International Journal of Inflammation, Cancer and Integrative Therapy

Review Article Open Access

Engineering Immune Cells for Precision Immunotherapy: Promises and Pitfalls

Xiang Liu*

School of Pharmacy, Nanjing University of Chinese Medicine, China

Abstract

Precision immunotherapy has revolutionized the landscape of cancer treatment by harnessing the power of engineered immune cells to target and eliminate tumors with remarkable specificity. This article explores the promises and pitfalls of engineering immune cells for precision immunotherapy, highlighting key advancements, challenges and future directions in this rapidly evolving field.

Keywords: Precision immunotherapy; Engineered immune cells; Cancer treatment; Pitfalls

Introduction

In recent years, precision immunotherapy has emerged as a groundbreaking approach in the field of oncology, offering new hope for patients with various types of cancer. Central to precision immunotherapy is the engineering of immune cells to enhance their tumor-targeting capabilities, modulate immune responses, and overcome immune evasion mechanisms employed by cancer cells. This innovative strategy has led to significant advancements in cancer treatment, including the development of chimeric antigen receptor (CAR) T cell therapy, engineered T cell receptor (TCR) therapy, and immune checkpoint blockade therapies [1].

Cancer treatment has witnessed a paradigm shift with the advent of precision immunotherapy, a revolutionary approach that leverages the engineering prowess of immune cells to target and eradicate tumors with unprecedented specificity. Unlike traditional therapies that often exhibit broad cytotoxicity, precision immunotherapy aims to tailor treatments to individual patients based on their unique tumor profiles, genetic makeup, and immune responses. This introduction delves into the promises and pitfalls of engineering immune cells for precision immunotherapy, heralding a new era in cancer treatment [2].

Historically, cancer therapies such as chemotherapy, radiation and surgery have focused on killing rapidly dividing cancer cells while inadvertently damaging healthy tissues. While these treatments have been effective to some extent, they often come with significant side effects and limited specificity, leading to systemic toxicity and compromised immune function. In contrast, precision immunotherapy capitalizes on the immune system's inherent ability to recognize and eliminate abnormal cells, including cancer cells, while sparing normal tissues [3].

The cornerstone of precision immunotherapy lies in the engineering of immune cells, particularly T cells, to recognize and target tumor-specific antigens. This approach has been exemplified by chimeric antigen receptor (CAR) T cell therapy, where patient-derived T cells are genetically modified to express synthetic receptors that recognize tumor-associated antigens. CAR T cells are then infused back into the patient, where they seek out and destroy cancer cells bearing the target antigen, effectively acting as living drugs with remarkable tumor specificity.

Similarly, engineered T cell receptor (TCR) therapy involves modifying T cells to express engineered T cell receptors that can recognize tumor-specific antigens presented by major histocompatibility complex (MHC) molecules [4]. This approach expands the repertoire of targetable antigens beyond cell surface markers, allowing for broader applicability in solid tumors and addressing challenges associated with antigen escape and heterogeneity.

Moreover, immune checkpoint blockade therapies have emerged as another pillar of precision immunotherapy. By blocking inhibitory signals such as programmed cell death protein 1 (PD-1) and cytotoxic T-lymphocyte-associated protein 4 (CTLA-4), these therapies unleash the full potential of T cells, reviving antitumor immune responses and promoting tumor regression. However, the efficacy of immune checkpoint blockade can vary among patients, necessitating further research into predictive biomarkers and combination strategies to enhance treatment outcomes [5].

The promises of precision immunotherapy are manifold. By targeting tumor-specific antigens, engineered immune cells offer the potential for durable responses, reduced toxicity, and improved quality of life for cancer patients. Furthermore, advancements in genetic engineering technologies, such as CRISPR-Cas9, have facilitated precise modifications of immune cells, enhancing their functionality, persistence, and safety profiles.

Despite these promises, precision immunotherapy is not without challenges and pitfalls. Identifying optimal target antigens with limited expression on normal tissues, mitigating off-target effects and immune-related toxicities, optimizing cell manufacturing processes, ensuring long-term efficacy and durability of responses, and addressing tumor heterogeneity and immune escape mechanisms are critical areas of ongoing research and development.

Discussion

Chimeric antigen receptor (CAR) T cell therapy: CAR T cell therapy involves genetically modifying patient-derived T cells to express chimeric antigen receptors that recognize specific tumor antigens.

***Corresponding author:** Xiang Liu, School of Pharmacy, Nanjing University of Chinese Medicine, China, E-mail: xiang@njucm.edu.cn

Received: 01-Apr-2024, Manuscript No. ijm-24-133606; **Editor assigned:** 03-Apr-2024, Pre-QC No. ijm-24-133606 (PQ); **Reviewed:** 17-Apr-2024, QC No. ijm-24-133606; **Revised:** 22-Apr-2024, Manuscript No; ijm-24-133606, **Published:** 29-Apr-2024, DOI: 10.4172/2381-8727.1000272

Citation: Xiang L (2024) Engineering Immune Cells for Precision Immunotherapy: Promises and Pitfalls. Int J Inflam Cancer Integr Ther, 11: 272.

