Modern Methods of Hirudotherapy During the Treatment and Rehabilitation of Patients with Rheumatoid Arthritis, Prospects for the Use of Artificial Intelligence

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Abstract. The quality of life of patients with rheumatoid arthritis includes health, social ties, living conditions, professional activity, treatment effectiveness, access to modern medical care, pharmaceutical provision of medicines of all clinical-pharmacological, nomenclature-legal and classification-legal groups. Rheumatoid arthritis is one of the most common chronic autoimmune diseases. It causes disability and deterioration of the quality of life of millions of patients in the world. The article is devoted to the analysis of modern approaches to the treatment and rehabilitation of patients using hirudotherapy in combination with traditional pharmacotherapy. The results of studies on the effectiveness of the use of medical leeches, which helps reduce pain, swelling, improve microcirculation and reduce the need for non-steroidal anti-inflammatory drugs and corticosteroids, are presented. Special attention is paid to the potential of artificial intelligence in rheumatology: from early diagnosis and monitoring to personalized selection of therapy and rehabilitation measures. The results indicate the feasibility of integrating hirudotherapy and digital artificial intelligence technologies in the complex treatment of rheumatoid arthritis.

Keywords: rheumatoid arthritis, quality of life, medical leeches, hirudotherapy, rehabilitation, pharmacotherapy, drugs, joint pain, deformities, artificial intelligence.

Introduction. The quality of life of each person and patient is associated with many factors that include health, social ties, living conditions, professional activities and personal beliefs. For the patient, in addition to these general factors, the quality of life closely depends on the effectiveness of treatment, access to modern medical care, pharmaceutical provision of medicines of all clinical-pharmacological, nomenclature-legal and classification-legal groups, the patient's ability to self-service and social activity [1-9].

Factors that affect the quality of life of patients with rheumatoid arthritis include: health, physical activity (exercise, sports), balanced nutrition, sleep, psychoneurological state (ability to adapt to the disease, positive attitude and sense of control over one's own life), absence of bad habits (smoking, alcoholism, drug addiction, substance abuse, etc.), adherence to a healthy lifestyle, living conditions (environmental safety, clean water), social support (help, family, friends, medical staff in overcoming difficulties associated with the disease).

Rheumatoid arthritis is a chronic systemic disease of connective tissue of immune genesis and unknown etiology. It is characterized by nonspecific symmetrical arthritis, extra-articular and systemic changes. It leads to pain, disability and premature death. Depending on the presence or absence of IgM rheumatoid factor autoantibodies or cyclic citrullinated peptide antibodies in the serum, seropositive or seronegative forms of the disease are distinguished [10, 11].

According to WHO, about 18 million people live with rheumatoid arthritis in the world. In addition [12, 13]:

- ✓ about 70% of citizens living with rheumatoid arthritis are women, and 55% of them are older than 55 years;
- ✓ 13 million patients suffering from rheumatoid arthritis have a moderate or severe level of the disease, which leads to disability and requires long-term rehabilitation;
- ✓ rheumatoid arthritis is a systemic autoimmune disease, in which the joints of the hands, wrists, feet, ankles, knees, shoulders and elbows are most often affected;
- ✓ more than 1.5 million people in the United States live with rheumatoid arthritis, a chronic autoimmune disease in which the immune system mistakenly attacks healthy tissue, leading to joint pain, bone erosion, deformity, limited mobility, and long-term disability [14, 15]:

• there is no cure for rheumatoid arthritis, and current pharmacotherapy is often limited by poor patient compliance and dissatisfaction with treatment;

• only 25% of patients with rheumatoid arthritis are satisfied with their pharmacotherapy, and up to 50% discontinue prescribed pharmacotherapy within two years, largely due to worsening outcomes or intolerable side effects from medication.

In modern conditions, studying the possibilities of using artificial intelligence in healthcare institutions using the example of the Pokhmursky Sisters Hospital of Traditional Medicine has the potential to revolutionize the treatment of rheumatoid arthritis due to faster, earlier and more accurate diagnostics, personalized treatment, rehabilitation measures and optimized monitoring [16]. At the level of use of medicines of all clinical and pharmacological, nomenclatural and legal, classification and legal groups in Ukraine, medical leeches are used during hirudotherapy in healthcare institutions during the treatment of patients with rheumatoid arthritis [17-19].

The purpose of the study was to consider the prospects for the use of hirudotherapy during the treatment and rehabilitation of patients with rheumatoid arthritis and the use of artificial intelligence technologies in modern treatment methods.

Materials and methods. Medical literature, patents on the websites of WHO, the USA, EU countries and Ukraine were studied and summarized [20-22]. The imperative material of the Ministry of Health of Ukraine, the Department of Health of the Lviv Regional Military Administration, the experience of the teaching staff of the departments of the Lviv Medical University and the Lviv National Medical University named after Danylo Halytsky, as well as the healthcare institution - the Medical Center of Traditional Medicine "Pokhmursky Sisters Hospital" were processed. Research data on 105 patients during 2021-2024 were analyzed. Research methods for rheumatoid arthritis are shown in Fig. 1 [23-26]. Laboratory tests include a complete and biochemical blood test, determination of rheumatoid factor, C-reactive protein and antibodies to cyclic citrulline-containing peptide, synovial fluid analysis. Instrumental methods: ultrasound diagnostics, magnetic resonance imaging, joint radiography.

Laboratory tests: erythrocyte sedimentation rate >30 mm after 1 h, increased concentration of fibrinogen and C-reactive protein, normocytic and hypochromic anemia, slight leukocytosis with unchanged leukogram, thrombocytosis (in very active form of the disease) or thrombocytopenia (as a drug complication), increased concentration of α1 and α2 globulin in plasma; rheumatoid factor of class IgM in the blood in ≈75% of patients (high titer correlates with rapid destruction of joints and development of extra-articular changes), antibodies to cyclic citrullinated peptide (in rheumatoid arthritis, sensitivity >50%, specificity 98%; present in ≈40% of patients without rheumatoid factor IgM; worsen the prognosis, similar to rheumatoid; are harbingers of rapid destruction of joints).

Synovial fluid examination: inflammatory fluid – rheumatoid factor (it may not yet be in the blood), possible ragocytes (neutrophils, macrophages, monocytes or synoviocytes that have phagocytized immune complexes).

Imaging diagnostics: X-ray examination of joints - the changes observed in this case depend on the stage of the disease

Ultrasound diagnostics makes it possible to detect synovitis and fluids in small and large joints, allows you to detect erosion of the joint surfaces earlier than with the help of X-ray examination; in tendons, loss of fibrous architecture, cyst or tendon rupture can be visualized.

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Magnetic resonance imaging makes it possible to detect synovitis, erosion of the joint surfaces and bone marrow edema early, which may precede synovitis.

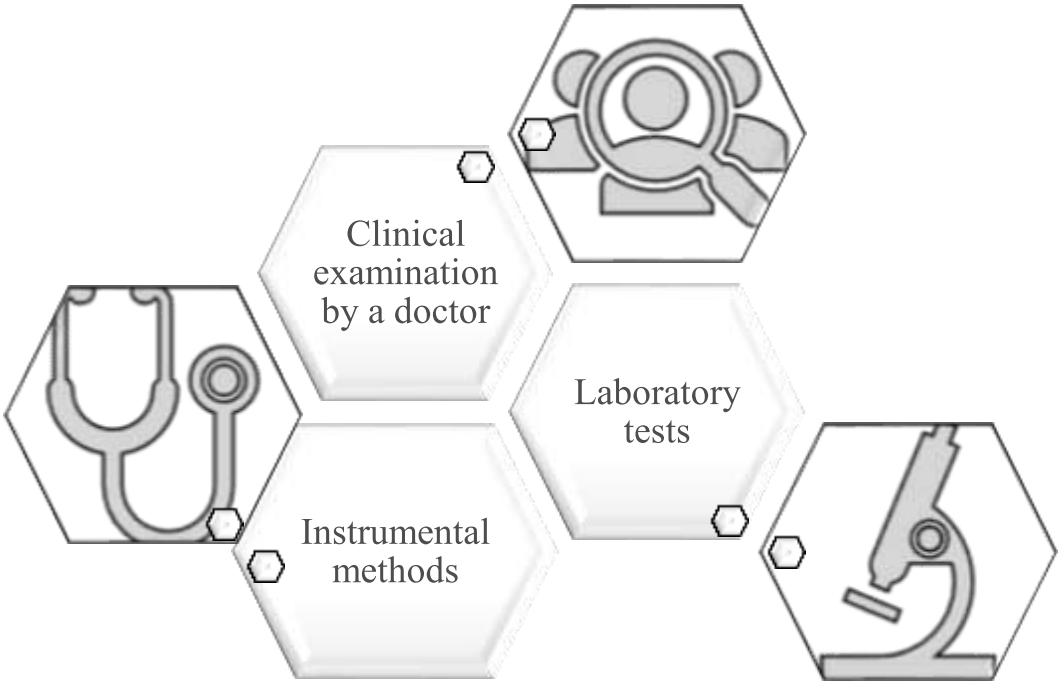

Fig. 1. Methods of investigation in rheumatoid arthritis [23-26].

