Exploration of Individualized Pharmacological Treatment and Prevention Strategies for Migraine

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Abstract: Migraine is a common primary headache disorder characterized by recurrent moderate to severe throbbing pain, often accompanied by nausea, vomiting, and photophobia. Its complex pathogenesis and significant individual differences lead to varying responses to conventional pharmacological treatments, making individualized treatment an important direction in clinical practice. This paper first reviews the pathological and physiological mechanisms of migraine, focusing on the roles of neurovascular regulation disorders, neurotransmitter imbalances, and genetic factors. Then, it explores individualized pharmacological treatment strategies from the perspectives of acute attack treatment and preventive treatment, aims to provide theoretical support and clinical reference for improving the efficacy of migraine treatment and reducing the recurrence rate.

***Keywords*:** migraine; Individualized treatment; pharmacological therapy; prevention strategy; neurotransmitter

1. Introduction

In recent years, with the in-depth study of migraine pathogenesis, factors such as genetic polymorphism, neurotransmitter system differences, and comorbidity characteristics have been gradually recognized as key determinants of treatment response. For example, the CGRP (calcitonin gene-related peptide) receptor gene polymorphism is closely related to the efficacy of CGRP monoclonal antibodies; patients with migraine combined with depression may have different responses to triptans compared with patients without comorbidities. Therefore, exploring individualized pharmacological treatment and prevention strategies based on individual characteristics is of great significance for improving clinical efficacy and quality of life of patients.

2. Pathophysiological Mechanisms and Individual Differences of Migraine

2.1 Pathophysiological Basis of Migraine

The pathogenesis of migraine has not been fully clarified, and the currently recognized "neurovascular hypothesis" believes that it is a comprehensive result of the interaction between cerebral blood vessel dysfunction and neuronal activity. On the one hand, the activation of trigeminal nerve vascular system leads to the release of neuropeptides such as CGRP and substance P, which cause vasodilation and neurogenic inflammation, and then trigger pain signals. On the other hand, the dysfunction of brainstem pain regulatory center and cortical spreading depression (CSD) are also important initiating factors. CSD refers to the wave-like depolarization of cortical neurons and glial cells, which can activate trigeminal nerve endings and promote the occurrence of neurogenic inflammation[1].

2.2 Individual Difference Factors Affecting Treatment Response

Genetic factors are important determinants of individual differences in migraine. Genes related to migraine include those encoding CGRP receptors (CALCRL), 5-HT receptors (HTR1B), and drug metabolism enzymes (CYP2D6, CYP3A4). For example, the HTR1B gene polymorphism can affect the affinity of triptans (5-HT1B/1D agonists) to receptors, resulting in different therapeutic effects. Patients with CYP2D6 poor metabolizer genotype may have slower metabolism of certain migraine drugs, increasing the risk of adverse reactions.

3. Individualized Pharmacological Treatment Strategies for Migraine

3.1 Individualized Treatment of Acute Migraine Attacks

The goal of acute attack treatment is to quickly relieve pain and accompanying symptoms, and restore patients' normal life functions. The selection of drugs should be based on the severity of the attack, frequency, comorbidities, and drug metabolism characteristics.

For patients with mild to moderate attacks and no comorbidities, NSAIDs are the first choice. For example, ibuprofen

and naproxen have good efficacy and high safety. However, for patients with a history of gastrointestinal ulcers, selective cyclooxygenase-2 (COX-2) inhibitors (such as celecoxib) should be selected to reduce the risk of gastrointestinal adverse reactions. For patients with moderate to severe attacks, or those who are ineffective to NSAIDs, triptans are recommended. Sumatriptan is the most commonly used drug, but its efficacy varies among individuals. Patients with HTR1B gene CC genotype have better response to sumatriptan than those with CT or TT genotypes. For patients with poor oral drug absorption or severe nausea and vomiting, subcutaneous injection or nasal spray of triptans can be used to improve bioavailability[2].

For patients with refractory migraine (no response to triptans and NSAIDs), ergot alkaloids (such as dihydroergotamine) or CGRP receptor antagonists (such as ubrogepant) can be considered. CGRP receptor antagonists have a new mechanism of action and are suitable for patients who cannot use triptans due to cardiovascular diseases, because they do not affect coronary blood vessels. However, attention should be paid to the contraindications of ergot alkaloids: they cannot be used in combination with triptans, and cannot be used in patients with severe cardiovascular diseases.

