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"CAROL DAVILA", BUCHAREST

DOCTORAL SCHOOL

PLASTIC SURGERY

**THERAPEUTIC CONDUCT AND POSTOPERATIVE RECOVERY
MANAGEMENT IN SERIOUS UPPER LIMB TRAUMA**

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-SUMMARY OF DOCTORAL THESIS-

THESIS TOPIC:

**THERAPEUTIC CONDUCT AND POSTOPERATIVE RECOVERY
MANAGEMENT IN SERIOUS UPPER LIMB TRAUMA**

Scientific coordinator:

PROF. EMERIT DR. IOAN LASCAR

PhD student:

Dr. COLCIGEANU (MAR. CARSTEA) ANCA-IULIA

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Introduction

The proposal of this PhD thesis aims to study and standardize rapid and personalized recovery protocols, designed to lead not only to a prompt improvement in functional status, but also to a close correlation between this improvement and a significantly improved clinical status, in the absence of complications.

In the elaboration of this doctoral thesis, I proposed as a general objective the identification and relief of the areas of intersection between the study of embryological development, descriptive anatomy, that of surgical techniques and recovery methods specific to the interventions necessary in the case of serious injuries of the upper limb.

I have chosen this topic out of the belief that a detailed assessment of the problem, combined with a personal way of approaching solutions, can bring more useful knowledge to both young surgeons and students or specialists interested in deepening the specific processes of diagnosis, prognosis and treatment.

The embryological evolution and the thorough anatomical study provide the primary knowledge, on which the surgeon can analyze and build the evolution of each patient, depending on the specifics of the patient and the priorities of the case in question.

By using this knowledge, the doctor increases his skills not to fall into error in the way of using the anamnestic data, either by overestimating some signs and symptoms, or by ignoring them.

In the research and studies considered, terms were used such as: serious trauma of the upper limb with loss of function or even the limb, fast and personalized recovery protocol, the classic recovery protocol, diagnosis and treatment and recovery methods specific to this pathology, the presentation of representative clinical cases and the retrospective, prospective, therapeutic statistical study on patients with serious upper limb trauma, computer tomography, electromyography, operative technique elements, motor and sensory postoperative sequelae.

Anatomy reveals scientific information for the purpose of accurately establishing the morphology and shape of the human body, in this case the upper limb.

Surgery induces possibilities of intervention on organisms affected by pathological processes incompatible with the proper functioning of both the whole and the component parts of the body, namely the upper limb.

Recovery, on the other hand, consists in the combined application of physical, psychological and technological techniques, which belong to specialized equipment, which together contribute to restoring the morphological and functional aspect of the human body, with a special emphasis on the upper limb in the context of this thesis .

This thesis brings to the fore the serious pathology of the upper limb and provides a comparative analysis of two assessment and recovery possibilities, with the aim of developing a generally applicable assessment and recovery system.

The proposal for this project is to study and standardize fast and personalized recovery protocols that lead not only to the rapid improvement of the functional status, but also to a correlation of this improvement with a clearly improved clinical condition or the absence of complications.

Accepting that anatomical, pathological, psychological and cognitive peculiarities can influence the course of the disease, it is possible that there may be discrepancies between the final expectations and the reality of each individual case.

The intersection between morphological study, surgical techniques and recovery methods can have a beneficial impact on empirical medical research and on increasing the scientific value of the therapeutic act.

Starting from these theoretical coordinates, the doctoral thesis was structured in ten successive chapters, and three studies thus building a compact and complex work. The doctoral thesis entitled "Severe injuries of the upper limb - Therapeutic conduct and management of postoperative recovery" aims to address the complexity and particularities of severe traumas of the upper limb, emphasizing the need for a well-structured therapeutic conduct and an adequate management of postoperative recovery. This paper is based on the finding that the frequency and diversity of trauma of this type is constantly increasing, which complicates case management and emphasizes the importance of personalized treatment.

The work is structured in two main parts: the general part and the special part. The general part provides a detailed exposition of the relevant scientific data from the specialized literature and defines the terms and concepts used in the thesis. The special part is dedicated to the objectives, research method, results, discussion and conclusions of the study.

The main objective of the research is the comparative evaluation of patients following a customized recovery protocol compared to those following a classic protocol. The necessity and frequency of surgical reinterventions and the frequency of postoperative sequelae in the same groups of patients are also monitored. The thesis also considers secondary factors, such as psychological impact, self-harm, chronic use of psychoactive substances, temperament and trust in the medical act, which can influence the recovery process.

