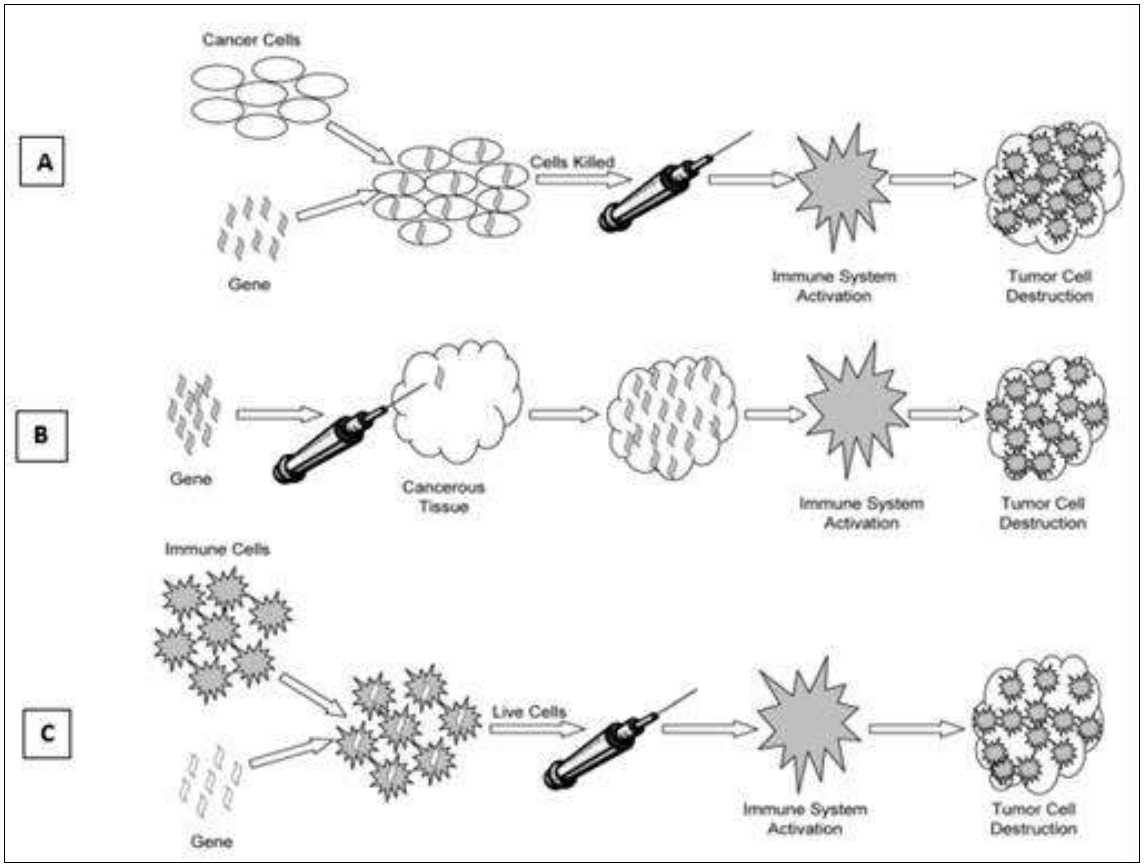

Fig 5: The schematic diagram of immunotherapy illustrates three different pathways for this approach to treating cancer

Pathway A: Represents immunotherapy that involves the use of altered cancer cells, where these cells are modified in a laboratory setting before being reintroduced to the patient's body to enhance their ability to fight cancer.

Pathway B: Illustrates *In vivo* immunotherapy, where genes are modified within the patient's body to enhance the immune system's ability to identify and kill cancer cells.

Pathway C: Demonstrates immunotherapy using altered immune cells, where the patient's immune cells are removed, genetically modified, and then reintroduced to the body to enhance the immune system's cancer-fighting capabilities. Each pathway offers a different approach to immunotherapy and may be used alone or in combination with other cancer treatments.

