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Inflammatory Diseases: Theranostics based on Nano Formulation

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Introduction

More than half of all deaths worldwide are attributed to chronic inflammatory conditions, which are a leading cause of death with a progressive course. These inflammatory conditions, which include heart disease, cancer, diabetes and even neurodegenerative diseases, are a major concern. Due to the complex pathophysiology, conventional diagnosis and treatment for these issues are frequently difficult and limited. Theranostic nanomaterials have been created to enhance current diagnostic and treatment methods. A combination of diagnostic biomarkers and therapeutic drugs with a common target in damaged cells or tissues is known as theranostics.

Description

Inflammation is a self-defence mechanism that is essential for avoiding harmful stimuli and beginning the healing process. Physical, chemical, biological, or environmental stimuli are all possibilities. Trauma, heat, cold, radiation, toxins, acidic substances, irritants, infections, pollutants, allergens and other environmental agents all have an impact on the biological response to these stimuli. Typically, the inflammatory response to these associated factors is self-healing; however, when not under control, it causes harm to organs and the body. The duration of biological responses, also known as acute or chronic, may serve as a defining characteristic of the inflammatory condition. Leukocyte migration and interstitial leukocyte infiltration are indicators of acute inflammation, which is characterized by short-term and rapid changes in tissue response and microcirculation. Red skin (erythema), heat effects (hyperemia), area swelling (exudation), pain (via nerves and chemical mediators) and loss of function (pain) are typical signs of this condition. However, the inflammatory feedback becomes more persistent over time and is characterized by a persistent release of cytokines. This can result in tissue damage that significantly harms the tissue site or particular organ. In point of fact, chronic inflammatory diseases, which include autoimmune and neurodegenerative conditions, coronary disease, stroke, tumour, diabetes, kidney disease and nonalcoholic fatty liver disease, have been identified as the leading cause of death worldwide and account for more than half of all deaths [1,2].

There is now evidence to suggest that the emerging risk of inducing inflammation can be traced back to earlier development and its long-term effects on adult health and mortality risk. Nonetheless, the wellspring of irritation is habitually obscure and, regardless of whether recognized, turns out to be not difficult to kill or stifle. As a consequence of this, there is growing interest in diagnosing and therapeutically enhancing the inflammatory response in order to halt the progression of the disease. The issues of overabundance, host compensation and the requirement for basic immune functionality frequently compromise the benefit–risk balance of anti-inflammatory medications because the inflammatory response is essential to the host homeostasis mechanism. Theranostic medicine combines diagnostic and therapeutic approaches to provide optimal illness management in order to comprehend the disease mechanism. Furthermore, by providing "the right diagnosis, the right therapy, at the right dose and at the right time," the nanomedicine combination has the potential to revolutionize healthcare. In order to address the challenges of suppressing inflammatory disorders with a strategy that can be used for specialized, personalized therapy, we present the development of a technology that achieves this specific objective [3].

The study of influencing atoms and molecules to create materials on the nanometer (nm) scale, preferably less than 100 nm, is the focus of the science known as nanotechnology. It involves the detailing and execution of physical, synthetic and organic frameworks where properties change as the boundary size changes. Nanoparticles are used to detect, treat, diagnose, monitor and control biological activity, making nanomedicine the most important application of nanotechnology today. The delivery of therapeutic and diagnostic substances and their efficacy in curing diseases are at the heart of nanomedicine. Nanoparticles offer another chance for getting aggravation through their capacity specially travel to the designated tissue from the site of organization. The traditional issue of therapies for inflammation that result in target side effects and systemic toxicity is solved by this. The proliferation of nanoparticles that not only have the capability of controlling the expression of anti-inflammatory chemicals but also of cell-eatingly targeting inflammatory sensors or macrophages shows a lot of promise for the efficient treatment of diseases that are linked to inflammation.

By coating nanoparticles with specific antibodies, the capability to passively target effector cells (by adjusting the size, surface area and surface charge of the nanoparticles) or actively target antigen-presenting cells (APCs) with nano carriers could be very helpful in increasing cellular response or immunological tolerance. To defeat the adverse consequences of customary prescription like vague focusing on, harmfulness issues, unreasonable portion and extended handling time, extraordinary accentuation has been put on the advancement of more compelling calming nano medicines. The removal of various chemical, anatomical, physiological and clinical obstacles that reduce the efficacy of standard drugs may be possible with the help of nano drugs. Nano therapeutics have the ability to precisely target the site of the infection, avoid undesirable side effects, increase effectiveness and enhance patient compliance and prognosis. The phenomenon known as the enhanced permeation and retention (EPR) effect occurs when the increased permeability and retention of the blood vessels in the area that is inflamed causes nanoparticles to accumulate in inflamed tissues. The little size of nanoparticles permits them to inactively diffuse into excited tissues, where they can amass and apply their remedial impacts [4,5].

Conclusion

The field of theranostic nanomedicine, which makes use of inorganic nanoparticles for both therapy and imaging, is relatively new. Gold, silver, silica, or magnetic materials are all possible materials for these nanoparticles. They can be used to deliver therapeutic substances like drugs, ligands, or antibodies or to entrap drugs. With this dual delivery system, imaging and

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therapy can occur simultaneously. The contrast agent used in the development of non-invasive nanomedical inflammatory therapy needs to be able to work with existing detection methods like X-ray, computed tomography (CT), magnetic resonance imaging (MRI) and positron emission tomography (PET) or single photon emission. A summary of some recent developments in nano theranostics, which are used to treat a variety of inflammatory diseases, is provided in this study. We also discuss issues with theranostic nanoparticles for inflammation and their clinical translational potential.

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