



Acne Drugs: Mechanisms of Action, Efficacy, and Future Directions in Treatment

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Description

Acne vulgaris is a common dermatological condition characterized by the formation of comedones, papules, pustules, and nodules on the skin. Various pharmacological agents have been developed to target the multifactorial pathogenesis of acne, including topical retinoids, antimicrobial agents, and systemic therapies such as oral antibiotics and isotretinoin. Acne vulgaris stands as one of the most prevalent dermatological disorders, affecting individuals across diverse age groups and geographical regions. The pathogenesis of acne is multifactorial, involving the coordination of genetic predisposition, sebaceous gland hyperactivity, follicular hyperkeratinization, and colonization by *Cutibacterium acnes*.

Pharmacological interventions targeting these pathogenic mechanisms have revolutionized the management of acne, offering effective solutions to alleviate symptoms and prevent long-term sequelae. Topical retinoids, including tretinoin, adapalene, and tazarotene, represent cornerstone agents in the management of acne vulgaris. These compounds exert their therapeutic effects by modulating keratinocyte differentiation, promoting comedolysis, and reducing inflammation within the pilosebaceous unit. Tretinoin, a first-generation retinoid, functions by binding to Retinoic Acid Receptors (RARs) in the nucleus, thereby regulating gene expression and promoting the turnover of follicular epithelial cells.

Adapalene, a third-generation retinoid, exhibits selective affinity for specific RAR subtypes, conferring enhanced efficacy and tolerability compared to its predecessors. Tazarotene, a synthetic retinoid, exerts dual agonistic activity on RARs and Retinoid X Receptors (RXRs), augmenting its comedolytic and anti-inflammatory properties. Clinical studies have demonstrated the efficacy of topical retinoids in reducing both inflammatory and non-inflammatory lesions associated with acne vulgaris, with improvements observed as early as four to eight weeks following initiation of therapy. Adverse effects such as erythema, dryness, and irritation are common with topical retinoid use, necessitating cautious titration and concomitant use of moisturizers and sunscreens to minimize skin irritation and photosensitivity.

Vital role in the management of inflammatory acne by targeting *Cutibacterium acnes*, the gram-positive bacterium implicated in the pathogenesis of acne vulgaris. Topical antibiotics such as clindamycin and erythromycin inhibit bacterial protein synthesis and suppress

inflammatory responses within the pilosebaceous unit, thereby reducing the burden of *C. acnes* and ameliorating acne lesions. However, the emergence of antibiotic-resistant strains and concerns regarding long-term safety have prompted a shift towards the antibiotic use and combination therapy with non-antibiotic agents. Oral antibiotics, including tetracyclines (e.g., doxycycline, minocycline) and macrolides (e.g., azithromycin), are reserved for moderate to severe cases of inflammatory acne unresponsive to topical therapy.

These systemic agents exert bacteriostatic effects on *C. acnes* and possess anti-inflammatory properties, thereby addressing both infectious and inflammatory components of acne pathogenesis. Nonetheless, their use is associated with gastrointestinal disturbances, photosensitivity, and the risk of antibiotic resistance, necessitating periodic reassessment and consideration of alternative treatment options. Isotretinoin, a synthetic retinoid derivative of vitamin A, represents the most effective and durable treatment for severe, recalcitrant acne vulgaris. By exerting pleiotropic effects on sebaceous gland function, keratinization, and inflammation, isotretinoin induces profound and sustained remission of acne lesions, often leading to long-term clearance and improvement in quality of life.

Its mechanism of action involves normalization of sebaceous gland activity, reduction of sebum production, and inhibition of comedogenesis and inflammation within the pilosebaceous unit. Despite its remarkable efficacy, isotretinoin is associated with a myriad of adverse effects, including mucocutaneous dryness, cheilitis, xerosis, and teratogenicity. Additionally, isotretinoin use has been linked to potential psychiatric adverse events, including depression, anxiety, and suicidal ideation, although the causality of these associations remains a subject of debate. Strict adherence to pregnancy prevention measures and close monitoring of patients for adverse effects are essential components of isotretinoin therapy, necessitating a comprehensive risk-benefit assessment and informed decision-making process. In recent years, the field of acne treatment has witnessed the emergence of novel therapeutic modalities aimed at addressing unmet needs and improving treatment outcomes.

These include innovative topical formulations, such as fixed-dose combinations and microsphere delivery systems, designed to enhance drug efficacy and minimize cutaneous irritation. Furthermore, the advent of biologic agents targeting specific inflammatory pathways implicated in acne pathogenesis holds promise for individuals with severe, treatment-resistant disease. Moreover, advances in understanding the role of the skin microbiome and host-microbe interactions have paved the way for the development of microbiome-targeted therapies, including probiotics, prebiotics, and postbiotics, as adjunctive treatments for acne. By restoring microbial balance and modulating immune responses within the skin microenvironment, these interventions offer a potential alternative or complement to conventional pharmacological agents, thereby expanding the armamentarium of acne therapeutics.

Conclusion

In conclusion, acne drugs encompass a diverse array of pharmacological agents targeting the multifactorial pathogenesis of acne vulgaris. Through elucidation of their mechanisms of action, clinical efficacy, and adverse effects, clinicians can formulate

evidence-based treatment regimens tailored to the individual needs of patients with acne. Furthermore, ongoing study endeavors and technological innovations hold promise for the development of novel therapeutic modalities, ushering in a new era of personalized acne management focused on optimizing outcomes and enhancing patient satisfaction.