Editorial

Avicenna Journal of Medical Biotechnology
Volume 16, Issue 2, 66-67
https://doi.org/10.18502/ajmb.v16i2.14854

The Role of Biotechnology in Latest Therapeutic Approaches for Diabetes Mellitus

Sepideh Hajivalizadeh [1] and Shahin Akhondzadeh [2*]

1. Osteoporosis Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
2. Psychiatric Research Center, Roozbeh Hospital, Tehran University of Medical Sciences, Tehran, Iran

[*]**Corresponding author:** Shahin Akhondzadeh, Ph.D., FBPhS, Psychiatric Research Center, Roozbeh Psychiatric Hospital, Tehran University of Medical Sciences, Tehran, Iran
Tel: +98 21 55412222, **Fax:** +98 21 55419113
Email: s.akhond@neda.net
Received: 22 Jan 2024
Accepted: 22 Jan 2024

Diabetes Mellitus (DM), a common chronic disease resulting from interactions between environment and genetics, is mainly represented in two main types, T1DM and T2DM, considering whether the insulin is produced less than required or used ineffectively. The dramatically increasing burden of DM is described as an estimated global economic burden of US$ 825 billion and 3.8 million deaths related to diabetes from 2012 to 2015 [1]. Based on the DM type, pathogenesis, and complications of the disease known as Diabetes Mellitus-Related Conditions (DMRC), diverse therapeutic approaches such as lifestyle change, oral agents, insulin therapy, and sometimes islet or whole pancreas transplantation are suggested. Despite advancements in medicine, curing increased blood glucose levels and the subsequent DMRCs are still goals to meet [2]. Biotechnology, a pivotal multidisciplinary field in therapeutic approaches for various diseases, likewise has an impressive role in different therapeutic approaches for DM.

Insufficient or defective insulin as the leading cause of DM resulted in insulin therapy as an efficient therapeutic approach in DM. Improving insulin treatment over time through biotechnology is moving towards altering action periods, durability, and delivery routes. In 2014, the European Union approved the first biosimilar insulin. Novel forms of insulin are being developed as biosimilar insulins, which are more complex, have similar properties with lower costs than the reference product, and are one of the outputs of biotechnology in medicine [3]. Various insulin delivery options are introduced, such as oral insulin tablets, insulin pumps, inhaler insulins, and biosynthetic pancreas. Continuous subcutaneous insulin infusion is used to imitate basal insulin production, in which a particular insulin dose will be delivered to the body with a small pump [4]. Automated insulin delivery systems are the mechanisms of the artificial pancreas, which is also called a closed-loop glucose system. These systems utilize the control algorithm to adjust the infusion amount of insulin automatically with the blood glucose level at the time, which improves the efficacy and safety of insulin therapy [5]. Since decreasing the swing of serum glucose levels has been one of the goals of Insulin Replacement Therapy (IRT), the rise of glucose-responsive insulin-delivery technologies as smart systems are novel approaches for IRT. Altering the structure and bioavailability of insulin analogs based on glucose concentration without the need for external monitoring is the prospect of this novel approach [6].

Stem cell transplantation, as one of the principal treatments for autoimmune diseases, is reported as a practical approach for improving T1DM as an autoimmune disease. The combined transplantation of Mesenchymal Stem Cells (MSCs) and Hematopoietic Stem Cells (HSCs) amended T1DM by reducing the total daily use of insulin and HbA1c levels [7]. Studies indicate that the differentiation of MSCs can lead to the generation of Insulin-Producing Cells (IPCs) with tissue engineering techniques. Scaffolds can provide the microenvironment that enhances the differentiation of MSCs to IPCs, increases metabolic activity, produces insulin and pancreatic-specific transcription factors, and prevents cell death [8]. As mentioned before, islet transplant as a cell-based therapy is considered in DM treatment and enhanced post-transplantation insulin independence to 5 years in 50% of patients undergoing the intervention. Based on the limitations of this method, tissue engineering is needed for developing extracellular matrix molecules for insulin-producing cells in three-dimensional (3D) structures to make cells more viable and potent for secreting insulin and use encapsulation to limit the host's immune attack [9]. Various islet-encapsulating methods, including macro-, micro-, and nano-encapsulation and bioprinting, exist but have limitations that hinder the widespread implementation in the clinical phase [8].

Anti-CD3 monoclonal antibodies indicated improvements in HbA1c levels and had a potential role in reducing the exogenous insulin dependency in patients with new-onset T1DM by preserving beta cell function [10]. The crucial role of Gut Microbiota (GM) as the human's second genome is represented in many diseases, including T1DM. According to the results of the evidence, GM is significantly altered in T1DM. Hence, insulin resistance and glycemic control can be improved by fecal microbiota transplantation by modulating the gut microbiota in T1DM patients [11].

