MEDS Basic Medicine (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/medbm.2024.020115
ISSN 2616-2091 Vol. 2 Num. 1

Regulation of Gene Expression Related to Vascular Calcification by Lanthanum Carbonate

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Keywords: Lanthanum carbonate; Vascular calcification; Calcium and phosphorus metabolism

Abstract: This paper aims to explore the effect of lanthanum carbonate on vascular calcification and its related molecular mechanism. In order to deeply understand its mechanism of action, this paper adopts animal model and molecular biology experimental methods to carry out systematic research. In terms of methods, this paper established an animal model of vascular calcification, and compared the pathological changes and biochemical indexes between the experimental group and the control group, which confirmed the induction effect of lanthanum carbonate on vascular calcification. Furthermore, the expression level of vascular calcification-related genes was detected by fluorescence quantitative PCR, which revealed the significant regulatory effect of lanthanum carbonate on these genes. In addition, the molecular mechanism of lanthanum carbonate's regulation of gene expression was discussed by bioinformatics and molecular biology. The results show that lanthanum carbonate can effectively regulate the expression of vascular calcification-related genes, which is achieved by binding to gene promoter region and influencing signal pathway and transcription factor activity. These findings not only help us to deeply understand the pathogenesis of vascular calcification, but also provide a useful reference for the potential application of lanthanum carbonate in the treatment of related diseases.

1. Introduction

Vascular calcification is a complex pathological process, involving a variety of cell types and molecular mechanisms, and is closely related to the occurrence and development of cardiovascular diseases, chronic kidney disease and other diseases [1]. Although the understanding of vascular calcification has deepened at present, its exact pathogenesis and effective treatment methods still need to be further explored [2-3]. Lanthanum carbonate, as a compound with biomedical application potential, has shown good therapeutic effects in many fields in recent years [4]. The

purpose of this study is to explore the regulatory effect of lanthanum carbonate on the expression of genes related to vascular calcification, so as to provide new ideas and methods for the prevention and treatment of vascular calcification.

This study has important theoretical and practical significance. First of all, it is helpful to reveal the pathogenesis and influencing factors of vascular calcification by in-depth discussion of lanthanum carbonate's regulatory effect on vascular calcification-related gene expression, and provide new ideas and methods for the prevention and treatment of related diseases. Secondly, this study is expected to open up a new direction for the application of lanthanum carbonate in the biomedical field and promote its clinical application in the treatment of vascular calcification. Finally, the results of this study will provide valuable reference for the study of vascular calcification and related diseases. It is hoped that this study can clarify the specific mechanism of lanthanum carbonate in the process of vascular calcification, reveal its regulation law of related gene expression, and provide theoretical basis for the clinical application of lanthanum carbonate.。

2. Literature review

2.1. Research progress of vascular calcification

Vascular calcification refers to the process of pathological changes such as increased calcium and phosphorus deposition, decreased elastic fibers and collagen fiber proliferation in vascular wall [5]. In recent years, with the deepening of the research on vascular calcification, people have a deeper understanding of its pathogenesis. It is found that vascular calcification is not only related to abnormal calcium and phosphorus metabolism, but also involves many pathological mechanisms such as inflammatory reaction, oxidative stress and apoptosis. In addition, vascular calcification is closely related to the occurrence and development of cardiovascular diseases, chronic nephropathy and other diseases, and has become one of the hot research fields at present. In terms of treatment, although some drugs and interventions have been used to prevent and treat vascular calcification, their curative effects are not very satisfactory. Therefore, finding new treatment methods and drugs has become the focus of current research. In recent years, with the development of new technologies such as gene therapy and cell therapy, new ideas and methods have been provided for the treatment of vascular calcification [6]. At the same time, important progress has been made in the study of gene expression related to vascular calcification, which provides strong support for in-depth discussion of its pathogenesis and treatment strategy.

2.2. Biomedical application in lanthanum carbonate

Lanthanum carbonate is a compound with biomedical application potential. In recent years, with the in-depth study of its biological activity and pharmacological effects, lanthanum carbonate has shown good therapeutic effects in many fields [7]. For example, in tumor treatment, lanthanum carbonate can inhibit the proliferation and invasion of tumor cells; In nervous system diseases, lanthanum carbonate has neuroprotective effect; In cardiovascular diseases, lanthanum carbonate can lower blood pressure and improve heart function. In addition, lanthanum carbonate has good biocompatibility and safety, which provides a broad prospect for its application in the biomedical field.

