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Progress on Novel Therapeutic Drugs for Chronic Heart Failure

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Abstract: This article comprehensively analyzes the existing treatment methods for chronic heart failure (CHF), and focuses on exploring the research progress in new therapeutic drugs in recent years. This article examines the limitations of traditional treatment methods and emphasizes the necessity of developing new drugs. This article mainly evaluated the innovation of SGLT2 (Sodium-dependent Glucose Transporters 2) inhibitors in terms of mechanism, efficacy, and safety, and explored the potential impact of SGLT2 on individualized treatment. In the experimental research stage, it is divided into three experiments: preclinical pharmacological effect evaluation, acute toxicity study, and preliminary therapeutic effect and safety study. In the preclinical pharmacological efficacy evaluation experiment, the average left ventricular ejection fraction (LVEF) of the treatment group was 55%, while the average of the control group was 50%. In acute toxicity research experiments, as the dosage increases, the mortality rate of rats also increases continuously. The mortality rate of the high-dose group reached 70%. In the preliminary clinical efficacy and safety study experiment, the ejection fraction of the treatment group increased from 45% to about 50%, and the quality of life score increased from 70 points to 75 points. The control group showed no significant changes in both indicators. Based on the above data, it can be concluded that SGLT2 inhibitors have potential efficacy and safety in animal models of chronic heart failure and preliminary human clinical trials, and further research is needed to validate these findings.

1. Introduction

Heart failure, as a widely existing heart disease, seriously threatens the health status of the global population. Although traditional treatment methods can alleviate symptoms to a certain extent, their effectiveness in improving the long-term prognosis of patients is limited. In recent years, SGLT2 inhibitors have attracted much attention from the medical community as a new type of therapeutic drug. The initial design was used to treat type 2 diabetes. The latest research indicates that it also demonstrates potential therapeutic effects in patients with heart failure. Considering the high incidence of heart failure and its significant burden on society and healthcare systems, studying the application of SGLT2 inhibitors in the treatment of heart failure has important clinical and social value.

This article mainly studies the application of target drugs in the treatment of chronic heart failure.

Through three stages of experimental design, including preclinical pharmacological effect evaluation, acute toxicity study, and preliminary clinical efficacy and safety study, the overall efficacy and safety of SGLT2 inhibitors were evaluated. Experimental research provides experimental support for studying the application of drugs in the field of patient treatment, and also provides valuable data and insights for future clinical practice and in-depth research.

In this article, the background of heart failure and the development process of SGLT2 inhibitors are first introduced, and the experimental design and methods are described in detail, including animal model studies and preliminary human clinical studies. In the experimental stage, the article presented the experimental results, with data analysis presented in a graphical form. At the end of the article, the experimental results were discussed, and future research directions were proposed accordingly. This article mainly provides readers with a clear and comprehensive research perspective through this structural arrangement.

2. Related Works

In recent years, multiple studies have focused on novel treatment methods for heart failure. For example, Xia Yi conducted a study exploring the clinical efficacy of Shexiang Baoxin Pill combined with recombinant human brain natriuretic peptide in the treatment of ischemic heart failure. The research results indicate that the combination of Shexiang Baoxin Pill and recombinant human brain natriuretic peptide has achieved significant effects in improving clinical efficacy and heart function in patients with ischemic research disease [1]. Gu Chunling conducted a study on the application effect of rehabilitation intervention programs in patients with heart failure. Patients were divided into a control group and an observation group using random number method. The research results indicate that implementing rehabilitation intervention programs can effectively improve the cardiac function indicators of heart failure patients, enhance their self-management ability, and thus improve their quality of life. This study provides useful empirical support for the rehabilitation treatment of heart failure patients [2]. Yuan Yili conducted research on the etiology, pathogenesis, and treatment of heart failure. In recent years, Western medicine has developed rapidly in China, and people have gained a deeper understanding of basic medicine and evidence-based medicine, which has promoted the treatment of heart failure. In recent years, the understanding of heart failure syndrome has been further improved. At the same time, with the transformation of medical models and the development of humanities, philosophy, psychology, and general medicine, the diagnosis, treatment, and prevention concepts of heart failure have also undergone significant changes [3]. Xu Xiangmin studied the effectiveness of treating elderly patients with severe heart failure in cardiology. In the experiment, a control group with conventional treatment methods and a study group with increased treatment with metoprolol combined with irbesartan and hydrochlorothiazide were evenly divided. The research group was found to be significantly better than conventional treatment in cardiology, so the use of metoprolol and irbesartan hydrochlorothiazide is more effective in the treatment of elderly patients with severe heart failure. The above study provides useful reference for clinical treatment [4]. The research of the above scholars can prove that the treatment of heart failure requires symptom management and also needs to start from its pathological mechanism. However, current research is often limited to small-scale clinical trials, lacking extensive clinical applications and in-depth mechanism research.

