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Mechanism Analysis of Modified Bugan Yangrong Decoction in the Treatment of Meniere's Disease Based on Network Pharmacology and Molecular Docking

Junxia Hua

The First Clinical Medical College, Anhui University of Chinese Medicine, Hefei, China
2773917118@qq.com

Abstract. To explore the potential mechanism of Modified Bugan Yangrong Decoction (Angelicae Sinensis Radix, Paeoniae Radix Alba, Rehmanniae Radix Praeparata, Citri Reticulatae Pericarpium, Chrysanthemi Flos, Glycyrrhizae Radix et Rhizoma) from Chi Shui Xuan Zhu by Sun Yikui in the treatment of Meniere's disease (MD) using network pharmacology and molecular docking. Active components and targets of the six herbs were screened using TCMSP database. MD-related targets were obtained from GeneCards and DrugBank databases. Intersection targets were identified. A "Chinese medicine-component-target" network and a PPI network were constructed. GO and KEGG enrichment analyses were performed. Molecular docking was carried out using AutoDock Vina. Results 190 active components were screened, including quercetin, kaempferol, luteolin, etc. 292 drug targets and 186 disease targets were obtained, with 23 intersection targets. Core PPI targets included TNF, IFNG, CXCL8, NOS3, CASP9, CCL2, IL1A. KEGG pathways mainly involved AGE-RAGE, lipid and atherosclerosis, calcium signaling, NF-κB, IL-17, and TNF signaling pathways. Molecular docking showed stable binding. Conclusion Modified Bugan Yangrong Decoction may treat MD through multi-component (quercetin, kaempferol, luteolin), multi-target (TNF, IFNG, CXCL8, NOS3), and multi-pathway (AGE-RAGE, NF-κB, calcium) mechanisms, involving anti-inflammation, immunomodulation, and improvement of inner ear microcirculation.

Keywords: network pharmacology, molecular docking, Modified Bugan Yangrong Decoction, Meniere's disease, Sun Yikui

1. Introduction

Meniere's disease is an inner ear disorder whose etiology has not yet been fully clarified and whose typical pathological manifestation is endolymphatic hydrops of the membranous labyrinth. It was first reported by the French physician Prosper Ménière in 1861. The core clinical manifestations of this disease include recurrent rotational vertigo, fluctuating hearing loss, tinnitus, and aural fullness. Some patients may also present with autonomic nervous dysfunction symptoms such as nausea, vomiting, and pale complexion [1]. From the perspective of global incidence, its prevalence is approximately 34–200 per 100,000 people. The age group of 40–60 years is the high-incidence age

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group, and the probability of disease occurrence in females is slightly higher than that in males. Although Meniere's disease does not directly endanger the life of patients, frequent attacks of vertigo and progressively aggravated hearing impairment can significantly reduce patients' quality of life and interfere with their normal work and psychological state. Some patients may also develop negative emotions such as anxiety and depression.

At the present stage, the pathogenesis of Meniere's disease has still not been fully clarified. The pathological links generally recognized by the academic community include imbalance between the production and absorption of endolymph, immune inner ear inflammation, abnormal vascular regulatory function, ischemia-reperfusion injury, genetic susceptibility, and viral infection [2]. Modern medical treatment takes controlling acute attacks, reducing the frequency of vertigo attacks, protecting hearing, and relieving tinnitus as its core objectives. Commonly used therapeutic methods include low-salt diet regulation, diuretics, glucocorticoids, vestibular suppressants, vasodilators, and transtympanic low-pressure pulse therapy. For refractory cases with poor response to conventional treatment, intratympanic gentamicin injection or surgical intervention may be adopted, such as endolymphatic sac decompression and vestibular neurectomy [3]. However, existing treatment regimens have obvious deficiencies: some patients respond poorly to diuretics and glucocorticoids; intratympanic drug administration may cause hearing impairment; surgical treatment is not only highly traumatic and costly but also difficult to achieve a radical cure. Therefore, exploring safe and effective traditional Chinese medicine intervention regimens has important practical significance for the clinical treatment of Meniere's disease.

