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FACTORS AFFECTING BACTERIOLOGICAL DAMAGE MUSCLE LICE

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Abstract
The article theoretically analyzes the main internal (endogenous) and external (exogenous) factors that affect the process of muscle tissue regeneration against the background of bacterial infections. During the study, such mechanisms as the negative impact of pathogens Staphylococcus aureus, Clostridium perfringens on myofibrillary structure, such mechanisms as necrosis, inflammation, violation of angiogenesis and fibrosis formation are elaborately illuminated. The role of factors such as the state of the immune system, age, hormones, nutrition and oxygen supply in the recovery of muscle tissue is assessed. It also analyzes antibiotic therapy, biostimulants and modern methods of rehabilitation, and proposes conceptual directions for further scientific and experimental research. This theoretical study substantiates the need for a better understanding of the processes of muscle regeneration, improvement of clinical rehabilitation approaches as well as an in-depth study of this problem in the conditions of Uzbekistan.

Keywords: Bacterial infection, muscle tissue, regeneration, myofibrils, necrosis, angiogenesis, immune system, antibiotic therapy, fibrosis, rehabilitation, biostimulants, Uzbekistan healthcare.

Introduction

In recent years, in the field of traumatology, surgery and rehabilitation, the regeneration of muscular tissue against the background of bacterial infections is recognized as one of the urgent problems. World Health Organization (WHO) According to the Ministry of Internal Affairs of the Kyrgyz Republic, Every year, more than 300 million people worldwide undergoes soft tissue injuries of varying degrees, including their bacterial infections in 20–25 percent develops as a complication (WHO, 2022). This significantly slows down the muscle's natural recovery process

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and increases the risk of long-term disability. Bacteriological lesions, especially Staphylococcus aureus, Clostridium perfringens, Pseudomonas aeruginosa As a result of the activity of such pathogenic microorganisms, it occurs with necrosis of muscle tissue, violation of cell regeneration, excessive production of inflammatory mediators and a slowdown in the process of angiogenesis. It is as a result of such complex physiological mechanisms that the process of muscle tissue biting is compared to normal slows down 1.5–2 times (Kumar et al., 2021). The urgency of this problem is directly related not only to the quality of life of the patient, but also to the economic burdens on the health system. For example, The annual cost of treating soft tissue infections in the US is $ 6 billion, which further increases the need for improved disease prevention and rehabilitation techniques (CDC, 2023). Viewed in this context, in-depth study of physiological, biochemical and immunological factors that influence the licking process of bacteriologically damaged muscle tissue is one of the priority areas of research today. Especially, activity of macrophages, cytokine balance, the process of renewal of capillaries, oxygen and nutrient supply Factors such as these are highlighted as key components of transaction mechanisms.

In the framework of this article, the physiological basis of muscle regeneration under conditions of bacterial lesion, internal and external factors affecting it, as well as modern therapeutic approaches are scientifically analyzed.

Bacterial infections and damage to muscle tissue

Structure and physiology of muscle tissue: Skeletal muscles are one of the basic tissues that perform voluntary movements in the human body and their main structural unit are muscle fibers (myosinfibrils and actinfibrils), which have myofibrils. Each muscle fiber produces energy through the nucleus and mitochondria, which are surrounded by a sarcolemma and located inside the sarcoplasm.

When muscle tissue is injured, its regeneration occurs in the following three stages:

1. Inflammatory stage – phagocytic cells (macrophages, neutrophils) are activated in the affected area.
2. New muscle cell differentiation – satellite cells (myooblasts) are activated and turn into new muscle fibers.
3. Remodeling – new fibers form a functional structure and are supplied to the blood through angiogenesis.

The role of myofibrils is precisely related to the production of contractile proteins required for movement, their regeneration of which is important for the restoration of muscle function.

Bacterial pathogens and their effects on muscle tissue

Bacterial infections complicate muscle regeneration, especially in open wounds or often caused by pathogens that are rarely found at the site of surgery.

The most common pathogens are:

1. Staphylococcus aureus – produces enterotoxins, alpha-tissue toxins.
2. Clostridium perfringens is the main cause of gas gangrene, which produces α-toxin.
3. Pseudomonas aeruginosa – increases inflammation in severe immunosuppressive cases.

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Cellular and tissue mechanisms of lesion:

1. **Effects of toxins**– Exotoxins excreted by pathogenic bacteria (e.g. α-toxin of S. aureus) disrupt the sarcolemm, which disrupts ion balance, increases calcium flux, and leads to cell necrosis.

2. **Excessive excretion of inflammatory mediators**– Mediators produced by neutrophils and macrophages, such as interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), accelerate apoptosis of muscle cells.

3. **Impairment of fibrosis and angiogenesis**– Against the background of infection, fibroblasts become overactive and fibrosis is formed as a result of excessive production of collagen tissue. This disrupts the elasticity and function of the muscles. At the same time, angiogenesis (the formation of new capillary vessels) is also slowed down, which prevents regeneration.