On the basis of traditional treatment methods, some studies have attempted new methods such as stem cell therapy and gene editing technology, aiming to directly solve the problems of heart tissue damage and functional decline. For example, Yuan Huajing believed that cells have become a new hot topic in current medicine due to their potential for self-proliferation and multi-directional differentiation, and are also a popular treatment direction for myocardial injury in coronary heart

disease. Traditional Chinese medicine theory believes that there is a correlation and consistency between "essence" and stem cells. The kidney stores essence, governs bone and generates marrow. The treatment of heart disease based on kidney theory and the exploration of bone marrow mesenchymal stem cell therapy for heart failure from the perspective of heart kidney intersection theory provide new ideas for the treatment of heart failure in traditional Chinese and Western medicine [5]. These methods have shown positive effects to a certain extent, but also exposed issues such as high costs and unknown long-term effects. Therefore, this article can focus on exploring SGLT2 inhibitor drug therapy in order to find more effective and cost-effective treatment options.

3. Methods

3.1 Chronic Heart Failure

Chronic heart failure is a slowly developing heart disease characterized by the heart gradually losing its effective pumping function. This disease may be caused by various factors, including hypertension, coronary artery disease, myocarditis, or heart valve problems. In the case of chronic heart failure, the function of the heart can gradually deteriorate, mainly because the contraction and relaxation ability of the heart is weakened, resulting in the inability of blood to be effectively pumped out. In such cases, patients often feel particularly tired, have difficulty breathing, or have swelling in their bodies. These symptoms have a significant impact on the daily life of patients [6-7].

The treatment for patients with chronic heart failure is not only as simple as taking medication, but also includes changing lifestyle and regularly going to the hospital for examination. In terms of drug therapy, diuretics, ACE inhibitors may be used β receptor blockers are drugs that help reduce the workload of the heart, maintain water balance in the body, and improve the quality of life for patients. In addition, lifestyle changes such as adjusting diet, eating less salt, exercising appropriately, and quitting smoking are also crucial. Patients also need to pay attention to their physical changes, and whenever there are any new symptoms, they must inform the doctor so that the doctor can adjust the treatment plan according to the situation. Overall, these comprehensive management measures can help patients improve their quality of life and keep their condition stable [8-9].

3.2 SGLT2 Inhibitors

The SGLT receptor, also known as the sodium glucose co transporter protein, is crucial for the absorption of glucose in the human body. SGLT-1 and SGLT-2 are the two main types of receptors in this category. SGLT-1 is mainly distributed in the S3 segment of the proximal tubules in the small intestine, heart, and kidneys, where it helps glucose to be absorbed. SGLT-2, on the other hand, is mainly located in the S1 segment of the renal proximal tubules, where it plays a crucial role in the reabsorption of glucose by the renal tubules. This means that these two receptors play an important role in maintaining blood sugar levels and overall metabolic health. After entering epithelial cells, it is reabsorbed into the bloodstream through SGLT1 and SGLT2 receptors, which play important roles in renal tubular epithelial cells. SGLT1 serves as a carrier to reverse the concentration gradient of glucose into the intestinal mucosa in the small intestine, ensuring the absorption and utilization of carbohydrates. SGLT inhibitors achieve hypoglycemic effects by inhibiting these two pathways [10-11].

Under normal conditions, the glomerulus filters approximately 180g of glucose per day, of which 90% is reabsorbed by SGLT2 located in the proximal tubules S1 and S2, and the remaining is reabsorbed by SGLT1. Studies have proved that the solubility of SGLT2 in renal tubular epithelial

cells of diabetes patients gradually increases, leading to glucose reabsorption into the blood, further increasing blood sugar, increasing the ability to reabsorb glucose, and increasing the threshold of renal glucose. SGLT2 inhibitors can not only inhibit SGLT2 receptors, but also to some extent limit the action of SGLT1, thereby reducing the reabsorption of glucose in the kidneys and improving the excretion of glucose in the urine. They can also reduce glucose absorption by inhibiting intestinal SGLTl, independent of insulin, to lower glucose levels [12-13].

