Drug repurposing: Speed, savings, precision medicine.

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Introduction

Drug repurposing, the strategy of finding new uses for existing drugs, has emerged as a critical and transformative approach in modern medicine. This methodology significantly accelerates the drug development process and reduces the substantial costs associated with bringing new therapies to market. Its versatility allows for application across a wide spectrum of diseases, offering hope for conditions that historically lacked effective treatments. The fundamental principle involves understanding and leveraging the molecular mechanisms through which established drugs can be effectively re-positioned to target specific disease pathways. For instance, in cancer therapy, existing drugs are being repurposed by identifying their anti-cancer effects at a molecular level, leading to faster development and cost reduction in oncology [1].

Innovation in computational methods has propelled the field forward. Artificial Intelligence (AI) and Machine Learning (ML) play a pivotal role in accelerating drug repurposing by leveraging vast biomedical datasets. These computational approaches, including network-based methods and deep learning, enable the identification of novel therapeutic indications for existing drugs, streamlining the discovery process significantly [2]. This blend of computational power with pharmacological insight allows researchers to predict and validate new drug-disease associations with unprecedented efficiency.

A crucial aspect of successful drug repurposing lies in understanding drug metabolism and pharmacokinetics. The metabolic stability of repurposed drugs is paramount, with cytochrome P450 (CYP) enzymes often playing a critical role in their biotransformation. Knowledge of these CYP-mediated pathways is essential for predicting pharmacokinetics, identifying potential drug-drug interactions, and ultimately ensuring the safety and efficacy of repurposed drugs [3]. This detailed understanding of how drugs are processed by the body is fundamental to their successful re-application.

Drug repurposing holds immense promise for addressing neglected tropical diseases (NTDs), a category of illnesses often characterized by a lack of adequate treatment options. Recent advancements focus on identifying and evaluating existing drugs for new indications against various NTDs. This strategy offers a viable path to overcome the high costs and long timelines typically associated with traditional drug development for these underserved conditions, bringing much-needed therapies to affected populations [4].

A paradigm shift towards precision medicine is evident with pharmacogenomics-guided drug repurposing. This approach integrates individual genetic profiles to optimize the identification and application of existing drugs for new therapeutic uses. By matching drugs to patients based on their genetic predispositions related to drug response and metabolism, it aims for greater efficacy and reduced adverse effects, personalizing treatment strategies [5].

For viral infections, drug repurposing often involves targeting host cellular pathways. This strategy elucidates molecular mechanisms where existing drugs modulate host responses to inhibit viral replication or mitigate disease severity. It carries significant clinical implications for rapidly developing antiviral therapies, especially vital during emerging pandemics, by offering a quick response using already approved compounds [6].

Further complicating and enriching the understanding of drug repurposing is the dual role of ATP-binding cassette (ABC) transporters. These transporters are explored both as potential targets and as factors influencing drug pharmacokinetics. Modulating ABC transporter activity presents opportunities to enhance the efficacy or alter the distribution of repurposed drugs, though challenges remain concerning drug-transporter interactions affecting metabolism and therapeutic outcomes [7].

Metabolomics, the comprehensive study of metabolites, has proven highly useful in advancing drug repurposing. Metabolomic profiling provides critical insights into disease pathways and drug mechanisms of action. By observing metabolic changes induced by drug candidates, it enables the identification of novel therapeutic targets and the discovery of new indications for existing drugs [8]. This approach offers a granular view of drug effects at the biochemical level.

In the realm of neurological disorders, drug repurposing strategies are actively being examined. This includes understanding the molecular mechanisms of repurposed drugs on neural pathways and disease pathologies for conditions like Alzheimer's, Parkinson's,

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and stroke. The clinical translation of these findings is emphasized, acknowledging the unique challenges of developing treatments for complex neurological conditions while aiming for faster development and improved patient access [9].

Finally, the burgeoning field of epigenetics offers new avenues for drug repurposing. This involves elucidating molecular mechanisms by which epigenetic modifications influence gene expression and cellular function. Understanding these pathways can lead to identifying existing drugs that modulate epigenetic targets for new therapeutic indications, offering innovative treatments for diseases with epigenetic components [10]. Collectively, these diverse approaches highlight drug repurposing as a dynamic and increasingly sophisticated strategy in pharmaceutical innovation.

Conclusion

Drug repurposing is a powerful strategy accelerating drug development and reducing costs across various therapeutic areas. It leverages existing drugs for new indications in challenging fields like cancer therapy, where it targets specific molecular mechanisms to exert anti-cancer effects. This approach is also crucial for neglected tropical diseases, addressing unmet needs by identifying new uses for existing drugs, and for viral infections, where it modulates host responses for rapid antiviral development. Key methodologies include Artificial Intelligence (AI) and Machine Learning (ML) for identifying novel therapeutic indications, and advanced biological insights from metabolomics and epigenetics to understand disease pathways and drug mechanisms. Critical considerations involve the metabolic stability of repurposed drugs, particularly the role of cytochrome P450 enzymes, and the impact of ATP-binding cassette (ABC) transporters on pharmacokinetics. Pharmacogenomics-guided repurposing further refines treatment by matching drugs to patients based on genetic profiles, leading to precision medicine. For neurological disorders, it aims to accelerate treatment development by targeting neural pathways. Overall, drug repurposing offers an efficient, cost-effective, and versatile pathway for addressing a wide range of medical conditions.

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