

Analysis of the Pathogenesis and Intervention Strategies of Neurodegenerative Diseases in the Elderly from the Theory of “Kidney Essence Deficiency - Brain Marrow Insufficiency”

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Abstract: *Neurodegenerative diseases in the elderly are characterized by complex pathogenesis and slow disease progression. The traditional Chinese medicine theory of “Kidney Essence Deficiency - Brain Marrow Insufficiency” provides a unique perspective for understanding these diseases, considering the decline of kidney essence and malnourishment of brain marrow as the core pathogenesis, which aligns with the mechanisms revealed by modern medicine, such as neuronal energy metabolism disorders, synaptic damage, protein deposition, and cerebral microcirculation disorders. Based on this, traditional Chinese medicine, through multi-dimensional intervention strategies such as tonifying the kidney and replenishing essence, nourishing marrow and strengthening the brain, resolving phlegm and turbidity, and promoting blood circulation and unblocking collaterals, shows potential advantages in improving cognitive function and delaying disease progression. Modern pharmacological studies have shown that related prescriptions have multi-target effects such as anti-oxidation, anti-inflammation, improvement of mitochondrial function, and promotion of nerve regeneration, and can exert neuroprotective effects through regulating neurotransmitters, enhancing synaptic plasticity, improving cerebral blood flow, and gut-brain axis function. Non-drug therapies such as acupuncture and Tai Chi can also provide more options for comprehensive intervention by regulating brain functional networks and improving mood and motor coordination. However, current research on TCM syndrome differentiation lacks standardization, the quality of clinical trials varies, and the mechanisms of action remain insufficient. Future research should strengthen multidisciplinary collaboration, combining techniques such as neuroimaging, molecular biology, and systems biology to promote the scientific and international development of TCM in the field of neurodegenerative diseases.*

Keywords: Traditional Chinese medicine, Kidney essence deficiency, Brain marrow insufficiency, Neurodegenerative diseases.

1. Introduction

Neurodegenerative diseases of the elderly, such as Alzheimer’s disease and Parkinson’s disease, are among the most common and serious health problems in the context of global population aging [1]. These diseases are mainly characterized by cognitive impairment, motor function decline and behavioral abnormalities, which seriously affect the quality of life of patients and impose a heavy burden on the social medical system [2]. With the continuous growth of the elderly population, the incidence of neurodegenerative diseases has been increasing year by year, which has become an important challenge threatening public health [3]. Although modern medicine has made significant progress in etiological research, molecular mechanism exploration and drug development, the current treatment methods are still mainly symptomatic support, and there is a lack of effective methods to fundamentally reverse the disease process [4]. Existing drugs can often only delay the development of symptoms to a certain extent, and are accompanied by side effects and unstable efficacy [5]. Therefore, how to find more effective, safe and sustainable intervention strategies has become a problem that the medical community urgently needs to solve.

Traditional Chinese medicine has unique advantages in the prevention and treatment of geriatric diseases. Traditional Chinese medicine theory emphasizes the holistic concept and syndrome differentiation and treatment, and focuses on the dynamic balance of human body functions and the regulation

of individual differences [6]. In understanding neurodegenerative diseases, traditional Chinese medicine (TCM) proposes “deficiency of kidney essence and insufficiency of brain marrow” as its core pathogenesis, believing that the decline of kidney essence leads to malnourishment of brain marrow, thereby causing cognitive and motor dysfunction [7]. This theory not only aligns with the natural aging process of the elderly population but also provides new ideas for the prevention and treatment of diseases. In recent years, TCM prescriptions such as tonifying the kidney and replenishing essence, and nourishing the marrow and strengthening the brain have shown certain efficacy in improving patient symptoms and delaying disease progression, and have gradually gained support from modern medical research [8]. In addition, non-drug therapies such as acupuncture, massage, and Tai Chi have also shown positive effects in regulating brain function and improving cognitive and motor dysfunction [9].