In the theoretical system of traditional Chinese medicine, there is no disease name corresponding to "Meniere's disease." Based on its core symptoms, such as vertigo, tinnitus, and deafness, it may be classified into the categories of "vertigo," "aural vertigo," and "wind vertigo." Physicians of past dynasties continuously deepened their understanding of the pathogenesis of vertigo. The *Huangdi Neijing* proposed that "all wind, shaking, and dizziness belong to the liver"; Zhang Zhongjing proposed the view that "phlegm-fluid retention causes vertigo"; Zhu Danxi emphasized that "without phlegm, vertigo does not occur"; Zhang Jingyue advocated that "without deficiency, vertigo does not occur"; and Ye Tianshi proposed the theory of "liver yang transforming into wind." These theories provided important theoretical support for later clinical syndrome differentiation and treatment. Meniere's disease is characterized by recurrent attacks and vertigo accompanied by tinnitus and deafness. Its disease location mainly involves the liver, kidney, and spleen. The core pathogenesis is "deficiency in origin and excess in manifestation": deficiency in origin is mainly characterized by insufficiency of liver blood and deficiency of kidney essence, while excess in manifestation is mostly manifested as upward disturbance of wind-yang, internal obstruction of turbid phlegm, and obstruction due to blood stasis.

Sun Yikui, a Xin'an physician in the Ming Dynasty, was a core representative figure of the warm-tonifying school. In his work *Chishui Xuanzhu*, he specifically established the "Vertigo Section," systematically expounded the treatment methods for vertigo, and clearly proposed that insufficiency of liver blood could cause vertigo. When liver blood is deficient, wind-yang disturbs upward, thereby leading to dizziness of the head and eyes. Based on this theory, Sun Yikui created Bugan Yangrong Decoction. The original prescription consists of Angelica sinensis, Paeonia lactiflora, Rehmannia glutinosa Preparata, Ligusticum chuanxiong, Citri Reticulatae Pericarpium, Chrysanthemi Flos, and Glycyrrhizae Radix et Rhizoma. Its core effects are nourishing blood and softening the liver, extinguishing wind, and stopping vertigo. In clinical practice, Ligusticum chuanxiong is often removed from this prescription, mainly for three reasons. First, Ligusticum chuanxiong is pungent, warm, aromatic, and drying in medicinal nature, and has strong moving and

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dispersing properties. Although it has the effects of activating blood and promoting qi movement, for patients with blood deficiency and yin depletion, its use may easily consume yin-blood and promote wind-yang, which conforms to the traditional Chinese medicine principle that "dryness should be avoided in blood deficiency." Second, Sun Yikui clearly pointed out in the "Vertigo Section" of *ChishuiXuanzhu*that aromatic and drying substances should not be used excessively in blood-tonifying treatment, while the pungent and intense nature of Ligusticum chuanxiong easily damages yin fluid. Third, modern pharmacological studies have shown that ligustrazine, the active component in Ligusticum chuanxiong, can dilate blood vessels, but some patients may experience adverse reactions such as headache and facial flushing after taking it. For patients with Meniere's disease who already have abnormal vascular permeability in the inner ear, excessive vasodilation may aggravate endolymphatic hydrops of the membranous labyrinth. Removing Ligusticum chuanxiong can effectively reduce the risk of such adverse reactions. Therefore, this study adopts a modified Bugan Yangrong Decoction with Ligusticum chuanxiong removed, which consists of six Chinese medicinal herbs. It not only retains the core effect of the original prescription in nourishing blood and softening the liver, but also avoids the disadvantage of pungent dryness damaging yin, making it more consistent with the core pathogenesis of Meniere's disease, namely "insufficiency of liver blood and internal disturbance of deficient wind."