The research is carried out in the form of an observational, longitudinal and retrospective-prospective, retrospective and prospective study, with an external control group, and is carried out within the Clinic of Plastic, Aesthetic and Reconstructive Microsurgery, led by Prof. Dr. Ioan Lascăr, at the "Floreasca" Bucharest Emergency Clinical Hospital. The personalized recovery protocol involves periodic monitoring of patients at intervals of 1 month, 3 months, 6 months and 1 year, using clinical and paraclinical methods, the collected data is documented and supported by photographic and video images, which contribute to the evaluation of postoperative progress. Limitations of these studies include several aspects that may influence the validity and generalizability of the results: Small sample size for studies one and two, seven psychiatric patients from study three, two patients from studies one and two, and those who had were from rural areas and did not want follow-up recovery were ten from study three, six from studies one and two.

An essential aspect of the thesis is the discussion of the need for recovery protocols that focus not only on the rapid improvement of the patients' functional status, but also on the correlation of this improvement with the clinical status and the absence of complications. Intermediate research results are published in specialized journals to ensure their scientific exploitation.

The study methodology proposed for this PhD thesis aims to investigate and standardize postoperative recovery protocols for patients with severe upper limb trauma. These traumas represent a major medical challenge, both in terms of their complexity and the high risks of loss of function or even the limb, having a significant impact on the quality of life of patients. The main purpose of the proposed studies is the development of personalized recovery protocols that rapidly improve the patients' functional status, reduce the incidence of postoperative complications and contribute to their socio-economic reintegration.

The research aims to develop and validate rapid postoperative recovery protocols, customized according to the particularities of each case. One of the studies will compare the effectiveness of rapid recovery, which begins 72 hours postoperatively, with classic recovery, which begins after a longer period. Another important aspect of the research is the retrospective evaluation of the correlation between intraoperative decisions and long-term recovery outcomes, trying to establish clear links between surgical interventions and the success of functional recovery. It will also analyze the impact of different factors on recovery, trying to identify the variables that contribute to the success or failure of therapeutic interventions.

It is important to note that the study may be limited by the variability of the cases studied and uncontrollable factors such as patient adherence to recovery protocols and diversity in trauma complexity. Also, psychological and socio-economic factors can influence the recovery process, requiring special attention in the interpretation of the results.

In conclusion, the proposed methodology aims at a comprehensive and systematic approach for the standardization of postoperative recovery protocols in the case of severe trauma of the upper limb. Implementation and validation of these protocols could bring about significant improvements in clinical and functional outcomes, thus contributing to the development of evidence-based practice guidelines in the field of reconstructive surgery and postoperative recovery. The bibliography will include relevant scientific papers, case studies and other specialist resources, which will be properly cited throughout the writing of the thesis and updated as the research progresses, thus ensuring a solid foundation for the conclusions and propositions of the thesis.

Thanks

I would like to express my sincere thanks and gratitude to those who had a significant impact on the completion of this PhD thesis.

First of all, I would like to express my special thanks to Prof. Dr. Emeritus Ioan Lascăr for his exceptional academic guidance, constant support and vast expertise, which were essential in the completion of this project. Under his guidance, I gained valuable knowledge and was inspired to achieve high academic standards.

I am also deeply grateful to Prof. Dr. Adriana Sarah Nica for her unconditional support, constructive suggestions and continuous availability to provide guidance. His valuable inputs were invaluable in directing my research and achieving my proposed objectives.

Last but not least, I want to thank Dr. Sebe Ioana Teona for her support throughout this project, for her encouragement and valuable advice, which were essential in overcoming the challenges encountered during the research.

Each of you had an important role in the realization of this thesis, and for this I am deeply grateful. This work would not have been possible without your contribution, support and trust. Thank you from the bottom of my heart!

General part

1. History of Serious Upper Limb Trauma

Upper limb trauma has evolved throughout history in parallel with the development of medical knowledge and surgical techniques. The first evidence of surgery to treat these injuries dates back to 31,000 years ago, indicating a surprisingly advanced understanding of anatomy and post-operative care techniques. In ancient Mesopotamia, the Code of Hammurabi and the Smith Papyrus document the first methods of treatment and standardization of medical care.

The 19th century was marked by advances due to the Industrial Revolution and the evolution of antiseptic and anesthetic techniques, which greatly improved treatment outcomes. In the 20th century, world wars accelerated the development of effective rehabilitation protocols, and the integration of multidisciplinary approaches became the norm.

In recent decades, advanced technologies such as bionic prostheses and personalized recovery methods have revolutionized the treatment of severe upper limb trauma, focusing on rapid and complete restoration of function. This historical development laid the foundation for modern standards of care, which prioritize a holistic and individualized approach to rehabilitation with the goal of maximizing functional recovery and minimizing complications.

2. Definition of serious trauma. Peculiarities of serious injuries of the upper limb.

Severe injuries of the upper limb represent a complex problem in trauma medicine, due to the frequency and severity of these injuries that affect anatomical structures essential for daily functionality. The upper limb, composed of the arm, forearm and hand, includes bones, muscles, tendons, nerves and blood vessels, all of which are interdependent, and any severe injury can significantly affect an individual's functional ability.

