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TREATMENT OF MULTI-FRAGMENT DIAPHYSEAL BONE FRACTURES BY BLOCKING INTRAMEDULLARY OSTEOSYNTHESIS TECHNIQUE (ANALYSIS OF ERRORS AND COMPLICATIONS)

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Возрастание уровня травматизма и распространенности ортопедической патологии определяет необходимость совершенствования диагностики и лечения повреждений и заболеваний опорно-двигательного аппарата как приоритетного направления развития здравоохранения. Улучшение диагностических возможностей современных методов визуализации состояния костей, суставов и мягких тканей, расширение сферы применения высокотехнологичных малоинвазивных способов остеосинтеза позволят изменить концепцию предоставления ортопедо-травматологической помощи.

Приведенный обзор литературы посвящен актуальности проблемы и анализу структуры травматических повреждений, а также принципиальным преимуществам их лечения методом внутрикостного остеосинтеза, который заключается в том, что, благодаря закрытой репозиции отломков и малому хирургическому доступу вне зоны повреждения, не наносится дополнительная травма тканям в зоне перелома.

Изучены и проанализированы основные ошибки хирургов при выполнении интрамедуллярного блокирующего остеосинтеза. Показано, что лечение пациентов с диафизарными оскольчатыми переломами длинных трубчатых костей должно включать меры по восстановлению анатомических структур травмированного сегмента и функции поврежденной конечности. Установление четких показаний и последовательное предоперационное планирование оперативного вмешательства с тщательным подбором параметров фиксирующих конструкций являются основными факторами, влияющими на качество фиксации отломков, и обеспечивают конечный результат.

Ключевые слова: *травма, переломы костей, блокирующий интрамедуллярный остеосинтез, ошибки хирургов, осложнения*

The growth of the level of traumatism and the prevalence of orthopedic pathology determine the necessity to advance diagnostics and treatment of injuries and diseases of the musculoskeletal system as a priority trend in the development of health care. Improvement of diagnostic capabilities of modern methods of visualizing conditions of bones, joints and soft tissues, expansion of the scope of high-tech minimally invasive osteosynthesis techniques will change the concept for implementation of orthopedic trauma care.

The proposed literature review is dedicated to the urgency of the problem and analysis of the structure of traumatic injuries, as well as the fundamental advantages of their treatment by the method of intraosseous osteosynthesis, which, due to the closed reposition of fragments and low surgical access outside the damage zone, doesn't cause any additional injury to the tissues in the fracture zone.

The main errors of surgeons when performing intramedullary blocking osteosynthesis have been studied and analyzed. It has been shown that treatment of patients with diaphyseal multi-fragment fractures of the long tubular bones should include measures to restore the anatomical structures of the injured segment and the function of the injured limb. The determination of clear indications and consistent preoperative planning of surgical intervention with careful selection of parameters of fixing structures are the main factors affecting the quality of fixation of fragments and they ensure the final result.

Keywords: *trauma, bone fractures, intramedullary osteosynthesis, surgical errors, complications*

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Introduction

In recent decades, the number of fractures of the long tubular bones of the skeleton has significantly increased due to an increase in severe road traffic injuries and disasters [1, 2, 3, 4]. According to the WHO, by 2020 injuries resulting from an accident will have probably become the third leading cause of death or injury [5, 6, 7]. In recent years, there is a clear tendency to an increase in victims with high-energy injuries [8, 9]. Their feature is the high proportion of polysystem and multi-organ injuries, which are characterized by severe course, high disability and mortality [10]. In the USA, up to 17 million people suffer from injuries every year, about 1% of them die, and 2% become

disabled [11, 12, 13]. In the structure of primary disability, they steadily occupy the third place, conceding only to diseases of the cardiovascular system and oncological diseases [14]. The number of cases of temporary disability due to injuries has increased by 36%, and makes up 5.3 cases per 100 employees [15]. The peculiarity of injuries of the musculoskeletal system is that they lead to the most pronounced socio-economic losses, as they predominate among young and middle-aged people who have a high labor activity. Recently, the problem of significant losses from injuries has been discussed both at the national level in Ukraine and in the world [16, 17]. According to the Institute of Demography and Social Studies, annual economic losses due to injuries and deaths in Ukraine exceed 10 billion hryvnias, which is 2.5% of gross domestic product and 1/3 of the cost of health care [16].

