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Conventional and mRNA Vaccine Treatments for Pancreatic Cancer

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Abstract. Pancreatic cancer is a highly invasive tumor that has an extremely low probability of prediction. The impact of traditional treatment procedures such as surgery, chemotherapy and radiotherapy is still insufficient and new treatment approaches is in urgent need. Cancer immunotherapy particularly vaccine treatment has taken centre stage in research in the recent years. This is a review of research advances with both conventional vaccines and up-and-coming mRNA vaccines used in the treatment of pancreatic cancer therapy. Conventional vaccines consist of dendritic cell vaccines, exosome vaccines and peptide vaccinations, etc. Such vaccines have anti-tumor effects inducing antigen presentation and T-cell responses and were found to have some safety and immune activity in clinical trials. Nevertheless, these methods continue to have issues including the lack of immunogenicity, low level of personalization, complicated processes of preparation and suppression of tumor microenvironment. By comparison, mRNA vaccines, featuring the benefits of an extremely personalized vaccine design, can be well engineered in a short time and very immunogenic, have the potential to encode patient-specific neoantigens and induce long-lasting T-cell responses, which are one potential means of overcoming the cold tumor phenotype of pancreatic cancer. The paper provides a systematic discussion of classification and mechanisms of traditional vaccines and the research progress and perspective of mRNA vaccines, outlines characteristics of action, existent limitations and future directions of development of a variety of vaccines, attempting to provide references to further studies and clinical application of pancreatic cancer immunotherapy.

Keywords: mRNA vaccine, pancreatic cancer, dendritic cell-linked vaccines, peptide.

1. Introduction

Pancreatic cancer is an aggressive and lethal malignancy, which is considered to have rapid progression, early metastasis, and very poor clinical outcomes. Despite the fact that medical technology has advanced, the overall survival of the patient with pancreatic cancer is low as there is a lack of effective treatment options and there is a late diagnosis in most cases. Many patients are diagnosed at their advanced stages making surgical resection impossible and hence high burden of the disease and high mortality of the disease is experienced in most parts of the world.

Existing treatment measures of pancreatic cancer are surgery, chemotherapy and radiotherapy. The standard therapy of the advanced disease is chemotherapy, especially gemcitabine-based.

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Nevertheless, it has a low clinical utility and usually comes at an enormous cost in terms of toxicity and form of drug resistance. Radiotherapy may help in local tumor control in a selected group of patients but has not shown much effect on long term survival. Overall, the traditional treatment modalities failed to yield significant changes in patient outcomes, Thus, novel therapeutic modalities are urgently required.

As part of current oncology efforts, cancer immunotherapy has emerged as a promising modality, which has increased interest in vaccine-based therapies of pancreatic cancer. Traditional vaccines used against pancreatic cancer encompass the dendritic cell vaccines, whole tumor cell vaccines as well as peptide and exosome vaccines. These methods aim at augmenting tumor-specific immune reactions by increasing antigen presentation and the activation of cytotoxic T lymphocytes. Clinical trials have shown that immunotherapy using dendritic cells is capable of generating antitumor immune responses, and can increase the survival of patients with resected pancreatic cancer, which is the immunologically cold microenvironment to use vaccine-based immunotherapy [1].

Over the past few years, RNA technology has resulted in the creation of mRNA cancer vaccines, which have many benefits, such as a good safety profile, fast production and high immunogenicity. Monoantigen personalized neoantigens mRNA vaccines have demonstrated elicitation of long-term $CD8^+$ T-cell effects on pancreatic cancer, and this approach assists in a renewed means of immunotherapy [2]. In comparison to traditional platforms of vaccine delivery, mRNA vaccines enable targeted delivery of patient-specific tumor antigens and can serve to overcome immune tolerance.

This article is an overview of the current advances in the pancreatic cancer treatment with the emphasis on the conventional vaccine-based therapies and new mRNA-based vaccinations, their mechanisms, therapeutic potential, and future perspectives of pancreatic cancer immunotherapy.