The approach to these injuries requires a multidisciplinary intervention, involving both surgical treatment and intensive rehabilitation. The patient's psychological state and comorbidities such as diabetes further complicate recovery, necessitating a holistic approach that considers both the physical and psychosocial aspects of trauma. Through careful and coordinated management, optimal functional recovery can be achieved, minimizing the long-term impact on the patient's quality of life.

3. Embryology and development of the upper limb

Development of the upper limb begins in the fourth week of embryonic development, with the formation of limb buds, mesenchymal structures that gradually transform into the bones and connective tissues of the limb. The apical ectodermal ridge (AER) plays a critical role in limb growth, maintaining cells in an undifferentiated state necessary for proximodistal growth. The anterior-posterior axis of the limb is regulated by the protein Sonic Hedgehog (SHH), and the dorsoventral axis is controlled by WNT7a. As the limb grows, the mesenchymal cells differentiate, forming the bones and joints of the limb. Abnormalities in this process can lead to congenital conditions, such as meromelia or phocomelia, caused by genetic or teratogenic factors.

4. Anatomy of the upper limb

The upper limb consists of the shoulder, arm, forearm and hand, each component having a complex and interdependent anatomical structure.

The shoulder is composed of the clavicle, scapula, and humerus, facilitating a wide range of motion through the glenohumeral joint, supported by the rotator cuff muscles and the deltoid muscle. Vascularization is provided by the axillary artery.

The arm, dominated by the humerus, allows essential movements such as flexion and extension, being supported by the biceps and triceps muscles, innervated by the musculocutaneous and radial nerves. Vascularization is provided by the brachial artery.

The forearm includes the radius and ulna, allowing pronation and supination movements. It is divided into anterior and posterior compartments, responsible for flexion and extension of the wrist and fingers. The radial and ulnar arteries provide the blood supply.

The hand is a sophisticated structure made up of 27 bones, including the carpals, metacarpals and phalanges, allowing for the precise movements required for everyday activities. Intrinsic and extrinsic muscles control hand movements, and blood supply is provided by the superficial and deep arterial arches.

As a whole, the upper limb functions through a precise coordination of these structures, being essential for daily functions and interaction with the environment. Detailed understanding of the development and anatomy of this limb is crucial to the effective diagnosis and treatment of conditions and injuries.

5. Orthopedic and surgical conservative treatment of serious traumatic injuries of the upper limb - general considerations.

The treatment of severe traumatic injuries of the upper limb involves a complex and multidisciplinary approach, necessary due to the complicated anatomical structure and the potential for

severe functional impairment. These injuries frequently occur following high-energy trauma, such as traffic or industrial accidents, and require the involvement of orthopedic surgeons, plastic surgeons, and physical therapists to ensure optimal recovery.

Conservative treatment is often the first line of intervention and includes the use of immobilization, physical therapy, and pharmacological treatment. Immobilization methods, such as casts, splints, and braces, are essential for stabilizing fractures and preventing further injury. Physical therapy plays a crucial role in restoring strength and flexibility, and pain management is through anti-inflammatories, opioids, and local anesthetic injections.

Surgical treatment is necessary in cases of complex fractures, vascular injuries or significant soft tissue injuries. Techniques include open reduction and internal fixation (ORIF) for bone stabilization, arterial revascularization through anastomoses or vein grafts, and nerve repair to restore motor and sensory function. Soft tissue injuries are treated with debridement, skin grafts, and flap reconstruction.

Possible complications include infection, nonunion or malunion of the bones, and chronic pain, which requires careful management with additional surgery, ongoing physical therapy, and psychological support.

Long-term rehabilitation is essential for restoring patients' functionality and independence, involving occupational therapy, strength training and joint mobilization. The success of treatment depends on a global and coordinated approach, adapted to the individual needs of patients, with the active involvement of a multidisciplinary team.

This comprehensive approach is essential to achieve good functional outcomes and minimize long-term disability, thus ensuring the best possible quality of life for affected patients.

Special part

6. Working hypothesis and general objectives

Severe injuries of the upper limb, caused by various mechanisms such as crushing, avulsion, burns or penetrating wounds, require complex medical interventions to restore the functionality of the affected limb and ensure a healing process without major complications. This paper explores different treatment modalities, including conservative surgical approaches and advanced techniques, to identify the most effective interventions and to understand the factors that influence treatment outcomes.

One of the main objectives of the research is to compare the effectiveness of two postoperative recovery protocols: a classic one and a personalized one, applied early, 72 hours post-intervention. The study aims to determine the superiority of one of these protocols in terms of functional recovery, reduction of complications and the need for reoperations. It also analyzes the impact of social, psychological and behavioral factors on the recovery process.

