The Role of Inflammation in The Development of Osteoarthritis: A Review Based on Recent Studies

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Abstract

Osteoarthritis (OA) is a degenerative condition characterized by cartilage destruction, subchondral bone changes, and inflammation, which can impair the quality of life of sufferers. This review aims to analyze the role of inflammation in the development of OA. The method used included a literature search of international and national databases for articles published in the last five years. The results showed that risk factors, such as age, obesity and trauma, can trigger the inflammatory process by involving pro-inflammatory cytokines such as IL-1β and TNF-α. Interventions for OA include pharmacological therapies, such as NSAIDs and corticosteroids, as well as non-pharmacological approaches through lifestyle modification. This review concludes that OA management requires an integrated approach to address inflammation and symptoms. A deeper understanding of the mechanisms of inflammation may support the development of more effective and efficient treatment strategies.

Keywords: Osteoarthritis, Inflammation, Pro-Inflammatory, Cytokines, Pharmacologic Therapy, Lifestyle Modification.

Introduction

Osteoarthritis (OA) is a degenerative condition characterized by destruction of joint cartilage, changes in the subchondral bone, and inflammatory reactions within the joint. It is one of the most common forms of arthritis and often occurs in adults, especially among the elderly. OA can cause symptoms of pain, stiffness, and reduced mobility, which significantly affects the quality of life of the sufferer.[1,2]

The role of inflammation in the pathogenesis of OA is becoming increasingly important to understand, especially in the context of how this process contributes to joint damage. Although OA was previously thought to be a disease primarily related to aging and joint wear, recent evidence suggests that chronic inflammation, triggered by factors such as obesity and joint injury, can accelerate cartilage degeneration and trigger severe pain.[3,4] Pro-inflammatory cytokines such as IL-1β and TNF-α have been identified to contribute to the inflammatory process within the joint, which not only affects cartilage tissue but also triggers changes in bone structure and surrounding soft tissues.[5]

The choice of this topic is relevant to the increasing prevalence of OA worldwide, which is expected to continue to rise as the population ages and obesity rates increase.[6] Challenges in the management of OA, including difficulties in managing pain and maintaining joint function, demand a better understanding of the mechanisms underlying the disease. With the right approach, including pharmacological and non-pharmacological interventions, it is hoped that more effective strategies can be developed to prevent and manage OA.

The aim of this literature review was to analyze the current evidence regarding the role of inflammation in the development of osteoarthritis. The main research questions to be answered are: How do inflammatory mechanisms influence OA progression? This review aims to provide a deeper understanding of the interactions between inflammatory processes and joint degeneration, as well as explore possible treatment approaches related to inflammation modulation in OA management.[7,8]

Methods

This research is a literature search and review using the narrative method. The literature search was conducted using international databases, namely Google Scholar, PubMed, ScienceDirect, and the national database, Garuda. This literature search was conducted in October

2024 with articles published in the last 5 years, namely 2019-2024. The search keywords used were “Osteoarthritis”, “inflammation”, “pathogenesis mechanism”, “pro-inflammatory cytokines”, “anti-inflammatory therapy” in international and national databases. Articles from the search were then included in the study and reviewed according to the search criteria.

Discussion

Definition of Osteoarthritis

Osteoarthritis is a condition affecting movable joints, characterized by cellular stress and extracellular matrix degradation caused by micro and macro injuries. This activates inappropriate repair responses, including pro-inflammatory pathways of the innate immune system. The disease appears first as a molecular disorder (abnormal joint tissue metabolism), followed by anatomical and/or physiological changes (characterized by cartilage breakdown, bone remodeling, osteophyte formation, joint inflammation, and loss of normal joint function), which can lead to further disease.[15]

Etiology

Osteoarthritis occurs due to a combination of mechanical and biological factors that can cause degradation of cartilage and other joint structures. The main causes of OA include aging, which naturally reduces the cartilage's ability to repair itself, as well as trauma or injury factors that damage the cartilage directly. In addition, metabolic and genetic factors can influence a person's susceptibility to OA.[16]

Inflammatory Mechanisms in Osteoarthritis

Osteoarthritis (OA) is a degenerative disease that involves cartilage degradation and synovial inflammation. Chondrocytes under stress from injury or aging release pro-inflammatory cytokines such as IL-1β and TNF-α, which activate the NF-κB signaling pathway. This pathway stimulates the expression of MMPs, which play a role in extracellular matrix degradation and accelerate cartilage damage.[8] Activation of macrophages in the synovium also exacerbates inflammatory conditions, accelerates tissue damage, and increases the production of inflammatory mediators.

