Biological Times
Volume No. 3 | Issue No. 9 | Pages 15-16

Viruses: From Pathogens to Therapeutic Agents

Najia Ali[1], Zainab Fatima[1], Alishbah Roobi[2], Maliha Tauseef Butt[1], Dania Noor[1], Saleha Tahir[3*]

1. Department of Biotechnology, The University of Faisalabad, Pakistan
2. Department of Physiology, The University of Faisalabad, Pakistan
3. Department of Microbiology, University of Agriculture Faisalabad, Pakistan

*Corresponding Author: salehatahir999@gmail.com

ABSTRACT

Viruses are now known that they are instrumental in diseases of global economic and animal-human implications. Examining these examples, the pandemics of bats, birds and rats (influenza) or arthropods has led to identification and emergence of viruses with pathogenic capabilities within human populations. Instead, advances in the science of virology have revealed how these viruses actually could be used to benefit human health. Oncolytic virotherapy is actually an example of this newest therapeutic use and involves using viruses that have been specifically engineered to target and kill only cancer cells. Furthermore, through studying their biology they can also shed light on viral pathogenesis and assist in the development of therapies for other diseases. For a true change in medicine to occur, such research should be conducted across multiple disciplines and collaborating fields within the confines of ambitious vaccine strategies reimagining viruses as potential therapeutics for modern day medical practice. We also take a look at the Janus faces that viruses present in this article.

Keywords: Zoonotic Viruses, Therapeutic agents, Genetic engineering

Introduction

Viruses are unique for being on the boundary between non-living and living things. Viruses consist of genetic material surrounded by a protective protein coat and are incapable to replicate without the aid of its host cells due to lacking the essential cellular apparatus for self-replication. Although viruses are generally thought of in terms of their capacity to cause disease, they represent some of the most fascinating biological agents because each seems endowed with an array of intrinsic properties and diverse functions. Historically, viruses have been notorious for causing devastating diseases in humans, animals, and plants. For instance, the zoonotic viruses alone have been responsible for spreading from animals to humans. Similarly, the HIV virus, which causes AIDS, has led to a global health crisis, affecting millions of lives since its discovery [1]. Other viruses include Influenza, Chicken pox, Measles, Mumps, Herpes, Rubella, COVID-19. These viruses occur worldwide with seasonal outbreaks and the percentage of people infected with these viruses are 290 million to 700 million. Prevention of these viruses includes vaccination, good hygiene and proper food handling [1]. Recent developments in virology, however, have altered certain viewpoints on viruses and highlighted their possible advantages in medical applications. It has affected all modifications of virus research. Given that several nanomaterials have been produced with different virions and virus-like particles as templates in recent biochemical research, emphasis has also started being laid on biocompatibility issues and biosynthesis methods [2].

The most visible is gene therapy, a process in which the delivery of genetic material into cells utilizes modified viruses to fix issues with genes. Take adeno-associated viruses (AAVs), which have shown promise in the case of spinal muscular atrophy. Additionally, oncolytic viruses that selectively replicate in and kill tumor cells, but not normal tissues are being developed as new cancer treatments [3]. Viral duality provides the latest medicinal advances and in turn, brings out more reasons to continue with virological research. Although faced with this adversarial contagion known as the virus, we do now understand something about what viral behavior is and how it can be turned into a useful tool when working in common cause on viruses not to fight us but against various diseases.

Emergence of viral diseases

Viruses which can replicate and infect human cells are generally pathogenic, meaning they cause illness. The advent of emerging and re-emerging pathogenic viruses constitutes a serious threat to public health. Public health and international stability have been threatened by the spread of infectious diseases. Emerging infectious illnesses are those that have become more common in humans during the last 20 years or that are expected to become more common in the years to come. Furthermore, beta-coronaviruses also include three highly pathogenic viruses such as severe acute respiratory syndrome coronavirus (SARS-CoV), Middle East respiratory syndrome coronavirus (MERS-CoV) and SARS-CoV-2 that induce severe pneumonia in humans [4]. Infectious disease outbreaks have been related to biological, social, and environmental variables. These include modifications brought about by disease evolution and shifts in the ways that various human populations interact with their surroundings and with one another.