The study is prospective, with an external control group, carried out at the Clinic for Plastic, Aesthetic and Reconstructive Microsurgery, SCUB "Floreasca", and involves a periodic monitoring of patients through detailed clinical and paraclinical assessments. Preliminary results suggest that a customized postoperative recovery protocol can lead to faster recovery and a significant reduction in complications.

7. General research methodology

The study methodology focuses on the comparative evaluation of personalized versus classic recovery protocols. These studies aim to investigate the effectiveness and impact of these protocols on the postoperative recovery process, providing a solid basis for standardizing therapeutic approaches in severe upper limb trauma.

The first study is designed as a comparative evaluation between two types of postoperative recovery protocols: a customized one, which begins 72 hours after surgery, and a classic one, which begins after a longer period of time. The study will be conducted in an observational, longitudinal framework, including patients diagnosed with serious trauma of the upper limb, treated in the Clinic of Plastic Surgery, Aesthetics and Reconstructive Microsurgery of the "Floreasca" Bucharest Emergency Clinical Hospital. Participants will be divided into two groups: one following the customized protocol and one following the classic protocol. Evaluation of recovery effectiveness will be performed by monitoring patients' functional and clinical progress at 1-month, 3-month, 6-month, and 1-year postoperative intervals. Data will be collected through clinical and paraclinical methods, including physical assessments, medical imaging, and measurements of motor and sensory function. Statistical analysis of results will include comparison of time to functional milestones, frequency of postoperative complications, and patient-reported quality of life.

The second study aimed to evaluate the need for reoperations in patients who followed a rapid recovery protocol, compared to those who followed the classic protocol. Patients, admitted to the same clinic and selected according to the same strict criteria as in Study 1, were randomly assigned to two groups: one that followed the rapid recovery protocol and another that followed the classic protocol. The research focused on long-term monitoring of patients to assess the frequency and type of reoperations required. Clinical data were systematically collected, recording each re-intervention, its reasons, and the post-intervention results. The statistical analysis of these data allowed the identification of the factors that influenced the need for reinterventions and the effectiveness of each type of protocol in preventing complications that could require additional interventions.

The third study aims to retrospectively assess the correlation between intraoperative decisions and long-term recovery outcomes in severe upper limb trauma. This study will be based on the analysis of medical records of

previously treated patients to identify the intraoperative variables that influenced the success of functional recovery. The impact of surgical decisions, such as the operative technique used and intraoperative wound management, on postoperative outcomes, including the occurrence of motor and sensory sequelae, as well as the need for reoperations, will be assessed. Data will be analyzed retrospectively, correlated with recovery data and long-term assessments, using advanced statistical techniques to determine links between intraoperative factors and recovery success. In addition, the influence of psychological and socio-economic factors on postoperative outcomes will be analyzed through a detailed assessment of patient histories and individual risk factors.

The three studies will contribute to the development and validation of personalized recovery protocols, providing important data to improve the treatment and postoperative management of severe upper limb trauma. The results will be documented and published in specialized journals to ensure their dissemination and application in medical practice.

8. Study 1, Study and comparative evaluation over time of residual postoperative sequelae in patients following the rapid recovery protocol (72h) compared to those following a classic recovery protocol