The compatibility of this formula has profound significance. Angelica sinensis, as the monarch drug, is sweet, warm, moist in texture, and can tonify blood, activate blood, nourish the liver, and moisten the vessels. Paeonia lactiflora is the minister drug; it is sour and cold, astringes yin, softens the liver, and calms the liver. When combined with Angelica sinensis, the two mutually reinforce each other and can significantly enhance the effect of nourishing blood. Rehmannia glutinosa Preparata nourishes yin, tonifies blood, replenishes essence, and supplements marrow, assisting the monarch drug in nourishing the liver and kidney. Chrysanthemi Flos clears and calms the liver, guides the herbs upward, and directly reaches the disease location. Citri Reticulatae Pericarpium regulates qi and harmonizes the middle, preventing the nourishing herbs from being too rich and greasy and thereby hindering the transportation and transformation functions of the spleen and stomach. Glycyrrhizae Radix et Rhizoma harmonizes all the herbs, benefits qi, and tonifies the middle. The entire prescription has rigorous compatibility and clear hierarchy, jointly exerting the effects of nourishing blood and softening the liver, extinguishing wind, and stopping vertigo. However, at present, the molecular mechanism of this formula in treating Meniere's disease has not yet been clarified, and its synergistic action mode involving multiple components, multiple targets, and multiple pathways still requires systematic analysis.

Network pharmacology, based on systems biology and bioinformatics as its core foundation, can analyze the interactions between drugs and the body from the level of the overall network. It conforms to the action characteristics of traditional Chinese medicine compound prescriptions involving multiple components, multiple targets, and multiple pathways, breaks through the research limitations of the traditional single-target model, and has become a core tool for the modernization research of traditional Chinese medicine [4, 5]. This study adopts network pharmacology combined with molecular docking technology to systematically predict the active components, core targets, and key pathways of modified Bugan Yangrong Decoction in the treatment of Meniere's disease, reveal its modern scientific connotation in treating Meniere's disease, and provide reliable theoretical support for the rational clinical application of this formula and subsequent experimental research.

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2. Materials and methods

2.1. Screening of active components and targets of modified Bugan Yangrong Decoction

Using the TCMSP database as the data source, the chemical components of the six Chinese medicinal herbs, namely Angelica sinensis, Paeonia lactiflora, Rehmannia glutinosa Preparata, Citri Reticulatae Pericarpium, Chrysanthemi Flos, and Glycyrrhizae Radix et Rhizoma, were retrieved respectively. The screening criteria were set as follows: oral bioavailability (OB) ≥ 30% and drug-likeness (DL) ≥ 0.18. Active components with good oral absorption capacity and druggability were screened out. After merging and removing duplicates, the total active component set of this compound prescription was obtained.

The potential action targets corresponding to each active component were obtained through the TCMSP database. The target protein names were imported into the UniProt database, with the species limited to humans (*Homo sapiens*), to complete the standardized conversion of gene names. For non-standard target names that could not be automatically matched, manual verification and literature cross-validation were used for confirmation. Finally, the drug target gene set of modified Bugan Yangrong Decoction was obtained.

2.2. Collection of Meniere's disease-related targets

Using "Meniere's disease" as the keyword, the GeneCards, DrugBank, and OMIM databases were searched respectively to obtain disease targets related to Meniere's disease. Among them, targets with a relevance score ≥ 10 were selected from the GeneCards database to ensure the correlation between the targets and the disease. The disease targets obtained from the three databases were merged and duplicates were removed to construct the Meniere's disease target set.

2.3. Acquisition of drug-disease intersection targets

The Venny 2.1.0 online tool was used to draw a Venn diagram. The intersection of the drug targets and disease targets was taken as the potential action targets of modified Bugan Yangrong Decoction in the treatment of MD. See Figure 1.

