OPEN ACCESS Freely available online

ISSN: 2153-2435
Pharmaceutica Analytica Acta

Commentary

Analysis of Antiretroviral Drugs and its Mechanisms in Treating Human Immunodeficiency Virus Infections

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DESCRIPTION

Antiretroviral Drugs (ARVs) represent as knowledge in the management and treatment of Human Immunodeficiency Virus (HIV) infections. Since their introduction in the mid-1990s, these medications have extremely transformed HIV from a fatal disease to an adaptable chronic condition. This study provides an in-depth analysis of antiretroviral drugs, describing their classes, mechanisms of action, clinical efficacy, challenges and future prospects.

Mechanisms of action

ARVs are categorized into several classes based on their mechanisms of action, targeting different stages of the HIV life cycle:

Nucleoside Reverse Transcriptase Inhibitors (NRTIs): These drugs resemble natural nucleosides, the building blocks of Deoxy Ribo Nucleic Acid (DNA). By incorporating themselves into the viral DNA chain during reverse transcription, they terminate DNA synthesis. Examples include Zidovudine (AZT), Lamivudine (3TC) and Emtricitabine (FTC).

Non-Nucleoside Reverse Transcriptase Inhibitors (NNRTIs): Unlike NRTIs, NNRTIs bind directly to the reverse transcriptase enzyme, causing a conformational change that inhibits its activity. Common NNRTIs include Efavirenz (EFV), Nevirapine (NVP) and Rilpivirine (RPV).

Protease Inhibitors (PIs): These inhibit the HIV protease enzyme, which is essential for the breakdown of precursor proteins into mature viral particles. Without functional protease, new virions cannot be properly assembled. Ritonavir (RTV), Lopinavir (LPV) and Atazanavir (ATV) are prominent examples.

Integrase Strand Transfer Inhibitors (INSTIs): INSTIs block the integrase enzyme, preventing the integration of viral DNA into the host genome. This step is important for HIV replication. Examples include Raltegravir (RAL), Elvitegravir (EVG) and Dolutegravir (DTG).

Entry inhibitors: This class includes drugs that block HIV from entering host cells. Enfuvirtide (T-20) is a fusion inhibitor that prevents the virus from fusing with the host cell membrane, while Maraviroc (MVC) is a C-C Chemokine Receptor type 5 (CCR5) antagonist that blocks the receptor HIV uses to enter cells.

Pharmacokinetic enhancers: These are not antiretroviral agents but are used to boost the effectiveness of other ARVs. Ritonavir, used in low doses and cobicistat are examples, often used to enhance the levels of PIs and INSTIs.

The efficacy of ARVs has been demonstrated in numerous clinical trials and real-world studies. The advent of combination Antiretroviral Therapy (cART), which involves using three or more ARVs from different classes, has significantly improved patient outcomes. This approach reduces viral load to undetectable levels, enhances immune function and decreases the risk of HIV transmission. One of the most important measures of success in HIV treatment is achieving and maintaining an undetectable viral load. Studies have shown that patients who adhere to their cART regimen can achieve this goal, leading to improved quality of life and reduced mortality. Furthermore, the concept of "Undetectable=Untransmittable" (U=U) has revolutionized in public health, emphasizing that people with undetectable viral loads cannot transmit HIV to their sexual partners.

Despite their success, ARVs are not without challenges. Drug resistance is a significant concern, arising when HIV mutations render one or more drugs ineffective. This requires the development of new drugs and drug combinations to overtake viral evolution. Adherence to therapy is another critical issue. The necessity of taking medication daily, often for life, can lead to fatigue and non-adherence, resulting in treatment failure and resistance. Additionally, side effects and long-term toxicities, such as cardiovascular diseases, liver and kidney problems and

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Received: 26-Feb-2024, Manuscript No PAA-24-25870; **Editor assigned:** 28-Feb-2024, Pre QC No. PAA-24-25870 (PQ); **Reviewed:** 13-March-2024, QC No PAA-24-25870; **Revised:** 20-Mar-2024, Manuscript No. PAA-24-25870 (R); **Published:** 27-Mar-2024, DOI: 10.35248/2153-2435.24.15.773

Citation: Linder A (2024) Analysis of Antiretroviral Drugs and its Mechanisms in Treating Human Immunodeficiency Virus Infections. Pharm Anal Acta. 15.773.

bone density loss, pose substantial challenges. Access to ARVs remains uneven across different regions, particularly in low- and middle-income countries. While global initiatives like the President's Emergency Plan for AIDS Relief (PEPFAR) and the Global Fund have made significant strides in expanding access, disparities persist.

CONCLUSION

The future of antiretroviral therapy lies in addressing these challenges through innovation and research. Long-acting injectable ARVs, which require administration only once every few months, are an exciting development that could improve adherence and quality of life. Additionally, ongoing research into HIV cure strategies, including gene editing and immune modulation, holds the assurance of a future without the need for lifelong therapy. Another promising avenue is the development of broadly Neutralizing Antibodies (bNAbs) that can target multiple strains of HIV, offering a potential adjunct or alternative to traditional ARVs. These advancements, combined with continued efforts to improve access and reduce stigma, are essential for the global fight against HIV/AIDS. Antiretroviral drugs have revolutionized the management of HIV, transforming it from a death sentence to a chronic, adaptable condition. While challenges remain ongoing research and innovation ensures to enhance the efficacy, safety and accessibility of these life-saving medications. The ultimate goal is not only to control HIV but to find a definitive cure, providing insights for an HIV-free future.