2. Traditional vaccines on pancreatic cancer

2.1. Dendritic cell-linked vaccines

2.1.1. Autologous tumor cell based DC vaccines

In one of the studies, they examined a dendritic cell (DC) vaccine method that used RNA interference with programmed death-ligand 1 (PD-L1) to boost the overall effectiveness of immunotherapy in pancreatic cancer [3]. PD-L1 is an extremely important molecule in immune escape as it suppresses the T-cell activation in the tumor bed. The silencing of PD-L1 in the DC vaccines showed an increase in tumor-specific cytotoxic T lymphocyte activation, secretion of cytokines and improvement of antitumor immune responses. The cancer treatment efficacy of the modified DC vaccine was better than that of conventional DC vaccines and these results indicate that the level of immune checkpoint modulation can greatly enhance the antitumor immunity produced by vaccines. This study offers a valuable experimental data to the use of combination of DC-based vaccines with immune checkpoint control as a promising regimen in the treatment of pancreatic cancer [3]. This study investigated the process and treatment efficacy of dendritic cell vaccines loaded with tumor exosomes in the pancreas cancer [4]. The exosomes that are released by tumors are naturally good carriers of tumor-related antigens and immune-modulatory molecules, thus making it an effective source of antigens in opposition to the DC vaccination. The results showed that the exosome-loaded DCs showed increased maturation and antigen-presenting capacity which brought about vigorous T-cell responses of tumors. This method had better tumor suppression compared with the conventional antigen-loaded DC vaccines. Mechanistically, the researcher

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pointed to a better presentation of tumor antigens and a better immune response. These findings imply that DC vaccines made of tumor exosomes are a highly promising approach to enhancing the effectiveness of immune therapies in the treatment of pancreatic cancer [4]. This clinical trial assessed the functionality, safety and immunological effectiveness of dendritic cell-based immunotherapy in subjects that had undergone surgery to clear cancer of the pancreas [1]. DC vaccines were used as an adjuvant treatment to boost tumor-specific immunity and reduce the risk of recurrence. These findings indicated that DC vaccination was both well tolerated and had the capacity to elicit antigen specific T-cell responses in patients who had undergone surgery. Notably, some patients had a positive clinical outcome that was linked to the activation of immunity. In this study, clinical evidence was provided to support DC-based vaccines as a possible adjuvant immunotherapeutic measure to resected pancreatic cancer [1]. This research aimed at discussing the involvement of type I conventional dendritic cells (cDC1s) in the immunotherapy of pancreatic cancer [5]. cDC1s are dedicated antigen-presenting cells, which are needed to cause cross-presentation and to activate T cells of the $CD8^+$ type. The experiment established that the presence of cDC1s is a key to effective antitumor immune responses and a high level of immunotherapeutic interventions. T-cell-mediated tumor control was related to increased infiltration and functional activity of cDC1s. This has shown that receptor specific dendritic cell subsets can be targeted to maximize the use of Immunotherapy based on Vaccines in the treatment of Pancreatic cancer [5].

2.1.2. Allogeneic tumor cell-based vaccinations

Unlike autologous tumor cell-based technologies, allogeneic tumor cell-based vaccines are expected to address both practical and biological constraints in the form of feasibility and quality of patient-derived tumor material. These vaccines can be produced in bulk enabling consistent and pre-determined output of vaccines and still provoke clinically significant immunity by invasive shared tumor-associated antigens.

The potential effectiveness of this approach was supported by a clinical trial as they tested the use of neoadjuvant and adjuvant vaccination with an allogeneic tumor cell-based vaccine in patients with resectable pancreatic ductal adenocarcinoma [6]. Under such conditions, vaccination brought about the generation of intratumoral lymphoid aggregates, which were found to be ordered immigration frameworks akin to tertiary lymphoid frameworks. These aggregates were typified with a heavy influx of immune cells and had a strong correlation with the survival of the patient.

Significantly, the existence of vaccine-dependent intratumor lymphoid aggregates was associated with an improved immune response in the tumor microenvironment, implying effective immune remodeling in the tumor microenvironment over short term immune activation in the system of the whole body. The patients who had these types of immune structures revealed longer survival rate than those without such responses, which points to their potential application as a mechanistic operational indicator of vaccine efficacy as well as a prognostic biomarker.