Computed tomography allows to detect destructive changes in the joints much earlier than with the help of X-ray examination, is the best method of visualization of subchondral cysts (geodes) with preserved continuity of the cortical layer or with its slight interruption (with magnetic resonance tomography, an unchanged signal is observed, as a result of which changes may remain undetected); very effective in assessing changes in the cervical spine

In the treatment of rheumatoid arthritis, it is necessary to control the level of liver enzymes – aspartate aminotransferase and alanine aminotransferase. The fact is that drugs that can be hepatotoxic (harmful to the liver) are used in the treatment of rheumatoid arthritis, so liver function must be constantly monitored and, if necessary, the dosage of drugs must be adjusted.

The study is a fragment of the scientific research work of the Lviv Medical University on the topic “Improvement of the drug circulation system during pharmacotherapy on the principles of evidence-based and forensic pharmacy, organization, technology, biopharmacy and pharmaceutical law” (state registration number 0120U105348, implementation period 2021-2026).

Results and discussion.

Epidemiology of rheumatoid arthritis

According to the Center for Medical Statistics of the Ministry of Health of Ukraine, in 2017 in Ukraine (including Lviv region) the prevalence of rheumatic diseases was 9344.5 per 100 thousand population (5.5% in the structure of all diseases), which is shown in Fig. 2.

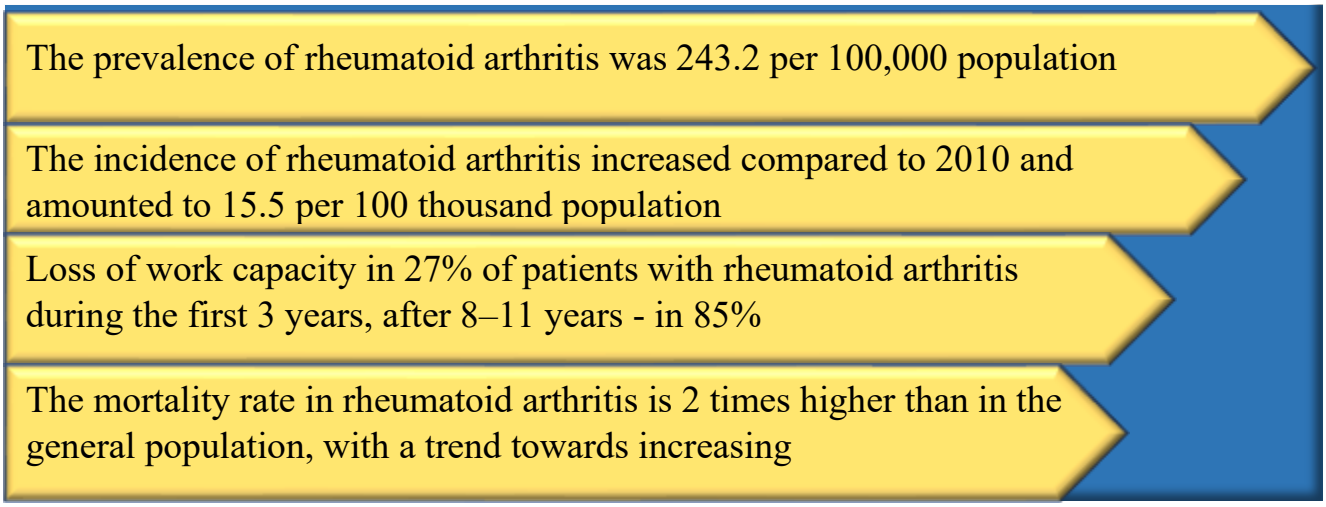

Fig. 2. Prevalence of rheumatic diseases [27].

Further studies indicate that in developed countries we have the following data regarding patients suffering from rheumatoid arthritis (Fig. 3).

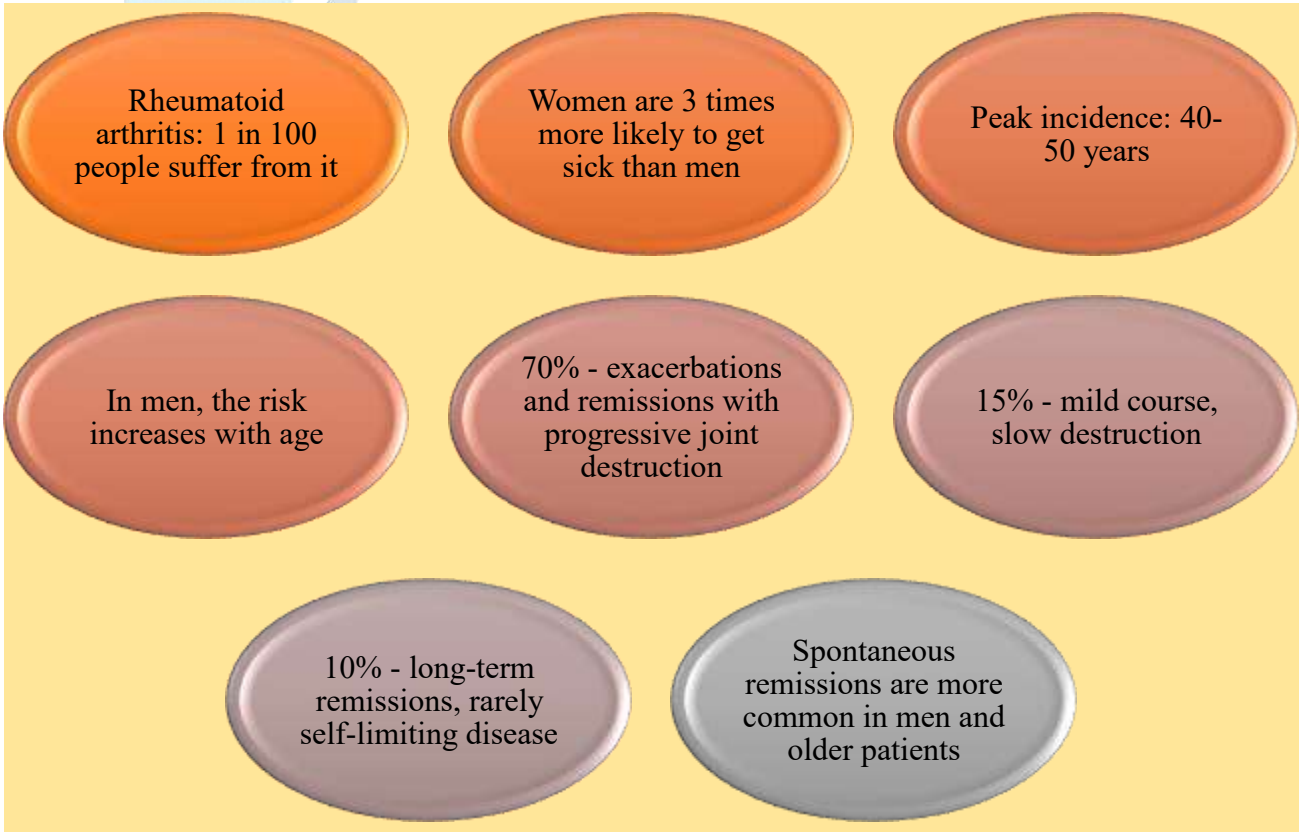

Fig. 3. Characteristics of the incidence of rheumatoid arthritis [28].

Usually the disease develops insidiously, over several weeks. In 10-15% of patients, the sudden onset of symptoms – within a few days. During pregnancy, in 75% of women, the symptoms decrease already during the first trimester. However, after childbirth and during lactation, they increase. In patients with arthralgia without other symptoms of inflammation and without another disease that could cause such pain, the risk of progression to rheumatoid arthritis is high if 3 of 7 criteria are present:

- joint symptoms have arisen recently (<1 year);
- symptoms from the metacarpophalangeal joints;

- duration of morning stiffness ≥60 min;
- maximum severity of symptoms in the early morning;
- difficulty in clenching the palm into a fist;
- positive lateral compression test of the metacarpophalangeal joints.