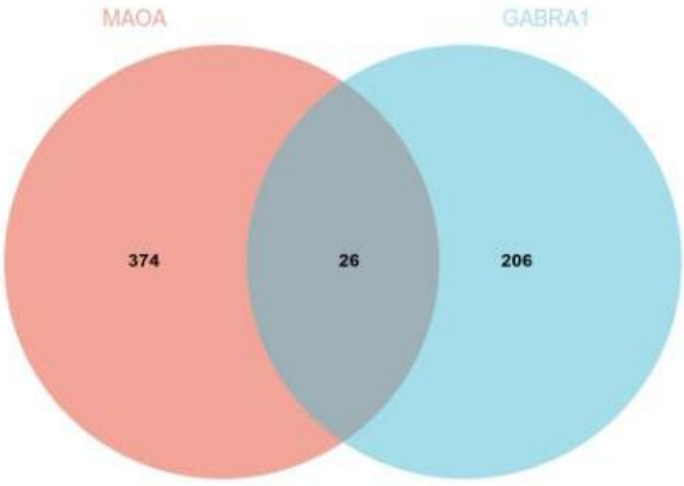

Figure 1. Venn diagram of drug-disease targets

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2.4. Construction of the "Chinese medicine-component-target" network

Three types of nodes, namely the six Chinese medicinal herbs, the screened active components, and the intersection targets, were imported into Cytoscape 3.9.1 software. The "Network from Table" function was used to construct a visualized "Chinese medicine-component-target" network. Topological parameters such as node degree values were calculated using the Network Analyzer tool. The higher the degree value, the more important the role of the node in the network. Based on this, the core active components of the compound prescription were screened out.

2.5. Construction of the PPI network and screening of core targets

The intersection target gene list was imported into the STRING database, with the species set as human, the minimum interaction threshold set to 0.400, and isolated nodes hidden, to construct a protein-protein interaction (PPI) network. The network data were imported into Cytoscape software for visual modification. The Degree, MCC, and Closeness algorithms in the CytoHubba plugin were used to comprehensively evaluate node importance. The intersection of the top 10 targets ranked by the three algorithms was selected as the core targets of this formula in the treatment of Meniere's disease.

2.6. GO functional and KEGG pathway enrichment analyses

The intersection target gene list was uploaded to the DAVID database for GO functional enrichment analysis and KEGG pathway enrichment analysis, with $P < 0.05$ set as the significance threshold. GO analysis was divided into three parts: biological process (BP), cellular component (CC), and molecular function (MF). KEGG analysis was used to identify the key signaling pathways enriched by the targets. The Bioinformatics online platform was used to draw bubble charts to display the enrichment results.

2.7. Molecular docking verification

The top five key targets ranked by comprehensive degree value in the PPI network were selected as receptor proteins, and the four core active components with relatively high degree values in the "Chinese medicine-component-target" network were selected as ligand small molecules to conduct molecular docking simulation. The three-dimensional crystal structures of the target proteins were downloaded from the RCSB PDB database. After water removal, ligand removal, and hydrogenation processing by PyMOL software, they were converted into PDBQT format. The 2D structures of the active components were downloaded from the PubChem database, optimized into 3D structures by Open Babel software, and converted into the corresponding format. AutoDock Vina 1.1.2 software was used for semi-flexible docking. Binding energy ≤ -5.0 kcal/mol was used as the criterion for determining effective binding. The lower the binding energy, the more stable the binding between the ligand and receptor.

3. Results

3.1. Screening results of active components and targets of modified Bugan Yangrong Decoction

After TCMSP screening and duplicate removal, a total of 190 active components of modified Bugan Yangrong Decoction were obtained, corresponding to 292 drug targets. The core components with

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relatively high degree values were quercetin, kaempferol, luteolin, isorhamnetin, and naringenin, which were the main pharmacodynamic substances of the compound prescription.

3.2. Meniere's disease-related targets and drug-disease intersection targets

After merging the retrieval results from the GeneCards, DrugBank, and OMIM databases and removing duplicates, a total of 391 disease targets of Meniere's disease were obtained. Intersection analysis was then conducted between these targets and the drug targets, and 23 potential therapeutic targets were finally obtained, as shown in Figure 2. These intersection targets included TNF, IFNG, CXCL8, NOS3, CASP9, CCL2, IL1A, and others, which were the key action targets of this formula in the treatment of Meniere's disease.