This study highlights a benefit of allogeneic tumor cell-based vaccines, which is that they can alter the local tumor immune environment. Instead of the use of the circulating immune responses, this approach facilitates long-term surveillance by the immune system within the tumor itself. All these results justify the inclusion of allogeneic tumor cell-based vaccines into multimodal treatments to pancreatic cancer and allow a justification on the continued clinical development of this modality [6].

In addition to showing the viability of the clinical application, induction of intratumor lymphoid aggregates after allogeneic tumor cell-based vaccination offers valuable mechanistic data concerning the potential efficacy of antitumor immunity in pancreatic cancer. These structured immune

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compartments have similarity to tertiary lymphoid structures and are believed to serve as local antigen presentation and T-cell priming and long-term immunosurveillance locations within the tumor microenvironment. Their existence implies the ability of vaccination to induce the systemic systemic immune reaction as well as the long-term, spatial immunity at the tumor location.

The association between intratumoral lymphoid aggregates and enhanced survival stresses on the significance of local immune contexture in dictating therapy responses. Instead of depending on circulating effector T cells, this vaccine approach seems to enable sustained immune homeostasis that occurs directly within the tumor and may overcome the structures that may encircle the tumor that are stromal density and immune exclusion, which is hallmark of pancreatic cancer. These observations highlight the idea that effective cancer vaccination should result in attaining effective immune remodelling in the tumor microenvironment, and not just in the generation of peripheral immune responses.

The other benefit of allogeneic tumor cell-based vaccines is that they are practical and scalable. The allogeneic vaccines may be prepared in advance using standardized tumor cell lines expressing common tumor-associated antigens as compared to autologous vaccines which require adequate amounts of patient-specific tumor tissue and may be delayed by surgical or technical factors. This aspect facilitates the timely administration in the neoadjuvant and adjuvant context and increases the wider clinical adoption.

However, there are still problems to this method. Since allogeneic vaccines are based on common antigens, their activity could be affected by antigen difference in patients. To achieve the maximum level of immune coverage, it will be necessary to find the best sources of antigens and enhance the antigen breadth. Moreover, the way to combine allogeneic vaccines with other immunomodulatory measures in the most suitable manner to promote the formation of lymphoid aggregates and immune maintenance is yet to be studied.

Altogether, allogeneic tumor cell-based vaccines are a good prospective of immunotherapies that strike a balance between clinical feasibility and meaningful immune modulation. They induce structured intratumor immune responses which gives a good reason why they should be further developed and introduced into multimodal treatment regimens as a way of treating pancreatic cancer [6].

2.2. Exosome based vaccines against pancreatic cancer

Vaccines Exosome-based vaccines have also become a new type of cell-free immunotherapeutic modalities in treating pancreatic cancer [7]. Tumor-derived exosomes are small nano size extracellular vesicles, which inherently include tumor-associated antigens, tumor cell membrane proteins and immune-regulatory molecules that resemble those of their mother tumors. These inherent properties render exosomes viable vaccine development targets, since it will allow easy delivery of antigens without having to use whole cells.

It has been shown that stromal cells are capable of antigen-presenting and becoming proliferated and upgraded into dendritic cells in response to the tumor-derived exosomes, which would not otherwise have been able to respond to antigens. When taken by dendritic cells, exosomal antigens are taken up, processed and presented to the T lymphocytes resulting in the generation of tumor-specific cellular immune responses. Exosomes are superior to traditional soluble antigen preparations in that they offer a stable and protecting antigenic cargo, enabling superior incorporation into facilitation of antigen cross-presentation, and activation of immunity [7].

This strategy has been further refined by capitalizing on the exosomes of dying tumor cells that were immunogenically dying [8]. Tumor cells also release exosomes that are highly enriched with

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danger-associated molecular patterns and immunostimulatory signals along with tumor antigens during immunogenic cell death. These exosomes of vaccination have been demonstrated to trigger strong dendritic cell functions, cytotoxic T-cell effectors, and remarkably enhance antitumor immunity in pancreatic cancer models. This will be an effective strategy to conjugate antigen delivery and innate immune stimulation, excessively overcoming the intrinsically low immunogenicity of pancreatic tumors [8].