An increase in the proportion of injuries in the structure of injuries due to high-energy actions has led to the emergence of a large number of victims with severe injuries of the musculoskeletal system, in which the bone tissue and the surrounding soft tissues suffer over a large area [18, 19]. Due to the development of technical progress, injuries have changed not only quantitatively but also qualitatively - the number and severity of polytrauma, severe multiple injuries, among which fractures of the long bones of the limbs of mainly comminuted and polyfocal character predominate [20, 21]. The indicated injuries are severely tolerated by victims, depriving them of their ability to move independently for a long time, and are among the main "sources" of unsatisfactory treatment results for injuries of the musculoskeletal system. Among the variety of injuries, it is diaphysial fractures of the long bones that are very common injuries among the population of Ukraine, their number is 48.5% of all fractures of the long bones, and comminuted and polyfragmental fractures constitute 16.5% of the fractures of all limb segments [22]. The frequency of diaphyseal fractures of large segments of the lower limbs is more than 26.3% of the total number of fractures of the long bones, while the greatest number of complications is observed with injuries of the lower limbs - 54.4%, and slightly less (29%) with the injuries of the upper limbs. Among all the fractures of the long tubular bones, the diaphyseal femur fractures take the second place and comprise from 10.4 to 23.9%, whereas the fractures of the diaphysis of the bones of the shin constitute up to 45%, remaining the most common among the injuries of the bones of the limbs [23].

It should be noted that the problems of the reparative osteogenesis disorders occurring after diaphyseal fractures of the long bones of the limbs remain relevant. The frequency of this pathology ranges from 2.5 to 18% [24]. The high material costs of treating patients with slow consolidation, refractures and false joints after diaphyseal fractures are one of the most important aspects of medical and social rehabilitation of patients with such pathology [25, 26. 27. 28. 29].

Treatment

At the present stage, the situation with the choice of a conservative or surgical treatment of comminuted fractures is obvious. A significant increase in operational activity over the past decades has clearly shown that one and all experts prefer the surgical method. The motive of the advantages of the surgical method is a complex of socio-economic factors [30]. About 2 million injuries are recorded every year in Ukraine, and as a result more than 150,000 bone surgeries are performed [31]. As a preoperative stage, as well as the main method of treatment in the presence of contraindications to surgery, skeletal traction is used. But one should not assume that surgical intervention will provide a positive solution to the quality and timing of treatment and rehabilitation of victims. The question of choosing the appropriate type of osteosynthesis and the quality of its implementation [32] is very relevant at this stage. When choosing a method of treatment, surgical access and method of fragments fixation, it is necessary to take into account all the features of the local and somatic status of a particular victim. The fixation of the fragments should, on the one hand, allow an early painless functional load on the limb, and on the other hand, it should be adequate during the whole period of the formation of a complete bone regenerate. In such situations, the choice is made between transosseous, bone and intramedullary osteosynthesis. However, each of these clamps, with its advantages, has several disadvantages.

The basic principles of restoring the integrity and function of the injured limb are the early use of rational treatment methods. The conditions for consolidation of such fractures are the matching of fragments with minimal traumatization and the timely use of stable functional osteosynthesis. This will give an opportunity to provide early loads on the operated limb with minimal risk of instability of bone fragments and restoration of the function of the injured limb in the shortest possible time. Currently, in the developed countries of the world, the technology of blocking intramedullary osteosynthesis (BIOS) is widely used for metal osteosynthesis, the main advantages of which are: low surgical access, reduced trauma of surgical interventions and intraoperative blood loss, biomechanically reasonable high stability of fixation

of bone fragments, optimal implant placement from the standpoint of biomechanics of the limb [12, 33, 34, 35]. In addition, its use provides a minimal cosmetic defect, helps to reduce by 2-3 times the length of patient's stay in the hospital, allows the structure to be dynamized during the consolidation process and the early dosed load on the injured limb in the postoperative period, and creates conditions for active rehabilitation and quick patient return to active full life [36]. V.A. Sokolov et al. investigated the results of treatment of patients with diaphyseal fractures, depending on the use of osteosynthesis methods [36]. The victims who were osteosynthesized with external fixation devices and hybrid methods stayed in the hospital for the longest time. This was due to the need for inpatient care not only for the condition of the limb in the device, but also for conducting systematic daily exercises in therapeutic gymnastics. The shortest hospital stay was observed in patients undergoing osteosynthesis with blocking rods [37].

The principal advantages of intraosseous osteosynthesis from the standpoint of "biology" are due to the closed reposition of fragments and low surgical access outside the damage zone; no additional injury is caused to the tissues in the fracture zone and the periosteal blood supply is maintained [25].

Errors and complications

In the process of treating severe injuries of the musculoskeletal system, in some cases, for various reasons, the mistakes are made that negatively affect both the duration of treatment of patients and the final results. The severity of injuries, errors and complications arising in the process of treating these injuries, mainly worsen the results of treatment and make it difficult to rehabilitate the victims [38]. Of all medical errors, technical accounted for almost half, about 30% - errors in treatment tactics, about 15% - errors of a diagnostic nature, 5% - errors of conservative treatment [32]. Separately, it is necessary to study medical errors associated with medical activities. Such errors are made at all stages of treatment of patients, most often occur on the background of a significant severity of injury and constitute in the structure of primary disability from 20% to 32%. The most common mistakes can be divided into tactical, technical and those that depend on the patient. Tactical errors include:

- underestimation of the severity and nature of the bone damage and the general condition of the victim;
- underestimation of damage to the skin of the limb;
- underestimation of the condition of the bone tissue - the use of the method of contraindications;
- use of the method in unacceptable for it cases (when it is better to perform another type of ostesynthesis);
- the use of an incorrect type of blocking (static, dynamic or compression);
- non-compliance with the technology of intramedullary blocking osteosynthesis, making their own "amendments" during the operation, changing the course of surgical intervention;
- inadequate rehabilitation treatment and medical rehabilitation [39].