Through screening in the TCMSP database, a total of 190 active components from the six Chinese medicinal herbs in modified Bugan Yangrong Decoction were obtained, and 292 corresponding drug targets were obtained after duplicate removal. The top five active components ranked by degree value were quercetin (degree value: 113), kaempferol (degree value: 43), luteolin (degree value: 49), isorhamnetin (relatively high degree value), and naringenin. These components constitute the main pharmacodynamic material basis of this compound prescription.

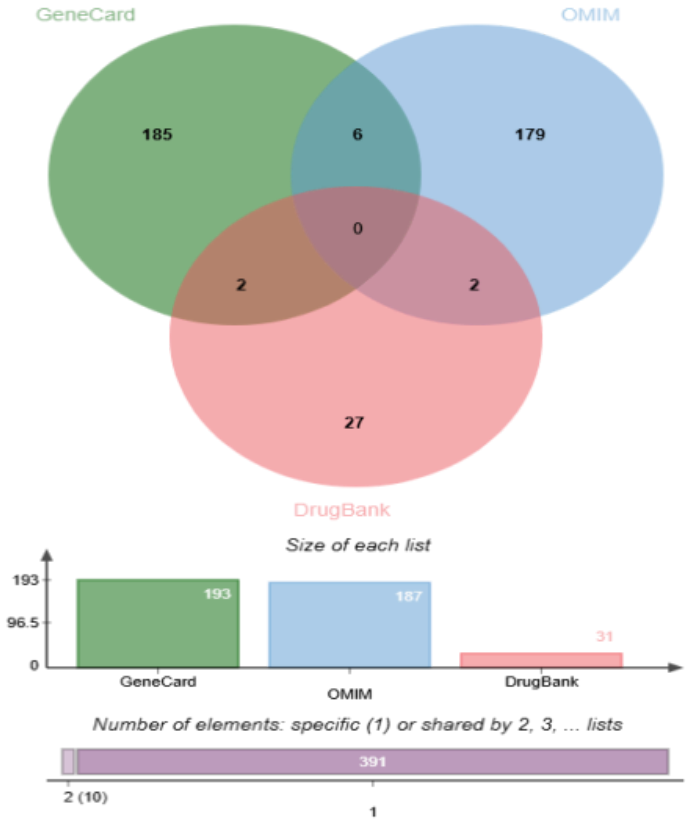

Figure 2. Meniere's disease-related targets and drug-disease intersection targets

3.3. Network analysis of chinese medicine-component-target

The constructed modified Bugan Yangrong Decoction-active component-intersection target network contained a total of 235 nodes and 1,742 edges. Network topology analysis showed that the active components with relatively high degree values, namely the core components, were quercetin,

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kaempferol, and luteolin. This result suggests that the above components may be the main material basis for modified Bugan Yangrong Decoction to exert its therapeutic effect on Meniere's disease. See Figure 3.

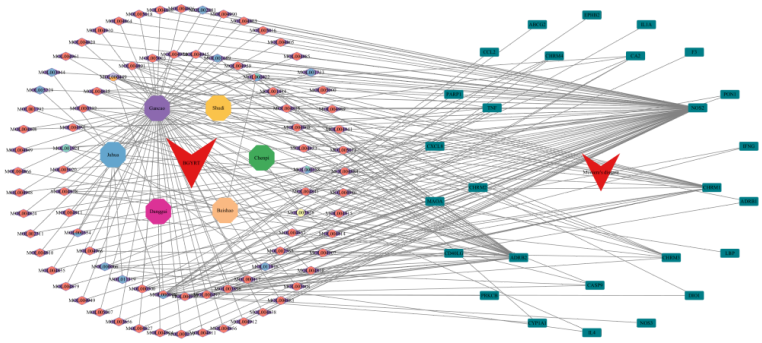

Figure 3. Compound prescription network regulation diagram

3.4. PPI network and screening of key targets

The constructed PPI network contained a total of 23 nodes and 58 edges. Screening with the CytoHubba plugin showed that the top seven key targets ranked by degree value were TNF, IFNG, CXCL8, NOS3, CASP9, CCL2, and IL1A (see Figure 4 and Figure 5, the PPI network diagram of core targets). These core targets play core regulatory roles in inflammatory response, apoptosis, and vascular function regulation, and are the key action targets of this formula in the treatment of Meniere's disease.