3.3 Pharmacological Evaluation

A table was designed in the "Pharmacological Evaluation" section of this section to record and analyze the pharmacological effects of SGLT2 inhibitors in animal models [14]. There are five main columns in the table that record the number of each animal and four key physiological parameters, including heart rate, systolic blood pressure, diastolic blood pressure, and creatinine levels. The animal number is an identification column used to identify each animal participating in the experiment. A total of 10 animals participated in the experiment. The physiological characteristics of heart rate record the heart rate of each animal. It is mainly an important indicator for evaluating cardiac function and the impact of drugs on the heart. The heart rate range is set at 60 to 120 beats per minute. The formula for calculating heart rate is shown in (1):

$$\mathrm{HR} = \frac{Number}{time} \times 60 \tag{1}$$

In formula (1), Number represents the number of heartbeats, and time is measured in minutes. The formula multiplied by 60 is used to obtain the number of heart beats per minute. Systolic blood pressure (mmHg) represents the systolic blood pressure of each animal. Systolic blood pressure is a key indicator for measuring blood pressure and circulatory health. The formula for calculating systolic blood pressure is shown in (2):

$$\mathrm{SSY} = N \times 2 + 80\mathrm{mm}hg(N \times 0.27 + 10.67kpa) \tag{2}$$

In formula (2), in the calculation formula for systolic blood pressure SSY, N represents age. The range of systolic blood pressure is set between 100 and 140 mmHg. Diastolic blood pressure (mmHg) indicates that this column records diastolic blood pressure, which, together with systolic blood pressure, reflects the blood pressure status of the animal. The specific calculation formula is shown in formula (3):

$$\mathrm{SZY} = N \times 2 + 1.15 \times W + 0.37 \times M - 7.03 \tag{3}$$

In formula (3), for the calculation of diastolic blood pressure SZY, N represents age, W represents weight, and M represents gender. The range of diastolic blood pressure is 60 to 90 mmHg. Creatine level (mg/dL) is an important biochemical indicator for evaluating renal function. The range of creatinine levels is 0.5 to 2.0 mg/dL. The pharmacological action evaluation form is used to collect and analyze basic data on the physiological effects of drugs. By comparing the changes before and after treatment, the pharmacological effects, potential therapeutic effects, and safety of SGLT2 inhibitors can be preliminarily evaluated. The specific pharmacological evaluation table is shown in Table 1:

The detailed table of pharmacological effects in Table 1 plays a key role in the study of pharmacological effect evaluation. The purpose of designing Table 1 is to provide a clear and orderly data recording framework for drug research, such as the physiological effects of SGLT2 inhibitors on different experimental animals. The above table provides detailed records of key physiological indicators such as heart rate, blood pressure, and creatinine levels, which are

particularly important for evaluating the effects of drugs on heart function and kidney health. If structured data can be presented, researchers can more intuitively analyze and understand the pharmacological effects of SGLT2 inhibitors, and provide a solid foundation for subsequent data comparison and statistical analysis. Table 1 is a key component of the experimental data collection and analysis process, which plays an important role in gaining a deeper understanding of the efficacy and safety of drugs.

Table 1: Details of pharmacological effects

Animal Number	Heart Rate	Systolic Pressure	Diastolic Pressure	Creatinine Level
1	92	109	65	1.5668
2	81	134	88	0.8326
3	117	107	90	0.6761
4	113	109	73	0.9450
5	93	106	63	0.9782
6	97	109	68	1.1363
7	95	117	72	1.2618
8	72	112	78	0.6283
9	78	137	68	0.8937
10	88	117	78	1.7015

4. Results and Discussion

4.1 Preclinical Pharmacological Evaluation

In the preclinical pharmacological effect evaluation experiment, two sets of rat models were used to explore the therapeutic effect of the target study drug in the treatment of heart failure. 10 rats were assigned to a control group and a treatment group, with 5 rats in each group. In the treatment group, rats received SGLT2 inhibitors, while in the control group, the rat model was injected with an equal amount of physiological saline. After one experimental cycle, the left ventricular ejection fraction (LVEF) of two groups of rats was recorded using echocardiography, and this value was used as a key indicator to evaluate cardiac pumping function. The specific results are shown in Figure 1.