4. **Destructive Activity of Immune Cells**– During infection, active CD8+ T-lymphocytes and neutrophils not only destroy bacteria but also damage regenerating muscle cells. This will lead to a slowdown of the recovery process.

5. **Metabolic Stress under Anaerobic Conditions**– For instance, Clostridium perfringens multiplies in oxygen-poor environments and leads to the accumulation of harmful substances such as H2S in the tissues. And this causes myositis, necrosis, ishanemic conditions.

Factors that affect muscle tissue biting: a theoretical analysis

The regenerative potential of the musculoskeletal system depends on complex physiological, biochemical, and immunological factors. In particular, against the background of a bacterial infection, these factors are more acute and adversely affect the rate of recovery of muscle tissues. Below these factors are theoretically analyzed.

Internal (endogenous) factors

During our study, internal (endogenous) factors that directly affect the process of muscle tissue regeneration after bacterial infections were systematically analyzed. A key role among them is the functional state of the immune system, age- and sex-specific physiological changes, genetic predisposition, and hormonal dysregulation. In particular, the balance of macrophages between M1/M2 phenotypes at different stages of the immune response, as well as cytokine activity are closely related to the rate and quality of muscle cell regeneration after necrosis. The table below clearly shows the biological mechanisms of these factors and their effects on muscle regeneration.

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Table 1: Internal (endogenous) factors influencing muscle regeneration

Factor type	Biologics tavsifi	Effects on muscle regeneration	Note
Immune system status	With the participation of macrophages (M1 / M2), T-lymphocytes, cytokines, the healing process is controlled	When activity is in balance: Activates recovery If Discharge: delays	Chronic inflammation, immunodeficiency slows down regeneration
Age	The activity of satellite cells decreases with age	Rapid recovery in a young organism slows down with old age	In old age, angiogenesis and collagen synthesis decrease
Gender	Estrogen (women) and testosterone (men) regulate muscle metabolism	When hormonal balance: recovery accelerates Hormone breakdown: slow	Estrogen stimulates cell defense, while testosterone stimulates growth
Genetic predisposition	IGF-1, TGF-β genes determine muscle growth and fibrosis	IGF-1: Activates recoveryTGF-β: excess fibrosis	Genetic factors determine the quality of regeneration
Hormones	Cortisol, insulin, somatotropin regulate metabolic processes in the muscle	Insulin and somatotropin – accelerates regeneration Cortisol – slows down	Increased cortisol under stress has catabolic effects

3 External (exogenous) factors

- **Infectious load and bacterial segregation:** The type and amount of bacteria present in muscle tissues determine the strength of the tissue reaction. For example, Clostridium perfringens multiplies very quickly, producing gas and necrosis in the tissues, which leads to myositis and gangrene (Bryant et al., 2021).

- **Quality of treatment: Antibiotics and antiseptics:** The proper choice of antibiotic therapy plays an important role in tissue recovery. Empirical antibiotics are used temporarily until the type of infection is determined, but when the dose and duration are insufficient, the infection becomes chronic and impairs regeneration.

- **Nutrition, diet, oxygen deficiency:**Protein, amino acids (in particular, leucine and glutamine) are necessary for muscle recovery. Micronutrients such as iron, zinc, vitamin C are essential for angiogenesis and collagen synthesis. In the case of hypoalbuminemia, fluid is retained in the tissues, which adversely affects regeneration. And lack of oxygen (e.g., in diabetic angiopathy) slows down the healing due to ischanemia and hypoxia.

- **Quality of surgical intervention:** Improper stitches, insufficient disinfection of the wound site, insufficient removal of necrotic tissue interfere with the healing process. Where complete debridement is not performed, bacteria can colonize, causing constant inflammation.

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Angiogenesis and alteration of fibroblast activity against the background of bacterial infection

The role of angiogenesis in recovery processes

Angiogenesis is the formation of new blood vessels in the affected area, creating the basis for the survival of muscle cells through the delivery of oxygen and nutrients. Against the background of bacterial infection, angiogenesis can be blocked due to overproduction of cytokines such as IL-1β and TNF-α (Ramasastry, 2022).

Infection disrupts angiogenesis in two ways:

→ Effect of toxins on endothelial cells

→ Ejaculation of new capillary vessels by lysingen enzymes

Collagen production and fibrosis: Fibroblasts produce collagen during muscle recovery, but fibrosis is formed when this process continues beyond normal. As a result of fibrosis, the muscle loses its elasticity, movement is limited, and pain syndrome occurs. Also, because fibrosis tissue is not adequately supplied with blood, there is constant hypoxia — which increases the risk of chronic inflammation and new injuries.

Possible treatment lines and research opportunities: An integrated approach in modern medicine is required to accelerate the regeneration of bacteriologically damaged muscle tissue and reduce complications. The treatment is predominantly based on suppressing infection, restoring immunological equilibrium and restoring the physiological functions of tissues.