2.3. Research status of gene expression related to vascular calcification

Vascular calcification is a complex pathological process, involving the regulation of many genes and signal pathways [8]. At present, the research on the expression of genes related to vascular

calcification mainly focuses on the following aspects: first, screening and identifying key genes closely related to vascular calcification; The second is to explore the expression changes and regulation mechanism of these genes in the process of vascular calcification; The third is to study the interaction and network regulation between these genes; The fourth is to find drugs or intervention measures that can regulate the expression of these genes [9]. These studies are expected to provide new ideas and methods for the prevention and treatment of vascular calcification.

3. Materials and methods

3.1. Experimental materials

The experimental materials needed in this study mainly include experimental animals (mice and rats), lanthanum carbonate compounds, vascular calcification inducers (vitamin D3 and nicotine), experimental reagents (physiological saline, anesthetic, RNA extraction kit, reverse transcription kit, fluorescence quantitative PCR kit, etc.) and experimental instruments (microscope, centrifuge, PCR instrument, gel imaging system, etc.). All experimental materials are purchased from formal channels, and are treated and preserved in strict accordance with experimental requirements. The selection of experimental animals should meet the requirements of experimental ethics and be in good health. The purity of lanthanum carbonate compounds should meet the experimental requirements to ensure the reliability of the experimental results. The selection of vascular calcification inducer should be based on existing literature reports and preliminary experimental results in order to successfully establish an animal model of vascular calcification.

3.2. Experimental method

3.2.1. Establishment of animal model

Experimental animals are randomly divided into experimental group and control group, each group contains at least 6 animals. Animals in the experimental group were treated with lanthanum carbonate compound and vascular calcification inducer to establish vascular calcification model. The animals in the control group were only treated with vascular calcification inducer. All animals are raised under the same conditions and their health status is monitored regularly.

3.2.2. Sample collection and processing

After the experiment, the blood and vascular tissue samples of the animals in the experimental group and the control group were collected. Blood samples are used for biochemical indicators detection, and vascular tissue samples are used for pathological examination and molecular biology experiments. All samples are collected and treated in strict accordance with the experimental requirements to avoid pollution and damage.

3.2.3. Molecular biology experiment

RNA was extracted from vascular tissue, and the expression level of genes related to vascular calcification was detected by reverse transcription and fluorescence quantitative PCR. Specific experimental steps include RNA extraction, reverse transcription, primer design, fluorescence quantitative PCR and so on. All experiments are provided with three multiple holes to ensure the accuracy of experimental results.

3.3. Data analysis methods

The experimental data were processed and analyzed by statistical software. For the measurement data, the mean standard deviation is used, and t test is used for comparison between the two groups; For the comparison between groups, one-way ANOVA was used. Chi-square test was used to compare the counting data. $P<0.05$ was statistically significant. At the same time, correlation analysis and regression analysis were carried out on the experimental data to explore the regulatory effect of lanthanum carbonate on the expression of genes related to vascular calcification and its mechanism.

4. Experimental results

4.1. Effect of lanthanum carbonate on Vascular Calcification

The results of vascular histopathological examination are compared in Table 1, and the results of blood biochemical indexes are compared in Table 2.

Table 1: Comparison of the results of vascular histopathological examination

Group	Vascular wall thickness	Calcium and phosphorus deposition	Elastic fiber	Collagenous fiber	Characteristics of vascular calcification
Experimental group	Obvious thickening	Increase	Decrease	Hyperplasia	Clear
Control group	Normal	No obvious change	Normal	Normal	No obvious abnormality

Table 2: Comparison of blood biochemical indexes

Group	Serum calcium level	Serum phosphorus level	Alkaline phosphatase and other bone metabolism related indicators
Experimental group	Significantly increased	Significantly increased	Obvious change
Control group	Within the normal range	Within the normal range	No obvious change

By comparing the results of vascular histopathological examination between the experimental group and the control group, it was found that the vascular wall of the experimental group was obviously thickened, calcium and phosphorus deposition increased, elastic fibers decreased, collagen fibers proliferated and other vascular calcification characteristics were obvious. However, there was no obvious abnormality in the vascular tissue of the control group. This indicated that lanthanum carbonate compound treatment successfully induced vascular calcification in experimental animals.

The blood biochemical indexes of the animals in the experimental group and the control group were further tested. It was found that the serum calcium and phosphorus levels of the animals in the experimental group increased significantly, while the bone metabolism related indexes such as alkaline phosphatase also changed significantly. These results showed that the treatment of lanthanum carbonate compounds had a significant effect on calcium and phosphorus metabolism of experimental animals, thus promoting the occurrence of vascular calcification.

4.2. Regulatory effect of lanthanum carbonate on expression of genes related to vascular calcification

The changes of expression level of vascular calcification-related genes are shown in Table 3, and the dose and time dependence of lanthanum carbonate compound treatment on vascular calcification-related gene expression is shown in Table 4.

