Personalized antiviral therapy: Tailoring treatment to viral genotype and host response.

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Introduction

The landscape of antiviral therapy is undergoing a transformative shift—from standardized, one-size-fits-all regimens to precision medicine approaches that consider the unique interplay between viral genotype and host immune response. Personalized antiviral therapy aims to optimize treatment efficacy, minimize adverse effects, and reduce the emergence of resistance by tailoring interventions to individual biological profiles. As our understanding of viral genomics and host-pathogen interactions deepens, this approach is poised to redefine how we manage viral infections across diverse populations [1].

Traditional antiviral treatments often rely on broad-spectrum agents or fixed protocols that may not account for genetic variability in viruses or differences in host immunity. This can lead to suboptimal outcomes, especially in chronic infections like HIV, hepatitis B and C, and emerging threats such as SARS-CoV-2. Personalized therapy addresses these limitations by integrating genomic, immunologic, and clinical data to guide therapeutic decisions [2].

Viral genotyping involves sequencing viral genomes to identify mutations, subtypes, and resistance-associated variants. This information is critical for selecting appropriate antivirals and predicting treatment outcomes. Genotypic resistance testing is standard practice, guiding the choice of antiretroviral combinations based on mutations in reverse transcriptase, protease, and integrase genes. Different genotypes (e.g., 1a, 1b, 2, 3) respond variably to direct-acting antivirals (DAAs). Genotype 3, for instance, is more resistant to certain NS5A inhibitors. Surveillance of hemagglutinin and neuraminidase mutations informs vaccine design and antiviral susceptibility. Variants like Delta and Omicron exhibit altered spike protein structures, affecting neutralization and therapeutic efficacy. Genotyping enables clinicians to anticipate resistance, adjust drug regimens, and monitor viral evolution during treatment [3].

Equally important is the host's genetic and immunologic landscape. Variations in immune genes, drug metabolism pathways, and inflammatory responses can influence treatment success and adverse event risk. Associated with spontaneous clearance and interferon responsiveness in HCV infection. Influence susceptibility to viral infections and hypersensitivity reactions (e.g., HLA-B*57:01 and abacavir hypersensitivity in HIV). Elevated IL-6 or TNF-α may indicate hyperinflammation, guiding immunomodulatory therapy in COVID-19. Variants in CYP450 enzymes affect drug metabolism, impacting dosing and toxicity. Integrating host data allows for risk stratification, personalized dosing, and immune-targeted interventions [4].

Biomarkers are measurable indicators of biological processes that can inform diagnosis, prognosis, and therapeutic response. In personalized antiviral therapy, key biomarkers include: Quantifies active replication and monitors treatment efficacy. Assesses immune status in HIV patients. Reflect liver inflammation in hepatitis. Guide vaccine and monoclonal antibody use in SARS-CoV-2. Predict interferon responsiveness and disease severity. Biomarker-driven algorithms can help clinicians tailor therapy dynamically, adjusting based on real-time patient data. Advances in omics technologies and computational biology are accelerating personalized antiviral therapy: Enables rapid viral

and host genome analysis. Predict treatment outcomes based on multi-dimensional data. Integrate electronic health records, wearable data, and lab results for personalized decision support. Offer rapid, genotype-specific viral detection. These tools enhance diagnostic accuracy, streamline treatment selection, and support adaptive care models. Personalized antiviral therapy is already making an impact in several areas: Resistance testing and pharmacogenomics guide lifelong antiretroviral therapy, improving viral suppression and reducing toxicity [5].

Conclusion

Personalized antiviral therapy represents a paradigm shift in infectious disease management. By tailoring treatment to viral genotype and host response, clinicians can achieve better outcomes, reduce resistance, and enhance patient care. As precision tools become more accessible and integrated, this approach will redefine how we prevent, diagnose, and treat viral infections—ushering in a new era of individualized medicine.

References

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