ISSN 2692-5877
DOI: 10.46998/IJCMCR.2023.35.000861

International Journal of
Clinical Studies & Medical Case Reports

Review Article

How Do Cancer Vaccıne Work?

Hatice Banu KIROĞLU*
Istanbul University, Faculty of Science, Department of Molecular Biology and Genetics, Turkey

***Corresponding author:** Hatice Banu KIROĞLU, Istanbul University, Faculty of Science, Department of Molecular Biology and Genetics, Turkey

Received: October 16, 2023 **Published:** March 25, 2024

Abstract

Cancer is a series of diseases that occur when the controlled cell growth and division mechanism is lost caused by the disorder of a group of genes. Various biological causes such as genetic mutations, viral factors, activation of proto-oncogenes, dysfunction of the apoptosis mechanism, immunosuppression, and chronic inflammation can initiate carcinogenesis [1]. Are cancer and carcinogenesis preventable? Cancer vaccines, which aim to prevent and treat cancer, are a new hope recently. Cancer vaccines are a current approach that aims to protect against cancer by strengthening the immune system and treating cancer in combination with existing treatment approaches [2]. Treatment approaches vary depending on the type of cancer, the stage of the disease, the patient's age, and general health condition. Cancer vaccines can be personalized for the patient and particular cancer type. Cancer vaccines are examined under two headings: Therapeutic cancer vaccines and preventive cancer vaccines. Preventive cancer vaccines aim to prevent cancer types due to viral factors or infection [3]; therapeutic cancer vaccines do not directly target the tumor but stimulate the patient's immune system and stimulate the patient's immune cells to fight cancer. Biologically, we can examine cancer vaccines in five subgroups: There are five types: Antigen vaccines, tumor cell vaccines, antibody-based vaccines, DNA vaccines, and viral vector-based vaccines. [4] What cancer vaccines promise to the scientific world and patients is as follows: It is predicted that it can prevent cancer by enabling the patient to create memory cells that enable the patient to develop an immune mechanism against viral factors and antigens that cause cancer. If applied together with existing treatment methods, it gives the potential to fight cancer by strengthening the patient's immune system and has fewer side effects than existing treatment methods [5]. It may be functional in preventing recurrence during the follow-up period after treatment. Some cancer vaccines approved by the FDA and still in the developmental phase.

Keywords: Cancer; Cancer vaccines; Therapeutic cancer vaccines; Immunotherapy

Introductıon

Cancer is a series of diseases that occur when the controlled cell growth and division mechanism is lost caused by the disorder of a group of genes. Genetic factors, smoking and alcohol consumption, age, general health status, and obesity are the main risk factors for most cancers. Various biological causes such as genetic mutations, viral factors, activation of proto-oncogenes, dysfunction of the apoptosis mechanism, immunosuppression, and chronic inflammation can initiate carcinogenesis [1]. Are cancer and carcinogenesis preventable? Cancer vaccines, which aim to prevent and treat cancer, are a new hope recently. Cancer vaccines are a current approach that aims to protect against cancer by strengthening the immune system and treating cancer in combination with existing treatment approaches [2].

Treatment approaches vary depending on the type of cancer, the stage of the disease, the patient's age, and general health condition. Cancer vaccines can be personalized for the patient and particular cancer type. Cancer vaccines are examined under two headings: Therapeutic cancer vaccines and preventive cancer vaccines. Preventive cancer vaccines aim to prevent cancer types due to viral factors or infection [3]; therapeutic cancer vaccines do not directly target the tumor but stimulate the patient's immune system and stimulate the patient's immune cells to fight cancer. Biologically, we can examine cancer vaccines in five subgroups: There are five types: Antigen vaccines, tumor cell vaccines, antibody-based vaccines, DNA vaccines, and viral vector-based vaccines [4].

What cancer vaccines promise to the scientific world and patients is as follows: It is predicted that it can prevent cancer by enabling the patient to create memory cells that enable the patient to develop an immune mechanism against viral factors and antigens that cause cancer. If applied together with existing treatment methods, it gives the potential to fight cancer by strengthening the patient's immune system and has fewer side effects than existing treatment methods [5]. It may be functional in preventing recurrence during the follow-up period after treatment. Cancer vaccines approved by the FDA. For instance, Herceptin (Trastuzumab) for breast cancer, NeoVax for melanoma, and Rexin-G cancer vaccine. Surgical treatment, chemotherapy, radiotherapy, and immunotherapy and their combinations with cancer vaccines apply to the patient's general health condition and treatment process.

What are Cancer Vaccines?