Errors of a technical nature during the osteosynthesis are the most common group, since the variety of clinical situations, technical support during the synthesis, the presence of the electron-optical converter (EOC), an orthopedic table and etc, the type of implant chosen, the method of performing (closed or open), the degree of achievement of reposition, the presence of bone fragments - creates a significant number of options for the occurrence of technical errors [22]. However, technical errors, despite their diversity, can be systematized and the most typical of them can be identified:

- incorrect or insufficient preoperative planning, which leads to the wrong choice of type (antegrade, reconstructive, retrograde, etc.) and the size of the rod or locking screws (too short or, on the contrary, long) [40].
- wrong point of rod insertion;
- excessive or insufficient penetration of the rod into the bone marrow canal, which can lead to the penetration of the rod into the joint cavity, and also creates difficulties in its removal;
- the refuse to use an open method of osteosynthesis (in the cases shown), as a result of which there may be an unsatisfactory reposition of fragments (especially for fragmental and segmental fractures);
- difficulties when locking the rod - misses into the holes, a fracture of the drill;
- mismatch of rod diameter to the diameter of the medullary canal, which can lead to crushing of the bones, the rejection of reaming a channel [41];
- incorrect or insufficient reposition of fragments, at which there are displacements (rotational, in length, angular);
- intraoperative detection of the spread of a fracture zone or an additional fracture of the segment that was not diagnosed in time, due to insufficient x-ray examination;
- fracture of the bone at the site of the introduction of distal blocking screws as a result of repeated drilling during distal blocking [42];
- excessive trauma of own patellar ligament when administering the rod in the tibia and the

patella during the retrograde introduction into the femoral bone;

- perforation of the bone wall with the rod;
- significant deformation of the locking screw during the compression blocking;
- insufficient hemostasis, damage to neurovascular formations (more often with distal blocking of the humerus) [43].

In the process of treatment and dynamic observation of the patient, it is necessary to take into account the human factor, since it is obvious that the final result of treatment depends on the implementation of recommendations and compliance with the orthopedic regimen. It is necessary to pay attention to the patient:

- the load on the operated limb;
- the rod dynamization in the cases shown in optimal terms;
- performing a control X-ray and examination by a doctor at regular intervals;
- lack of continuity at the stages of treatment (patients are consulted by doctors of clinics or central regional hospitals who cannot know all the nuances of this technique).

An incorrect load regimen on the operated limb, most often early and complete, can lead to a fracture of the locking screws or the rod and vice versa; a late and insufficient load on the limb quite often leads to violations of consolidation processes. Successfully performed intramedullary blocking osteosynthesis allows patients to use the operated limb practically from the first days, and within 1 to 2 months, which is optimal for dynamization (removal of the blocking screw) of the rod, fully load it. Therefore, patients quite often ignore the recommendations of the doctor on the dynamization of the rod and fall out of sight of health workers. And not timely or undone dynamization of the rod can lead to a fracture of the locking screw ("self-dynamization") and disruption of bone consolidation processes (slowing down the fracture fusion, the formation of a false joint, etc.) [44, 45]. Specific technical errors in performing osteosynthesis lead to specific complications, the clinical manifestations of which can vary from discomfort at the injection site of too long blocking screw to the impaired repair processes, anatomical and functional disorders, bone fracture at the site of numerous attempts at blocking or suppuration of the bone wound during a fracture of the drill. Severe common complication, which is inherent in this method is fat embolism.

G. Klimovitsky et al noted the following complications of the method: postoperative phlebitis of the lower limb (2.1%), ligature fistulas (4.2%), osteomyelitis (2.1%), and fracture of the drill in the bone (10.6%) [46]. Rusin et al. (2013) indicates that acute thrombosis in the inferior vena cava system is the most common disease that complicates the postoperative period. Phlebothrombosis in 25% of cases lead to pulmonary thromboembolism (PE), which in 12% of cases results in death and in 30% leads to severe disability [47].

As can be seen from the above, there is no single reason for the development of complications, therefore, there is no and cannot be one measure to prevent them. However, a balanced, thoughtful approach to diagnosis, the choice of treatment tactics and performing gentle, adequate operational techniques can be the main way to solve existing problems.

Conclusions

1. Blocking intramedullary osteosynthesis is a minimally invasive method that has certain advantages over other methods of surgical intervention, that optimize timing of consolidation, improve outcomes and patient quality of life during treatment, as well as it is the method of choice in the surgical treatment of diaphyseal fractures of long bones.

2. To achieve good results in treating patients using the method of blocking intramedullary osteosynthesis, it is necessary to adhere to clear indications for blocking osteosynthesis, plan surgery in detail, correctly select metal constructions, meticulously adhere to intervention technology.

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Conflict of interest

The author declares that he has no conflict of interest.

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