Fig. 4 shows the localization of joint changes in rheumatoid arthritis (Illustration by Zoe Hansen for Verywell Health) [28].

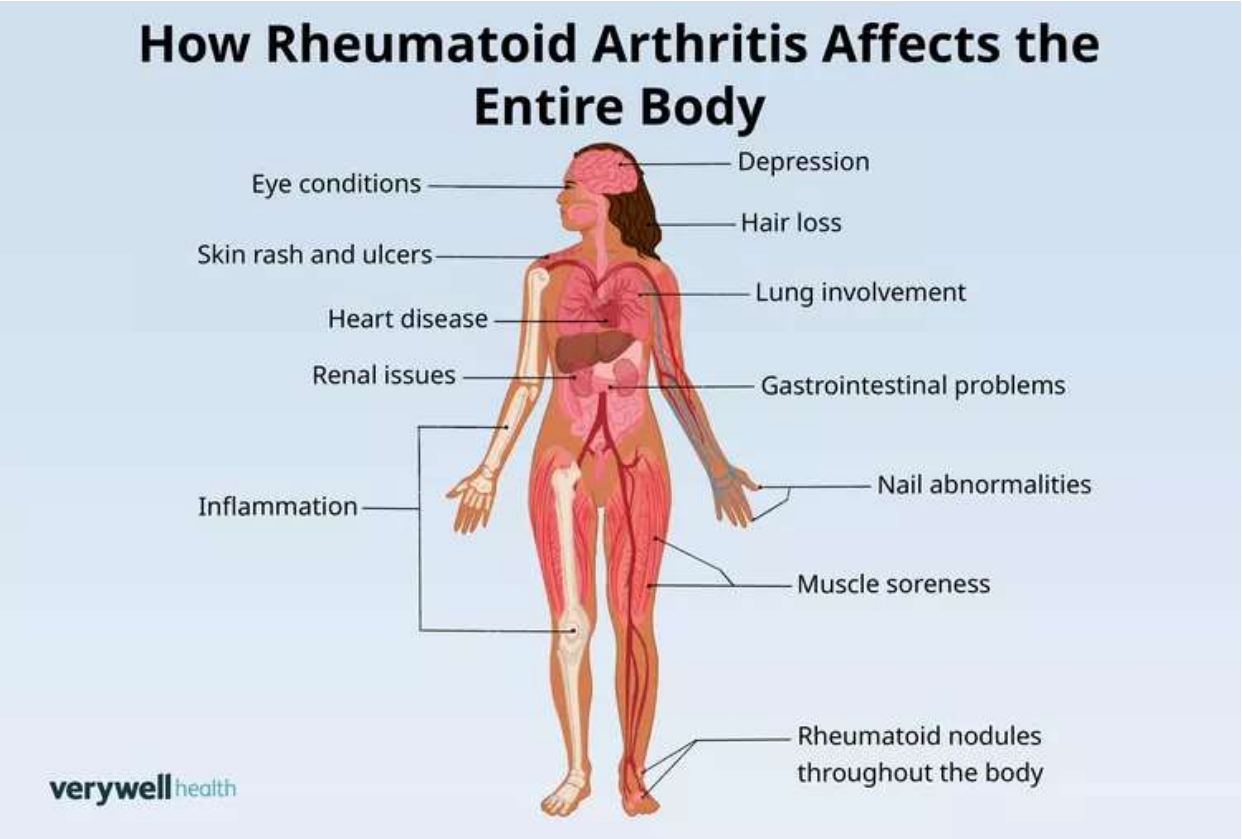

Fig. 4. Localization of joint changes in rheumatoid arthritis (Illustration by Zoe Hansen for Verywell Health) [28].

However, the studies of Dovzhuk V. et al. on the use of artificial intelligence in personalized medicine, alternative medicine, pharmaceutical design, in the search for optimal pharmacotherapy, and patient rehabilitation are relevant for the use of artificial intelligence technologies in hirudotherapy for patients with rheumatoid arthritis [29].

Studies show that artificial intelligence can improve the accuracy of diagnosis, rehabilitation, and monitoring of rheumatoid arthritis and related health disorders. Medical personnel and specialists familiar with digital technologies perceive it as a valuable tool. However [30-32]:

42% of participants named the lack of data standardization in medical systems as the main obstacle;

Artificial intelligence has the potential to revolutionize the treatment of rheumatoid arthritis through faster and more accurate diagnosis, personalized treatment, and optimized monitoring;

Early diagnosis refers to the process of detecting a condition in its early stages, before severe symptoms or complications occur, which is crucial to preventing disease progression and irreversible joint damage;

To ensure effective integration into clinical practice, issues such as cost, staff training, and data privacy need to be addressed;

Educational programs and interdisciplinary collaboration are essential to expand the implementation of artificial intelligence in rheumatology.

The essence of the disease lies in the inflammatory process that begins inside the joint. An unknown factor stimulates the synovial membrane, which lines the joint, to an inflammatory response. It grows and destroys neighboring structures (cartilage, bone, ligaments, tendons). Symptoms of this are initially pain and swelling, with subsequent irreversible destruction and loss of movement (mobility) of the joint. Damage to cartilage and other joint structures by the inflammatory process contributes to secondary degenerative changes.

Specialists have developed a unified clinical protocol for primary, secondary (specialized), tertiary (highly specialized) medical care and medical rehabilitation "Rheumatoid arthritis". Regulated by the order of the Ministry of Health of Ukraine dated April 11, 2014 No. 263 "On approval and implementation of medical and technological documents on the standardization of medical care for rheumatoid arthritis" [33].

The causes of rheumatoid arthritis have not been fully studied. The development of the disease requires the coexistence of many factors. The most important of them include the following (Fig. 5).

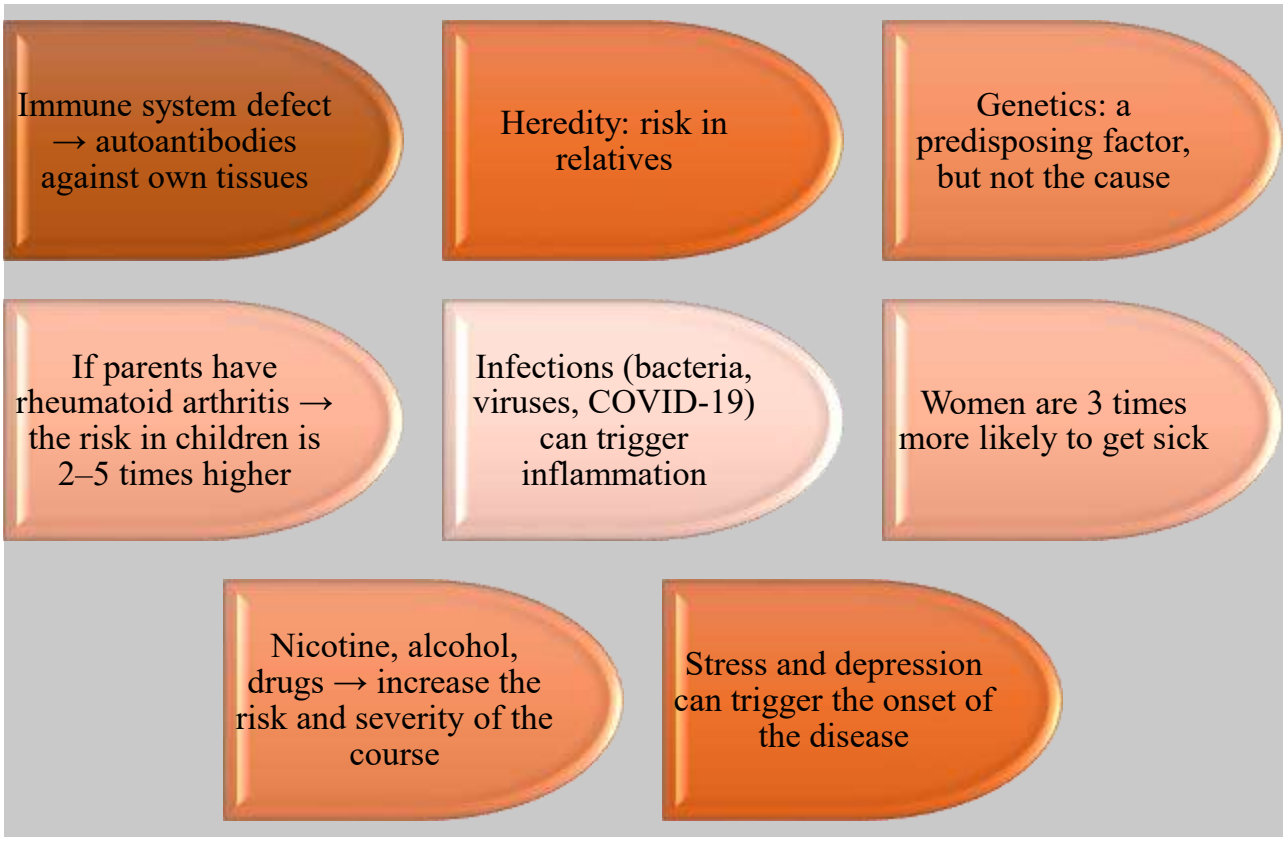

Fig. 5. Factors in the development of rheumatoid arthritis.