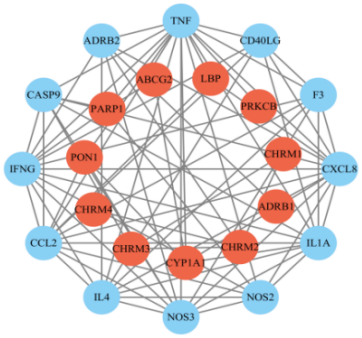

Figure 4. PPI network diagram

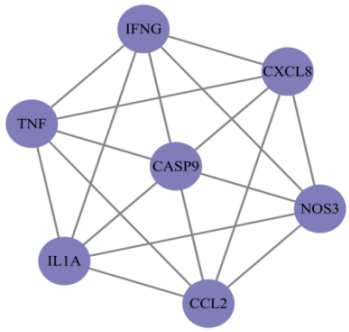

Figure 5. PPI network diagram of core targets

3.5. GO functional and KEGG pathway enrichment analyses

GO functional enrichment analysis obtained a total of 86 terms ($P < 0.05$). Among them, biological process (BP) mainly involved inflammatory response, response to lipopolysaccharide, nitric oxide biosynthetic process, negative regulation of apoptosis, angiogenesis, and others; cellular component (CC) was mainly enriched in extracellular space, plasma membrane, and synapse; molecular function (MF) mainly involved cytokine activity, heme binding, and protein binding.

KEGG pathway enrichment analysis screened out a total of 64 signaling pathways ($P < 0.05$). Ranked by the number of enriched genes, the top 20 pathways mainly involved the AGE-RAGE signaling pathway in diabetic complications, lipid and atherosclerosis pathway, calcium signaling

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pathway, NF-κB signaling pathway, IL-17 signaling pathway, TNF signaling pathway, PI3K-Akt signaling pathway, MAPK signaling pathway, and others (see Table 1 and Figure 6). These pathways are all closely related to the core pathological links of Meniere's disease, such as inner ear microcirculatory disturbance, immune-inflammatory injury, and neural function regulation, and constitute an important pathway basis for this formula to exert its therapeutic effects.

Table 1. Top 10 KEGG enrichment pathways of modified Bugan Yangrong Decoction in the treatment of Meniere's disease

ID	Pathway Name	Count	Genes
hsa04933	AGE-RAGE signaling pathway	7	TNF/F3/CCL2/CXCL8/PRKCB/NOS3/IL1A
hsa05417	Lipid and atherosclerosis	8	TNF/LBP/CASP9/CYP1A1/CCL2/CXCL8/NOS3/CD40LG
hsa04020	Calcium signaling pathway	8	CHRM3/1/2/ADRB2/NOS2/ADRB1/PRKCB/NOS3
hsa04064	NF-kappa B signaling pathway	6	TNF/LBP/CXCL8/PRKCB/PARP1/CD40LG
hsa05164	Influenza A	7	TNF/CASP9/CCL2/CXCL8/PRKCB/IFNG/IL1A
hsa04657	IL-17 signaling pathway	5	TNF/IL4/CCL2/CXCL8/IFNG
hsa04060	Cytokine-cytokine receptor interaction	7	TNF/IL4/CCL2/CXCL8/IFNG/IL1A/CD40LG
hsa04725	Cholinergic synapse	5	CHRM3/1/4/2/PRKCB
hsa04066	HIF-1 signaling pathway	4	NOS2/PRKCB/NOS3/IFNG
hsa04151	PI3K-Akt signaling pathway	5	CHRM1/2/CASP9/IL4/NOS3



Figure 6. Top 20 KEGG enrichment results

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3.6. Molecular docking verification results

The core components quercetin, kaempferol, and luteolin, and the key targets TNF, IFNG, CXCL8, and NOS3 were selected for molecular docking. The results showed (see Table 2) that the binding energies of all combinations were less than −5.0 kcal/mol. Among them, the binding energies of quercetin with NOS3 and luteolin with TNF were as low as −9.5 kcal/mol and −9.3 kcal/mol, respectively, indicating that the ligands and receptors had good affinity.