Outside the immunological effectiveness, exosome-based vaccines have a number of practical benefits. Exosomes, being a cell-free system, present better safety profiles, decreased complexity in manufacturing and have an enhanced stability in storage and transportation. In addition, their size permits easy trafficking to lymphoid organs and this serves in immune priming. Combined together, these aspects place exosome-based vaccines as an attractive and multifaceted delivery system of immunotherapy against pancreatic cancer, which should be further studied and improved [7].

Besides playing an effective antigen carrier role, tumor-derived exosomes also play a role in immune modulation by their interaction with innate immune signaling pathways [6]. Exosomes conserve the membrane topology and molecular composition of their parent tumor cells, such that tumor antigens can be produced in a natural-like environment that has a high likelihood of recognition by antigen presenting cells. This biological homogeneity increases distribution by dendritic cells and promotes successful antigen processing and presentation which is pivotal in eliciting tumor-specific T-cell responses within pancreatic cancer [6].

Besides, exosomes of immunogenically dying tumor cells have a greater immunostimulatory effect [7]. These vesicles are loaded with natural danger-associated molecular patterns which act as natural adjuvants, hence enhancing dendritic cell maturation, and enhancing cytotoxic T-cell activation. Immunogenic cell death -derived exosomes improve sensitive and sensible overcoming of the intrinsically low immune-detectability of pancreatic tumors by means of their association with antigen delivery and innate immune stimulation [7]. Translational From a translational standpoint, acellular exosome-based vaccines have convenient benefits of enhanced safety, ease of manufacture and stability in storage. In sum, all these characteristics are in favor of the exosome-based vaccines to be seen as an appealing and clinically flexible immunotherapeutic platform in pancreatic cancer [6,7].

2.3. Pancreatic cancer vaccines based on peptide

Another promising approach to the treatment of pancreatic cancer immunotherapy is the use of peptide-based therapeutic cancer vaccines [9]. These vaccines have the ability to specifically stimulate immune responses by application of short, defined peptides which are based on tumor-associated or tumor-specific antigens. Peptide vaccines are of special interest in clinical application because they are highly specific, have a good safety picture, and are relatively easy to synthesize.

Nevertheless, there are intrinsic issues associated with peptide-based vaccines, including reduced immunogenicity, as well as immune tolerance at the tumor microenvironment. As a response mechanism to these deficiencies, contemporary clinical and translational endeavors have been made on combination therapy and optimal use of adjuvants. Research reviews on the development of peptide based vaccines have noted the relevance of using immunodominant epitopes, the use of immune-stimulant adjuvants, and the combination of a vaccine with other conventional treatment methods in order to increase therapeutic effectiveness [9].

A phase I/II single-arm trial of TG01 peptide vaccine with gemcitabine adjuvant plus granulocyte-macrophage colony-stimulating factor (GM-CSF) in combination with adjuvant gemcitabine plus gemcitabine of resected patients with RAS mutant pancreatic adenocarcinoma has

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shown clinical evidence of the vaccine on peptide being used in pancreatic cancer [10]. This vaccination approach was also able to stimulate immune responses against RAS-specific antigens and was well tolerated, which indicated the potential of targeting oncogenic driver mutations with peptide vaccination.

Relevantly, when peptide vaccination was combined with chemotherapy it seemed to enhance and not to inhibit immune activation, which indicated that immune-based treatment and cytotoxic interventions may have acted mutually. The results of the immune responses were linked to positive clinical prognoses, which promotes the possibility of using peptide-based vaccines as adjuvant therapy after surgical resection. All those results demonstrate that peptide-based vaccines, especially in a combination with immune adjuvants and standard therapy, are a promising and developing trend in pancreatic cancer immunotherapy [10].

In spite of such positive improvements, there is more to be done toward maximizing the therapeutic use of peptide-based vaccines in pancreatic cancer. Diversification of immune coverage by the implementation of better antigen selection strategies to curb immune escape is a priority. Moreover, the timing of the vaccination cycle with reference to the surgical and chemotherapy may be very important as regards the immune priming and the immune response persistence. Further development of adjuvant systems and delivery models can further increase the immunogenicity of peptides and prolong the ability of effector T-cells to survive in the tumor microenvironment. Peptide-based vaccines can be a significant constituent of custom-made and combination immunotherapy therapy with the aim of enhancing long-term disease control in pancreatic cancer occasionally clinical experience expands [9].