Cancer vaccines are the current approach that aims to protect against cancer by strengthening the immune system and treating cancer alone or in combination with existing treatment approaches [6]. Developing cancer vaccines and getting ready to apply is a long and challenging process. That is demanding improvement in a single vaccine that will provide trouble-free and long-term protection against all types of cancer. Cancer vaccines are improved specifically to the type of cancer. Recent vaccine studies focus on the development of vaccines for patients [7]. Thus, during the development of cancer vaccines, personalization studies are carried out for the type of cancer and the patient. Cancer vaccines are divided into two main categories according to their purpose: Preventive cancer vaccines and therapeutic cancer vaccines. Preventive cancer vaccines aim to create the body's immune response against pathogens that can initiate carcinogenesis. Some popular preventive cancer vaccines approved by the FDA are, Hepatitis B and Hepatitis C for liver cancer and HPV for cervical cancer. Most cancer vaccines consist of therapeutic vaccines. The main goal of therapeutic vaccines is to facilitate cancer treatment in combination with existing treatment methods [8]. For example, there are vaccines such as HER/2 for breast cancer, some cancer vaccines for advanced-stage ovarian cancer [9], and DPX-0907 for small cell lung cancer, which are effective in more than one cancer, such as EP-2101.

How Do Work Cancer Vaccines?

Preventive cancer vaccines work in several steps. Cancer-causing antigens are injected into the patient in weakened or killed suspension form. To stimulate the patient's immune system and create an immune mechanism against cancer. Antigens stimulate the production of antibodies, and antibodies neutralize the disease agent. Cancer vaccines also enable the formation of memory cells. Memory cells are a group of cells that directly recognize cancer antigens and create a rapid immune response. Memory cells formed by antigens are by the secondary immune response. For example, Human Population Virus is one of the significant risk factors for cervical cancer. HPV vaccine is known as a preventive cancer vaccine for cervical cancer [10]. The biological functioning of the HPV vaccine is as follows: HPV vaccine contains virus proteins (L1 and L2 capsid proteins) and some virus-specific antigens. Antibody production begins against antigens detected by the immune system and neutralizes the HPV virus. In the next step, memory cells that will play an active role in long-term immunity occurs. Protection is provided against HPV-related cancer types, especially cervical cancer.

Therapeutic cancer vaccines do not directly target tumors and cancerous areas. Therapeutic cancer vaccines support the immune system and encourage the body to fight cancer. For this reason, therapeutic cancer vaccines apply in combination with existing cancer treatment approaches. The effectiveness of therapeutic cancer vaccines varies according to subtypes.

Types of Cancer Vaccines

Therapeutic cancer vaccines are classified according to their biological content and functioning. Therapeutic cancer vaccines are categorized into two main headings: Specialized and general cancer vaccines. Vaccines that aim to strengthen the immune system and trigger an immune response in a specific type of cancer are called specialized cancer vaccines. Specialized cancer vaccines target cancer cells or proteins that may be related to cancer, creating an immune response. In some types of cancer, patient-specific treatment approaches may need to improve. Specialized cancer vaccines are a hope for personalized treatment. General cancer vaccines aim to prevent, treat, or control cancer in almost all types of cancer. However, Improving a vaccine that works smoothly for all kinds of cancer is challenging. Therapeutic cancer vaccines have five subgroups:

1. Antigen vaccines
2. Tumor cell vaccines
3. Antibody-based vaccines
4. DNA vaccines
5. Viral vector-based vaccines.

Antıgen Cancer Vaccınes

Antigen cancer vaccines directly target the tumor and tumor cells and stimulate the immune system to create an immune response [11]. Antigen vaccines contain tumor-specific protein or peptide antigens. These antigens come from patients' tumors. Most antigens in the cancer process consist of the body's own modified proteins. For this reason, the immune system may have difficulty recognizing these antigens as foreign antigens. This tolerance must exceed for an effective antigen vaccine to work. Antigen vaccines work in several steps: A form of cancer antigens or cancer-specific antigens are given to the body along with the vaccine. The first goal is to perceive cancer antigens as foreign and harmful to the immune system. Once the immune response to detected antigens occurs, T and B immune cells are activated, and the antigen is destroyed. In the last step, the immune response is improved against cancer by the memory cells. T cells can generally recognize all antigen proteins, except for some exceptional cases. Some advantages of antigen vaccines are as follows: Although it depends on the type of cancer, it provides a specific treatment opportunity by directly targeting cancer cells and tumors. It may have minimal side effects compared to current treatment approaches. It causes less tissue damage. Since it aims to strengthen the immune system, it helps the body keep cancer under control. The major disadvantage of antigen vaccines is that they are ineffective in the patient. Cancer vaccines can be effective, but that process could take time. They can be economically challenging because they are too complex and expensive. Some possible side effects of antigen vaccines include pain and swelling at the injection site, fever and chills, skin reactions, nausea, and vomiting. Provenge (Sipuleucel-T) for prostate cancer, Oncophage (Vitespen) for kidney cancer, and HER2/neu for breast cancer are antigen vaccines improved.