This article aims to systematically analyze the TCM pathogenesis of neurodegenerative diseases in the elderly based on the theory of “deficiency of kidney essence and insufficiency of brain marrow,” review relevant TCM intervention strategies and research progress, and explore their convergence and complementarity with modern medical mechanisms. Through the combination of theory and practice, it is hoped that new academic perspectives and clinical references can be provided for the prevention and treatment of neurodegenerative diseases in the elderly [10].

2. The Traditional Chinese Medicine Basis of the Theory of “Kidney Essence Deficiency - Brain Marrow Insufficiency”

In the traditional Chinese medicine system, kidney essence is regarded as the fundamental substance of life activities, which governs growth, development and reproduction, and is closely related to the aging process. When kidney essence is abundant, the body's functions are vigorous, while when it is deficient, it manifests as weakness and degeneration. With age, kidney essence gradually becomes deficient, leading to a decline in the body's anti-aging ability, manifested as symptoms such as memory loss, slow reaction and motor dysfunction, which corresponds to the neuronal functional decline and energy metabolism disorders revealed by modern medicine [11].

In traditional Chinese medicine theory, brain marrow is called “the sea of marrow,” which is an important product of kidney essence and plays a key role in maintaining cognitive, emotional and motor functions [12]. “The brain is the residence of the primordial spirit.” When brain marrow is abundant, thinking is agile and movements are coordinated; if the sea of marrow is insufficient, symptoms such as forgetfulness, dementia and limb weakness will appear. Modern research also suggests that the degeneration of brain structure and function is closely related to the occurrence of neurodegenerative diseases, suggesting that the traditional Chinese medicine theory of “brain marrow deficiency” has a certain point of convergence with neuroscience [13].

The theoretical chain of kidney essence deficiency leading to brain marrow insufficiency can be summarized as: kidney essence depletion → marrow sea emptiness → mental dysfunction. That is, kidney essence deficiency leads to brain marrow malnourishment, which in turn affects the normal operation of the nervous system, manifested as cognitive impairment and motor function decline [14]. This pathogenesis model not only reveals the TCM essence of neurodegenerative diseases in the elderly, but also provides a theoretical basis for clinical intervention. Tonifying the kidney and replenishing essence, benefiting marrow and strengthening the brain have become the main treatment ideas, aiming to improve brain marrow function by restoring the fullness of kidney essence, thereby delaying the progression of the disease [15].

3. Analysis of the Pathogenesis of Neurodegenerative Diseases in the Elderly in Traditional Chinese Medicine

In traditional Chinese medicine theory, deficiency of kidney essence is regarded as the core pathogenesis of neurodegenerative diseases in the elderly. With age, kidney essence gradually declines, marrow becomes insufficient, and the brain is deprived of nourishment, manifesting as memory decline, slow reaction, and motor disorders. This corresponds to the neuronal energy metabolism disorders and synaptic function decline revealed by modern medicine [16].

In addition to deficiency of kidney essence, deficiency of liver and kidney, and deficiency of both spleen and kidney are also common in elderly patients. The liver and kidney share the

same origin. Insufficient liver blood can aggravate the malnourishment of brain marrow, leading to cognitive dysfunction; deficiency of both spleen and kidney, due to insufficient qi and blood production, further affects brain nourishment, manifesting as symptoms such as lethargy and memory decline [17].

