Chapter 1

ORGANIZATION OF RESEARCH AND APPLICATION OF LABORATORY MARKERS TO ASSESS THE HEALTH OF PATIENTS AFTER COMBAT TRAUMA OF LARGE JOINTS

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Introduction

The problem of laboratory studies of patients with combat trauma is quite relevant today, considering the situation in Ukraine. This is due to the full-scale invasion of the Russian Federation into Ukraine, which led to large-scale military actions to protect our Independence. Combat trauma is characterized by a large number of metabolic changes, in particular, an increase in certain biochemical markers in the blood. It is known that the risk factors for bone damage in the military are well described in the literature, but their etiology is very complex, especially in the high-stress military environment[1].

According to modern research, conscripts have a special risk of fracture. Recent efforts by American and Israeli military researchers have identified important mechanisms of this risk. Stress fracture prevention, including simple strategies to identify and reduce risk, is critical[2].

It is clear that stress fractures are a serious problem for soldiers and can lead to severe complications or even disability. It was found that genetic factors play an important role in the development of stress fractures in people who are exposed to heavy physical and mechanical stress. The current findings can be applied to the planning of future studies that will further elucidate the genetics of stress fractures.[3].

Research has shown that heterotopic ossification is a significant problem for wounded warriors who have survived high-energy blast injuries. However, there is currently no panel of biomarkers capable of globally characterizing, diagnosing and monitoring the progression of heterotropic ossification. The

[1]Julie P. Greeves, Belinda Beck, Bradley C. Nindl, Thomas J. O'Leary. Current risk factors and emerging biomarkers for bone stress injuries in military personnel. J. Sci. Med. Sport. 2023 Jun:26 Suppl 1:S14-S21. doi: 10.1016/j.jsams.2023.04.006. Epub 2023 Apr 20.

[2]Karl E. Friedl, Rachel K. Evans, Daniel S. Moran. Stress fracture and military medical readiness: bridging basic and applied research. Med Sci Sports Exerc. 2008 Nov;40(11 Suppl):S609-22. doi: 10.1249/MSS.0b013e3181892d53.

[3]Konnyu KJ, Pinto D, Cao W, Aaron RK, Panagiotou OA, Bhuma MR, Adam GP, Balk EM, Thoma LM Rehabilitation for Total Hip Arthroplasty: A Systematic Review. Am. J.Phys. Med. Rehabil. 2023. 102(1). P. 11 – 18. doi: 10.1097/PHM.0000000000002007. Epub 2022 Mar 12.

aim of these studies was to identify biomarkers for heterotropic ossification using proteomic methods and blood serum.According to the obtained results, the proteomic study of patient serum includes 1,220 proteins and was enriched in proteins involved in response to increased levels of calcium, platelets, wound healing, and extracellular matrix organization. Proteolytic peptides from three of ten proteins, osteocalcin preprotein, osteomodulin precursor, and collagen alpha-1(v) chain isoform 2 preprotein from serum are potential clinical biomarkers for heterotropic ossification[4].

It is also known that heterotropic ossification can occur after trauma and burns. Heterotropic ossification develops in more than 60% of servicemen with blast-related amputations. This suggests that the blast effect itself is a major factor contributing to heterotropic ossification after blast injury[5].

However, there are no clear data on the algorithms and schemes of clinical and laboratory research of military personnel with combat trauma of the musculoskeletal system. Soldiers who have injured large joints and damaged bone tissue have, in addition to the injury, concomitant diseases that affect metabolism. Therefore, a complete assessment of the state of health of patients with combat trauma is an important and relevant direction of research in traumatology and orthopedics.

1. Materials, methods and purpose of research

In the clinic of orthopedic arthrology and endoprosthesis “Sytenko Institute of Spine and Joints Pathology of National Academy of Medical Sciences of Ukraine" regularly conducts activities for the examination and treatment of patients (2022–2024) with combat injuries.