3.2 Individualized Preventive Pharmacological Treatment

Preventive treatment is suitable for patients with high attack frequency (≥4 times a month), severe attack symptoms, or adverse reactions to acute treatment drugs. The goal is to reduce the attack frequency, severity, and improve the response to acute treatment. The selection of preventive drugs should fully consider individual factors such as genetic background, comorbidities, and drug tolerance.

β-blockers (such as propranolol) are the first-line preventive drugs, which are especially suitable for patients with migraine combined with hypertension or tachyarrhythmia. However, patients with asthma or bradycardia should be avoided. Antiepileptic drugs (such as topiramate) are suitable for patients with migraine combined with epilepsy, but they may cause adverse reactions such as weight loss and cognitive impairment, so they should be used with caution in young women and patients with cognitive requirements. Antidepressants (such as amitriptyline) are suitable for patients with migraine combined with depression or anxiety, but they have anticholinergic adverse reactions, so they should be avoided in patients with benign prostatic hyperplasia or glaucoma[3].

4. Optimization of Individualized Prevention Strategies for Migraine

4.1 Identification and Intervention of Individual Risk Factors

In addition to pharmacological prevention, the identification and intervention of individual risk factors are also important parts of individualized prevention. Migraine risk factors include lifestyle factors (such as irregular work and rest, excessive coffee intake), environmental factors (such as strong light, noise), and psychological factors (such as stress, anxiety). Through detailed medical history collection and lifestyle assessment, individual risk factors can be identified, and targeted intervention measures can be formulated.

For example, for patients whose migraine attacks are triggered by sleep deprivation, it is recommended to maintain a regular sleep schedule and avoid staying up late; for patients triggered by excessive coffee intake, the daily coffee intake should be controlled within 200mg; for patients triggered by work pressure, psychological intervention measures such as cognitive behavioral therapy (CBT) can be combined to reduce the impact of psychological factors on migraine attacks[4].

4.2 Combination of Non-pharmacological and Pharmacological Interventions

The combination of non-pharmacological and pharmacological interventions can improve the effect of individualized prevention. Non-pharmacological interventions include CBT, biofeedback therapy, and acupuncture. CBT can help patients change bad cognitive patterns and coping styles, and reduce the sensitivity to migraine triggers. Biofeedback therapy can help patients adjust physiological indicators such as heart rate and blood pressure, and relieve neurogenic inflammation. Acupuncture has been confirmed by clinical studies to have a certain preventive effect on migraine, and it is suitable for patients who are unwilling to use drugs or have poor drug tolerance.

For example, for patients with migraine combined with anxiety, the combination of propranolol and CBT can not only reduce the attack frequency but also improve anxiety symptoms; for elderly patients with poor drug tolerance, the combination of acupuncture and low-dose topiramate can reduce the drug dose and adverse reactions.

5. Discussion and Conclusion

Migraine is a heterogeneous disease with complex pathogenesis and significant individual differences. Conventional one-size-fits-all pharmacological treatment cannot meet the clinical needs of all patients. Individualized treatment based on genetic background, comorbidity characteristics, and lifestyle factors is the key to improving treatment efficacy and reducing

adverse reactions.

In the aspect of acute treatment, the selection of NSAIDs, triptans, or CGRP receptor antagonists should be based on the severity of the attack and individual drug response. In the aspect of preventive treatment, β-blockers, antiepileptic drugs, and CGRP monoclonal antibodies should be selected according to comorbidities and genetic polymorphism. At the same time, the combination of non-pharmacological interventions such as identification of individual risk factors and CBT can further optimize the preventive effect.

However, there are still some limitations in the current individualized treatment of migraine. For example, the research on genetic markers related to drug efficacy is not sufficient, and the detection of genetic polymorphism has not been popularized in clinical practice. In the future, with the development of precision medicine, more genetic markers and biological markers should be explored to establish a more accurate individualized treatment prediction model. At the same time, the combination of multi-disciplinary diagnosis and treatment (such as neurology, psychology, and genetics) should be strengthened to provide more comprehensive individualized treatment plans for patients.

In conclusion, individualized pharmacological treatment and prevention strategies for migraine should be based on a comprehensive assessment of individual characteristics, and combine pharmacological and non-pharmacological interventions to achieve the goal of improving efficacy, reducing recurrence, and improving quality of life.

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