Therapeutic interventions in parasitology: advancing strategies for effective management of parasitic diseases.

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Introduction

Parasitic diseases remain a significant global health challenge, particularly in low- and middle-income countries. Despite advances in diagnostics, therapy remains the cornerstone of parasite control and eradication. This perspective explores current and emerging therapeutic strategies in parasitology, the challenges posed by drug resistance, and the future direction of novel therapies, including host-targeted approaches, nanomedicine, and vaccine development. A multidisciplinary and innovation-driven approach is crucial to achieving long-term control and elimination of parasitic diseases. Parasitic infections such as malaria, leishmaniasis, schistosomiasis, and filariasis affect millions worldwide, leading to severe health and economic burdens. While preventative measures and vector control are essential [1, 2, 3, 4], effective therapeutic interventions remain critical for disease management and control. However, the emergence of drug-resistant parasites, lack of vaccines for many parasitic diseases, and limited treatment options necessitate innovative and adaptable therapeutic strategies [5, 6].

Conventional Antiparasitic Therapy

Traditional antiparasitic drugs such as chloroquine, albendazole, praziquantel, and metronidazole have long been used as first-line treatments. While effective, their widespread and prolonged use has contributed to the development of resistance, particularly in malaria (Plasmodium falciparum) and leishmaniasis (Leishmania donovani). Monotherapy approaches are increasingly insufficient, highlighting the need for combination regimens and novel drug development [7, 8, 9, 10].

Emerging Therapeutic Approaches

Drug Repurposing

Repurposing existing drugs approved for other indications (e.g., antibiotics, anticancer drugs) offers a cost-effective and time-saving approach. For instance, miltefosine, originally developed for cancer, is now used in leishmaniasis treatment.

Nanomedicine and Targeted Drug Delivery

Nanoparticle-based formulations enhance drug solubility, bioavailability, and targeted delivery. These systems minimize off-target toxicity and improve efficacy, particularly in intracellular parasites such as Toxoplasma gondii and Plasmodium species.

Immunotherapy and Host-Directed Therapy

Modulating the host immune response to better combat parasitic infections is a promising strategy. Therapies that enhance macrophage activation or cytokine modulation show potential in diseases like leishmaniasis and schistosomiasis.

Vaccine Research and Preventive Therapy

While no fully effective vaccines exist for most human parasitic diseases, several candidates are under clinical evaluation. RTS,S/AS01, the malaria vaccine, is a landmark development. Continued investment in vaccine development, especially for neglected tropical diseases (NTDs), is imperative for long-term disease control.

Challenges and Future Directions

Drug Resistance: Addressing multidrug-resistant strains requires global surveillance, rational drug use, and development of new mechanisms of action.

Limited Pipeline: Investment in parasitology R&D is comparatively low; public-private partnerships can stimulate innovation.

Diagnostic Integration: Therapies must be linked with rapid, accurate diagnostics for timely and precise treatment.

One Health Approach: Integration of human, animal, and environmental health perspectives can lead to better understanding and control of zoonotic parasitic infections.

Conclusion

Therapeutic interventions in parasitology are at a pivotal point. Traditional drugs, while still relevant, must be supplemented by innovative approaches such as nanomedicine, host-directed therapy, and vaccine development. Collaborative research, increased funding, and integrated public health strategies will be essential to effectively tackle parasitic diseases and reduce their global impact.

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