The Department of Laboratory Diagnostics and Immunology performs the duties of a coordinator in organizing and conducting rounds of interlaboratory comparisons of the results of instrumental measurements in the institutions of the National Academy of Medical Sciences of Ukraine in Kharkiv. In November 2015, the department successfully passed certification within the program for interlaboratory comparisons of instrumental measurement results. In 2019, he received a certificate of compliance of the measurement system with the requirements of DSTU ISO 10012: 2005. The department participates in international programs for quality control of clinical and laboratory research. The arsenal of the department includes unique, specially developed and improved biochemical methods for studying the state of connective tissue. A feature of the department's clinical activity is the use of developed diagnostic schemes for studying the metabolism of connective tissue in various orthopedic diseases. Research is being conducted on the peculiarities

[4]Laura E. Edsberg, Erin L. Crowgey, Patrick M. Osborn, Jennifer T. Wyffels. A survey of proteomic biomarkers for heterotopic ossification in blood serum. J Orthop Surg Res. 2017 May 4;12(1):69. doi: 10.1186/s13018-017-0567-2.

[5]Zepur Kazezian, Anthony MJ Bull. A review of the biomarkers and in vivo models for the diagnosis and treatment of heterotopic ossification following blast and trauma-induced injuries. Bone. 2021 Feb:143:115765. doi: 10.1016/j.bone.2020.115765. Epub 2020 Dec 4.

of the somatic status of orthopedic patients with concomitant (comorbid) cardiovascular, endocrine and other pathologies. Changes in concentrations of biochemical, immunological, hematological markers, coagulogram indicators are studied. Biological fluids, including joint punctures, exudates and transudates, are studied using 201 methods. The main directions of the department's work are: the study of the metabolism of connective tissue; study of immune status in pathological processes of the locomotor system; development of diagnostic algorithms for dystrophic, inflammatory, traumatic, oncological and other diseases of the musculoskeletal system; study of the blood coagulation system in diseases and injuries of the locomotor system.

Since 2023, the Department of Laboratory Diagnostics and Immunology has been carrying out the research fundamental topic "Investigating the pathogenetic relationship between disorders of the hemostasis system and inflammatory-destructive changes in the conditions of diseases, lesions and combat trauma of large joints", state registration No. 0123U100163, in which they take participation of clinicians and specialists in laboratory diagnostics.

The purpose of the study: to analyze the clinical and diagnostic informativeness of various laboratory markers as promising for the organization of the examination of patients with combat trauma of the hip and knee joints.

2. The clinical-pathogenetic role of biopolymers of connective tissue in the diagnosis of pathology of the musculoskeletal system

Connective tissue is a part of cartilage, ligaments, bone matrix, serves as the basis for skin and mucous membranes, participates in fixation of blood vessels, forms the basis of intercellular substance in parenchymal organs (liver, kidneys, muscles). The supporting and mechanical function of the connective tissue is provided by extracellular insoluble threads of high-polymeric compounds immersed in the matrix or the main substance. Synthesis of insoluble threads and soluble matrix is carried out by chondrocytes, fibroblasts, besides which other cells are present here – macrophages, labrocytes (mast cells), as well as in a smaller number of undifferentiated cells. The main components of the main substance are glycosaminoglycans (mucopolysaccharides), collagen, elastin and reticulin. Thus, all types of connective tissue contain cellular elements, fibrous structures and the main intercellular substance. Connective tissue fibers are formed from fibrillar proteins – collagen and elastin, and the basis of the intercellular substance consists of carbohydrate-protein complexes – glycoproteins and proteoglycans.

Collagen is a glycoprotein, the most common protein in the human and animal body, making up approximately 25–33% of all protein. About 19 types of collagen are known, differing from each other in the primary structure of peptide chains, functions, organ and tissue localization. The first five types

are the most common, the others are quite rare in small quantities and have not yet been sufficiently studied.