Zoonotic Viruses

The World Health Organization (WHO) has identified the Nipah Virus (NiV) as a global health threat and included it in the list of epidemic threats treated as a priority in research and development activities (R&D Blueprint) because of its high human mortality rate, zoonotic nature, potential for human-to-human transmission, and lack of a vaccine. NiV was categorized as category C in the classification of diseases that constitute a terrorist threat by the Centers for Disease Control and Prevention (CDC) and the National Institute of Allergy and Infectious Diseases (NIAID) [5]. According to the most recent data, the NiV virus first appeared in India in September 2021 [6]. In terms of morphology, NiV is similar to other paramyxoviruses. It is an enclosed virus that is pleomorphic, spherical, or thread-like, and it ranges in size from 40 to 1900 nm. Negatively polarized single-stranded RNA is present in the Nipah virus. Although they are already thought to be the primary etiological factors responsible for 25–44% of recently emerging infectious diseases, RNA viruses exhibit an increased probability of infection of new host species due to their extremely short generation time and faster evolution [6].

Arboviruses

For some harmful viruses to spread among vertebrates, arthropods, mostly mosquitoes and ticks are necessary. We call these viruses arthropod-borne (arboviruses). Vectors are arthropods that efficiently transfer viruses from susceptible hosts to other hosts. A certain arthropod's vector competence and vectorial ability determine how successful it is as a vector. Vector competence refers to an arthropod's innate capacity to spread a certain virus. A competent vector is one in which the virus enters the body through food, multiplies in the stomach and salivary glands, enters salivary secretion, and eventually enters a new host through food. Vectorial capacity refers to an arthropod's ability to promote the development of a virus based on the time elapsed between the virus's uptake and transmission capability. Mosquitoes are the most significant arbovirus vectors. It is difficult to stop arboviruses from spreading. Aedes aegypti is the mosquito vector used by several arboviruses that are harmful to humans, including Zika virus (ZIKV), Chikungunya virus (CHIKV), and yellow fever virus (YFV) [7]. Moreover, mosquitoes of many species, including Ae.*aegypti*, Ae. albopictus, and Culex quinquefasciatus, which are common in tropical and subtropical locations, can spread viruses, including ZIKV. A virus needs to be able to avoid the mosquito's antiviral immune reactions in order to successfully infect, multiply, and spread throughout its cells in order for mosquitoes to carry it out effectively [8]. The distribution of various mosquito-borne viruses, including Dengue virus (DENV), WNV, CHIKV, and ZIKV, has expanded as a result of increased travel and trade, among other factors. As a result, viruses are now considered to be the new global pathogens.

Viruses as Therapeutic agents

Oncolytic Viruses

Tumor-selective, multi-mechanistic anticancer medicines are known as oncolytic viruses (OVs). By using direct oncolysis to destroy contaminated cancer and its allied endothelial cells, they also target tumor vasculature and

To cite this article: Ali N, Z Fatima, A Roobi, MT Butt, D Noor & S Tahir. Viruses: From Pathogens to Therapeutic Agents. Biological Times. 2024. September 3(7): 15-16

cause a bystander effect to kill uninfected cells. In addition to sending strong warning signals to dendritic cells, multimodal immunogenic cell death (ICD) and autophagy which is frequently triggered by OVs also effectively cross-present tumor-associated antigens from cancer cells to dendritic cells and T cells, resulting in the induction of adaptive antitumor immunity [9]. Owing to this advantageous immunological environment, OVs' potential as cancer vaccines is further enhanced by genetic engineering and thoughtful combination studies. When OVs are equipped with immunostimulatory genes or GM-CSF (like T-VEC and Pexa-Vec), they can effectively generate anti-tumor immunity in both human patients and animal models. When combined with other immunotherapy regimens, the overall effectiveness of treatment is improved [10].

Gene Therapy

Viruses are used as vectors in gene therapy to transfer therapeutic genes to patient cells. Because lentiviruses and adeno-associated viruses (AAV) can induce long-term gene expression with little to no immune response, they are frequently employed. Gene therapy has been remarkably successful in curing hereditary illnesses such retinal dystrophy, hemophilia, and spinal muscular atrophy in recent years [11]. In order to treat spinal muscular atrophy in babies, the FDA-approved gene therapy Zolgensma delivers a functional copy of the SMN1 gene using an AAV vector [12].