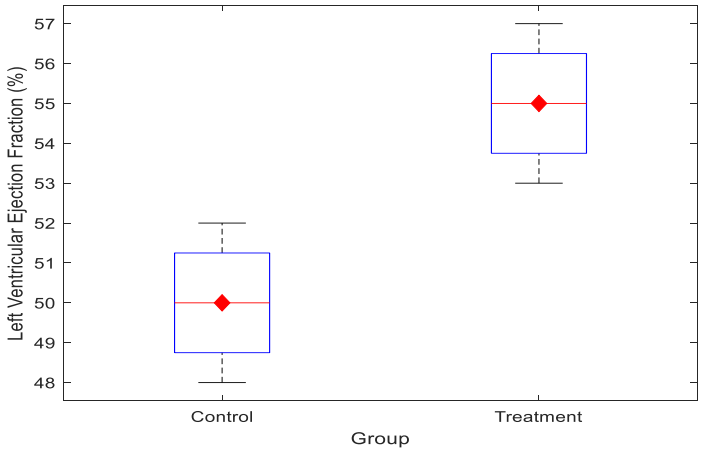

Figure 1: Preclinical pharmacological evaluation

In preclinical pharmacological efficacy evaluation studies, a rat model with target soldiers was treated to compare the effects of drugs and placebo on cardiac function. As shown in Figure 1, the average left ventricular ejection fraction (LVEF) of the treatment group rats was 55%, while the average left ventricular ejection fraction (LVEF) of the control group was 50%. The above data conclusion indicates that SGLT2 inhibitors can significantly improve the cardiac pumping efficiency of heart failure animal models. The experimental conclusion provides an experimental basis for the application of SGLT2 inhibitors in the research content of this article.

4.2 Acute Toxicity

The main purpose of this acute toxicity study experiment is to evaluate the acute toxicity level of SGLT2 inhibitors. Healthy rats were selected as experimental animals and divided into a control group and four groups treated with three different doses of SGLT2 inhibitors. Within 24 hours after administration, the general reactions and vital signs of the rats were observed and recorded. And by calculating the mortality rate of each group, the data can be plotted into a chart, as shown in Figure 2.

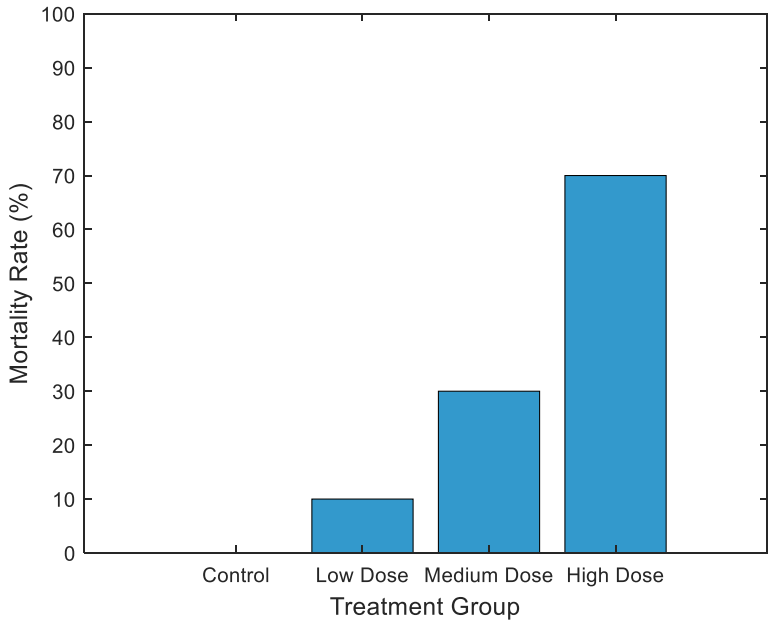

Figure 2: Acute toxicity study

In the acute toxicity study experiment, four groups of rats were treated with SGLT2 inhibitors at different doses, including a control group and three different doses. From Figure 2, it can be seen that the mortality rate of the control group is 0%, indicating no relevant toxicity. In the treatment group, the mortality rate was 10% in the low-dose group, 30% in the medium dose group, and 70% in the high-dose group. The above data conclusion suggests that as the dosage of SGLT2 inhibitors increases, the mortality rate of rats also increases, indicating a positive correlation between the acute toxicity of the drug and dosage. The above experimental data conclusion provides preliminary data for the safe dose range of SGLT2 inhibitors, and further research may be needed to determine their safety for humans.