Collagen is synthesized by cells from free amino acids. However, the amino acid residues that are specific for the collagen molecule (hydroxyprolyl and hydroxylysyl) are not formed from the corresponding free amino acids, but appear only after the inclusion of proline and lysine in the polypeptide chain. The breakdown of collagen is catalyzed by the enzyme collagenase, which cleaves the peptide bonds between glycine and oxyproline.

Collagen fibers are built from bundles of fibrils cemented by glycosaminoglycans and glycoproteins and contain about 65% water. The marker amino acids of mature collagen are hydroxyproline and hydroxylysine. The intensity of collagen breakdown is indicated by the content of free oxyproline in blood and urine. It is known that with age in an adult, the level of excretion of oxyproline with urine increases due to the destruction of collagen.

Collagen interacts with adjacent cells. Some of them, for example, hepatocytes, have collagen receptors in the plasma membrane and directly bind to it, others bind through special binding proteins – fibronectin, chondronectin, and laminin.

Due to tissue fibrosis, the collagen content in the tissues increases significantly. Thus, the synthesis of type I collagen increases in the case of progressive systemic sclerosis, in the process of the formation of keloid scars. Fibrous and granulation tissue, connective tissue and keloid scars are actually composed of collagens. In the case of inflammation and regeneration, collagen is actively rebuilt. Collagenases of fibroblasts, macrophages and neutrophils destroy collagen, then mechanocytes (which synthesize collagen cells from the internal environment of the body) synthesize collagens, and fibers are restored.

Elastin is a glycoprotein, the main structural component of elastic fibers, which are abundant in ligaments, walls of blood vessels, and lungs. Elastin molecules contain approximately 800 amino acid residues, most of which are hydrophobic amino acids (alanine, valine, leucine, proline). As in collagen, one-third of the amino acid residues are glycine, oxyproline is also present, but its amount in elastin is approximately 10 times less. With age, the elasticity of elastin fibers decreases.

Proteins of a non-collagenous nature include proteins of the cytoplasm and nuclei of cellular elements, blood serum proteins (albumins, globulins), soluble extracellular proteins (proteins of proteoglycans, soluble fractions of collagen) and insoluble extracellular proteins. Extracellular proteins make up a group of "non-collagenous" connective tissue proteins – they are glycoproteins with different content of carbohydrate components. Noncollagenous structural proteins of the intercellular matrix include fibronectin and laminin.

Fibronectin is a high-molecular glycoprotein present in the connective tissue of many species, mainly near the cytoplasmic membrane of cells. The

main function of fibronectin is adhesive: it is a participant in the adhesion of cells, connecting them to each other and to various substrates, in particular biopolymers of the extracellular matrix – collagens of various types and glycosaminoglycans (GAG), as well as to fibrin.

Laminin is the most common non-collagen glycoprotein of basement membranes, which interacts with all their structural components, including collagen and fibronectin. Its functions are to bind cells, it can also affect the growth, morphology, differentiation and motility of cells.

The basis of the intercellular (main) substance of the connective tissue is formed by proteoglycans, which consist of a small protein part (5–10%) and glycosaminoglycans (90–95%).

Glycosaminoglycans contain N-acetylhexosamines, glucose, galactose, mannose, fucose and N-acetylneuraminic acid (sialic acid). Acidic GAGs are characterized by a high content of uronic acids (glucuronic, iduronic) and sulfates. The most important representatives of GAG are hyaluronic acid, chondroitin-4-sulfate, chondroitin-6-sulfate, dermatan sulfate, keratan sulfate, heparan sulfate, and heparin.

Hyaluronic acid has the largest molecular weight among all GAGs. Its main function is the binding of water, due to which the intercellular substance acquires a jelly-like matrix. The gel-like structure of hyaluronic acid ensures the function of synovial fluid in the joints.

Chondroitin is a non-sulfated GAG, the main polysaccharide of cartilage proteoglycans. The most important components of cartilage are chondroitin-4-sulfate and chondroitin-6-sulfate, which differ in physical and chemical properties, as well as distribution in the connective tissue of different species. So, chondroitin-4-sulfate prevails in bone tissue, cartilage, sclera, aorta, and chondroitin-6-sulfate – in tissues of articular cartilage, tendons, skin, heart valves, intervertebral discs.

