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AREAS OF USE OF METALS IN MEDICINE

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Abstract: This article covers the areas of application of metals in medicine. Metals are widely used in medicine in the manufacture of prostheses, implants, surgical instruments and diagnostic tools. Their biotechnological properties, corrosion resistance and biological compatibility make them important materials in medical and surgical practice. In particular, the importance of metals such as titanium, stainless steel, cobalt-chromium alloys, gold and silver is emphasized. The article also analyzes the effect of these metals on the human body, their safety and long-term service life. The study also covers innovations and prospects in medical metallurgy.

Keywords: medicine, metal, titanium, implant, prosthesis, surgical instrument, biocompatible, corrosion, stainless steel, cobalt-chromium, gold, silver, diagnostics, materials science, biocompatibility, medical technology, safety, bioinertness, innovation, medicinal

1.Introduction

The development of modern medicine relies on many technological advances, one of which is the role and importance of metals in medicine. Although metals have been used to maintain and restore human health since ancient times, today their areas of application have expanded significantly. In particular, metals and their alloys, which have properties such as high mechanical strength, corrosion resistance, biocompatibility, and chemical inertness, have become the most important materials for modern medical procedures. Some of the metals used in medicine - for example, titanium, cobalt-chromium alloys, stainless steel, gold, silver, and platinum - perform many important functions[1]. Titanium is used in bone implants, cobalt-chromium in prosthetic systems, and stainless steel in surgical instruments. The main advantage of these metals is that they do not have an allergic or toxic effect on the human body, have a long service life, and are resistant to various physicochemical factors. Therefore, when choosing metal materials in the medical field, not only their physical and chemical properties, but also their biological safety are of great importance.

On the other hand, medical metallurgy is not limited to the use of existing materials, but is also aimed at developing new generation biomaterials. In this case, their effectiveness is being increased by creating metal nanoparticles, bioactive surface coatings, and corrosion-resistant thin films[2]. Metal materials developed based on new technologies are successfully used in pacemakers, artificial heart valves, orthopedic screws, and other types of implantable devices. Such processes not only simplify surgical procedures, but also reduce the patient's recovery time and accelerate the rehabilitation process. The wide-scale use of metals in medicine is directly related to the strength, reliability, and long-term service

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life of medical devices. At the same time, environmental safety and recyclability are also urgent issues. In short, the use of metals in medicine is not only a combination of science and technology, but also an important direction aimed at improving human health and quality of life[3].

2. Research and method

This study examined how metals and their alloys are used in medicine, their effectiveness and safety, as well as their physical, chemical, and biological properties. During the study, previously published scientific articles, monographs on medical technologies, metrological reports, and recommendations of international health organizations were analyzed. The goal was to identify the most commonly used metals and their properties in medicine, and to evaluate the effectiveness of implants, prostheses, and devices made from them and their effects on the human body[4]. The study used analytical, experimental, and comparative methods. The physicochemical and biological characteristics of each metal were studied using the analytical method. In the experimental part, statistical analyses were conducted on the effects of different metals on the human body based on the available data. Using the comparative approach, a comparative analysis of different metals was conducted. In particular, the corrosion resistance, biocompatibility, strength and reliability of metals such as titanium, stainless steel, cobalt-chromium alloys, gold and silver were determined, and the service life, safety and adaptation of medical devices made on their basis to the patient's body were studied. The metals were evaluated in various aspects: their weight, elastic modulus, tensile strength, biological inertness, corrosion resistance and cost-effectiveness. In particular, titanium and its alloys have a high level of biocompatibility and are distinguished by being one of the lightest metals in terms of weight. Stainless steel is distinguished by its low cost and strength, but can sometimes cause allergic reactions in cases of long-term contact. Cobalt-chromium alloys, on the other hand, are highly valued in terms of mechanical strength, but have a slightly higher weight. Gold and silver are usually used in aesthetically necessary dental devices, skin and facial implants[5].

