Cancer Immunotherapy: An Emerging Pillar in Cancer Treatmet

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***Abstract*–Our body has natural resistance that can fight with cancer. It was known before the modern medicine, based on the reports where tumors sometimes shrank on their own. One of the successful immunotherapies on cancer was using BCG bacteria for bladder cancer. It was started in 1976 and is still using today. It is done by activating the immune cells to attack cancer cell. Immunotherapy is a strategy, enhances the immune system to eliminate malignant cells. This review article discusses about the types, mechanisms, applications, advantages, and future prospects.**

***Keywords*– Cancer Immunotherapeutics; monoclonal antibodies; cancer vaccines; personalized immunotherapy.**

I. INTRODUCTION

Cancer is a serious disease in which cells grow uncontrollably and disseminated throughout the body [(1)]. Common treatments such as surgery, chemotherapy, and radiotherapy help control cancer but also damage healthy cells. This leads to side effects like weakness, hair loss, nausea, and reduced immunity, affecting the patient's quality of life [(2)]. Cancer immunotherapy is a newer treatment that helps overcome these problems by strengthening body's natural defence system. Normally, immune system removes abnormal cells, but cancer cells can escape this protection. It helps immune system to notice, fight with cells successfully, and leads to produce a firm and long-lasting anti-cancer response [(3,4)].

Types of Cancer Immunotherapy:
The classification of cancer immunotherapy is primarily based on the mechanism by which the immune system is activated.
1.Immune Checkpoint- Targeted Therapy-
PD-1, PD-L1, and CTLA-4 are natural regulators that prevent immune hyperactivation and autoimmunity[(2,15)]. However, many cancer cells utilize these checkpoints to inhibit T-cell activity enables tumors to avoid immune detection and destruction [(3,4,16)].

Mechanism: Checkpoint inhibitors are specialized monoclonal antibodies that bind to suppress[(15,12)]. This reactivates T-cells, allows them to recognize, more effectively eliminate cells [(3,4,9)].
Examples: Widely used immunotherapies include Ipilimumab (anti-CTLA-4), Nivolumqb and Pembrolizumab (anti-PD-1), and Atezolizumab (anti-PD-L1)[(12,17,10)].
Clinical applications: These treatments have been successfully used in Neoplasms including malignant melanoma, NSCLC, and renal cell carcinoma (RCC)[(4,9,10,13)].

2.Monoclonal Antibody- Mediated Cancer Therapy-
Monoclonal antibodies are specifically engineered proteins created in the laboratory to detect and bind with particular molecules on cancer cells [(2,14)].
Mechanism: They can directly inhibit the growth or signals of tumor cells, preventing them from multiplying [(13,18)]. They can recruit immune cells to destroy cancerous cells tagged by antibodies for destruction via ADCC [(14,19)]. They can carry toxic drugs or radioactive materials. Substances directly to tumor cells to kill them while not harming healthy cells (these are called Antibody-drug conjugates) [(20,21)].
Examples: Trastuzumab –Ideal for managing HER2+ disease.
Rituximab is employed to manage CD20 positive follicular and aggressive B-cell lymphomas [(13,22,23)].

3.Cancer Vaccines-
Cancer vaccines are treatments that train the immune system to recognize foreign protein markers on tumors, including direct immune attack against the cancer [(2,4)].

Types:
Vaccines designed for prevention- target cancer causing viruses; for instance, the HPV shot helps shield against cervical cancer [24,25].
Therapeutic vaccines are designed to activate the immune system to recognize and eliminate established tumor cells [4,26]. For example, Sipuleucel-T is used in prostate cancer [27,13].
Mechanism: Cancer vaccines help the immune system by improving the presentation of tumor antigens and activating T cells, which then identify and destroy cancer cells more effectively [2,4,26].

4. Adoptive Immunotherapy-
Immune cells with strong anti-cancer activity are taken from the patient, enhanced or modified in the lab, and then reintroduced into the body to fight the tumor [2,28].