Working hypothesis and general objectives

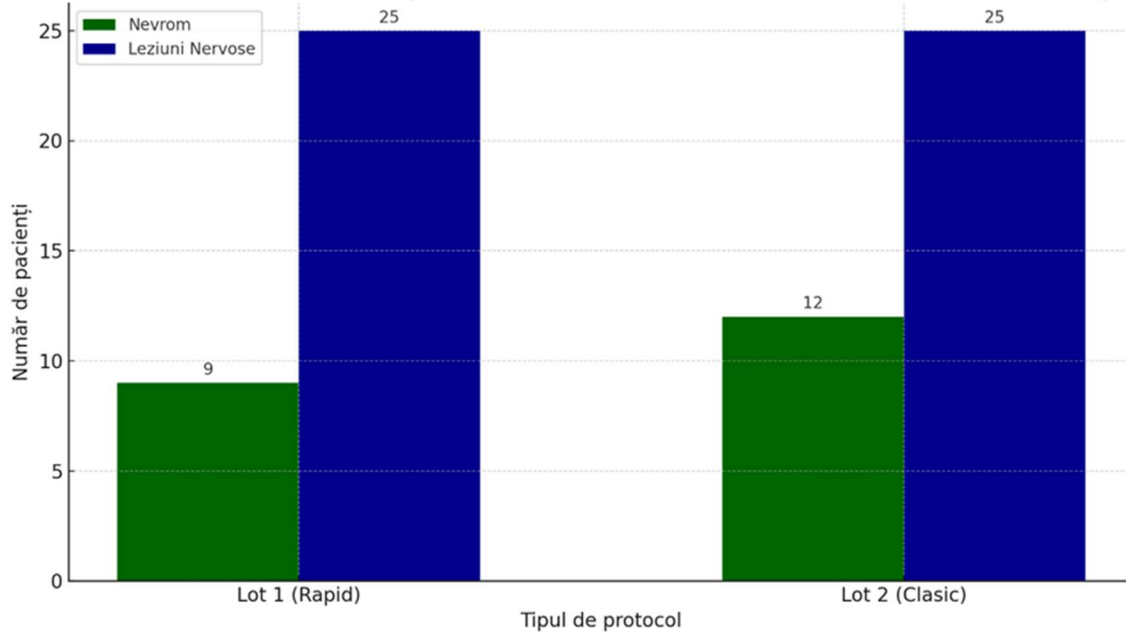
The present study aimed to analyze and compare the evolution of postoperative sequelae in patients who followed two recovery protocols: a rapid one, initiated 72 hours postoperatively, and a classic one. The research was conducted on a group of 50 patients who suffered severe traumatic injuries to the upper limb, affecting both nerves and arteries. The primary objective was to evaluate the effectiveness of each protocol in reducing postoperative sequelae and restoring the functionality of the affected limb.

The study was prospective, involving the monitoring of patients for one year, with periodic evaluations at 1, 3, 6 and 12 months postoperatively. Evaluations included clinical and paraclinical tests to measure functional recovery and reduction of complications, using methods such as the TINEL test, Quick Dash, Semmes Weinstein, echo Doppler and radiographs.

Results

Comparison of nerve injuries and neuromas between rapid and classic recovery protocols

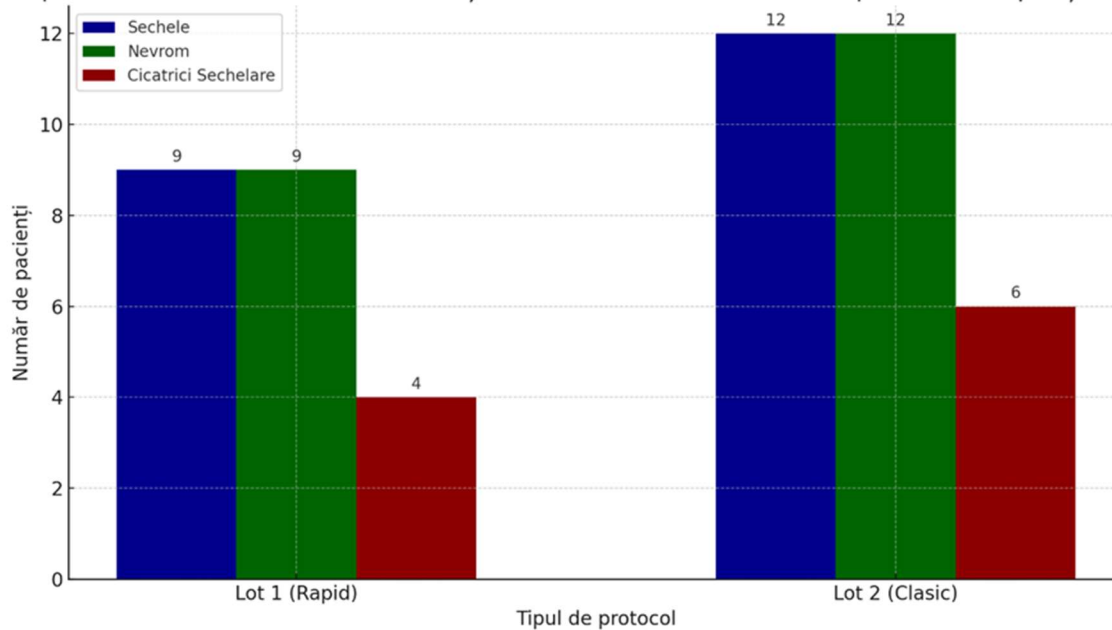
Compararea leziunilor nervoase și nevromelor între protocoale de recuperare rapidă și clasică



The graph shows a comparison of the incidence of nerve damage and neuromas in patients who underwent two different recovery protocols: one rapid and one classic. According to the data presented, in both groups of 25 patients, all of them suffered nerve damage, which underlines the severity of the analyzed traumas. However, differences become apparent when the incidence of neuromas is analyzed. In the group that followed the rapid protocol, 9 patients developed neuromas, while in the group that followed the classic protocol, this number increased to 12 patients.