Antibiotic therapy and effects on regeneration: Antibiotics are the main means in controlling bacterial infection, reducing the infectious load on muscle tissues and reducing the production of inflammatory mediators. But improperly selected antibiotics or their overuse:

→ Suppresses the immune response

→ Interference with healthy cell proliferation

→ May cause mitochondrial dysfunction (Nguyen et al., 2022)

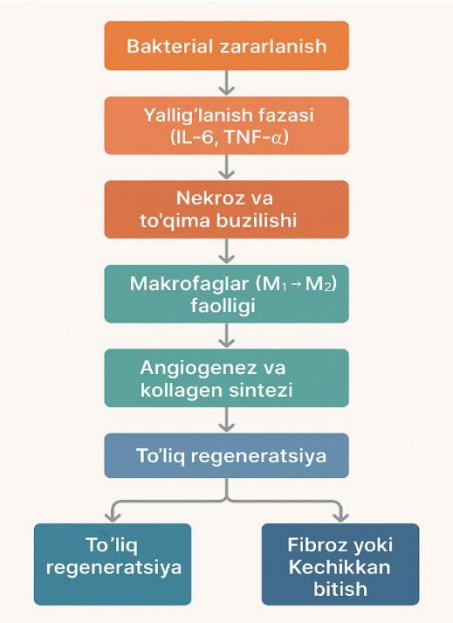

Figure 1. Algorithm for muscle tissue regeneration under the action of bacterial infection.

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In the modern approach, dose selection is not only based on pathogen sensitivity, but also taking into account the patient's immune status, metabolic activity and stage of finish. Especially in the presence of a bacterial biofilm, simple antibiotic therapy is not sufficient, so combined or combined treatment with topical antibiotics is recommended (Koo et al., 2017).

Biostimulants and methods of rehabilitation

Biostimulants

Drugs that activate tissue regeneration – epidermal growth factor (EGF), basic fibroblast growth factor (bFGF), platelet-rich plasma (PRP) – is used to accelerate the recovery phase after bacterial lesions.

– Platelet-separated growth factors present in PRP regulate angiogenesis, fibroblast activity, and reduce inflammation.– Cytokines such as interleukin-10 (IL-10) or IL-4 promote regeneration by directing macrophages to the M2 phenotype.

Methods of rehabilitation

Physiotherapy, electrostimulation, oxygen therapy (HBO – hyperbaric oxygen) and nutrition play a special role in rehabilitation. For example:

→ Hyperbaric oxygen therapy reduces hypoxia in muscles and activates angiogenesis.

→ Physiotherapy stimulates the activation of muscle fibers and serves as a prevention of contractures.

Proposal of scientific and experimental directions for further research

Fundamental and practical research should be carried out within the framework of this topic. The following areas are relevant:

Creating a model on animals

– It is proposed to create an experimental model of muscle infection (for example, in mice, rabbits or pigs) to study the regeneration process step by step – It is possible to assess the dynamics of microbiological load, immune response and histological changes.

Control of cytokine levels

– Monitoring the expression of inflammatory cytokines such as IL-1β, TNF-α, IL-6, studying their changes in blood and muscle biopsy will allow you to determine the signaling pathways affecting regeneration.– These indicators will be evaluated using molecular technologies such as ELISA, PCR and Western blot.

The need to analyze the situation in Uzbekistan

– Clinical and epidemiological analyses of the effect of bacterial infections on muscle wasting in local conditions (against the background of surgery, sports injuries, diabetic injuries) are insufficient.

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CONCLUSION

The process of recovery of muscle tissue under conditions of bacterial damage is one of the most complex and interrelated biological-molecular systems in the body. On the basis of this theoretical analysis, it is established that against the background of bacterial infection, muscle regeneration is disrupted under the influence of various factors, and this condition sharply changes the physiological dynamics of the healing process. First of all, bacterial pathogens, in particular *Staphylococcus aureus*, *Clostridium perfringens* va *Pseudomonas aeruginosa* Toxins excreted by microorganisms such as "Intoxication" damage the membranes of muscle cells, disrupt ion equilibrium and provoke cell necrosis. This infectious load significantly damages the normal mechanisms of muscle recovery, especially by slowing angiogenesis, excessive production of inflammatory mediators, destructive activity of immune cells, and the development of fibrosis. Internal (immune status, age, sex, genetic predisposition, hormones) and external (infectious load, quality of antibiotic therapy, nutrition, oxygen supply and surgical interventions) factors that influence the rate of regeneration form a complex system. In particular, the activity of growth factors, cytokine balance, and activation of fibroblasts are the main determinants of finish quality. Theoretical analyses show that the integration of modern treatment approaches - combination of antibiotic therapy, PRP and growth factor-based biostimulants, hyperbaric oxygen therapy and physiotherapeutic measures significantly improves the quality of regeneration. At the same time, the available scientific analyses support the need for in-depth clinical and experimental studies of this problem in Uzbekistan. In particular, the creation of a model of bacterial infection in animals, the study of the relationship between inflammatory cytokines and tissue regeneration, and the establishment of clinical statistical monitoring in local conditions allow expanding the fundamental scientific foundations in this area.

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