Tumor Cell Vaccines

Tumor cell vaccines work in such a way as to stimulate the patient's immune system to create an immune response to the patient's cancer cells. The content of the vaccine consists simply of tumor cells isolated and made safe from the patient himself or another patient. For the immune system to detect tumor cells as foreign, gene recombination and sometimes different chemicals are added to the cells [11]. There are two types of tumor cell vaccines: Allogeneic and autologous vaccines. Allogeneic vaccines come from isolating the tumor cells of another patient. It is injected into the patient together with one or more adjuvants. Autologous vaccines, on the other hand, consist of the isolation of the patient's tumor cells as a content. Tumor cell vaccines work biologically; firstly, preparation of the vaccine content, cells are isolated in the tumor and made pure by irradiation. Antigens are injected into the patient to detect the immune system. The immune response to the detected cells is improved, and after the formation of memory cells, the immune

system is strengthened against the antigen. Dendritic vaccines are a subset of tumor cell vaccines, and dendritic vaccines target a potent immune response to provide more effective stimulation of the immune system [13]. Some of the advantages of tumor cell vaccines are that they are specially produced for each patient and thus offer the possibility of personalized treatment. It trains the immune system to fight cancer. It can reduce the recurrence rate. It has minimal side effects compared to current treatment approaches. The disadvantage of tumor cell vaccines is they may be ineffective on cancer. Even if effective, this process can be slow, and tumor cell vaccines are expensive. Inflammation, pain, allergic reactions, malaise, and fever are present in the side effects. Rexin-G cancer vaccine, Gvax for pancreatic cancer, and Herceptin(Trastuzumab) for breast cancer are some tumor cell vaccines developed.

Antıbody Cancer Vaccines

Antibody cancer vaccines target specially produced antibodies against cancer cells to stimulate the immune system. Antibody cancer vaccines are less likely to damage other tissues because vaccines target cancer cells directly. Antibody cancer vaccines work on the same principle as other cancer vaccines. The immune system recognizes antibodies, and then the memory cells are formed to improve the immune response. The possibility of specific treatment, low side effects, and long-term immunosuppressive antibody cancer vaccines are among the advantages. High cost and the duration and speed of effectiveness are slow is one of the disadvantages of antibody cancer vaccines. Rituximab(Rituxan) for lymphoma and types of leukemia, and Ipilimumbab (Yervoy) are examples of antibody cancer vaccines used to treat melanoma.

DNA-Based Cancer Vaccines

DNA cancer vaccine is a suspension containing genetic material obtained by isolating a cancer cell's DNA [14]. The essential purpose of DNA vaccines is to ensure that the body can have a unique immune response to its tumor cells. The goal of the vaccine is the formation of an immune response with the release of more T-lymphocytes. DNA isolated and purified from tumor cells is injected into the patient in a naked form or with a harmless virus. An antigen-specific response occurs by the immune system, and the attack on tumor cells begins. With the formation of memory cells, the vaccine is considered to have functioned flawlessly. DNA caser vaccines are easy to administer and offer the possibility of a personalized treatment. DNA vaccines are generally safe, but a vaccine prepared with oncogenic DNA can increase management. DNA-based cancer vaccines should be applied with caution by oncologists and patient cooperation. Its production is cheaper compared to other types of vaccines. DNA vaccines may cause minimal side effects, such as mild fever and sensitivity at the injection site. Lucaniz is an example of a DNA-based cancer vaccine developed for lung cancer, Renal kidney cancer, and OncoVax for colorectal cancer.

Viral Vector-Based Cancer Vaccınes

Viral vector-based vaccines are a kind of nucleic acid vaccine. Vaccine suspension containing viral vectors genetically modified to stimulate the immune system to fight cancer are viral vector-based cancer vaccines. Viruses, bacteria, or an antigen inside the body apply as a viral vector(immunotereupatic agent). The viral vector is selected, and the vector is ensured that it will not cause disease. The genetic material of the cancer antigens combines with the viral vector. After the vaccine injection, the viral vector begins to multiply in the body. An immune response occurs against this new antigen. The triggered immune cells take action against tumor cells, and as a result, an immune response to cancer has formed with the memory cells. Viral vector-based vaccines are very diverse. It ensures the creation of a long-term and effective immune response [15]. Increasing malignity in viral vector-based cancer vaccines is one of the side effects. It may cause immunotolerance. The production of viral vector-based vaccines, on the other hand, is too costly and complicated. The clinical trial phase can also be challenging. OncoVex GM-CSF for head and neck cancer, Ad-VEC for breast cancer, and JX-594 are some viral vector-based vaccines developed for liver cancer.