Dermatansulfate quantitatively predominates among the GAGs of the dermis, from where it was first isolated. In addition to the dermis, it is found in the arteries, cornea, sclera, heart valves, and gastric mucosa. Dermatan sulfate has properties to stabilize collagen fibers and exhibits an anticoagulant effect, resistant to hyaluronidase.

Keratansulfates. There are two varieties – keratan sulfate I and keratan sulfate II. Keratansulfate I is isolated from the cornea of the eye, keratan sulfate II – the glycosamnoglycan of cartilage and bones – is characterized by a higher degree of sulfation. Keratansulfates are resistant to the action of hyaluronidase, but are split by other enzymes. In all types of connective tissue, the concentration of keratansulfates increases markedly with age.

Heparin differs from other GAGs in localization in tissues and functions. It is an intracellular component of mast cells and a strong inhibitor of blood coagulation. It was first found in the liver, later in the lungs, artery walls, and skin.

Heparansulfate is similar to heparin. It is located mainly on the surface of endothelial cells and platelets, is a component of basement membranes in the kidneys and liver.

In the connective tissue, all GAGs are covalently connected to proteins, creating macromolecular proteoglycan aggregates. During the destruction of connective tissue, the amount of free GAGs in the blood increases, which leads to an increase in their excretion with urine. An increase in the content of connective tissue components in biological fluids can also be caused by the inability of the liver to synthesize and destroy GAG due to the development of hepatopathies. All this makes it possible to determine metabolic disorders of connective tissue components in various diseases of organs and systems.

In medicine, there are two large groups of hereditary diseases – collagenoses and mucopolysaccharidoses. These are genetically determined pathologies of the metabolism of the main biochemical components of connective tissue – collagen and GAG. In traumatology and orthopedics, biochemical markers of connective tissue are used to diagnose diseases of the musculoskeletal system – osteoarthritis, rheumatoid arthritis, bone neoplasms, aseptic necrosis of the head of the hip joint, etc. However, in orthopedic science and practice, there is no clear list and algorithm for the use of biochemical markers to assess the state of health of patients with combat trauma. This makes this direction of research very relevant in modern conditions.

3. Clinical and diagnostic value of biochemical markers for assessing the condition of patients with combat trauma

Glycoproteins–proteins that contain oligosaccharide chains of various lengths covalently attached to a polypeptide base. The carbohydrate component of glycoproteins (glucose, fructose, mannose, galactose, etc.) is smaller in mass than that of proteoglycans and makes up no more than 40% of the total mass. Almost all proteins on the surface of animal cells are glycoproteins. Glycoproteins include most of the proteins secreted by cells, as well as blood plasma proteins. In general, we can say that most proteins that are located or function outside the cell are glycoproteins. For example, on the surface of erythrocyte membranes there is a specific glycoprotein – glycophorin, which performs the function of glucose transport, binding of viral antigens, and also determines the blood group. Fibronectin is a glycoprotein present on the plasma membranes of cells of dense tissues, which has pronounced adhesive properties and ensures intercellular contacts.

Glycoproteins perform various functions in the human body and are present in all classes of proteins – enzymes, hormones, transport and structural proteins. Representatives of glycoproteins – collagen, elastin, immunoglobulins, angiotensinogen, transferrin, ceruloplasmin, thyroid-stimulating hormone of the pituitary gland, α2-glycoprotein, α1-antitrypsin, lactoferrin, some tumor markers (chorionic gonadotropin, cancer-embryonic antigen, tumor-associated antigens – CA markers, etc.) .