Table 2. Molecular docking binding energies of core active components with key targets (unit: kcal/mol)

Active Component	TNF	IFNG	CXCL8	NOC3
Quercetin	-7.2	-6.8	-7.5	-9.5
Kaempferol	-6.9	-6.5	-7.1	-9.4
Luteolin	-9.3	-7.0	-7.6	-9.3

4. Discussion

The core pathological change of Meniere's disease is endolymphatic hydrops of the membranous labyrinth, and its pathogenesis is closely related to immune-inflammatory responses, inner ear microcirculatory disorders, abnormal vascular permeability, and autonomic nervous dysfunction [6]. Modified Bugan Yangrong Decoction targets the core pathogenesis of Meniere's disease, namely "insufficiency of liver blood and internal disturbance of deficient wind," and reflects the therapeutic idea in traditional Chinese medicine that "to treat wind, blood should be treated first; when blood circulates, wind will be extinguished by itself." This study, for the first time, systematically predicted the mechanism of action of this formula through network pharmacology technology and explained the rationality of its compatibility from the perspective of modern medicine.

Further explanation regarding the removal of Ligusticum chuanxiong from the formula is as follows. As a commonly used medicinal herb in traditional blood-tonifying formulas, such as Siwu Decoction, Ligusticum chuanxiong is pungent and warm in medicinal nature and has moving and dispersing properties. It is good at activating blood, promoting qi movement, dispelling wind, and relieving pain. However, when Bugan Yangrong Decoction is used to treat vertigo of the blood-deficiency and wind-stirring type, physicians often remove Ligusticum chuanxiong as appropriate. The specific reasons can be summarized into four points: first, from the perspective of traditional Chinese medicine theory, patients with blood deficiency are often accompanied by insufficiency of yin fluid, and pungent, warm, aromatic, and drying substances can easily consume yin fluid and induce deficient fire, namely "dryness should be avoided in blood deficiency," while Ligusticum chuanxiong precisely belongs to this type of medicinal herb; second, Sun Yikui clearly pointed out in the "Vertigo Section" of Chishui Xuanzhu that "those with liver blood deficiency should be nourished quietly and should not be treated with ascending and dispersing methods." Ligusticum chuanxiong is pungent, dispersing, moving, and upward-directing to the head and eyes, which is contrary to the therapeutic principle of "quiet nourishment"; third, from the perspective of modern pharmacology, although ligustrazine contained in Ligusticum chuanxiong has the effects of dilating blood vessels and inhibiting platelet aggregation, some patients may experience adverse reactions such as headache and facial flushing after taking it. For patients with Meniere's disease who already have abnormal vascular permeability in the inner ear, excessive vasodilation may aggravate endolymphatic hydrops of the membranous labyrinth; fourth, modern clinical practice has confirmed that Bugan Yangrong Decoction after the removal of Ligusticum chuanxiong has a higher vertigo

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control rate and a lower incidence of adverse reactions in the treatment of Meniere's disease. Therefore, the modified formula used in this study is more consistent with the pathogenesis characteristics of Meniere's disease and has higher clinical application value.

The core flavonoid components of this formula constitute the material basis for its therapeutic effects. Quercetin has anti-inflammatory, antioxidant, and microcirculation-improving effects, and can reduce the levels of inflammatory factors in the inner ear [7]. Kaempferol can protect vascular endothelial cells, reduce blood-labyrinth barrier leakage, and inhibit the activation of the NF-κB signaling pathway [8]. Luteolin can inhibit microglial activation and reduce the release of pro-inflammatory factors [9]. The synergistic action of the three can effectively relieve endolymphatic hydrops of the membranous labyrinth and improve the clinical symptoms of patients with Meniere's disease.