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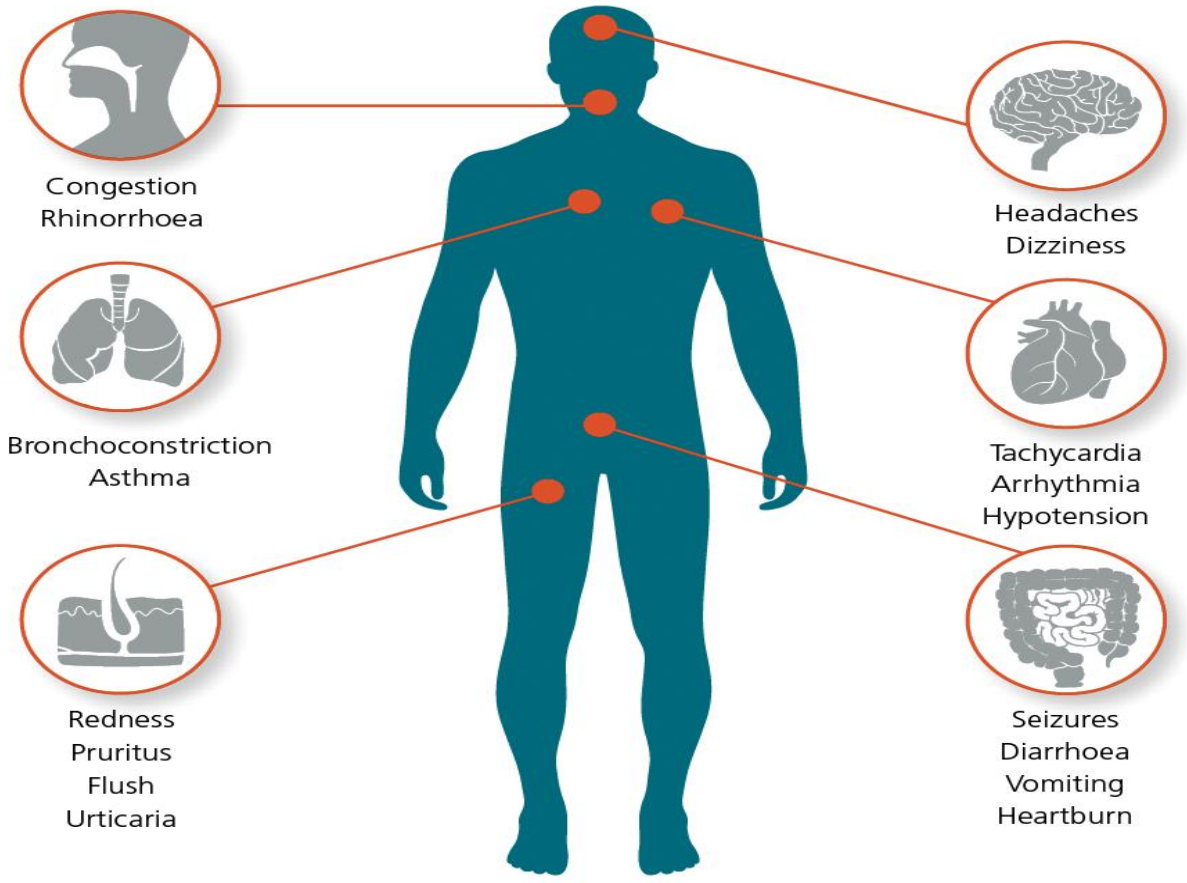

Figure 1. Use of metals in the human body

The table summarizes the main properties, advantages and disadvantages of metals widely used in medicine. The results show that in medical practice, each metal is selected for a specific task: for example, titanium is used in bone implants, cobalt-chromium in joint prostheses, and stainless steel is used in equipment and surgical parts. When choosing such materials, doctors and engineering specialists work together, which ensures patient safety and a long service life of the medical device. Based on the data recorded during the study, prospects for developing new innovative approaches, improving biomaterials and creating implants that meet the needs of individual patients were also identified. The possibility of manufacturing metal implants using modern 3D printers, their individualized manufacture and thereby reducing the complexity of operations were also discussed[6].

Based on the analysis, titanium was considered the most recommended and in many ways universal material among all the metals considered. However, since each metal has its own characteristics, they should be used in practice with purpose and caution. Such research requires a scientific approach to the process of metal selection in medicine, which is an important step in the development of medical technologies[7].

Table-1.
The Use of Metals in Medicine

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Metal	Biocompatibility	Corrosion resistance	Strength	Weight	Main application area	Advantages	Disadvantages
Titanium	Very high	Very high	Good	The lightest	Bone implants, pacemakers	Lightweight, non-toxic, long-lasting	The price is relatively high.
Stainless steel	Medium	High	High	Average	Surgical instruments, prostheses	Cheap, durable	May cause allergic reactions
Cobalt-chrome	High	High	Very high	Heavy	Dentures, joints	Very strong, abrasion resistant	Heavy, high price
Gold	Good	Very high	Average	Heavy	Dental veneers, aesthetic implants	Inert, non-allergenic	The price is too high.
Silver	Good	High	Average	Average	Dentistry, wound dressings	Antibacterial, aesthetic	Expensive, sometimes color can change

3. Results and discussion

The results of the study show that the use of metals in medicine directly depends on their physicochemical properties, biological compatibility and technological processing capabilities. According to the analysis, the most effective and widely used metal is **titanium** , which is considered an ideal material for bone implants, pacemakers, orthopedic screws, and many other implantable medical devices. The main advantages of titanium are its biological inertness, non-allergic reactions, light weight and high corrosion resistance. Especially with long-term use, titanium perfectly adapts to the body, which makes it a universal medical metal[8].

