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A Study of the Cell Biological Mechanisms of Hormonal Osteonecrosis of the Femoral Head

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Abstract: Hormonal necrosis of the femoral head is a common degenerative bone disease whose pathogenesis involves multiple factors in which hormones play an important role. Past studies have shown that hormones can affect the metabolism and function of osteoblasts, but their specific cell biological mechanisms are not yet fully understood. However, there are still many issues that need to be further investigated in order to deeply explore the pathophysiological mechanisms of hormonal osteonecrosis of the femoral head and provide a more reliable scientific basis for clinical practice.

Keywords: Hormonal osteonecrosis of the femoral head; Cell biology; Mechanism study

Introduction

Hormonal osteonecrosis of the femoral head is a bone disease caused by long-term or heavy use of hormonal drugs. Focusing on the cell biological mechanism of hormonal osteonecrosis of the femoral head, especially how hormones affect the function of bone cells through cell signalling pathways. The aim of this study is to investigate the cell biological mechanism of hormones in femoral head necrosis. Through cellular experiments and animal model studies, the effects of hormones on apoptosis and neovascularisation in the femoral head were found, which provide a basis for the pathogenesis of hormonal femoral head necrosis. [1]

1. Theories related to hormonal femoral head necrosis

1.1 Definition of hormonal osteonecrosis of the femoral head

Hormonal necrosis of the femoral head, also known as non-traumatic necrosis of the femoral head, is a common bone disease caused by long-term steroid hormone treatment. The disease mainly affects the tip of the femoral head, manifesting as ischaemia, hypoxia and necrosis of bone tissue triggered by insufficient blood supply. Patients often experience hip pain, stiffness and dysfunction, which can lead to hip arthritis and disability in severe cases. Prolonged use of hormones (especially glucocorticoids) can lead to apoptosis of bone cells and reduce the vitality of bone tissue. Hormones also damage the endothelial cells of blood vessels, affecting their normal function. Hormones may trigger or exacerbate the inflammatory response, further damaging bone tissue Hormones may impede blood vessel neogenesis, reducing the blood supply to the femoral head and leading to ischaemic necrosis. Although the exact pathogenesis is not yet fully understood, the combination of the above factors is an important cause of hormonal osteonecrosis of the femoral head. Hormonal osteonecrosis of the femoral head usually requires early diagnosis and interventional therapy, including reduction of hormone use, improvement of blood supply to bone tissue, protection of the femoral head and improvement of joint function. Therefore, an in-depth understanding of the pathogenesis of hormonal osteonecrosis of the femoral head is of great significance for clinical diagnosis and treatment. [2]

1.2 Epidemiology of hormonal osteonecrosis of the femoral head

Hormonal necrosis of the femoral head is a common bone disease, especially in patients with long-term steroid hormone use. Epidemiological investigations have shown that the incidence of hormonal osteonecrosis of the femoral head increases with the increase in hormone use. The age of onset of hormonal osteonecrosis of the femoral head is concentrated between 30 and 50 years of age, but there are also reports of its onset in children and the elderly. There is little difference in the incidence of hormonal femoral head necrosis between men and women, but there may be differences in the incidence in different populations. For example, patients with chronic kidney disease, diabetes mellitus, and rheumatoid arthritis have a higher risk of developing hormonal osteonecrosis of the femoral head with long-term hormone use. Studies have shown that the prevalence of hormonal femoral head necrosis is higher in Asian populations and relatively lower in African populations Geographically, the prevalence of the disease is usually higher in urban populations than in rural areas, which may be related to urban lifestyles, dietary structure, and environmental factors. Epidemiological studies provide important references for understanding the risk factors of

this disease and developing preventive measures and treatment strategies. [3]

2. Effects of hormones on femoral head cells

2.1 Effects of glucocorticoids on bone cells

Glucocorticoids are a class of commonly used anti-inflammatory drugs, but long-term use may have a negative effect on bone cells. Glucocorticoids have an important place in medical therapy, but long-term use can have multiple effects on bone cell function. These effects include inhibition of bone formation, specifically inhibition of osteoblast differentiation and function, and decreased bone matrix synthesis, leading to decreased bone density and osteoporosis. At the same time, glucocorticoids also promote bone resorption, increase apoptosis of osteoblasts and inhibit the formation of trabeculae, further destroying bone tissue and reducing bone mass. More seriously, glucocorticoids induce apoptosis of bone cells, accelerating bone loss and destruction by regulating the expression of apoptosis-related proteins. Together, these effects may lead to hormonal bone diseases, such as osteoporosis, hormonal fracture, and even hormonal necrosis of the femoral head, when glucocorticoids are used for a long period of time. For patients who require long-term glucocorticoid use, it is critical to prevent and treat hormonal bone disease. This includes increasing calcium and vitamin D intake, maintaining appropriate physical activity, regular monitoring of bone density, and considering the use of bone density-increasing medications when necessary to minimise the adverse effects of glucocorticoids on bone health.