Conclusıon

Cancer is a disease that occurs due to the loss of control of the cell cycle and growth due to changes in the activity of a specified group of genes. Studies have been intensively continuing to prevent cancer and develop new treatments. Cancer vaccines are one of the current treatment approaches developed for this purpose. The cancer vaccines improve the immune system and provide long-term protection against cancer by creating an immune response to possible cancer agents. There are two types of cancer vaccines: preventive cancer vaccines and therapeutic cancer vaccines. Most of the cancer vaccines developed are in the group of therapeutic cancer vaccines. Therapeutic cancer vaccines train the immune system to fight the body's cancer cells. it provides specific treatment and long-term protection and has minimal side effects compared to current treatment approaches, which are the main advantages of cancer vaccines. Disadvantages of cancer vaccines are that they are produced at a high cost and complex process, and have no effect or slow effectiveness. Cancer vaccines have minimal side effects, but the viral vectors used in some types of vaccines may increase malignity [16]. Some cancer vaccines are approved by the FDA, and some vaccines are still in developmental phase.

Funding: This research received no external funding.

References

1. Raymond W. Ruddon, Cancer Biology Fourth Edition, Oxford Express, 2007; ISBN-13: 978-0-19-517543-1.
2. Jacques Banchereau and Karolina Palucka, Cancer vaccines on the move, Nature, 2017; 547: 222–226.
3. Pier-Luigi Lollini, Federica Cavallo, Patrizia Nanni, Elena Quaglino. The Promise of Preventive Cancer Vaccines, Vaccines, 2015; 3: 467-489, 10.3390/vaccines3020467.
4. Melahat Akdeniz, Bülent Yardimci, Cancer Vaccines, Klinik Tıp Aile Hekimliği Dergisi, 2016.
5. Jagmohan Singh, Wilbur B Bowne, Adam E. Snook, Cancer Vaccines and Immunotherapy for Tumor Prevention and Treatment, Vaccines, 2021; 9: 1298. DOI: 10.3390/vaccines9111298.
6. Matthew J Lin, Judit Svensson-Arvelund, Gabrielle S Lubitz, et al. Cancer vaccines: the next immunotherapy frontier, Nature Cancer, 2022; 3. DOI: 10.1038/s43018-022-00418-6.
7. Uğur Sahin, Özlem Türeci. Personalized vaccines for cancer immunotherapy, Science, 2018; 359: 1355–1360.
8. Zhuting Hu, Patrick A Ott, Catherine J Wu. Towards personalized, tumor-specific, therapeutic vaccines for cancer, Cancer Immunotherapy, 2018; 18. DOI: 10.1038/nri.2017.131.
9. Hatice Banu Kiroğlu. Ovarian Cancer, International Clinical Studies and Medical Case Reports, 2023. DOI: 10.46998/IJCMCR.2023.30.000745.
10. Claire P Rees1, Petra Brhlikova, Allyson M Pollock. Will HPV vaccination prevent cervical cancer? Journal

of the Royal Society of Medicine, 2020; 113(2): 64–78. 10.1177/0141076819899300.
11. Luigi Buonaguro, Maria Tagliamonte. Selecting Target Antigens for Cancer Vaccine Development, Vaccines, 2020; 8: 615. DOI: 10.3390/vaccines8040615.
12. Robert E Hollingsworth, Kathrin Jansen. Turning the corner on therapeutic cancer vaccines", NPJ Vaccines, 2019. DOI: 10.1038/s41541-019-0103-y.
13. Karolina Palucka, Jacques Banchereau1. Dendritic-Cell-Based Therapeutic Cancer Vaccines, Cell Press, Immunity, 2013; 39. DOI: 10.1016/j.immuni.2013.07.004.
14. Alessandra Lopes, Gaëlle Vandermeulen, Véronique Préat. Cancer DNA vaccines: current preclinical and clinical developments and future perspectives, Journal of Experimental & Clinical Cancer Research, 2019; 38: 146. DOI: 10.1186/s13046-019-1154-7.
15. Zong Sheng Guo, Binfeng Lu, Zongbi Guo, et al. Vaccinia virus-mediated cancer immunotherapy: cancer vaccines and oncolytic, Journal for ImmunoTherapy of Cancer, 2019. DOI: 10.1186/s40425-018-0495-7.
16. XD Li, JY Gao, Y Yang, et al. Nanomaterials in the application of tumor vaccines: advantages and disadvantages, OncoTargets and Therapy, 2013; 629-634. DOI: 10.2147/OTT.S41902.