Comparison of sequelae, neuromas and sequelae scars between the rapid and classic protocol

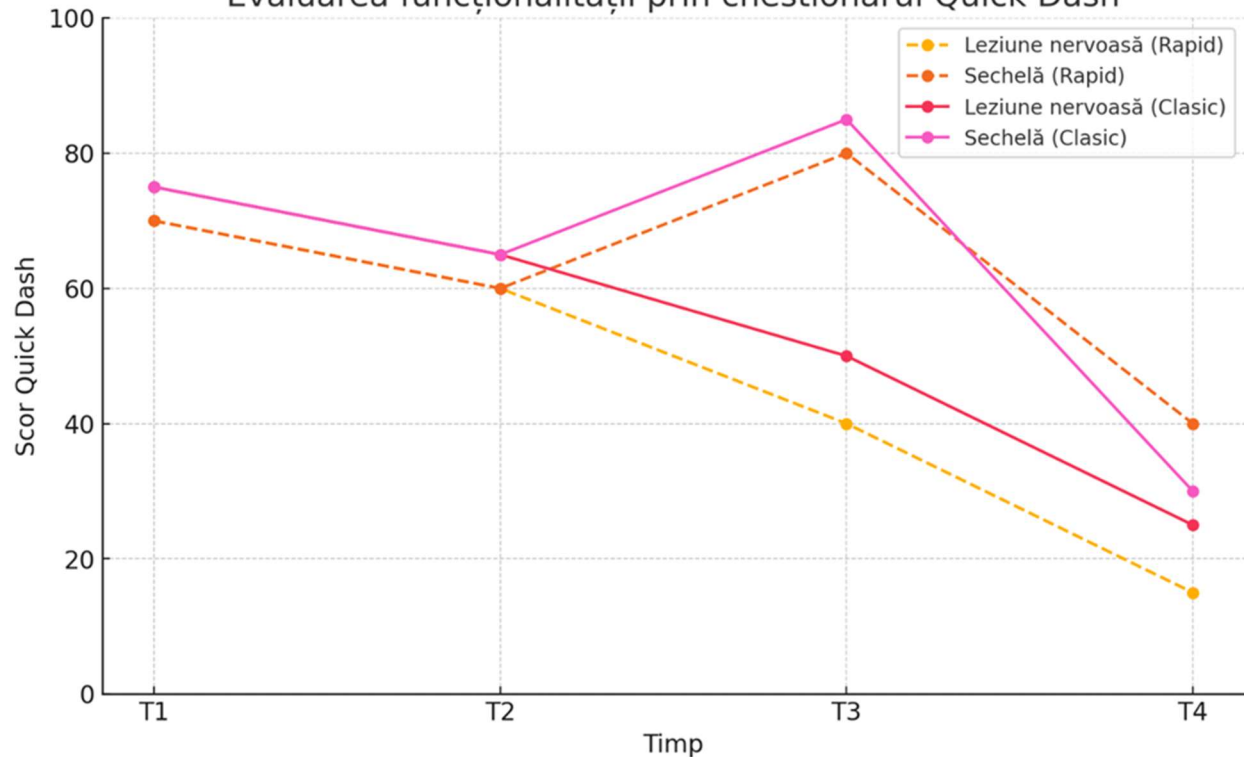
Compararea sechelelor, nevromelor și a cicatricilor sechelare între protocolul rapid și cel clasic



The graph shown provides a visual comparison between the incidence of sequelae, neuromas and sequelae scars in two groups of patients, each group following a different post-traumatic recovery protocol: one rapid and one classic. The data show that in Batch 1, which followed the rapid protocol, there were 9 sequelae, 9 neuromas and 4 cases of sequestration scars. In contrast, Group 2, which followed the classical protocol, had a higher incidence of all these complications, with 12 sequelae, 12 neuromas, and 6 cases of sequestration scars.

Comparison of the Rapid and Classic protocol, Evaluation of functionality through the Quick Dash questionnaire

Compararea Protocolului Rapid și Clasic Evaluarea funcționalității prin chestionarul Quick Dash



The conclusion of this graph suggests that the fast protocol is more effective than the classic protocol in improving the function of patients with nerve damage and sequelae according to Quick Dash scores. In particular, at the final assessment (T4), the rapid protocol demonstrated lower scores, indicating less disability and faster recovery compared to the classic protocol. This suggests that adopting the rapid protocol could provide significant benefits in the treatment of these conditions.

Comparison of the two protocols revealed significant advantages for the fast protocol. Patients who followed this protocol showed faster and more complete recovery of nerve functions, improved motor control, reduced postoperative pain, and more effective revascularization. The Semmes Weinstein and Quick Dash tests showed faster improvement in sensation and superior function of the affected limb in the rapid recovery group.