In addition to antigen specificity, peptide vaccines are essentially an adaptable platform allowing targeting of known molecular motor of pancreatic cancer [8]. The rationale of vaccine design and decreased off-target activation is feasible by the ability to select peptides resulting both to oncogenic mutations and overexpressed tumor-associated antigens. This accuracy especially applies in pancreatic cancer where it is important to maintain normal functions of the tissue and induce anti-tumor immunity. The improved prediction algorithms of the epitopes and immunopeptidomics have enhanced the identification of clinically significant peptide targets that assist in establishing better vaccine formulation [8].

Moreover, peptide vaccines can be effectively used in combination in order to increase the immune responsiveness. The tumor microenvironment can be manipulated by chemotherapy and immune adjuvants to augment the release of antigens and mitigate the effects of immune suppression so as to open up the necessary conditions that activate T-cells through the activation of peptide-type antigens [9]. The evidence of the TG01 clinical study that supports the safety of peptide vaccine incorporation with standard chemotherapy without affecting immune system is present-day [9]. With the current development of knowledge about immune regulation in pancreatic cancer, the peptide-based vaccines can be significant in terms of multimodal approaches to treatment, especially in the postoperative or minimal residual disease context. Improved antigen selection, adjuvant systems and sequencing of their treatment can also continue to be optimized to improve their therapeutic effect [8,9].

3. mRNA vaccine in pancreatic cancer

The use of messenger RNA (mRNA) vaccines as immune therapeutic models to treat pancreatic cancer is a promising therapy, especially when used on an individualized basis of cancer vaccination. In contrast to traditional vaccines, which use predetermined shared tumor antigens, mRNA vaccination has the ability to encode patients-specific neoantigens leveraging tumor-specific

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mutations, and this allows micro-targeting the immune response with high precision. The methodology is particularly applicable to pancreatic ductal adenocarcinoma that inherently exhibits a high capacity of immune evasion, solid stromal repellent, and resistance against conventional immunotherapy.

Research on the potential of mRNA neoantigen vaccines in pancreatic cancer have also indicated the applicability and effectiveness of their use, as studies have shown the potential to induce persistent cytotoxic T-cell reaction [2]. The author also reported that in this study, individualized RNA neoantigen vaccines caused strong activation of the $CD8^+$ T-cells, whose T cells produced by the vaccines sustained an extended duration and demonstrated sustained cytotoxic effect. Notably, they were not transient but helped to maintain long-term immunosurveillance, implying that even with mRNA vaccination, pancreatic cancer can be partially immune-treated despite an immunologically cold tumor microenvironment. Long-lived memory $CD8^+$ T cells induction is also a significant therapeutic benefit, since long-term immunity is also essential in preventing relapse of disease after the surgery [2].

Table 1. Comparison table of key characteristics of pancreatic cancer immunotherapeutic vaccines

Vaccine Type	Core Mechanism of Action	Main Advantages	Ref.
Dendritic Cell (DC) Vaccine - Autologous Tumor Cell Type	Load tumor antigens/exosomes, silence PD-L1 expression, enhance antigen-presenting capacity, and activate tumor-specific cytotoxic T lymphocytes	Strong antigen targeting, can induce specific antitumor immune response, suitable for adjuvant therapy after surgery to reduce recurrence risk	[1,3,4]
Dendritic Cell (DC) Vaccine - Allogeneic Tumor Cell Type	Utilize shared tumor-associated antigens, induce intratumoral lymphoid aggregation (tertiary lymphoid structure-like), and reshape the local tumor immune microenvironment	Standardized mass production, timely administration, and sustainable local tumor immune surveillance	[6]
Exosome Vaccine	Carry tumor-associated antigens, immunomodulatory molecules, and damage-associated molecular patterns, promote DC maturation and T cell activation, and achieve cross-presentation of antigens	High safety of cell-free system, simple preparation and storage, ability to penetrate lymphoid organs, and dual functions of antigen delivery and innate immune stimulation	[6-8]
Peptide Vaccine	Take tumor-associated antigen/mutant antigen short peptides as epitopes, combine with immune adjuvants (e.g., GM-CSF) or chemotherapy to activate specific T cell response	High specificity, simple synthesis, good safety, and synergistic effect with conventional treatment	[8-10]
mRNA Vaccine	Encode patient-specific neoantigens, induce durable $CD4^+$/$CD8^+$ T cell response, and synergistically regulate the tumor immune microenvironment with the ferroptosis pathway	High degree of personalization, strong immunogenicity, short preparation cycle, and ability to overcome "cold tumor" immune escape	[2,11,12]