Research has led to substantial improvements in the control of DM. Nevertheless, despite all of the remarkable advances in the treatment of DM, managing DM and the complications of the disease are still under investigation. Some of the introduced approaches are not well-used for reasons such as high costs, complications, and uncertainty regarding safety. There is no doubt, cooperation between basic sciences, especially neuroscience and biotechnology, and internal medicine can create a brighter future for the treatment of endocrine diseases [12-16]. Representing solutions to overcome the limitations, optimizing, expanding, and proving the safety of the presented methods by well-designed clinical trials are the future perspectives for research in this field. More investigations for more advanced discoveries with the fundamental assistance of biotechnology are essential.

Keywords: Artificial pancreas, Gastrointestinal microbiome, Glucose, Insulin, Monoclonal antibody, Stem cell transplantation, Tissue engineering, Treatment

Acknowledgement

This paper received no specific grant from public, commercial, or not-for-profit funding agencies.

Conflict of Interest

The authors had no competing interests.

References

1. Elnashar M, Vaccarezza M, Al-Salami H. Cutting-edge biotechnological advancement in islet delivery using pancreatic and cellular approaches. Future Sci OA 2020 Nov 23;7(3):FSO660.
2. Reyes-Martínez JE, Ruiz-Pacheco JA, Flores-Valdéz MA, Elsawy MA, Vallejo-Cardona AA, Castillo-Díaz LA. Advanced hydrogels for treatment of diabetes. J Tissue Eng Regen Med 2019 Aug;13(8):1375-93.
3. Davies M, Dahl D, Heise T, Kiljanski J, Mathieu C. Introduction of biosimilar insulins in Europe. Diabet Med J Br Diabet Assoc 2017 Oct;34(10):1340-53.
4. Hanif N, Wu H, Xu P, Li Y, Bibi A, Zulfiqar A, et al. Proteomic changes to the updated discovery of engineered insulin and its analogs: pros and cons. Curr Issues Mol Biol 2022 Feb 11;44(2):867-88.
5. Rodríguez-Sarmiento DL, León-Vargas F, García-Jaramillo M. Artificial pancreas systems: experiences from concept to commercialisation. Expert Rev Med Devices 2022 Nov;19(11):877-94.
6. Jarosinski MA, Dhayalan B, Rege N, Chatterjee D, Weiss MA. 'Smart' insulin-delivery technologies and intrinsic glucose-responsive insulin analogues. Diabetologia 2021 May;64(5):1016-29.
7. Madani S, Amanzadi M, Aghayan HR, Setudeh A, Rezaei N, Rouhifard M, et al. Investigating the safety and efficacy of hematopoietic and mesenchymal stem cell transplantation for treatment of T1DM: a systematic review and meta-analysis. Syst Rev 2022 May 2;11(1):82.
8. Khazaei M, Khazaei F, Niromand E, Ghanbari E. Tissue engineering approaches and generation of insulin-producing cells to treat type 1 diabetes. J Drug Target 2023 Jan;31(1):14-31.
9. Amer LD, Mahoney MJ, Bryant SJ. Tissue engineering approaches to cell-based type 1 diabetes therapy. Tissue Eng Part B Rev 2014 Oct 1;20(5):455-67.
10. Ashraf MT, Ahmed Rizvi SH, Kashif MAB, Shakeel Khan MK, Ahmed SH, Asghar MS. Efficacy of anti-CD3 monoclonal antibodies in delaying the progression of recent-onset type 1 diabetes mellitus: A systematic review, meta-analyses and meta-regression. Diabetes Obes Metab 2023 Nov;25(11):3377-89.
11. Zhang S, Deng F, Chen J, Chen F, Wu Z, Li L, et al. Fecal microbiota transplantation treatment of autoimmune-mediated type 1 diabetes: A systematic review. Front Cell Infect Microbiol 2022;12:1075201.
12. Akhondzadeh S. Hippocampal synaptic plasticity and cognition. J Clin Pharm Ther 1999;24(4):241-8.
13. Akhondzadeh S. The 5-HT hypothesis of schizophrenia. IDrugs 2001;4(3):295-300.
14. Akhondzadeh S, Ahmadi-Abhari SA, Assadi SM, Shabestari OL, Kashani AR, Farzanehgan ZM. Double-blind randomized controlled trial of baclofen vs. clonidine in the treatment of opiates withdrawal. J Clin Pharm Ther 2000; 25(5):347-53.
15. Kashani L, Eslatmanesh S, Saedi N, Niroomand N, Ebrahimi M, Hosseinian M, et al. Comparison of saffron versus fluoxetine in treatment of mild to moderate postpartum depression: a double-blind, randomized clinical trial. Pharmacopsychiatry 2017;50(2): 64-8.