Types:
CAR-T therapy works by altering a patient's own immune cells to express specialized CARs, which redirect them to recognize and attack specific antigens on the surface of cancer cells [29].
TIL (Tumor-Infiltrating Lymphocytes) therapy amplifies the body's natural cancer- killing immune cells extracted from a tumor and returns them to destroy cancer throughout the body [29].
Clinical application: This therapy is particularly effective against blood cancers like leukemia and lymphoma, where it has demonstrated remarkable success in eliminating cancer cells [29,13].

5.Cytokine Therapy-
Cytokine therapy utilizes naturally occurring proteins called cytokines to increase the immune system acts as a surveillance network to destroy developing tumors [2,28]. Cytokines help regulate and coordinate immune responses, increasing immune cells effectiveness in recognizing and destroying cancer cells [2,14].
Examples include interleukin-2(IL-2), promotes the growth of T cells. Important for attacking cancer cells [28].
Interferon-alpha (IFN-α) helps immune cells present tumor antigens. Improves overall immune function against tumors [14,28,13].

6. Oncolytic Virus Therapy-
Viruses used to precisely infect, kill cancer cells sparing normal cells [2,35]. These viruses not only destroy tumors. Boosting the body's natural defenses to locate and destroy malignant cells [30].
Mechanism: The virus enters and multiplies within cancer cells, eventually causing the cells burst (lysis) [2]. This process releases tumor antigens that stimulate the immune system. System responds more strongly against the remaining cancer cells [35,4].
Example: Talimogene laherparepvec (T-VEC) is an oncolytic virus used in the treatment of melanoma [13].

Clinical Applications:
- Used in the treat melanoma by increasing immune cell activity against cancer cells [4,2].
- Applied in lung cancer to improve immune recognition and destruction of tumor cells [2,3].
- Beneficial in breast cancer, especially in certain subtypes responsive to immune-based therapies [13].
- Effectively used in hematological cancers. CAR-T immunotherapy is an example of advanced immunotherapy [28,29].
- Used in renal cell carcinoma to promote immune-mediated tumor control [2].
- This treatment is effective as monotherapy or in combination with chemotherapy, helping to enhance survival rates and reduce tumor recurrence [4,12].

Advantages of Cancer Immunotherapy:
- Specifically targets cancer cells with minimal harm to normal tissues [4,2].
- Offers long-term effects via immune memory [2,3].
- Effective for advanced and metastatic cancers [13,12].
- Can reduce the risk of recurrence [3,6].
- Often better tolerated than chemotherapy [4,13].

Future prospects:
- Development of personalized immunotherapies [2,4].
- Identification of new immune targets [4,3].
- Better combination therapies with other treatments [12,9].
- Reduced side effects through precise immune activation [2,12].
- Use of advanced technologies for improved outcomes [4,9].

II. CONCLUSION

In order to treat patients, cancer therapy has traditionally relied on methods that directly target tumor cells. The use of a patient's immune system to combat cancer is known as cancer immunotherapy, and it is currently becoming a significant supplement to traditional treatments. One of the most remarkable developments in cancer treatments in recent years has definitely been immune checkpoint blockade therapy. James P. Allison recently received the 2015 Lasker-DeBakey Clinical Medical Research Award for discovering and developing an anti-CTLA-4 mAb that unlocks the immune system's brakes to fight cancer, demonstrating the significance of this scientific breakthrough. The mAb ipilimumab, which blocks CTLA-4, has already helped thousands of patients with metastatic melanoma, a condition that used to kill people in shorter than a year. Most significantly, the clinical success of anti-CTLA-4 led to the development of a new field known as immune checkpoint therapy. In addition to the release of other immune inhibitory checkpoints, such as PD1 and its ligand PD-L1, these are now being used in conjunction with conventional therapies or with one another to induce strong and long-lasting antitumor responses in a wide range of tumors. While it is still necessary to identify the best combinations of regimens and to make significant efforts in the discovery and the most effective way to improve therapeutic success for a variety of tumor types is through the validation of predictive biomarkers, checkpoint blockade immunotherapy, and its combination with other (immune) therapeutic modalities.

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