Conclusions

The study concludes that the rapid postoperative recovery protocol is superior to the classic protocol in terms of reducing sequelae and improving upper limb functionality. The results suggest that this protocol should be considered a preferred option in the postoperative management of severe upper limb trauma, due to the significant positive impact on patients' quality of life and their functional recovery.

9. Study 2, Study and comparative evaluation of the need for reoperations in patients who follow the rapid postoperative recovery protocol (72h) compared to those who follow the classic recovery protocol

Introduction

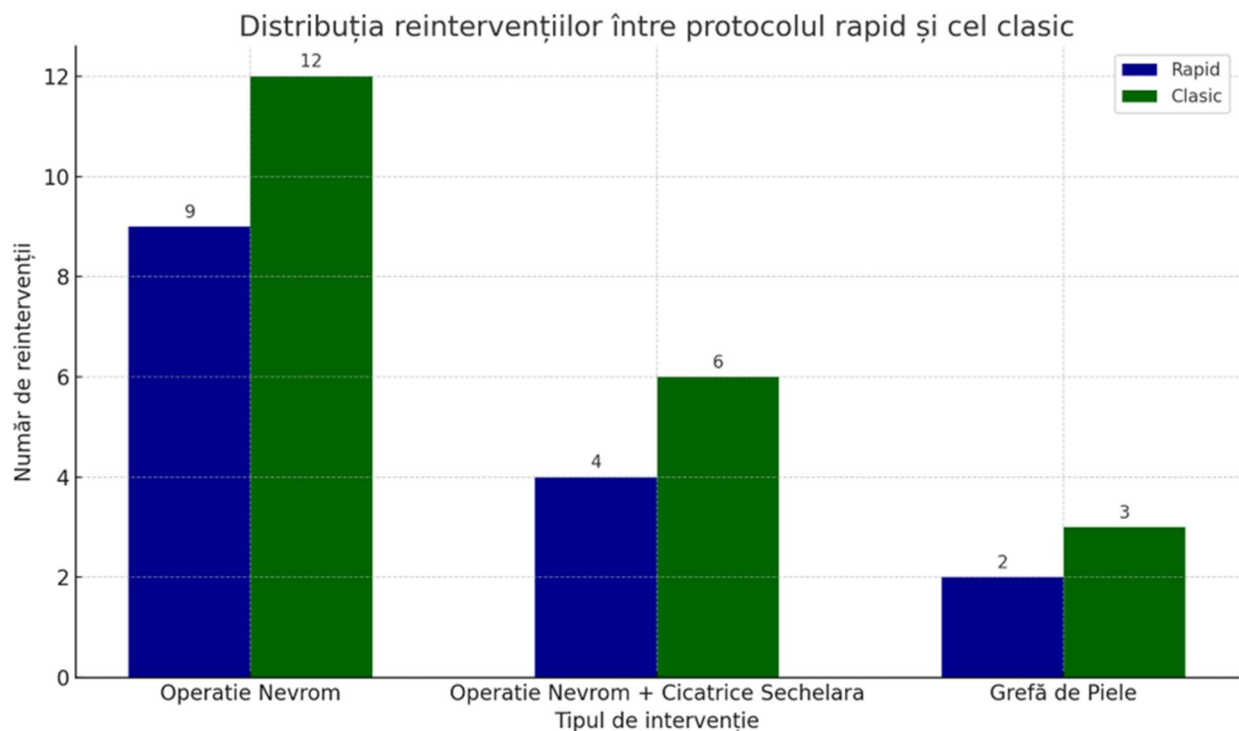
The study analyzes the need for surgical reinterventions in patients with severe trauma of the upper limb, comparing two postoperative recovery protocols: a rapid one, initiated at 72 hours, and a classic one. Operative reinterventions are a crucial factor in evaluating the effectiveness of these protocols, having a direct impact on the prognosis and quality of life of patients.

Material and method

The study included 50 patients, divided into two equal groups, who followed either the rapid recovery protocol or the classic protocol. Patients were monitored to assess the need for reoperations, and data were collected retrospectively and prospectively. Statistical analysis was used to compare the frequency of reoperations between the two groups, trying to identify significant differences.

Results

Distribution of reinterventions between the rapid and classic protocol



The graph illustrates the distribution of surgical reoperations between two recovery protocols: rapid and classic. For patients in the fast protocol, 9 neuroma surgeries were recorded, 4 of which also involved sequestration scars, and 2 skin grafts. In contrast, the classic protocol required a higher number of reoperations, with 12 neuroma operations (of which 6 involved sequestration scars) and 3 skin grafts. These data suggest that the classic protocol was associated with a higher incidence of complications that required additional interventions.

Of the 25 patients who followed the rapid protocol, 13 required reoperations, compared with 19 patients in the classic protocol group. The trend suggests greater effectiveness of the rapid protocol in reducing the need for reoperations. The graph shows a higher incidence of complications that required additional interventions in the classical protocol group.