Key targets play core regulatory roles in the pathological process of Meniere's disease. TNF, as an important pro-inflammatory factor, is highly expressed in the inner ear tissues of patients with Meniere's disease and can activate the NF-κB signaling pathway, thereby aggravating inflammatory injury of the inner ear [10]. IFNG participates in the occurrence and development of autoimmune inner ear injury and further aggravates the inflammatory response of inner ear tissues. CXCL8 can chemotactically attract inflammatory cells to gather at the lesion site and aggravate inner ear edema. NOS3 can regulate the generation of nitric oxide, thereby affecting vascular tone and endolymphatic homeostasis [11]. Modified Bugan Yangrong Decoction can simultaneously regulate the above key targets and intervene in the pathogenesis of Meniere's disease through multiple links.

The pathway analysis results showed that this formula mainly exerts its therapeutic effects by regulating multiple signaling pathways. The AGE-RAGE pathway can connect inflammatory responses and oxidative stress and promote the release of inflammatory factors [12]. Relevant receptors in the calcium signaling pathway participate in the regulation of inner ear neural and vascular functions [13]. The NF-κB signaling pathway is the core regulatory pathway of inflammatory responses [14]. The IL-17 signaling pathway can damage the blood-labyrinth barrier and aggravate inner ear edema [15]. The PI3K-Akt and MAPK signaling pathways participate in the regulation of cell survival and angiogenesis. These pathways intersect with one another and are coordinately regulated, jointly affecting the occurrence and development of Meniere's disease and constituting the therapeutic mode of "multi-pathway synergy" of this formula.

Clinical significance of the molecular docking results: molecular docking verification showed that the binding energies of quercetin with NOS3 and luteolin with TNF reached −9.5 kcal/mol and −9.3 kcal/mol, respectively, far lower than the effective binding threshold of −5.0 kcal/mol, suggesting strong hydrogen-bonding and hydrophobic interactions between these core active components and key targets. From the perspective of molecular structure, multiple phenolic hydroxyl groups of quercetin can form stable hydrogen bonds with key amino acid residues in the catalytic domain of NOS3, such as GLU363 and ARG365. The hydroxyl groups on the B ring of luteolin can produce steric hindrance at the trimeric binding interface of TNF, thereby interfering with the binding between TNF and its receptor [16]. These computational-level pieces of evidence provide clear research directions for subsequent animal experiments and cellular experiments.

Limitations and prospects of the study: This study has certain limitations. First, the prediction results of network pharmacology depend on the completeness and accuracy of database information, and some water-soluble components, such as polysaccharides and glycosides, may have been omitted due to the limitations of the OB/DL screening criteria. Second, this study did not consider the interactions among chemical components during the decoction process of traditional Chinese medicine compound prescriptions or the in vivo metabolic transformation processes. Third, the

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targets and pathways predicted in this study still need to be further verified through animal experiments, such as guinea pig models of endolymphatic hydrops of the membranous labyrinth, and cellular experiments, such as experiments using endothelial cells of the stria vascularis of the inner ear. Fourth, molecular docking only considered the geometric matching degree and energy score of ligand-receptor binding, and molecular dynamics simulation analysis was not included. Future studies may combine transcriptomics, metabolomics, and experimental verification to further clarify the molecular mechanism of modified Bugan Yangrong Decoction in the treatment of Meniere's disease and provide more solid experimental support for its clinical application.

5. Conclusion

Based on network pharmacology and molecular docking technology, this study preliminarily revealed the "multi-component, multi-target, and multi-pathway" mechanism of modified Sun Yikui's Bugan Yangrong Decoction in the treatment of Meniere's disease. The core active components of this formula may be quercetin, kaempferol, and luteolin, and the key action targets include TNF, IFNG, CXCL8, and NOS3. It mainly exerts anti-inflammatory, immunoregulatory, inner ear microcirculation-improving, and endolymphatic hydrops-relieving effects by regulating signaling pathways such as AGE-RAGE, NF-κB, calcium signaling, and IL-17. This study provides a theoretical basis for the rational clinical application of modified Bugan Yangrong Decoction and its subsequent in-depth research.

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