2.2 Effects of glucocorticoids on vascular endothelial cells

The effect of glucocorticoids on vascular endothelial cells is a complex and diverse process. Glucocorticoids affect the function and metabolism of vascular endothelial cells by binding to intracellular glucocorticoid receptors. Glucocorticoids can affect the permeability of vascular endothelial cells. In states of inflammation or injury, the function of vascular endothelial cells is altered. Glucocorticoids reduce vascular permeability by regulating the expression of endothelial cell gap junction proteins, which helps to reduce vascular leakage and oedema in the inflammatory response. It inhibits the expression of inflammatory mediators and cell adhesion molecules, reduces leukocyte adhesion and inflammatory cell infiltration, and effectively reduces the inflammatory response. Glucocorticoids affect the oxidative stress response of vascular endothelial cells and regulate nitric oxide synthesis and release, which further affects the vasodilatory function. However, the potential risks of long-term use of high-dose glucocorticoids should not be overlooked, including increased risk of thrombosis and impact on vasodilatory function, which need to be noted and monitored at the time of use. Therefore, the use of glucocorticoids needs to be weighed against their effects on the vascular endothelium, and vascular function and related biochemical indices should be closely monitored to minimise their potential adverse effects, especially when used at high doses for prolonged periods of time.

2.3 Effects of other hormones on femoral head cells

In addition to glucocorticoids, other hormones also have significant effects on femoral head cells, mainly including oestrogen, parathyroid hormone and vitamin D. Oestrogen plays a key role in bone metabolism. It promotes bone formation, inhibits bone resorption, and helps maintain bone mass and density. After menopause, estrogen levels decline in women and bone metabolism becomes imbalanced, increasing the risk of osteoporosis and fractures. Parathyroid hormone regulates the important hormone of calcium and phosphorus metabolism. It promotes the formation and activation of osteoblasts and increases bone formation. At the same time, parathyroid hormone also promotes bone resorption; therefore, its abnormal levels may increase the risk of osteoporosis. In clinical practice, parathyroid hormone analogues are used to treat bone metabolic disorders such as osteoporosis. Vitamin D is essential for maintaining the balance of calcium and phosphorus metabolism. It promotes intestinal absorption of calcium and phosphorus, and is also involved in regulating the function of osteoblasts to promote bone formation. Vitamin D deficiency is closely associated with bone diseases such as osteoporosis. Thus, oestrogen, parathyroid hormone (PTH) and vitamin D play an important role in maintaining the health of femoral head cells. Abnormal levels of these hormones may lead to imbalances in bone metabolism, which in turn may lead to skeletal diseases such as osteoporosis. At the same time, in clinical practice, the effects of various hormones need to be considered together in order to maintain bone health. Therefore, monitoring and regulating the levels of these hormones are important for the prevention and treatment of related skeletal diseases. [4]

3. Studies on cell biological mechanisms

3.1 Relationship between inflammatory response and femoral head necrosis

Inflammatory response plays an important role in the occurrence and development of femoral head necrosis. Necrosis of the femoral head is a disease of bone tissue necrosis caused by insufficient blood supply to the bone marrow, and the inflammatory response is closely related to its occurrence. Inflammatory response may be one of the triggers of femoral head necrosis. Inflammatory response may lead to increased permeability of vascular endothelial cells, which may lead to leukocyte and inflammatory mediator leakage. These changes may lead to local vasospasm and thrombosis, which may significantly reduce the blood supply to the femoral head, which may lead to necrosis. There-

fore, controlling the inflammatory response is essential for the prevention of femoral head necrosis. The inflammatory response may also be involved in the pathophysiological process of femoral head necrosis. During the development of femoral head necrosis, the release of inflammatory mediators and activation of the inflammatory response may lead to destruction of bone tissue and apoptosis of bone cells, accelerating the process of osteonecrosis. The inflammatory response may also affect the treatment and prognosis of osteonecrosis of the femoral head. The persistence of the inflammatory response poses a serious threat to the condition of osteonecrosis of the femoral head, which may not only exacerbate the condition, but also affect the outcome of treatment and increase the risk of complications such as fractures and arthritis. These adverse outcomes significantly reduce the quality of life of patients and may lead to a poor prognosis of osteonecrosis of the femoral head. Therefore, there is a close relationship between the inflammatory response and femoral head necrosis, and the activation and persistence of the inflammatory response may be an important factor contributing to the development and progression of femoral head necrosis. In the prevention and treatment of femoral head necrosis, it is very important to reduce the inflammatory response, control the release of inflammatory mediators and the persistence of the inflammatory response.