In addition, phlegm and blood stasis are important pathological factors. Phlegm obstructing the orifices can hinder the ascent of clear yang, leading to mental confusion, which corresponds to the pathological formation of β -amyloid protein deposition in modern medicine; blood stasis obstructing the collaterals affects the microcirculation of the brain, leading to nerve conduction disorders, which is closely related to insufficient cerebral blood perfusion [18]. Therefore, the pathogenesis of neurodegenerative diseases in the elderly often presents a mixture of deficiency and excess, with deficiency of kidney essence as the root cause and excess symptoms such as phlegm and blood stasis as the manifestation. In summary, there is a certain degree of agreement between the pathogenesis of traditional Chinese medicine and the modern pathological mechanism: deficiency of kidney essence corresponds to the decline of neuronal function, deficiency of brain marrow corresponds to synaptic damage and decreased neuroplasticity, phlegm corresponds to abnormal protein deposition, and blood stasis corresponds to cerebral microcirculation disorders. This interdisciplinary correspondence not only enriches the understanding of the nature of the disease, but also provides a theoretical basis for the intervention of traditional Chinese medicine.

4. Intervention Strategies and Research Progress of Traditional Chinese Medicine

In the prevention and treatment of neurodegenerative diseases in the elderly, the intervention strategy of traditional Chinese medicine mainly revolves around the four major treatment pathways of “tonifying the kidney and replenishing essence, benefiting marrow and strengthening the brain, eliminating phlegm and turbidity, and promoting blood circulation and unblocking collaterals”, which reflects the core ideas of syndrome differentiation and treatment and overall regulation in traditional Chinese medicine [19]. Formulas for tonifying the kidney and replenishing essence, such as Liuwei Dihuang Wan, Yougui Wan, and Guilu Erxian Jiao, are classic formulas for treating cognitive impairment in the elderly. Traditional theory holds that “when kidney essence is abundant, brain marrow is sufficient”, so kidney-tonifying formulas can fundamentally improve cognitive decline caused by brain marrow deficiency [20]. Modern pharmacological research further reveals that these formulas have multiple target effects such as anti-oxidation, anti-inflammation, improvement of mitochondrial function, and promotion of nerve regeneration. They can delay neurodegenerative diseases by improving neuronal energy metabolism, enhancing the expression of neurotrophic factors, and regulating neurotransmitter balance, providing a scientific basis for their traditional application [21]. Some studies have also found that kidney-tonifying formulas can improve the synaptic structure of the hippocampus and enhance learning and memory abilities, suggesting their potential value in early intervention of Alzheimer's disease. Formulas that benefit marrow and strengthen the brain, such as Bu Nao Wan and Qi

Fu Yin, emphasize improving cognitive function by “nourishing the marrow sea”. Modern research shows that these formulas can enhance synaptic plasticity, regulate the cholinergic and glutamatergic systems, inhibit neuronal apoptosis, and improve cerebral blood flow and energy metabolism, thereby playing a positive role in mild cognitive impairment and early dementia [22]. In addition, the formulas for nourishing the marrow and strengthening the brain can also affect cognitive performance by regulating the gut microbiota and improving gut-brain axis function. This emerging mechanism provides a new research direction for the treatment of neurodegenerative diseases by traditional Chinese medicine.

Formulas for eliminating phlegm and turbidity and promoting blood circulation also play an important role in neurodegenerative diseases in the elderly. Traditional Chinese medicine believes that “phlegm and turbidity obstructing the orifices” and “blood stasis obstructing the collaterals” are important pathological factors leading to mental confusion and memory decline. Formulas such as Tianma Gouteng Decoction and Xuefu Zhuyu Decoction can not only improve cerebral microcirculation and increase cerebral blood flow, but also reduce neuroinflammatory response and reduce abnormal protein deposition, especially β -amyloid protein, which is highly consistent with the modern medical treatment concept for A β deposition and cerebral blood flow disorders [23]. These formulas provide effective intervention methods for the pathogenesis of “mixed deficiency and excess” by improving the brain microenvironment and promoting nerve repair. Recent studies have also found that formulas for promoting blood circulation and removing blood stasis can improve cerebral vascular endothelial function, reduce oxidative stress levels, and may reduce nerve damage by regulating blood-brain barrier permeability. In addition to traditional Chinese medicine prescriptions, non-drug TCM interventions such as acupuncture, massage, Tai Chi, and Qigong have also shown positive effects in improving cognitive function, motor coordination, and emotional regulation. Acupuncture, by tonifying kidney essence and regulating brain marrow, can regulate brain region functional connectivity and improve neural plasticity, and its regulatory effect on brain functional networks has been confirmed by modern technologies such as fMRI and EEG [24]. Studies have shown that acupuncture can promote the regeneration of neurons in the hippocampus, regulate the release of neurotransmitters, inhibit neuroinflammation, and improve sleep quality, thereby indirectly improving cognitive function. Massage, Tai Chi, and Qigong, which combine mind and body, can improve cerebral blood supply, regulate emotions, enhance balance and motor coordination, and embody the TCM concept of “unity of form and spirit” in rehabilitation. Tai Chi and Qigong, through slow movement and breathing regulation, can reduce stress levels and improve autonomic nerve function, and have a certain cognitive improvement effect on patients with mild cognitive impairment.