Furthermore, clinical evidence indicates that individual RNA neoantigen vaccines can induce tumor specific T-cell reactions in individuals with pancreatic cancer [11]. The combination of both next-generation sequencing and personalized vaccine development meant that through this process, multiple personalized neoantigens were discovered and encoded into mRNA constructs. Immune monitoring showed that both the T-cells ($CD4^+$ and $CD8^+$) had been activated in the presence of neoantigens that were encoded as a part of the vaccine, that is, a coordinated response to the adaptive immune activation was observed. It is also interesting to note that a group of patients had a delayed recurrence of the disease after the vaccination, which is the preliminary clinical evidence of the therapeutic association of these immune responses. The findings also suggest the possibility of creating personalized mRNA vaccines within a short time and their possibility of use in the adjuvant scenario [11].

In addition to direct immune activation, emergent studies have broadened the conceptual framework of mRNA vaccines through investigation about how they interface with tumor-intrinsic cell death pathways. Recently, it was demonstrated that there is a crosstalk between ferroptosis

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regulators and tumor immunity in pancreatic adenocarcinoma and has provided new insights into the way in which mRNA vaccines can be added to further the immunological response [12]. In particular, Ferroptosis is an iron-dependent programmed cell death that has been associated to mediate tumor immune microenvironment functions by regulating antigen release, inflammatory signaling and recruitment and exclusion of immune cells. The interactions of ferroptotic-related processes and immune response indicate that tumor cell destruction pathways can affect the availability of antigens and immunity after mRNA vaccination.

Therapy Therapeutically mRNA vaccines can be used in combination with antitumor immune-enhancement strategies that involve induction of immunogenic tumor cell death. Ferroptosis-related pathways may be synergized with mRNA-based antigen delivery by increasing antigen release into the tumor microenvironment and enhancing immune-stimulatory signals in the tumor microsystem. This view goes beyond the expression of antigens as a sole effect of mRNA vaccines and puts them in a complex web of tumor-immune interaction which explains efficacy of treatments collectively [12].

Taken together, the evidence nationwide suggests that mRNA vaccines constitute a massively flexible and versatile mechanistic immunotherapeutic approach to pancreatic cancer. Their ability to activate lasting, neoantigen-specific T-cell reactions [2], stimulate personalized adaptive immune reactions in patients [11], and in some cases, to interact with tumor cell death and immune control systems [12] supports further clinical development. With the further development of the understanding of tumor-immune interactions, the mRNA vaccines could eventually become a new foundation of personalized immunotherapy in pancreatic cancer, especially as part of rational combinations.