It is important to note that the disease usually attacks symmetrical sites on both sides of the body (swelling of the joints of the fingers), Fig. 6 [34]. Initially, these are small joints of the hands and feet. And as the disease progresses, many other joints. An atypical (but possible) onset of the disease is inflammation of one large joint (for example, the knee or shoulder), or migration of the disease through many joints.

Fig. 6. Early changes in rheumatoid arthritis (joint swelling) [34].

Clinical and diagnostic indicators of rheumatoid arthritis

The main symptoms of rheumatoid arthritis are shown in Fig. 7.

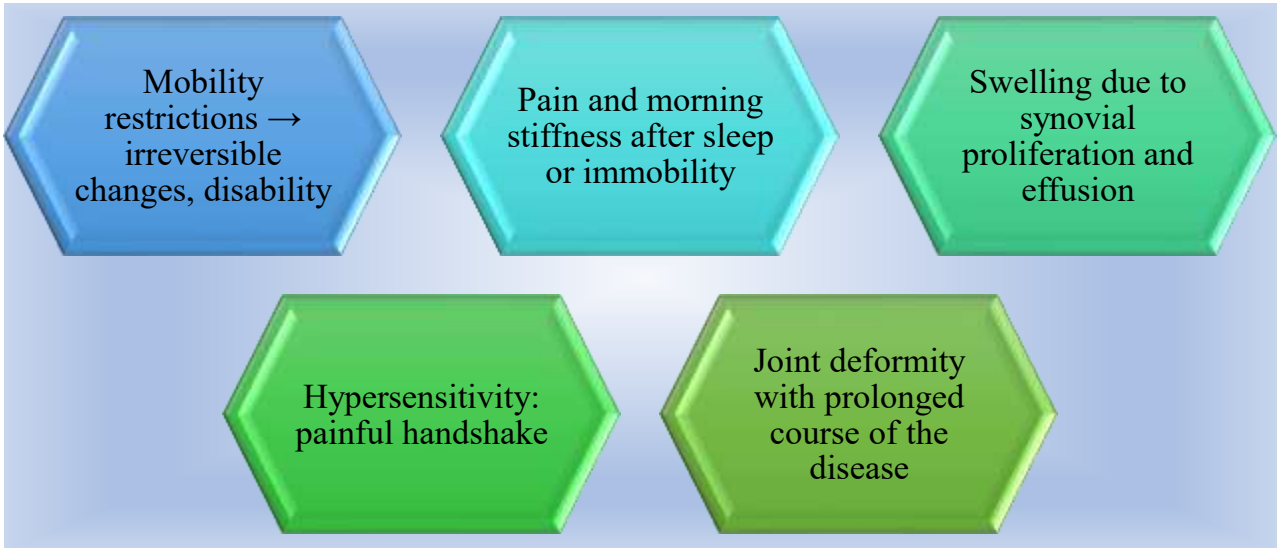

Fig. 7. Main symptoms of rheumatoid arthritis [35].

Clinical and diagnostic indicators of rheumatoid arthritis are given in the Table 2.

Table 1. Clinical and diagnostic indicators of rheumatoid arthritis [35].

Characteristic symptoms:	Symmetrical pain, swelling of the joints of the hands and feet, less often of large joints (e.g., knee or shoulder joints); morning stiffness of varying duration, usually >1 year.

General symptoms:	Subfebrile temperature, myalgia, fatigue, lack of appetite, weight loss.
Changes in the musculoskeletal system:	Arthritis, mainly symmetrical; in the early stage of the disease – the joints of the wrists, hands and feet are affected. The proximal interphalangeal, metacarpophalangeal and metatarsophalangeal joints are most often affected. Later, the knee, shoulder, elbow and hip joints may develop. The joints of the upper limb (especially the wrist) are affected much more often than the joints of the lower limb. An atypical onset is also possible – in the form of monoarthritis or palindromic rheumatism. In the early stages of the disease, the following symptoms are detected: slight hyperthermia around the joint, its soreness during compression. May be accompanied by: tendovaginitis and bursitis; changes in tendons and ligaments.

Changes in the musculoskeletal system include changes in the hand joints (Fig. 8), changes in the elbow joints (Fig. 9), changes in the shoulder and clavicular-acromial joints (Fig. 10), changes in the metatarsophalangeal joints (Fig. 11), changes in the ankle joints (Fig. 12), changes in the hip joints (Fig. 13), changes in the knee joints (Fig. 14), changes in the spinal joints (Fig. 15), changes in other joints (Fig. 16).

at an early stage

- fusiform edema of the proximal interphalangeal and metacarpophalangeal joints
- atrophy of the interosseous and vermiform muscles
- palmar erythema of the thenar area of the first finger and hypothenar

in the future

- deformities, most often elbow deviation of the fingers

in case of an advanced disease

- palmar subluxation of the phalanges
- fingers bent in the form of a swan's neck, in the form of cufflinks (due to changes in ligaments, tendons and muscle contracture)
- significant limitation of finger mobility

due to bone changes

- narrowing of the interarticular gap
- destruction of the tendon-ligamentous apparatus of the wrist
- development of carpal tunnel syndrome

Fig. 8. Changes in the joints of the hands.

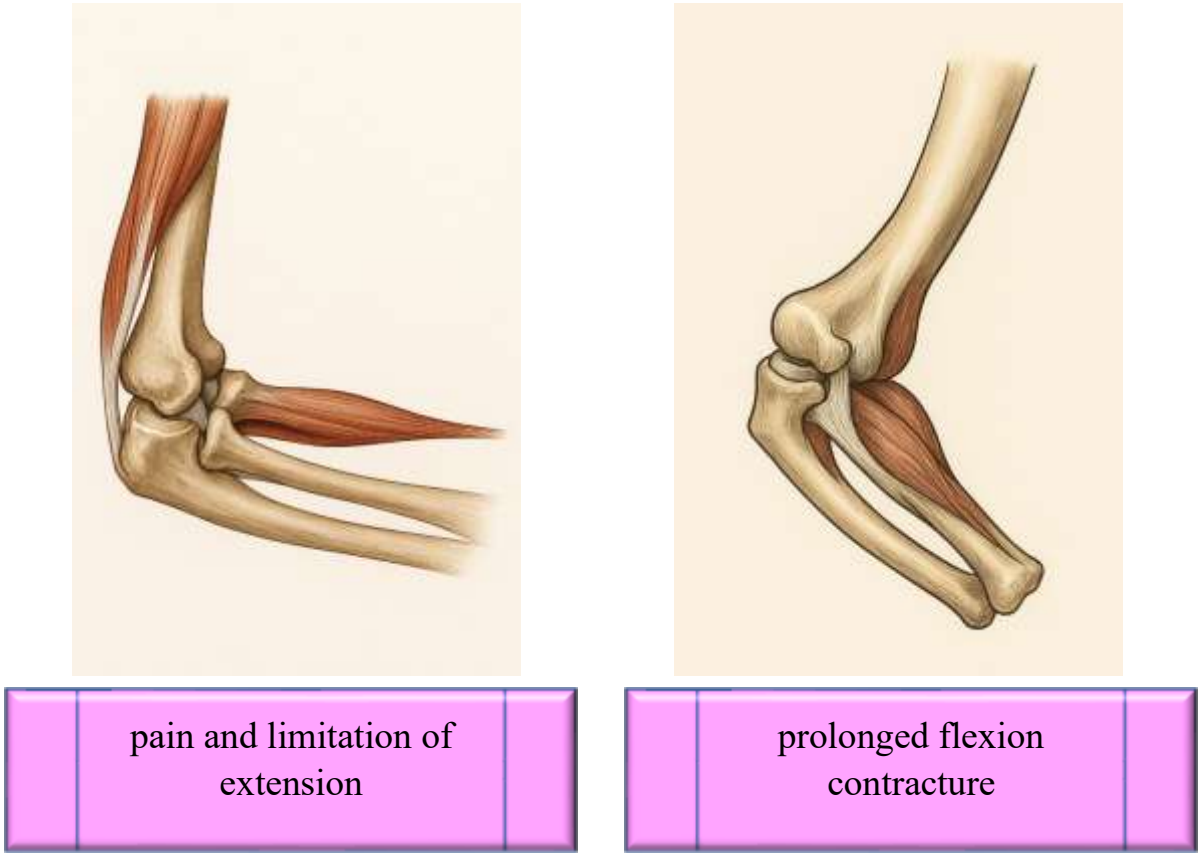

Fig. 9. Changes in the elbow joints (illustration created using artificial intelligence).