1.5 Cancer-specific promoters

Are a type of genetic material that are working within cancer cells but have no activity in normal cells. These promoters can be used to propel the expression of genes selectively in a vast type of tumor cells. Although they do not target any particular tissue or tumor, they are functional for various types of cancers. The first gene to be known as cancer-specific was telomerase, and its promoter (hTERT) has been useful to drive the expression of genes particularly in a vast type of tumor cells. The use of cancer-specific promoters offers a promising approach to cancer therapy, as it allows for more targeted and selective treatment of cancer cells while minimizing harm to normal cells [33, 34].

Studies have shown that approximately 90% of human cancers shows excessive amount of telomerase. Telomerase is an enzyme in cells that plays a crucial role in helping to keep them alive by adding DNA to telomeres. During cell division, telomeres lose a small amount of DNA and become progressively shorter over time. This shortening can lead to chromosome damage and ultimately cause cells to die. However, telomerase helps to prevent this from happening by adding DNA to telomeres and thus maintaining their length. In contrast to cancer cells, the activity of telomerase is normally absent in normal somatic cells. This difference in telomerase activity between normal and cancer cells makes it a promising target for cancer therapy [35, 36].

The use of cancer-specific promoters, such as the telomerase promoter, has the potential to be a powerful tool for targeting a wide range of different tumor types and selectively killing cancer cells. These promoters are practical within cancer cells but plays no role in normal cells, making them ideal for driving the expression of therapeutic genes specifically within tumor cells. By particular terminating cancer cells while leaving normal cells without any harm, cancer-specific promoters offer a promising approach to cancer therapy with the potential for fewer side effects than traditional treatments. Overall, the use of cancer-specific promoters has great potential for enhancing the effectiveness and selectivity of cancer treatment.

Now a days, other cancer specific promoters have been examined, among them is cyclooxygenase (COX), cytokeratin 18, cytokeratin 19, survivin and chimeric antigen receptors (CAR) and others [37]. Cancer-specific promoters control genes that are often over-expressed in cancer cells. This property has led to the development of genetic constructs that use these promoters to selectively direct the expression of suicide genes in tumor cells for cancer gene therapy. By using these promoters to drive the expression of therapeutic genes specifically within tumor

cells, it is possible to selectively kill cancer cells while sparing normal cells. This approach to cancer therapy offers the potential for more targeted and effective treatment, with fewer side effects than traditional treatments. Overall, the use of cancer-specific promoters represents a promising avenue for the development of new cancer therapies [38].

1.6 Tumor-specific promoters

are a type of promoter that is active in a limited type of cancer cells and their activity can vary widely between different tumors. However, unlike other types of promoters, their main characteristic is that they are either little or non-active in normal cells. This selective activity of tumor-specific promoters within cancer cells makes them promising targets for cancer therapy. By using these promoters to drive the expression of therapeutic genes selectively within tumor cells, it is possible to kill cancer cells while leaving normal cells unharmed. Overall, the use of tumor-specific promoters represents a promising approach to developing more targeted and effective cancer therapies with the potential for fewer side effects. [39]

Tumor promoters are chemicals that are typically lipid-soluble and can be found in a variety of sources, primarily plants. These promoters have the ability to transform normal cells into malignant ones, capable of uncontrolled growth. They play a significant role in the development of cancer by promoting the growth and proliferation of cancer cells. Due to their ability to transform normal cells into cancerous ones, they are considered to be potent carcinogens. Overall, the role of tumor promoters in cancer development highlights the importance of identifying and avoiding exposure to these chemicals as a potential means of reducing cancer risk [40].