Clinical and diagnostic value. Determination of general glycoproteins and their specific representatives allows to diagnose acute inflammatory processes, chronic inflammatory processes in the stage of exacerbation, as well as to detect neoplasms of various organs and tissues – mammary gland, uterus, ovaries, intestines, liver, rectum. The content of total glycoproteins changes in many human diseases. In patients with combat trauma of large joints, it is promising to use glycoproteins as markers of the systemic inflammatory process during the initial examination, as well as to monitor the effectiveness of operative and conservative treatment.

Haptoglobins– glycoproteins that bind free hemoglobin to form a complex that is metabolized in the reticulo-endothelial system. This mechanism is necessary to prevent iron loss and kidney damage. Haptoglobins make up 25% of all α2-globulins in the blood. In addition to protecting the body from iron loss, haptoglobin participates in detoxification processes, transport of vitamin B12, and also protects against proteolysis (inhibitor of cathepsin B), has an inhibitory effect on the properdin system.

Clinical and diagnostic value. An increase in the concentration of haptoglobin is observed in the acute period of infectious diseases, allergic diseases, destruction of connective tissue, rheumatoid arthritis, myocardial infarction, malignant tumors, pyelonephritis, in the postoperative period, a decrease is due to hemolytic anemias, hemolytic processes, microangiopathies (diabetic nephropathy), severe injuries liver parenchyma, effects of corticosteroids. Since haptoglobin is an acute phase protein, low haptoglobin levels are often observed during the simultaneous development of the hemolytic process and inflammation. In patients with combat trauma of bones and joints, haptoglobin can be used as a test to evaluate a possible hemolytic process associated with necrotic and necrobiotic changes in the affected tissues.

Ceruloplasmin – glycoprotein, which includes up to 3% of the body's copper, but it does not take part in its exchange. About 40% of copper contained in blood plasma is part of ceruloplasmin. Belongs to α_2-globulins, acute phase proteins. This protein can limit the oxidation of divalent ferrum to trivalent, weakening the processes of free radical oxidation, which require ferrum ions. Ceruloplasmin acts as an oxidase of ascorbic acid, adrenaline, actively participates in the destruction of toxins, including bacterial ones. Therefore, it can be considered as one of the factors of neuroendocrine regulation and protection of the body in stressful situations, inflammation, and allergic processes.

Clinical and diagnostic value.An increase in the concentration of ceruloplasmin is observed in the acute period of infectious diseases, with anemia, leukemia, malignant neoplasms, cirrhosis of the liver, mechanical jaundice, as well as in the case of activation of chronic inflammatory processes; decrease – due to liver diseases, lack of copper in the body, nephrotic syndrome. This test can be used to assess co-morbidities in patients admitted to the inpatient joint pathology clinic after combat trauma.

C-reactive protein – glycoprotein, acute phase protein. Able to enter into a precipitation reaction with C-polysaccharide of pneumococci. Promotes phagocytosis, increases the mobility of leukocytes, activates immune reactions and binding of complement.

Clinical and diagnostic value.C-reactive protein in blood serum can be detected in rheumatic diseases of the joints, cancerous tumors, diseases of the respiratory system (pneumonia and bronchopneumonia). In normal people, C-reactive protein is detected in the blood serum in a minimal amount. During combat trauma, C-reactive protein can serve as a marker of the inflammatory process, in particular, associated with tissue infection.

α_1-antitrypsin – glycoprotein, forms complexes with proteinases, inhibiting the proteolytic activity of such enzymes as trypsin, chymotrypsin, plasmin, thrombin and proteases, which are released as a result of the destruction of leukocytes or foreign cells in the focus of inflammation. An increase in the content in blood serum is observed during inflammatory processes, necrotic pancreatitis. Can be used in the diagnosis of protein-losing enteropathy. This test can be considered as a marker of necrosis and necrobiotic changes in tissues, however, according to our experience, the glycoprotein index exceeds the diagnostic significance of this test in patients.

α_2-macroglobulin – glycoprotein, protein of α_2-globulin fraction. Universal serum protease inhibitor. The biological role of macroglobulin is in the regulation of tissue proteolysis cells, which are important in the processes of blood coagulation, fibrinolysis, functioning of the complement system, inflammatory reaction, regulation of cellular tone, in the processes of functioning of various links of immunity.