Genetic Engineering

Originating from bacterial defense systems against viruses, the CRISPR-Cas9 system has evolved into a potent genome editing tool. One possible treatment for viral illnesses like hepatitis B and even HIV, among others, CRISPR has been used by researchers to target not only viral DNA but RNA [13]. It is also exploring the possibility of CRISPR-mediated modification in viral vectors for more efficient and targeted gene therapy applications [14].

Conclusion

Viruses are famously versatile entities — with the ability to serve as novel therapeutic agents and deadly pathogens all at once. However, on the flipside of their virulent behavior necessitating constant study and development for creating strong antiviral treatments comes utilized therapeutic potential to combat a whole host of diseases. Knowledge of the biology of viruses will continue to increase our understanding of viral pathogenesis and inroads into using these pathogens therapeutically for human diseases. No better example of the new potential for viruses to transform medicine than multidisciplinary research and collaboration. Perhaps, one day as we progress with a deeper comprehension of the molecular biology underlying viruses and innovate novel therapeutic utilities viral infections may no longer merely be perceived as liabilities but actually beneficial tools in the armamentarium modern medicine.

References

[1] Shanmugaraj, B., Kothalam, R., & Mohamed Sheik, T. A. A. (2024). A brief overview on the threat of zoonotic viruses. Microbes and Infectious Diseases.

[2] Zhao, L., Zhou, J., & Deng, D. (2024). Inorganic virus-like nanoparticles for biomedical applications: a minireview. Journal of Future Foods, 4(1), 71-82.

[3] Li, X., & Cheng, Z. (2024). Oncolytic Viruses in Cancer Immunotherapy. Advanced Therapeutics, 7(7), 2300445.

[4] Auda, I. G., Auda, J., & Salih, R. H. (2023). SARS-CoV-2 and other Coronaviruses: A matter of variations. Al-Kindy College Medical Journal, 19(1), 5-10.

[5] Sah, R., Paul, D., Mohanty, A., & Padhi, B. K. (2024). Outbreak of an emerging zoonoses Nipah virus: an update. IJS Global Health, 7(4), e0265.

[6] Bruno, L., Nappo, M. A., Ferrari, L., Di Lecce, R., Guarnieri, C., Cantoni, A. M., & Corradi, A. (2022). Nipah virus disease: epidemiological, clinical, diagnostic and legislative aspects of this unpredictable emerging zoonosis. Animals, 13(1), 159.

[7] Rückert, C., & Ebel, G. D. (2018). How do virus–vector interactions lead to viral emergence? Current Opinion in Virology, 28, 37-42.

[8] Mushtaq, I., Sarwar, M. S., & Munzoor, I. (2024). A comprehensive review of Wolbachia-mediated mechanisms to control dengue virus transmission in Aedes aegypti through innate immune pathways. Frontiers in Immunology, 15, 1434003.

[9] Shalhout, S. Z., Miller, D. M., Emerick, K. S., & Kaufman, H. L. (2023). Therapy with oncolytic viruses: progress and challenges. Nature reviews Clinical oncology, 20(3), 160-177.

[10] Wang, X., Shen, Y., Wan, X., Hu, X., Cai, W. Q., Wu, Z., ... & Xin, H. W. (2023). Oncolytic virotherapy evolved into the fourth generation as tumor immunotherapy. Journal of Translational Medicine, 21(1), 500.

[11] Wang, H., Zhang, Y., & Zhang, Y. (2020). Gene therapy for inherited genetic disorders: A review of recent advancements. Molecular Therapy, 28(5), 1159-1173.

[12] Lejman, J., Panuciak, K., Nowicka, E., Mastalerczyk, A., Wojciechowska, K., & Lejman, M. (2023). Gene therapy in ALS and SMA: advances, challenges and perspectives. International Journal of Molecular Sciences, 24(2), 1130.

[13] Ebina, H., Misawa, N., Kanemura, Y., & Koyanagi, Y. (2013). Harnessing the CRISPR/Cas9 system to disrupt latent HIV-1 provirus. Scientific reports, 3(1), 2510.

[14] Yin, H., Kauffman, K. J., & Anderson, D. G. (2017). Delivery technologies for genome editing. Nature reviews Drug discovery, 16(6), 387-399.