These are examples of tumor-specific promoters that are active in a limited type of cancer cells and vary in their activity in different tumors. They are distinct from cancer-specific promoters in that they are little or non-active in normal cells. These promoters include alpha-fetoprotein promoter (AFP), thyroid transcription factor 1 (TTF-1), glypican-3 protein (GPC3), human secretory leukocyte protease inhibitor (HSLPI), ERBB2, Mucin 1 (MUC1), L-plastin, α lactalbumin (LALBA), cyclooxygenase 2 (COX2), epithelial glycoprotein (EPG2), A33, UPAR, carcinoembryonic antigen (CEA), breast cancer 1 (BRCA1), and BRCA2. These promoters can be used to selectively target cancer cells with gene therapies, as they are more active in cancer cells compared to normal cells. However, their limited specificity across different types of cancer cells means that they may not be suitable for all types of cancer [41, 42].

The use of tumor-specific promoters allows for targeted gene expression in cancer cells only. Specific transcription factors present in cancer cells can induce the expression of therapeutic genes, while normal cells lack these factors, preventing the expression of the gene. This principle helps to ensure that the therapy is specific to cancer cells and avoids harming normal, healthy cells.

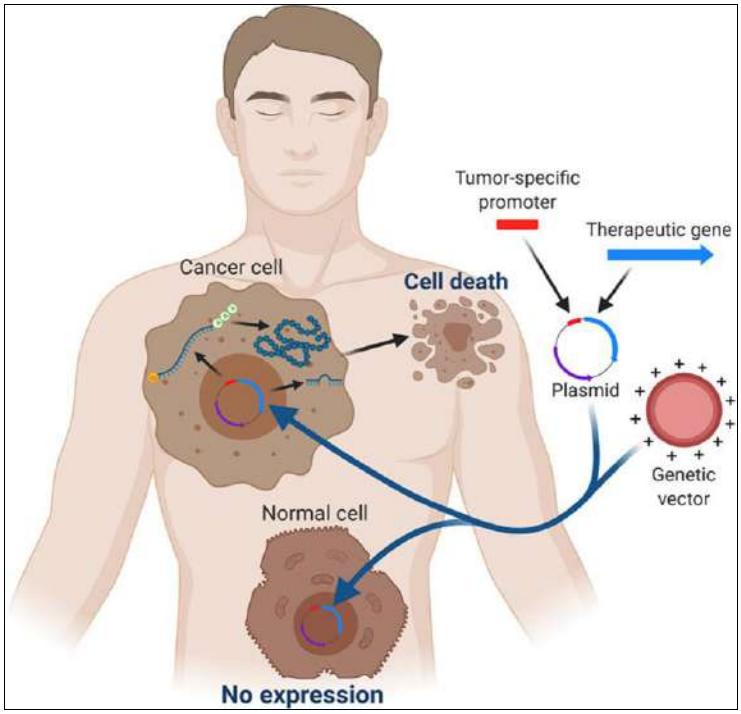

Fig 6: Tumor specific promoter

Conclusion

Gene therapy is a promising approach for treating diseases that currently lack satisfactory cures. In particular, gene therapy for cancer has shown significant progress over the last three decades, with a number of drugs having been approved for clinical use and others still in various stages of clinical trials.

Compared to chemotherapy, gene therapy has demonstrated better safety with fewer adverse effects for cancer treatment. In the future, advancements in tumor genomic analysis and our ability to assess the host's humoral and cellular immunity will facilitate the selection of the most appropriate patients for gene therapy.

One important feature of gene therapy for cancer is the use of cancer and tumor-specific promoters, which are crucial elements in constructing recombinant DNA molecules for effective gene therapy. However, a more in-depth

understanding of cancer genetics is needed to identify safe and effective elements for controlling gene expression.

In summary, gene therapy offers a promising alternative for managing diseases that currently lack satisfactory treatments. In cancer treatment, gene therapy has shown promise, with ongoing research expected to continue improving its efficacy and safety. As our understanding of cancer genetics advances, we can expect to see more personalized and targeted gene therapies that offer new hope to patients with cancer and other diseases.

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