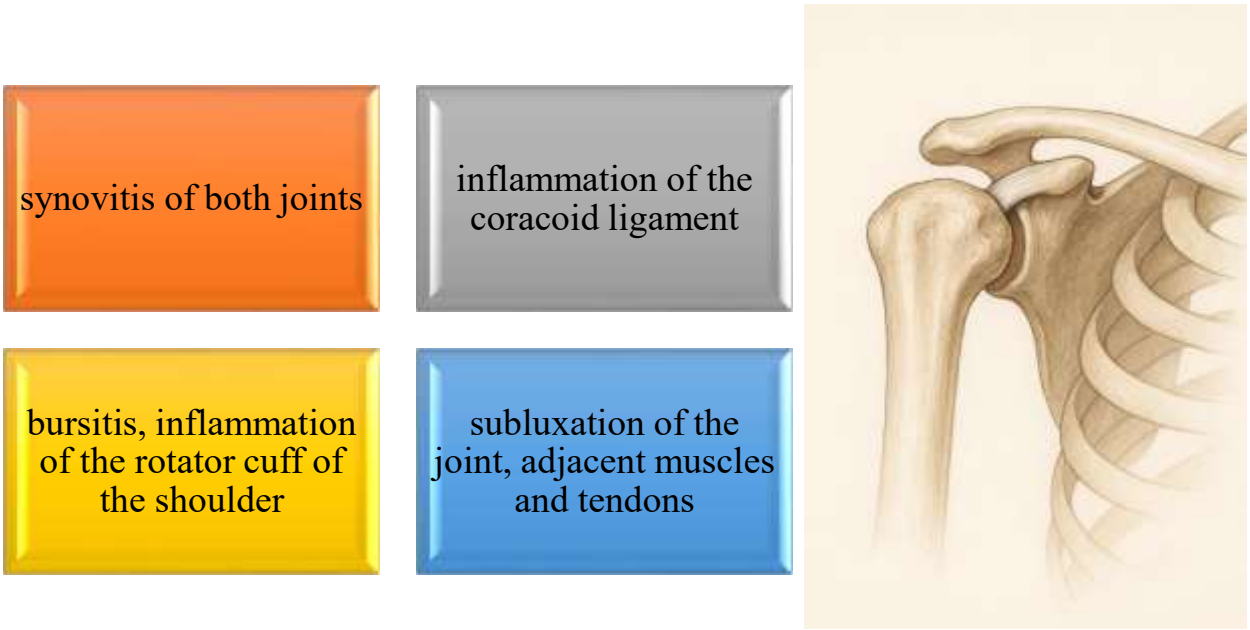

Fig. 10. Changes in the shoulder and clavicular-acromial joints (illustration created using artificial intelligence).

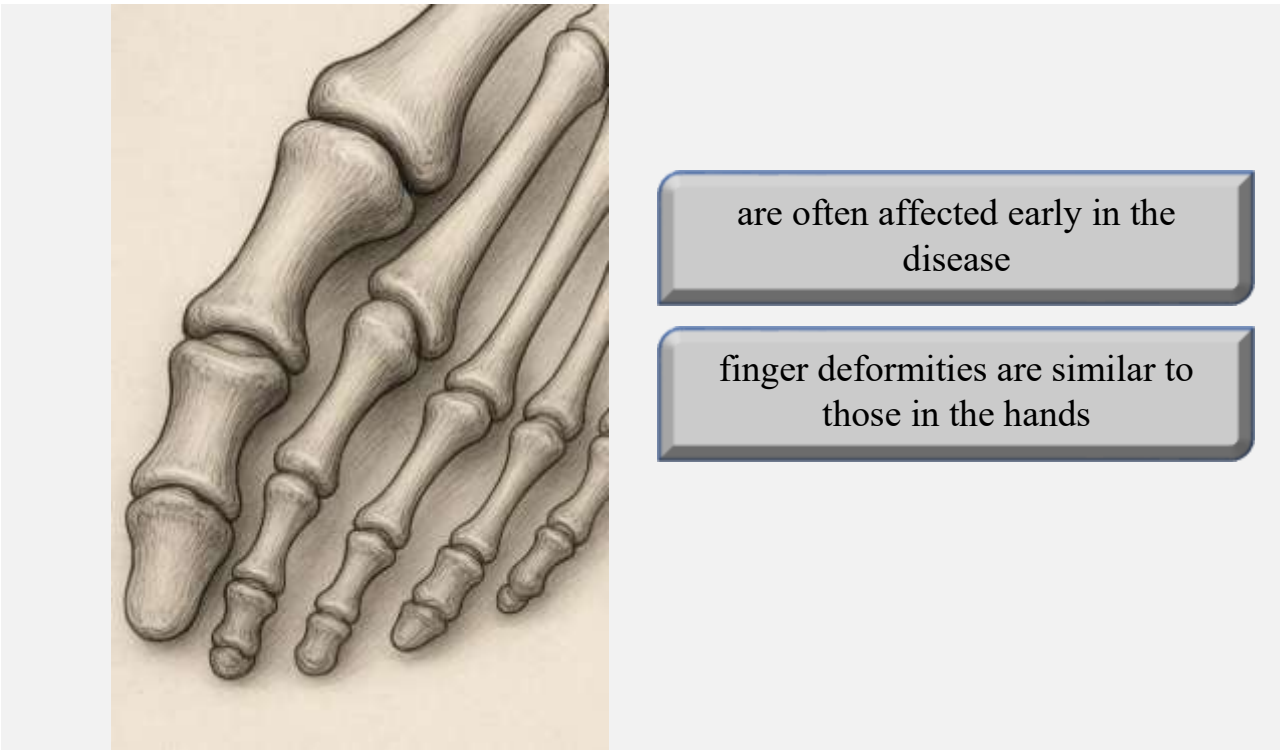

Fig. 11. Changes in the metatarsophalangeal joints (illustration created using artificial intelligence).