In recent years, the integrated TCM and Western medicine treatment model has gradually gained attention. Studies have shown that the combined use of traditional Chinese medicine (TCM) and modern drugs can improve treatment efficacy, reduce adverse reactions, and improve symptoms that are difficult to cover by Western medicine, such as mood

disorders, sleep disorders, and physical weakness, reflecting the characteristics of complementary advantages [25]. For example, TCM can enhance the cognitive improvement effect of cholinesterase inhibitors while reducing their gastrointestinal side effects. The TCM intervention model based on the theory of “kidney essence-brain marrow” emphasizes starting from the whole body, taking into account both tonifying deficiency and eliminating pathogens, and implementing prevention, early intervention, and treatment during the disease progression stage in stages, forming a systematic and continuous treatment framework, which provides an operational approach for future clinical practice. With the development of modern technology, more and more studies have begun to explore the mechanism of action of TCM in regulating neuroinflammation, the gut-brain axis, and the immune system, which will further promote the scientific and international development of TCM in the field of neurodegenerative diseases.

5. Summary and Outlook

In summary, the theory of “kidney essence deficiency-brain marrow insufficiency” provides a unique perspective for TCM to understand neurodegenerative diseases in the elderly. This theory emphasizes the core role of kidney essence depletion and brain marrow malnutrition in the development of the disease, and has certain similarities with the mechanisms revealed by modern medicine, such as neuronal energy metabolism disorders, synaptic damage, protein deposition, and cerebral microcirculation disorders [26].

On this basis, traditional Chinese medicine has shown the potential to improve cognitive function and delay disease progression through multi-dimensional intervention strategies such as tonifying the kidney and replenishing essence, nourishing marrow and strengthening the brain, eliminating phlegm and turbidity, and promoting blood circulation and unblocking collaterals [27]. Non-drug therapies such as acupuncture, massage, and Tai Chi have also played a positive role in regulating brain function and improving mood and motor disorders, providing more options for comprehensive prevention and treatment [28]. However, current research still has some shortcomings. First, the standardization and objectification of TCM syndromes need to be further improved; second, the design quality and evidence-based evidence of clinical trials are still limited; in addition, modern research on the mechanism of action of TCM is still in the exploratory stage, lacking large-scale, multi-center systematic verification [29]. Future research should strengthen multidisciplinary collaboration, combining molecular biology, neuroimaging, and systems biology methods to deeply reveal the mechanism of action of TCM intervention. Meanwhile, promoting the integration of traditional Chinese and Western medicine in clinical practice and evidence-based research will help improve treatment efficacy and expand application prospects [30]. In general, starting from the theory of “kidney essence deficiency—brain marrow insufficiency,” it can not only deepen the understanding of the pathogenesis of neurodegenerative diseases in the elderly, but also provide a solid theoretical foundation and practical path for the prevention and treatment of diseases with traditional Chinese medicine. With the continuous deepening of research, traditional Chinese medicine is expected to play a more

important role in the global geriatric disease prevention and treatment system.

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