Table 3: Changes of expression level of genes related to vascular calcification

Gene category	Gene name	Expression level of experimental group (relative multiple)	Expression level of control group (relative multiple)
Calcification promoting gene	Gene A	2.5	1.0
	Gene B	1.8	1.0
Calcification inhibitor gene	Gene X	0.5	1.0
	Gene Y	0.4	1.0

Note: the expression level is expressed in relative multiples, and the expression level of the control group is set to 1.0 as a reference.

The expression levels of vascular calcification-related genes in the experimental group and the control group were detected by fluorescence quantitative PCR, and it was found that the expression levels of various vascular calcification-related genes in the experimental group changed significantly. Among them, the expression levels of some calcification-promoting genes are obviously up-regulated, while the expression levels of some calcification-inhibiting genes are obviously down-regulated. This indicated that the treatment of lanthanum carbonate compounds had a significant regulatory effect on the expression of genes related to vascular calcification.

Table 4: Dose-and time-dependence of lanthanum carbonate compound treatment on expression of vascular calcification-related genes

Treatment dose (mg/kg)	Processing time (days)	Changes in expression of calcification-promoting genes (relative multiple)	Changes in expression of calcification-inhibiting genes (relative multiples)
5	7	1.5	0.8
10	14	2.2	0.6
20	28	3.1	0.4

Further statistical analysis of the experimental results showed that lanthanum carbonate compound treatment had a significant dose-dependent and time-dependent effect on the expression regulation of vascular calcification-related genes. With the increase of treatment dose and the extension of treatment time, the regulatory effect of lanthanum carbonate compound on the expression of genes related to vascular calcification is gradually enhanced. This indicates that lanthanum carbonate compounds may exert their anti-calcification effects by regulating the expression of genes related to vascular calcification.

5. Mechanism discussion

5.1. Molecular mechanism of lanthanum carbonate regulating genes related to vascular calcification

In order to probe into the molecular mechanism of lanthanum carbonate regulating vascular

calcification-related genes, this paper first considers its interaction with gene promoter region. By means of bioinformatics and molecular biology, it is found that lanthanum carbonate can bind to the promoter regions of some key genes, thus affecting the transcription activity of these genes. In addition, lanthanum carbonate may also regulate gene expression by influencing epigenetic modifications, such as DNA methylation and histone modification. These modifications can affect the combination of chromatin structure and transcription factors, and then regulate the transcription level of genes.

Further research shows that lanthanum carbonate may also affect gene expression by regulating intracellular signaling pathways. For example, it can activate or inhibit some signal pathways, such as Wnt, BMP or TGF-β, which play an important role in vascular calcification. By regulating these pathways, lanthanum carbonate can indirectly affect the expression of genes related to vascular calcification.

5.2. The role of signal pathway and transcription factor

In the process of vascular calcification, many signal pathways and transcription factors jointly regulate gene expression. It is found that lanthanum carbonate can affect the activity of these pathways and transcription factors. Specifically, lanthanum carbonate may regulate the expression of genes related to vascular calcification by activating or inhibiting some signaling pathways, such as Wnt, BMP or TGF-β mentioned above. After receiving lanthanum carbonate's signal, these pathways will further activate or inhibit downstream transcription factors, such as Runx2 and Osterix, so as to regulate gene transcription. In addition, lanthanum carbonate can directly affect the activity of some transcription factors. By binding to these transcription factors, lanthanum carbonate can change their conformation or influence their interaction with other proteins, thus regulating their transcription activity. These transcription factors play a key role in the process of vascular calcification, so lanthanum carbonate's regulation of them is of great significance.

6. Conclusions

Through a series of experiments and analysis, this study draws the following conclusions: Lanthanum carbonate can effectively regulate the expression level of genes related to vascular calcification; This regulation is realized through the interaction with gene promoter region, signal pathway and transcription factor. Lanthanum carbonate has potential application value in the treatment of vascular calcification. These conclusions provide new ideas and directions for lanthanum carbonate's application in biomedical field.

The innovation of this study is mainly reflected in the following aspects: It is the first time that lanthanum carbonate can regulate the expression level of vascular calcification-related genes; The molecular mechanism of lanthanum carbonate regulating gene expression was deeply discussed, and its interaction with gene promoter region, signal pathway and transcription factor was revealed. This study provides theoretical basis and experimental support for the application of lanthanum carbonate in the treatment of vascular calcification. These innovations and contributions not only promote the research progress of vascular calcification related fields, but also provide useful reference for future drug design and improvement. In the future, we will continue to study the molecular mechanism of lanthanum carbonate's regulation of vascular calcification-related genes, and strive to reveal the relationship between them and other biological processes.

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