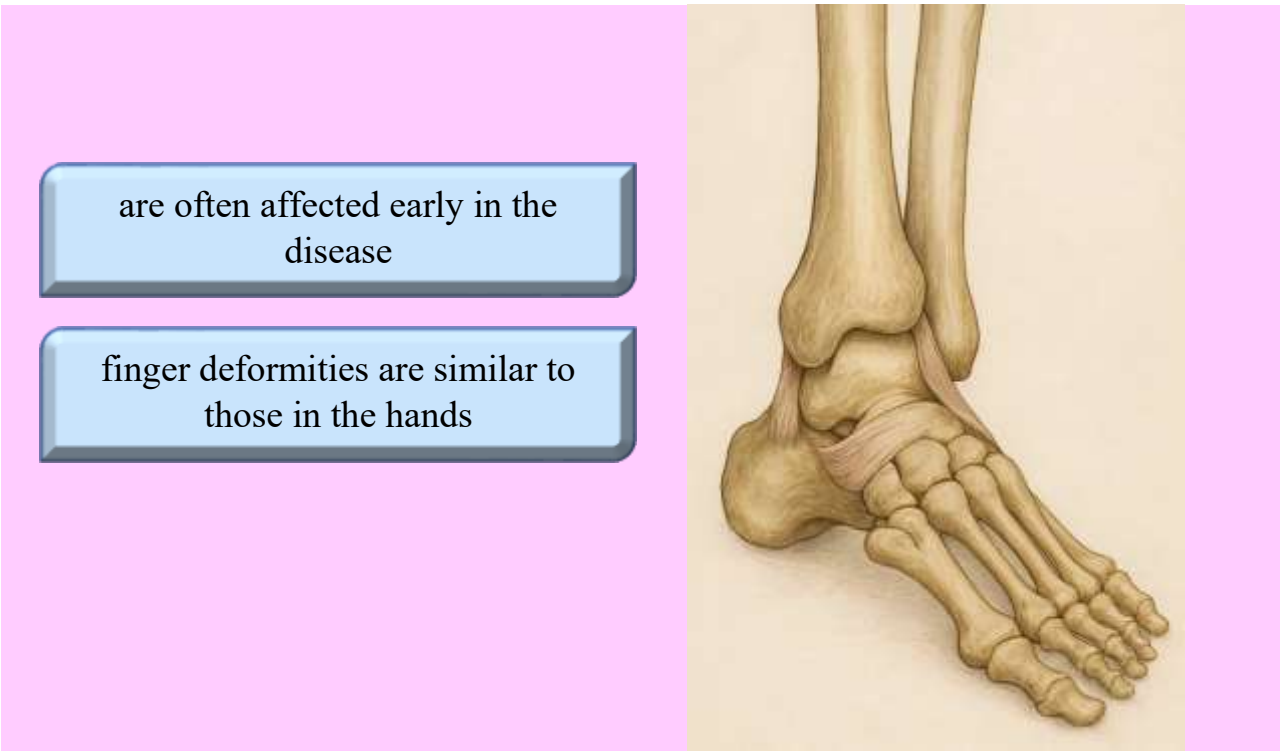

Fig. 12. Changes in the ankle joints (illustration created using artificial intelligence).

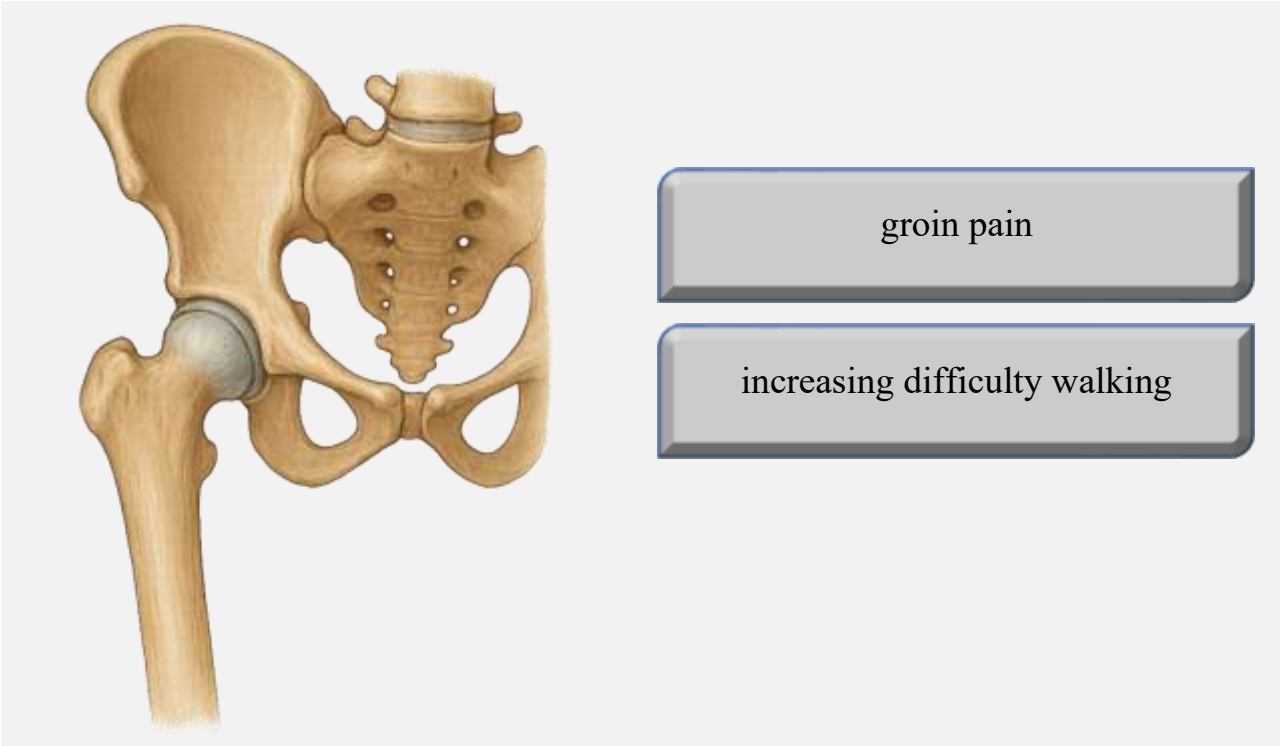

Fig. 13. Changes in the hip joints (illustration created using artificial intelligence).

rarely affected at the beginning of the disease
exudate in the joint leads to the appearance of a symptom of patellar bulging or a bulge on the outside of the joint
increases when pressing on the area above the patella
baker's cyst may develop – felt as a bulge in the popliteal region
Cyst rupture
fluid penetration into the tissues of the lower leg
significant swelling of the lower leg
increased pain
knee contracture

Fig. 14. Changes in knee joints (illustration created using artificial intelligence).

changes in the cervical spine are typical and present in most patients
lead to subluxations, microfractures, destruction of the fibrous ring of the intervertebral disc and prolapse of the nucleus pulposus

subluxation in the atlanto-axial joint is dangerous
pain radiating to the back of the head
paresthesia of the shoulder girdle and upper limbs
spastic paresis of the limbs with spinal cord compression

Fig. 15. Changes in the joints of the spine (illustration created using artificial intelligence).

pain in the temporomandibular region	hoarseness
difficulty opening the mouth and eating	sternoclavicular changes

Fig. 16. Changes in other joints.

The basis of the pathological process in rheumatoid arthritis is systemic autoimmune inflammation. The synovial membrane of the joints is most often affected. It is the development of progressive uncontrolled synovial inflammation that distinguishes rheumatoid arthritis from other chronic inflammatory diseases of rheumatic and non-rheumatic nature.

Stages of rheumatoid arthritis

The early stage (asymptomatic) is characterized by vascular and cellular activation [36]. The advanced stage (rapid chronicity of inflammation) is manifested by impaired angiogenesis, endothelial activation, cellular migration; infiltration of synovial tissue by activated CD4+ T-lymphocytes, the formation of rheumatoid factor and other autoantibodies, immune complexes; synthesis of pro-inflammatory cytokines, prostaglandins, metalloproteases, collagenases. The late stage is characterized by somatic mutations and defects in apoptosis of synovial tissues.

Thus, rheumatoid arthritis is a heterogeneous, multifactorial disease. Environmental factors and genetically determined risk factors lead to the formation of different variants of the course of the disease. This explains the difficulties of anti-inflammatory therapy of rheumatoid arthritis; it is effective within a rather narrow "therapeutic window". In the future, target cells lose the ability to respond to physiological "anti-inflammatory" stimuli and acquire resistance to pharmacological effects

Functional insufficiency of joints. Functional insufficiency of joints of the I degree is manifested in a slight restriction of movements in the joints; professional ability is preserved.

Functional insufficiency of joints of the II degree is a restriction of movements in the joints, persistent contractures, moderate difficulty in self-care, professional ability is lost. Functional insufficiency of joints of the III degree is stiffness or complete absence of movements in the joints, lost ability to self-care, the patient needs outside help

Extra-articular changes

Rheumatoid arthritis is a systemic disease that affects not only the joints, but also many organs, it is a long-term form of the disease with a severe course. In addition to relatively frequent mild lesions, such as rheumatoid nodules or dryness syndrome, severe complications leading to premature death (for example, stroke or myocardial infarction [37]) can very rarely occur.

Extra-articular changes are given in Table 2.

Table 2. Extra-articular changes in rheumatoid arthritis [37].