4. Conclusion

The paper sketches the research development of vaccine-based therapies in treating pancreatic cancer in a more organized fashion and a series of breakthroughs have been accomplished into solving the major dilemma facing immunotherapy treatment of pancreatic cancer; low response rate. In traditional vaccines, dendritic cell vaccines promote T-cell activation and antigen presentation via antigen loading, PD-L1 regulation and have demonstrated potential in postoperative adjuvant vaccine. Exosome vaccines present as cell-free platforms have favorable safety and manufacturability due to their innate propensity in antigen delivery and immunomodulatory capabilities. Peptide vaccines have proven to be safe and capable of induction of specific immunity with targeting of specific tumor antigens with adjuvants or chemotherapy. New mRNA vaccine technology also enables rapid encoding and delivery of patient-specific neoantigens which can induce long-lasting specific T-cell immunity successfully in clinical trials. This has given a very promising new outlook of overcoming cold tumor microenvironment of pancreatic cancer (See table 1). In the future, the technology advancement in this sector will reflect a general tendency of multi-platform integration and smart development. The future directions of R&D will concentrate on creating a synergistic effect of combination therapies (vaccines with immune checkpoint, oncolytic viruses, drugs to modify the tumor microenvironment, and deep integration of artificial intelligence and multiomics technologies) to predict more accurately and effectively antigens and create vaccines. In the meantime, the driving force behind the process of facilitating the shift in individualized therapy to larger application will be the development of next-generation delivery systems and breakthroughs in large-scale and low-cost production processes. The ultimate direction of development is to transition the treatment of patients at an advanced stage to earlier stages including neoadjuvant and postoperative adjuvant, and to investigate how best to integrate the new

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treatment with already existing standard treatments and, as a result, to provide higher level of disease control during the long term and patient survival of pancreatic cancer.

References

[1] van 't Land, F.R., Willemsen, M. and Bezemer (2024) Dendritic Cell-Based Immunotherapy in Patients With Resected Pancreatic Cancer. Journal of Clinical Oncology : Official Journal of the American Society of Clinical Oncology, 42(26), 3083-3093.
[2] Sethna, Z., Guasp, P. and Reiche, C. (2025) RNA neoantigen vaccines prime long-lived $CD8^+$ T cells in pancreatic cancer. Nature, 639, 1042-1051.
[3] Jiang, H., Zhao, X., Zhao, H., Zhu, X. and Li, D. (2018) RNAi Targeting PD-L1 Enhances DC Vaccination Antitumor Immunologic Therateupic Effect Against Pancreatic Cancer. , 38(1), 40-43.
[4] Xiao, L., Erb, U., Zhao, K., Hackert, T. and Zöller, M. (2017) Efficacy of vaccination with tumor-exosome-loaded dendritic cells combined with cytotoxic drug treatment in pancreatic cancer. Oncoimmunology, 6(6), e1319044.
[5] Mahadevan, K.K., Dyevoich, A.M. and Chen, Y. (2024) Type I conventional dendritic cells facilitate immunotherapy in pancreatic cancer. Science, 384(6703), eadh4567.
[6] Zheng, L., Brat, D.J., Melstrom, L.G. (2021) Vaccine-induced intratumoral lymphoid aggregates correlate with survival following treatment with a neoadjuvant and adjuvant vaccine in patients with resectable pancreatic adenocarcinoma. Clinical Cancer Research, 27(5), 1278-1286.
[7] Naseri, M., Gholami, S. and Tafvizi, F. (2020) Tumor-derived exosomes: the next generation of promising cell-free vaccines in cancer immunotherapy. Oncoimmunology, 9(1), 1779991.
[8] Zhou, W., Chen, X. and Zhou, Y. (2022) Exosomes derived from immunogenically dying tumor cells as a versatile tool for vaccination against pancreatic cancer. Journal of Steroid Biochemistry and Molecular Biology, 214, 106044.
[9] Liu, W., Tang, Y. and Wei, Z. (2021) Peptide-based therapeutic cancer vaccine: current trends in clinical application. Cell Proliferation, 54(4), e13025.
[10] Palmer, D.H., Valle, J.W. and Ma, Y.T. (2020) TG01/GM-CSF and adjuvant gemcitabine in patients with resected RAS-mutant adenocarcinoma of the pancreas (CT TG01-01): a single-arm, phase 1/2 trial. British Journal of Cancer, 122(7), 971-977.
[11] Rojas, L.A., Sethna, Z. and Soares, K.C. (2023) Personalized RNA neoantigen vaccines stimulate T cells in pancreatic cancer. Nature, 618, 144-150.
[12] Shi, Y., Wang, Y. and Dong, H. (2023) Crosstalk of ferroptosis regulators and tumor immunity in pancreatic adenocarcinoma: novel perspective to mRNA vaccines and personalized immunotherapy. Apoptosis : An International Journal on Programmed Cell Death, 28(9-10), 1423-1435.