Osteophyte formation as the body's response to tissue damage often exacerbates localized inflammation and pain, further impairing joint mobility. Inflammatory mediators such as prostaglandins produce amplified pain and inflammation, thus worsening the progressivity of OA. Uncontrolled synovial inflammation is one of the main focuses in therapeutic approaches to inhibit OA progression.[9]

Risk Factors for Inflammation in Osteoarthritis

Risk factors for inflammation in osteoarthritis (OA) are diverse and contribute significantly to disease progression. Age is one of the main factors as aging leads to decreased regenerative ability of cartilage and increased inflammation. Obesity also plays an important role, where increased body weight leads to mechanical stress on the joint as well as the release of pro-inflammatory cytokines such as TNF-α and IL-6. In addition, joint injury from trauma or overuse can trigger a chronic inflammatory response that accelerates cartilage degeneration. Genetic factors also play a role, with certain genetic variations increasing susceptibility to inflammation and OA. Lifestyle, such as excessive physical activity, can exacerbate the risk, especially in vulnerable joints. The combination of these factors exacerbates inflammation and accelerates the progression of OA, making it an important focus of clinical management.[9,10]

Inflammatory Triggering Factors in Osteoarthritis (OA)

The main factors that trigger the inflammatory response in osteoarthritis (OA) include obesity, joint trauma and aging. Obesity increases the mechanical load on joints, especially in the knee and hip joints. These stresses stimulate the release of pro-inflammatory cytokines such as TNF-α and IL-6, which contribute to cartilage damage and chronic inflammation, accelerating the progression of OA.[11]

In addition, joint trauma such as sports injuries or accidents can trigger an inflammatory response. Trauma causes tissue damage that activates immune cells such as macrophages, which release inflammatory mediators and proteolytic enzymes. This exacerbates the degradation of cartilage and joint tissue, which often leads to chronic inflammation if not properly addressed.[12]

The aging process also plays an important role in increasing the risk of inflammation in OA. As we age, the ability to regenerate cartilage decreases, while the production of pro-inflammatory cytokines increases. These changes accelerate cartilage breakdown, increasing the

risk of inflammation in already degenerated joints. Aging also results in decreased immune cell function, slowing down the tissue repair response.[9]

The combination of these factors not only accelerates the progressivity of OA, but also increases the complexity of its management. Treatment strategies often combine pharmacologic approaches such as NSAIDs and corticosteroids with non-pharmacologic interventions such as weight loss and physical activity to reduce inflammation and improve patients' quality of life.[13]

Therapeutic Interventions Against Inflammation in OA

Interventions against inflammation in osteoarthritis (OA) involve both pharmacological and non-pharmacological approaches. Pharmacological therapy often starts with the use of non-steroidal anti-inflammatory drugs (NSAIDs), which are effective in reducing pain and inflammation. NSAIDs function by inhibiting the cyclooxygenase (COX) enzyme, which reduces the production of prostaglandins, thereby lowering the level of inflammation in the joint. Studies have shown that regular use of NSAIDs can help manage OA symptoms and improve physical function.[14]

In addition to NSAIDs, corticosteroids are also used in the treatment of OA, especially for cases with severe inflammation. The use of corticosteroids, either in the form of injection into the joint or orally, can provide significant pain relief and reduce inflammation. However, their use must be done with caution as they can cause long-term side effects, such as soft tissue damage and bone thinning.[9] Therefore, close supervision and periodic evaluation are important in the use of this therapy.

On the other hand, non-pharmacological interventions play an important role in OA management. Lifestyle modifications, including weight loss and increased physical activity, have been shown to reduce mechanical stress on affected joints. Significant weight loss in obese patients can substantially improve OA symptoms, and regular exercise helps strengthen the muscles around the joint, improving stability and mobility. This approach not only reduces inflammation but also improves the patient's overall quality of life.[9]

Physical therapy, acupuncture, and the use of assistive devices such as orthotics can also help OA patients manage symptoms. By using proper rehabilitation techniques, patients can learn to avoid movements that aggravate pain, as well as develop exercise routines that are appropriate for their condition. An integrated approach that includes both pharmacological and non-

pharmacological therapies offers an effective way to address the inflammation and symptoms of OA, improving the patient's overall quality of life.[14]

CONCLUSION

Based on this discussion, osteoarthritis (OA) is a condition that involves joint damage due to cartilage degradation and a complex inflammatory response. Risk factors such as age, obesity, and joint trauma contribute to the activation of inflammatory processes that exacerbate the destruction of cartilage and surrounding tissues. Effective management approaches require a combination of pharmacological and non-pharmacological therapies, including the use of anti-inflammatory drugs as well as lifestyle modifications to reduce mechanical stress on the joint. Further efforts in understanding the inflammatory mechanisms in OA will support the development of more efficient treatment strategies to prevent the progression and complications of this disease.

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