Rheumatoid nodules	painless subcutaneous nodules, most often located around the elbows, wrist joints and other places subject to pressure, can occur in internal organs
Atherosclerosis	accelerated development is the result of activation of inflammatory processes, complications of atherosclerosis are the main cause of premature death of patients, the risk of myocardial infarction, heart failure, sudden cardiac death, stroke is 2-3 times higher
Heart	in addition to ischemic heart disease, myocardial infarction, which is a consequence of the development of atherosclerosis, pericarditis, cardiomyopathy, damage to heart valves can also develop, symptoms of these diseases are chest pain, shortness of breath and decreased tolerance to physical exertion
Vessels	vasculitis (inflammation of blood vessels) is a rare but serious complication, leads to ischemia of various internal organs, ulcers can also appear on the fingertips and skin
Lungs	development of pleurisy and pneumonia, which cause dry cough, shortness of breath and chest pain
Osteoporosis	steroids, used in pharmacotherapy significantly accelerate the development of osteoporosis, it is important to start treatment early enough to reduce the risk of bone fractures
Eyes	a common symptom is dry conjunctivitis, characterized by a feeling of sand or a foreign body under the eyelids, other eye structures and vision problems are less common
Nerves	a common carpal tunnel syndrome, a rare but serious complication is spinal cord compression due to subluxation of the vertebrae in the cervical spine, symptoms include headache, sensory disorders (numbness, tingling, decreased pain sensitivity), weakness or paresis of the limbs, this is a condition that requires urgent medical attention
Kidneys	the disease and drugs used during pharmacotherapy can damage the kidneys; it is important to conduct regular control tests of kidney function
Hematological disorders	with prolonged illness, moderate anemia, abnormal leukocyte counts often occur, exacerbations of the disease are characterized by an increase in the number of platelets, an increase in lymph nodes and spleen

In the advanced form of the disease, changes are observed, which are shown in Fig. 17. Numerous rheumatoid nodules are visible above the joints [38].

Fig. 17. Changes in rheumatoid arthritis [38].

The use of drugs during pharmacotherapy of patients with rheumatoid arthritis includes the use of the following clinical and pharmacological groups of drugs [39]:

- nonsteroidal anti-inflammatory drugs - to reduce pain and inflammation in the joints, the drugs are prescribed for a long period of time until a clinical effect is obtained;
- glucocorticosteroids – to reduce the pronounced inflammatory process in the joints;
- drugs that suppress the activity of the immune system and are included in basic therapy – to reduce inflammation;
- targeted synthetic drugs;
- Janus kinase inhibitors.

The use of machine technologies of artificial intelligence is important for the early diagnosis of rheumatoid arthritis [40].

It should be noted that in the USA the FDA approved the SetPoint system, which is confirmed by the results of the randomized, double-blind, controlled study RESET-RA with the participation of 242 patients. It demonstrated the safety and efficacy of the SetPoint system in patients with moderate to severe rheumatoid arthritis. The SetPoint system is an implantable integrated neurostimulation device designed to deliver daily electrical stimulation of the vagus nerve, activating the body's innate anti-inflammatory and immunoregenerative pathways [41, 42]. This innovative therapy has the potential to revolutionize the care of patients with rheumatoid arthritis and offers a treatment option without compromising immunity. It is important to note that drug treatments for rheumatoid arthritis alleviate symptoms and accelerate remission, but the patient needs to regain motor function. For this, a set of specific physical exercises under the guidance of an instructor or independently is effective. Also, between exacerbations, physiotherapy procedures and therapeutic massage are effective for relieving residual symptoms of rheumatoid arthritis and for initiating regenerative processes in

damaged tissues. Among the methods of physiotherapy used: drug electrophoresis, low-frequency pulsed currents, ultrasound treatment, magnetotherapy, balneotherapy, etc.

Today, the recovery of patients with rheumatoid arthritis is impossible, but modern methods of rehabilitation and therapy allow achieving stable remission. At the same time, the patient can live and work fully. Active rehabilitation pharmacotherapy of patients with rheumatoid arthritis reduces the need for painkillers by 30-40% due to physical exercises [43, 44].

The benefits of physical exercises in rheumatoid arthritis are shown in Fig. 18. [45-47].

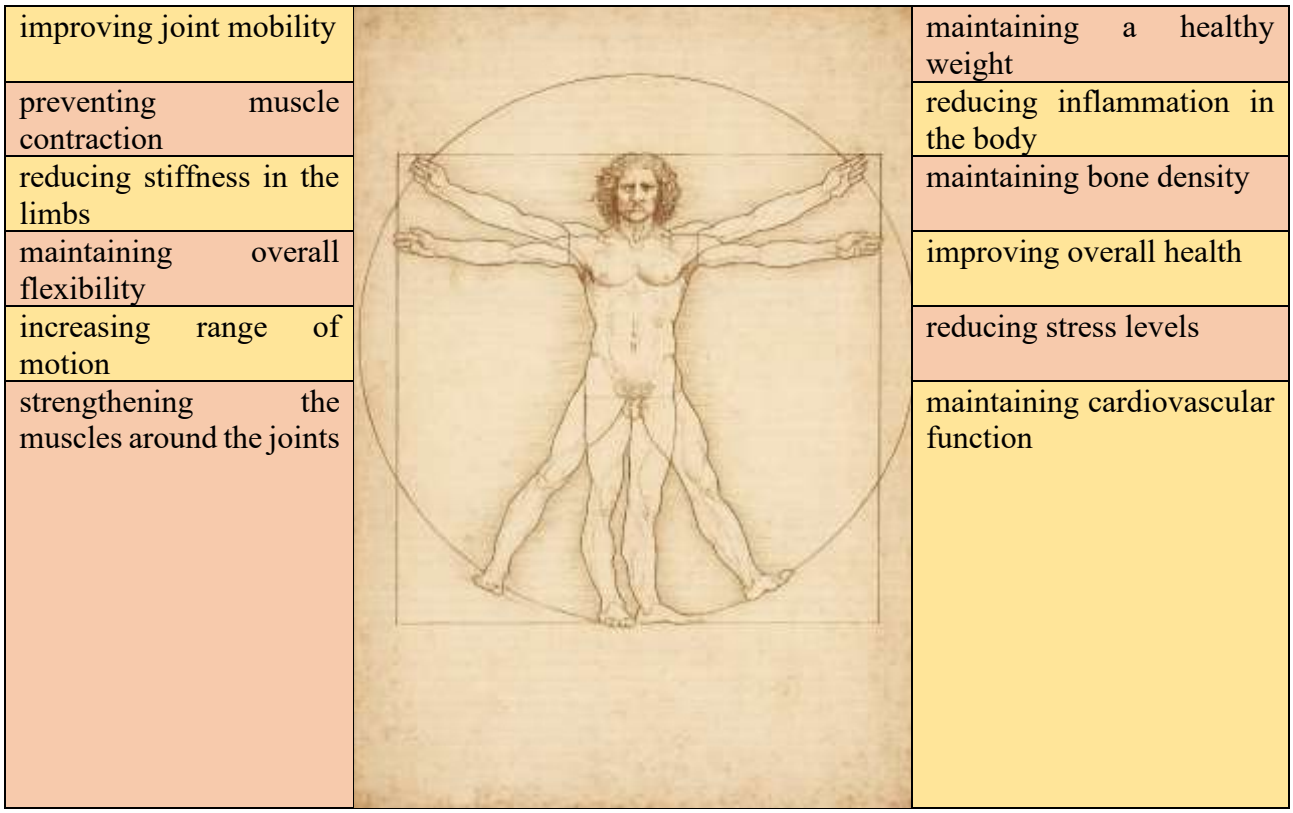

Fig. 18. The benefits of physical exercise in rheumatoid arthritis (illustration created using Sora artificial intelligence) [45-47].

The pathogenetic mechanisms of rheumatoid arthritis development consist of an inflammatory and immune component. A number of studies draw attention to the significant impact of microcirculation disorders on inflammation and destruction processes in the joints. The microcirculatory bed is actually a target organ where contact with the damaging agent occurs. As a result, inflammation occurs, metabolic and immune mechanisms are triggered.

The possibility of using hirudotherapy is considered as an addition to drug treatment and as a method that affects many links of the inflammatory process, primarily microcirculation [17, 21, 22, 48-52]. This method of treatment has practically no side effects, complications or contraindications. The effect of leech secretion is similar to the effect of chemotherapy administered subcutaneously with a long period of elimination from the body. Within 6 months, the leech secret will be detected in the blood of a person who has undergone a course of leech treatment in a sufficient therapeutic dose, as this can stabilize the patient's condition for a long period of time. When bitten, the leech forms a skin-capillary shunt, and thanks to hyaluronidase activity, delivers enzymes directly to the focus of inflammation, so it is very important to choose the right points for application to the affected joints to ensure maximum contact of the active substances with the target organ. The hyaluronidase enzyme helps to balance the hyaluronidase - hyaluronic acid balance, as a result of which it is possible to achieve a reduction in excess synovial fluid in the joint, which always accompanies synovitis and bursitis, and the effect lasts for a long time.