Clinical and diagnostic value.An increase in the concentration of α_2-macroglobulin is observed in chronic and recurrent processes: damage to the liver parenchyma, autoimmune diseases, nephrotic syndrome; decrease – in case of acute pancreatitis, nephritis, gastroenteritis with protein loss, burns, mechanical injuries. This indicator is significantly reduced for malignant tumors. For a combat injury, this test can be used as an indicator of inflammatory-destructive disorders, for example, for a burn received during an explosive injury.

Seromucoids – glycoproteins with acidic properties that dissolve in perchloric acid. They are determined in blood serum as markers of connective tissue metabolism disorders during inflammatory processes in various tissues and organs. The most diagnostic significance is the determination of seromucoids for the diagnosis of chronic inflammatory processes, which indicates their activation or exacerbation, even if clinical symptoms have not yet appeared.

Clinical and diagnostic value. An increase in the content of seromucoids in blood serum occurs during inflammatory and necrotic processes, jaundice against the background of a tumor process in the liver, rheumatic arthritis, myocardial infarction, stress; decrease – due to hepatodystrophy, infectious hepatitis, liver cirrhosis.

Sialic acids – acylated derivatives of neuraminic acid, found in all body tissues and fluids. They are part of the molecules of oligosaccharides, glycolipids and glycoproteins, and are also important components of many biologically active compounds – enzymes, hormones, receptor proteins. Sial-containing glycoproteins are part of connective tissue, biological fluids (for example, intra-articular fluid), mucus; they participate in the processes of intercellular interaction, specific reception on the surface of cells, signal transmission, ion transport, ensuring antigenic specificity and tissue compatibility. Sialic acids are usually markers of rheumatic joint damage, but their concentration can increase in other severe pathological conditions. It is known that to establish a more accurate diagnosis, research on the content of sialic acids should be carried out together with other indicators (for example, seromucoids, α-glycoproteins).

Clinical and diagnostic value.An increase in the content of sialic acids occurs in the case of diseases that are accompanied by inflammatory and destructive changes in the connective tissue.

As practice shows, the content of sialic acids in the blood of patients directly correlates with the severity of the pathological process. For example, with nephrosclerosis, the content of sialic acids in blood serum increases uniformly according to the stages of development of chronic renal failure. An increased concentration of sialic acids is characteristic of patients with malignant tumors of bone tissue, leukemia, osteomyelitis, and obstructive jaundice. The perspective of this test for assessing the condition of patients with a combat injury is very significant, because with this type of injury, the severity of the pathological process is very important for the formation of a treatment strategy and prognosis.

The content of sialic acids in blood serum moderately increases in gastroenteritis and chronic bronchitis, a significant increase occurs in diabetes, chronic kidney disease, chronic hepatitis, glomerulonephritis, and pneumonia. A decrease in the level of sialic acids is observed in cirrhosis of the liver, anemia, dystrophic processes in the central nervous system.

Glycosaminoglycans (GAGs) – carbohydrate components of proteoglycans, which are part of the intercellular substance of connective tissue. The content of GAG for diagnostic purposes is determined both in blood serum and in urine. The diagnostic informativeness of GAG in urine is determined by their important pathogenetic role in the development and progression of urolithiasis. It is known that GAGs are inhibitors of the formation of urolith crystals in urine, especially heparin. A decrease in urinary GAG concentration occurs in various forms of urolithiasis.

Glycosaminoglycans in blood serum are studied by special methods that allow them to be divided into the first, second and third fractions. The first fraction includes mainly chondroitin-6-sulfate, the second – mainly chondroitin-4-sulfate and dermatansulfate, the third – mainly heparan sulfate and keratan sulfate. An increase in total GAG is observed in diabetes, hepatitis

and urolithiasis, and glomerulonephritis. The content of total GAG decreases in rheumatic arthritis, connective tissue dysplasia, alimentary gastroenteritis.