3.2 The role of apoptosis in femoral head necrosis

Apoptosis plays an important role in femoral head necrosis. Necrosis of the femoral head is caused by ischemia and hypoxia of the bone tissue due to insufficient blood supply, and apoptosis is a programmed mode of cell death, which plays an important role in the occurrence and development of femoral head necrosis. The ischaemic and hypoxic environment severely damages femoral head cells and triggers oxidative stress, leading to an increase in oxygen free radicals, cell membrane lipid peroxidation and mitochondrial damage. These changes activate the apoptotic signalling pathway, leading to apoptosis and further exacerbating the condition of femoral head necrosis. Therefore, improving the ischemic and hypoxic environment and reducing oxidative stress are important strategies for the prevention and treatment of femoral head necrosis. Removal of apoptotic cells may affect the pathophysiological process of femoral head necrosis. Failure to remove apoptotic cells in a timely manner releases cellular inclusions and inflammatory factors, leading to activation of inflammatory responses, accelerating bone tissue destruction and osteoclast apoptosis, and exacerbating the process of femoral head necrosis. Thus, the role of apoptosis in femoral head necrosis is twofold, both due to apoptosis of osteoblasts as a result of the ischaemic and hypoxic environment, and through the removal of apoptotic cells, which affects the developmental process of femoral head necrosis. The regulation of apoptosis may provide new ideas for the treatment and prevention of femoral head necrosis. [5]

3.3 Association between angiogenesis and femoral head necrosis

Neovascularisation is closely associated with femoral head necrosis, which is a necrosis of bone cells due to insufficient blood supply to the bone tissue, and neovascularisation plays a crucial role in maintaining normal blood supply and nutrient metabolism of the tissue. Neovascularisation is limited by the development of femoral head necrosis. Due to the ischaemic and hypoxic environment of the femoral head necrotic region, neovascularisation is inhibited and it is difficult to form a new vascular network to meet the nutrient demand of the necrotic region, thus accelerating the necrosis of bone cells. By promoting neovascularisation, the blood supply to the necrotic area of the femoral head can be improved, and the delivery of oxygen and nutrients can be increased, which helps to reduce the ischemic and hypoxic condition of the necrotic area, and thus facilitates the repair and regeneration of bone tissue. Therefore, there is a close association between neovascularisation and femoral head necrosis. Promoting neovascularisation may become an important way to treat necrosis of the femoral head, and is expected to provide new ideas and methods for the prevention and treatment of necrosis of the femoral head.

4. Conclusion

In summary, the study of the cell biological mechanism of hormonal osteonecrosis of the femoral head provides a new perspective for an in-depth understanding of the pathogenesis of this disease. By deeply exploring how hormones affect the function of bone cells through cellular signalling pathways, the pathogenesis of hormonal osteonecrosis of the femoral head can be better understood, and new ideas and methods can be provided for the prevention and treatment of this disease.

References

[1] Zhao Shuai. USMI evaluation of hormone induced femoral head necrosis integrin in rats α V β Research on expression of 3 [D]. Guangzhou University of Chinese Medicine, 2021.000750.

[2] Hu Zhaolin. Study on the prevention and treatment of steroid induced femoral head necrosis in rats using human umbilical cord mesenchymal stem cells [D]. Shanxi Medical University, 2021.000733.

[3] Yang Dinglong. Expression of PLEK, TREM1, and TLR2 genes in steroid hormone induced femoral head necrosis and construction of

related endogenous competitive RNA regulatory mechanisms [D]. Shanxi Medical University, 2023.001419.

[4] Gao Xiangming, Zhou Mingwang, Wang Xiaoping, et al. A study on the correlation between circular RNA and the pathogenesis of steroid induced femoral head necrosis [J]. Life Science Research, 2023, 27 (01): 16-22.

[5] Cheng Jiqiang, Liu Bin. A review of the cellular biological mechanisms of steroid induced femoral head necrosis [J]. World Latest Medicine Information, 2019, 19 (35): 77-78+81.

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