Also, Stainless steel is widely used in medical surgical instruments, short-term implants, and orthopedic structures. Its low cost, strength, and machinability make it an effective and economically viable material. However, long-term use can sometimes lead to corrosion or allergic reactions, which limits its use.

Cobalt-chromium alloys are used where high strength and elasticity are required, particularly in joint prostheses and dental systems. These alloys are characterized by long service life and resistance to high loads. However, they are heavier and more expensive than titanium, and can sometimes cause adverse biological reactions in some patients.

Gold and silver is used mainly for its aesthetic and antibacterial properties. Gold is used in dental crowns, facial reconstructions, and sometimes heart valves. It is biologically inert, aesthetically pleasing, and well-adapted to the body. Silver is used in wound dressings, dental antiseptics, and sometimes internal implants because of its antibacterial properties.

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However, these metals are economically very expensive and are chosen only for specific situations. Another important aspect of the study is that the use of metals in medicine is in a state of constant evolution. New biomaterials - for example, nano-sized metal particles, bioactive coatings and individual implants produced using 3D printers - are offering advanced opportunities in medicine. In particular, 3D printing technologies open up wide possibilities for the manufacture of customized individual implants from titanium and other metals. This allows for a reduction in surgical time, accelerated patient rehabilitation and increased safety. During the discussion, it became clear that when choosing metals, attention is paid not only to their physical and chemical properties. The individual condition of the patient, the part of the body where the implant will be placed, the duration of use and the level of load are also taken into account. For example, for pacemakers or valves, only 100% reliable, inert and corrosion-resistant materials are selected, which can be titanium or platinum-based materials. At the same time, in dentistry, attention is also paid to the patient's appearance, and aesthetically attractive gold and silver are preferred[9].

The role of metals in medicine is enormous, and each material is indispensable in performing a specific task. Titanium is an ideal material in many cases, stainless steel is economically viable and widely used, cobalt-chromium is superior in areas where high loads and mechanical strength are required, and gold and silver are distinguished by their aesthetic and antibacterial properties. In the future, innovations in the field of biomaterials, especially nanotechnologies and customized manufacturing methods, will further increase the efficiency of using medical metals.

4.Conclusion

Based on the results of the research, it can be said that the role of metals in medicine is incomparable, they are important components of various diagnostic, therapeutic and surgical procedures. Each metal or its alloy is designed to perform a specific medical task due to its unique physicochemical and biological properties. Their effectiveness, safety and durability in medicine are directly related to their effect on the patient's body and the duration of use. First of all, titanium and its alloys have been highly valued as a universal medical biomaterial. It is widely used in everything from bone implants to pacemakers. The main advantages of titanium are light weight, high corrosion resistance, non-toxic inertness and excellent biocompatibility with the body. In this regard, it is the most recommended metal in medicine. Stainless steel is widely used in surgical instruments, short-term implants, and other devices due to its cost-effectiveness, ease of processing, and sufficient strength. However, its biological safety in long-term use is relatively low and can sometimes cause allergic reactions. Therefore, it is used with certain restrictions. Cobalt-chromium alloys are widely used in areas where strength, wear resistance, and elasticity are required, particularly in dentistry and orthopedics. Such alloys can withstand high loads, but their price and weight are higher than titanium. In such cases, the choice of material is based on the patient's condition and the type of surgery. Metals such as gold and silver are used more for aesthetic and antiseptic purposes, such as in dentistry, cosmetic implants, and wound dressings. Gold is inert, corrosion-resistant, and aesthetically pleasing, while silver has antibacterial properties and reduces the risk of wound infection. However, due to the high cost of these metals, they are only used in specific situations[10]. When choosing metals in the medical field, attention is primarily paid to their biocompatibility, non-toxicity, corrosion resistance, service life and mechanical strength. Modern medicine also uses 3D

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printing technologies, nanoparticles and bioactive coatings to develop special medical metal structures. This allows for the creation of individual implants suitable for each patient. In conclusion, the use of metals in medicine is not only a technological advance, but also an important direction aimed at improving human health and quality of life. By selecting the most optimal metal based on research, testing and scientific approaches, patient safety, treatment outcomes and rehabilitation can be significantly improved. In the future, scientific research in the field of metal biomaterials is expected to bring this process to a more efficient and safe level.

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