The antihypoxic effect of hirudotherapy is due to the fact that biologically active substances in the saliva of leeches are able to reduce edema, relieve vascular spasm, increase tissue oxygen saturation, dilate arteries without increasing blood pressure, and restore microcirculation. This is especially noticeable when leeches are placed directly on the focus of inflammation (painful points in the joint). The effectiveness of hirudin as a separate independent drug, as well as as a component of complex drugs (hirudon, anticoagulant complex) in the treatment of patients with thrombosis has been proven. Its advantages over heparin have been identified: achieving the effect in lower doses, the absence of side effects, including the development of hemorrhages, which is easier to control. Studies have shown a direct correlation between the dose of hirudin and the active partial thromboplastin time indicator. This makes it possible to use the active partial thromboplastin time as a criterion for assessing the effectiveness of leech treatment, as well as to avoid the risks of overdose of the procedures.

The analgesic effect of hirudotherapy is probably associated with the correction of microcirculation of transcapillary exchange, improvement of blood flow, blocking of pain [53-56]:

- ✓ leech secretion affects the level of endorphins, which are involved in the formation of the pain threshold in the receptor apparatus;
- ✓ kinases contained in leech saliva reduce the activity of bradykinin, which stimulates pain;
- ✓ hirudin and destabilase not only block platelet aggregation, reduce the proliferation of the vascular wall, increasing its permeability, but also provide a more effective analgesic effect of cytomedins;
- ✓ anti-inflammatory effect of medical leeches, blocks amidolytic and kininogenase activity;
- ✓ blood plasma kallikrein inhibits the formation of kinins, which are one of the triggering mechanisms of inflammation, as well as mediators of pain syndrome.;
- ✓ isolated eglins inhibit a-Chymotrypsin, subtelisin, neutral proteases of human granulocytes: elastase and cathepsin G, which are able to block the activity of leukocyte processes.

It is generally accepted that the immune system interacts with hemostasis through Hahnemann's contact factor, the kinin-kallikrein system, complement and the formation of autoantibodies to individual blood clotting factors. It has been established that after the application of leeches, the number of lymphocytes in the peripheral blood increases, phagocytosis is stimulated. Anticomplementary activity and activation of macrophages are apparently direct manifestations of the properties of hirudotherapy.

The multifactorial effect of hirudotherapy indicates the possibility of using and developing leech treatment methods in rheumatology, in particular in rheumatoid arthritis. In rheumatoid arthritis, leeches are placed above the lesion and on biologically active points.

In the USA, medical leeches are an FDA-approved hirudotherapy method for the treatment of a wide range of diseases [57-60]:

- venous stasis in transplanted tissue and others;
- they should be considered for non-operative tissue salvage in patients after plastic surgery;
- if used correctly, leeches can provide sufficient venous outflow before the occurrence of neovascularization of the flap;
- patients undergoing hirudotherapy should be monitored and treated for serious complications such as infection and anemia;
- additional studies are needed to assess the marginal benefit of medical leeches for venous stasis and to provide an accurate and up-to-date assessment of the risk-benefit ratio of their use.

In Ukraine, at the Pokhmursky Sisters Hospital, a medical center specializing in the use of alternative (folk) and complementary medicine methods, the authors of the article conducted a trial of hirudotherapy in patients with rheumatoid arthritis [61]. The studies lasted from 2021 to 2024. Patients with joint damage diagnosed with rheumatoid arthritis were treated and monitored. 105 patients participated in the observation.

Ninety-two patients received daily supportive basic drug therapy prescribed by a rheumatologist. These were mainly non-steroidal anti-inflammatory drugs, corticosteroids, cytotoxic

drugs of the antimetabolite class in various variations. Despite the constant use of medications, patients periodically complained of worsening pain and swelling in the joints. That is, only basic pharmacotherapy was not enough to treat these patients. Thirteen patients took basic drug therapy irregularly, since the pain was not very pronounced.

According to ultrasound diagnostics and X-ray diagnostics, patients were divided into four groups:

- the first group – 54 patients with arthrosis of the joints of the I degree (accompanying lesions on ultrasound diagnostics were synovitis, bursitis, tendinitis);
- the second group – 39 patients with arthrosis of the II degree;
- the third group – 9 patients with arthrosis of the III degree;
- the fourth group – 3 patients with arthrosis of the IV degree.

During the initial visit to the traditional medicine health care institution "Pochmursky Sisters Hospital", each patient was in the acute stage and was taking the drug therapy prescribed by the rheumatologist. The patients were dissatisfied with the effect of the prescribed treatment and therefore sought additional alternative treatment. The patients were prescribed a course of hirudotherapy (Fig. 19), which included the placement of leeches over the affected joints and on biologically active points with analgesic, immunomodulatory, and general strengthening effects. The number of sessions of application varied depending on the stage of arthrosis and was from 5 to 10 per course. The number of leeches in one session was from 2-3 to 5-6 depending on the placement site and the severity of the disease. As a result of the treatment, swelling in the joints decreased, joint mobility improved, pain intensity and the need for medications decreased. We were able to reduce the dose of drugs in 49 patients from the first group of patients, in 22 from the second group and in 5 from the third group.

12 patients from the first group achieved stable remission, which allowed them to completely discontinue non-steroidal anti-inflammatory drugs and corticosteroids. The remaining 42 patients remained on basic drug therapy with a reduced dosage and experienced a noticeable reduction in pain and stiffness of the joints. 29 patients from the second group and 2 patients from the third group experienced a noticeable reduction in pain and stiffness of the joints on basic anti-inflammatory pharmacotherapy.

Fig. 19. Leech application for rheumatoid arthritis [61].

Effectiveness of hirudotherapy depends on the degree of arthrosis and joint deformity
Hirudotherapy is effective for 1-2 degrees of arthrosis
Hirudotherapy is less effective for the 3rd degree of arthrosis, but is present
Hirudotherapy is ineffective for the 4th degree of arthrosis
Medical leeches are used once and have accompanying documents that allow their use in medical practice: • veterinary certificate • quality certificate • leeches are disposed of after the procedure in accordance with established rules

Fig. 20. Conclusions of the use of hirudotherapy in rheumatoid arthritis (illustration created using artificial intelligence).

The authors of the article summarized the monitoring data of the use of hirudotherapy in rheumatoid arthritis for 3 years from the moment of patients' request for treatment to discharge (Fig. 21).

Best indicators
in preserving the structure of the joint were observed in patients with seronegative and low RA activity index on the DAS 28 scale (Disease Activity Score 28), who underwent leeches treatment every 6 months. Such patients had stable periods of remission, which allowed them to be drug-free for a long time
Average indicators
in patients with seronegative rheumatoid arthritis and a low activity index who underwent a course of hirudotherapy once every 2 years, progression of joint damage on ultrasound and more frequent exacerbations of the disease were observed
Low indicators
in patients with seropositive rheumatoid arthritis of high activity, despite the daily use of basic pharmacological therapy, exacerbations occurred more frequently and the need for repeated hirudotherapy was observed more often than every 6 months, and joint deformity progressed

Fig. 21. Generalization of the use of hirudotherapy in rheumatoid arthritis.

Conclusions. Rheumatoid arthritis is a common systemic autoimmune disease that leads to significant disability and disability, particularly in patients of working age. Modern pharmacotherapy provides symptom control, but is not always sufficient to achieve long-term remission and patient satisfaction with treatment. Hirudotherapy demonstrates effectiveness as an auxiliary method in patients with rheumatoid arthritis, especially in the early stages of the disease, which helps reduce pain, swelling and the need for medications. Biologically active substances in the saliva of medical leeches have anti-inflammatory, analgesic, anticoagulant and immunomodulatory effects, which positively affects the course of the disease. Artificial intelligence technologies have significant potential in the diagnosis, monitoring and personalized rehabilitation of patients with rheumatoid arthritis, ensuring accurate prognosis and increasing the effectiveness of therapy. The combination of traditional pharmacological approaches, hirudotherapy and innovative digital technologies can significantly improve the quality of life of patients, reduce the risk of complications and increase the effectiveness of the treatment process.

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Ethical approval. Ethical clearance was obtained from the administration of the medical center "Pokhmursky Sisters Hospital". Permission statement for conducting the experiments was received from the administration of the medical center "Pokhmursky Sisters Hospital". Before any data collection, the main purpose of the study was clearly explained to each Before data collection, the main purpose of the study was clearly explained to each patient (interested personnel).

Data availability statement. The datasets analyzed during the current study are available from the corresponding author on reasonable request

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