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*Editorial*

# The Future Direction of Cancer Vaccines: An Editorial

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In the past, vaccines were defined as prophylactic entities. Today, there are two types of vaccines: prophylactic for prevention, and therapeutic for the treatment of infections or cancers. Therapeutic cancer vaccine, in fact, represents an option for active immunotherapy for the treatment of late-stage and/or prevention of recurrent diseases.[1] The function of a therapeutic cancer vaccine in patients is the eradication of cancer cells by strengthening the patient's own immune response.[2] This type of immunotherapy not only provides a new modality for cancer treatment but also paves the way for designing various therapeutic vaccines for chronic infections.[3]

In spite of vast progress in this pathway, developing effective and safe therapeutic vaccines is still in its infancy when compared with prophylactic vaccines and immunotherapeutic agents.[4] Before new technologies were applied for developing therapeutic vaccines, a few of them like bacilli galmette-guerrin (BCG) was used for the treatment of bladder, and prostate cancers.[5,6] Recently, it has been reported successful use of the human papilloma virus (HPV) vaccine for the treatment of multiple cutaneous malignancies.[7]

It should be noted that despite considerable advances in developing fairly effective and safer cancer vaccines like dendritic cell (DC) vaccine,[8] chimeric antigen receptor (CAR) T-cell,[9] human telomerase reverse transcriptase (hTERT) derived vaccines,[10] deoxyribonucleic acid (DNA) vaccines,[11] neoantigen vaccines,[12] the clinical translation of cancer vaccines into clinically effective therapies has been quite challenging.[13] Today, technological advances accelerated by the coronavirus disease-2019 (COVID-19) pandemic led to the emerging application of messenger ribonucleic acid (mRNA) technology in developing vaccines.[14] However, the recent approval of therapeutic monoclonal antibodies, namely Dostarlimab, which is a programmed death receptor-1 (PD-1)-blocking antibody used for the treatment of endometrial cancer.[15] There are a few others that have Food and Drug Administration (FDA) approval for clinical use. Pembrolizumab binds to PD-1 proteins found on T-cells. This antibody blocks PD-1 and helps the immune system kill cancer cells.[16] It is used to treat melanoma, Hodgkin's lymphoma, and several other types of cancer.[17] Panitumumab is another engineered monoclonal antibody that targets epidermal growth factor receptor (EGFR) for use in the treatment of colon cancer.[18] Rituximab targets CD20 found on B-cells. It is used for the treatment of Hodgkin lymphoma. Trastuzumab targets the Her2/neu receptor expressed in some types of breast cancer. Cetuximab targets the EGFR. It has been used in the treatment of metastatic colorectal cancer and squamous cell carcinoma of the head and neck.[19,20] Bevacizumab targets circulating vascular endothelial growth factor (VEGF) ligand. It is approved for use in the treatment of colon cancer, breast cancer, and non-small cell lung cancer.[21] Mogamulizumab is another humanized monoclonal antibody lacking fucose in the Fc region of the antibody molecule in order to enhance its antibody-dependent cell-mediated cytotoxicity effect. The target of this antibody is chemokine receptor-4 (CC4) and it has been used for the treatment of relapsed and/or refractory mycosis fungoides as well as cutaneous T-cell myeloma.[22] All these FDA-approved antibodies are developed based on targeted immunotherapy as major modalities of cancer treatment. Targeted cancer therapies are expected to be more effective than other forms of therapies that are more harmful to normal cells as well as cancer cells.

It should be noted that continued advancement in the application of molecular technologies and the growing attention of scientists to targeted cancer therapies would lead us to apply more personalized cancer therapies which require the cooperation of laboratory scientists and clinicians. Consequently, in the near future, the distinction between therapeutic vaccines and medicines will fade away.

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