These engineered CAR T cells can effectively target and eliminate cancer cells bearing the target antigen, leading to impressive clinical responses in hematological malignancies such as acute lymphoblastic leukemia and certain types of lymphoma. However, challenges such as antigen escape, cytokine release syndrome, and neurotoxicity have been observed, highlighting the need for optimization and refinement of CAR T cell therapies [6].

Engineered T cell receptor (TCR) therapy: Engineered TCR therapy involves modifying T cells to express engineered T cell receptors that recognize tumor-specific antigens presented by major histocompatibility complex (MHC) molecules. This approach broadens the range of targetable antigens beyond cell surface markers and has shown promise in solid tumors. However, challenges such as off-target effects, MHC restriction, and T cell exhaustion remain significant hurdles in the development of engineered TCR therapies [7].

Immune checkpoint blockade therapies: Immune checkpoint blockade therapies aim to restore antitumor immune responses by blocking inhibitory signals, such as PD-1/PD-L1 and CTLA-4, that dampen T cell activity. While these therapies have demonstrated remarkable efficacy in certain cancer types, including melanoma and non-small cell lung cancer, resistance mechanisms, immune-related adverse events, and limited efficacy in some patients underscore the complexity of immune checkpoint modulation [8].

Promises of precision immunotherapy: Precision immunotherapy holds immense promise in revolutionizing cancer treatment by offering targeted and personalized therapies with minimal off-target effects. Advances in genetic engineering technologies, such as CRISPR-Cas9, have facilitated precise modifications of immune cells, enhancing their specificity, persistence, and functionality against tumors. Combination therapies, including CAR T cell therapy with immune checkpoint blockade, are being explored to overcome resistance and improve treatment outcomes [9].

Pitfalls and challenges: Despite the promises of precision immunotherapy, several challenges and pitfalls need to be addressed. These include the identification of optimal target antigens with limited expression on normal tissues, mitigating off-target effects and immune-related toxicities, optimizing cell manufacturing processes, ensuring long-term efficacy and durability of responses and addressing tumor heterogeneity and immune escape mechanisms [10].

Conclusion

Precision immunotherapy represents a transformative approach in cancer treatment, offering targeted and personalized therapies that harness the power of engineered immune cells. While significant strides have been made in the development of CAR T cell therapy, engineered TCR therapy, and immune checkpoint blockade, ongoing research is needed to overcome challenges, optimize treatment strategies, and broaden the applicability of precision immunotherapy to a wider range of cancer types and patient populations. By addressing the promises and pitfalls of engineered immune cells, we can continue to advance the field of precision immunotherapy and improve outcomes for patients with cancer.

Acknowledgement

None

Conflict of Interest

None

References

1. Paucek RD, Baltimore D, Li G (2019) The cellular immunotherapy revolution: arming the immune system for precision therapy. Trends immunol 40: 292-309.
2. Mackenzie NJ, Nicholls C, Templeton AR, Perera MP, Jeffery PL, et al. (2022) Modelling the tumor immune microenvironment for precision immunotherapy. Clinical & Translational Immunology 11: e1400.
3. Obradovic A (2023) Precision immunotherapy. Science 379: 654-655.
4. Rossi JF, Céballos P, Lu ZY (2019) Immune precision medicine for cancer: a novel insight based on the efficiency of immune effector cells. Cancer Communications 39: 34.
5. Widodo SS, Hutchinson RA, Fang Y, Mangiola S, Neeson PJ, et al. (2021) Toward precision immunotherapy using multiplex immunohistochemistry and in silico methods to define the tumor immune microenvironment. Cancer Immunol Immunother 70: 1811-1820.
6. Mandal R, Chan TA (2016) Personalized oncology meets immunology: the path toward precision immunotherapy. Cancer Discovery 6: 703-713.
7. Lee JK, Priceman SJ (2019) Precision medicine-enabled cancer immunotherapy. Cancer Treat Res 178: 189-205.
8. Mukherjee S (2019) Genomics-guided immunotherapy for precision medicine in cancer. Cancer Biother Radiopharm 34: 487-497.
9. Du Y, Qi Y, Jin Z, Tian J (2019) Noninvasive imaging in cancer immunotherapy: The way to precision medicine. Cancer letters 466: 13-22.
10. Lau D, Bobe AM, Khan AA (2019) RNA sequencing of the tumor microenvironment in precision cancer immunotherapy. Trends cancer 5: 149-156.