Chondroitin sulfates – GAGs, which make up an important part of the extracellular matrix of various organs and tissues. It should be noted that chondroitin sulfates together with keratan sulfates and hyaluronic acid form the basis of the intercellular substance of the organic matrix of bone and cartilage tissues. It is the content of chondroitin sulfates that can be used as a diagnostic test for pathologies of the bone and joint system in experimental animals.

Due to the development of inflammatory and destructive processes in the parenchyma and stroma of parenchymal organs in the body, the content of chondroitin sulfates in the blood serum usually increases, in connective tissue dysplasia, it decreases. An increase in the content of chondroitin sulfates is observed in the case of liver diseases (acute and chronic hepatitis, cirrhosis), amyloidosis of the kidneys, chronic renal failure, nephrotic syndrome, malignant neoplasms of the mammary gland in the stage of decay, adenocarcinoma of the liver. The content of chondroitin sulfates and the change in the fractional composition of GAG in patients with combat trauma of large joints can provide valuable information about destructive changes in cartilage and bone tissue, as well as indicate the degree of this destruction during the development of inflammation.

Conclusions

1. In traumatology and orthopedics, biochemical markers of connective tissue are used to diagnose diseases of the musculoskeletal system – osteoarthritis, rheumatoid arthritis, bone neoplasms, aseptic necrosis of the head of the hip joint, etc., but there are practically no data on their use in combat injuries.

2. Today, in orthopedic science and practice, there is no clear list and algorithm for the use of biochemical markers of connective tissue to assess the state of health of patients with combat trauma. This makes this direction of research very relevant in modern conditions, in particular, in the public health system for assessing the condition of military personnel after receiving a combat injury.

3. In patients with combat trauma of large joints, the perspective of using glycoproteins as markers of the systemic inflammatory process during the initial examination, as well as to control the effectiveness of operative and conservative treatment.

4. For combat trauma of bones and joints, haptoglobin can be used as a test to assess a possible hemolytic process associated with necrotic and necrobiotic changes in affected tissues. C-reactive protein can serve as a marker of the inflammatory process, in particular, associated with tissue infection after explosive and gunshot wounds.

5. The perspective of sialic acids for assessing the condition of patients with a combat injury is very significant, because for this type of injury, the

severity of the pathological process is very important for the formation of a treatment strategy and prognosis.

6. Determination of the content of chondroitin sulfates and changes in the fractional composition of GAG in patients with combat trauma of large joints can provide valuable information about destructive changes in cartilage and bone tissue, as well as indicate the degree of this destruction during the development of inflammation.

Summary

The problem of laboratory studies of patients with combat trauma is quite relevant today, considering the situation in Ukraine. This is due to the full-scale invasion of the Russian Federation into Ukraine, which led to large-scale military actions to protect our Independence. Combat trauma is characterized by a large number of metabolic changes, in particular, an increase in certain biochemical markers in the blood. In traumatology and orthopedics, biochemical markers of connective tissue are used to diagnose diseases of the musculoskeletal system, but there are practically no data on their use in combat trauma. In patients with combat trauma of large joints, it is promising to use glycoproteins as markers of the systemic inflammatory process during the initial examination, as well as to monitor the effectiveness of operative and conservative treatment. Haptoglobin can be used as a test to evaluate a possible hemolytic process associated with necrotic and necrobiotic changes in affected tissues. C-reactive protein can serve as a marker of the inflammatory process, in particular, associated with tissue infection after explosive and gunshot wounds. The perspective of sialic acids for assessing the condition of patients with a combat injury is very significant, because with this type of injury, the severity of the pathological process is very important for the formation of a treatment strategy and prognosis. Determining the content of chondroitins and changes in the fractional composition of GAG in patients with combat trauma of large joints can provide valuable information about destructive changes in cartilage and bone tissue, as well as indicate the degree of this destruction during the development of inflammation.

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