4.3 Preliminary Clinical Efficacy and Safety Studies

In the preliminary clinical efficacy and safety study experiment, the aim was to explore the

efficacy and safety of SGLT2 inhibitors in patients with chronic heart failure. The experimental records were randomly divided into two groups, a treatment group and a control group, with 100 patients in each group of 50 people. Patients in the treatment group received SGLT2 inhibitors, while patients in the control group received placebo. After one experimental cycle, it can record the patient's cardiac ejection fraction and quality of life score, and then use this score to evaluate cardiac function and overall improvement, and closely observe and record any adverse reactions to evaluate drug safety. The purpose of the above experimental study is to explore the potential and safety of SGLT2 inhibitors in practical clinical environments. The specific data distribution is shown in Figure 3.

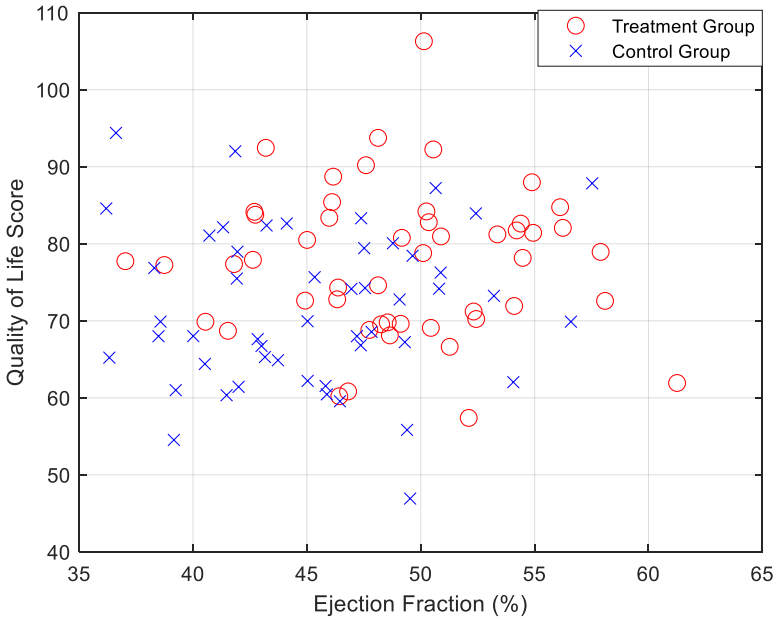

Figure 3: Preliminary clinical efficacy and safety study

In the preliminary clinical efficacy and safety study experiment, a total of 100 patients with chronic heart failure were randomly divided into a treatment group and a control group, with 50 patients in each group. As shown in Figure 3, that the average cardiac ejection fraction of the treatment group patients increased from about 45% at baseline to around 50%, while the average cardiac ejection fraction of the control group remained around 45%. The average quality of life score of the treatment group increased from 70 points at baseline to 75 points, while the data of the control group decreased. The above data conclusion suggests that it improves cardiac function on the surface and also enhances the quality of life of patients. No serious adverse reactions were observed in the treatment group, indicating that SGLT2 inhibitors have good safety.

5. Conclusions

In this paper, a comprehensive evaluation of the effectiveness of SGLT2 inhibitors in the treatment of chronic heart failure was conducted. The article provides a detailed evaluation of the pharmacological effects and acute toxicity of SGLT2 inhibitors through three stages of experiments, and also explores their clinical efficacy and safety. The research results of this article show that SGLT2 inhibitors have potential positive effects in improving heart function and improving quality of life. In terms of dosage and safety, SGLT2 inhibitors also showed good response. The above research in this article also has some limitations, such as insufficient sample size and diversity, which may affect the broad applicability of conclusions. Of course, there is still insufficient

in-depth exploration of the mechanism of drug action, including further research on long-term efficacy and safety evaluation. In the future, plans can be made to expand the sample size, such as targeting more diverse populations or increasing the number of experiments, in order to improve the reliability of research results. It can be believed that the above efforts can contribute to providing more effective drug selection and deeper understanding for the treatment of heart failure.

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