Discussions

The results indicate that the rapid recovery protocol could be associated with a lower incidence of operative reoperations, probably due to early mobilization and intensive monitoring. However, individual variables such as injury severity and comorbidities may influence the results. Adherence to the protocol and correct implementation are critical factors that may vary between medical centers.

Conclusions

The study highlights the importance of continuous evaluation of post-operative recovery protocols with a focus on reducing re-operations. Although the rapid protocol shows potential advantages, further research is needed to confirm these results. Implementation of a customized recovery protocol that combines the efficiency of the rapid protocol with patient-specific considerations could improve the postoperative management of severe upper limb trauma.

10. Study 3, Study and comparative evaluation of factors affecting the finality of severe upper limb trauma cases - prospective study

Introduction

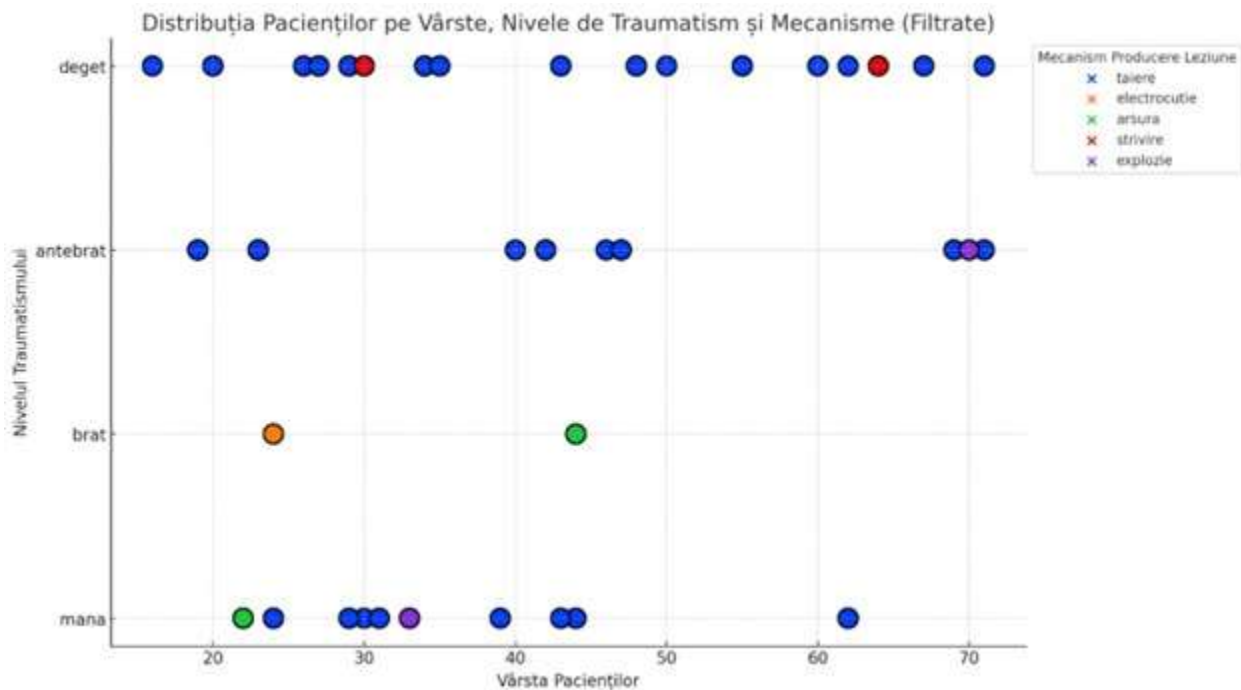
Severe trauma to the upper limb represents a major challenge in the medical field, due to the anatomical and functional complexity of these structures. Upper limbs are essential for daily activities, and their injuries can profoundly affect quality of life. This prospective study analyzes and compares factors influencing clinical outcomes in severe upper limb trauma with the aim of developing more effective and personalized treatment protocols. The study focuses on demographic variables, mechanisms of injury and associated comorbidities, taking place over an eight-year period during which patients were actively monitored.

Material and method

The study included 365 patients admitted for severe upper limb trauma at a university hospital over eight years. Data collected included demographic information such as age, gender, background, occupation and education level. Also, details about the mechanisms of trauma production, the types of injuries and the comorbidities of the patients were recorded. Advanced imaging was used to assess the anatomical details of the lesions, and therapeutic interventions were documented, including surgery, prostheses, grafts, and fixation devices. Statistical analyses, such as correlation tests and multivariate analyses, were applied to explore the relationships between these variables and clinical outcomes. Patients were followed up for six months to assess long-term recovery and complications.

Statistical results

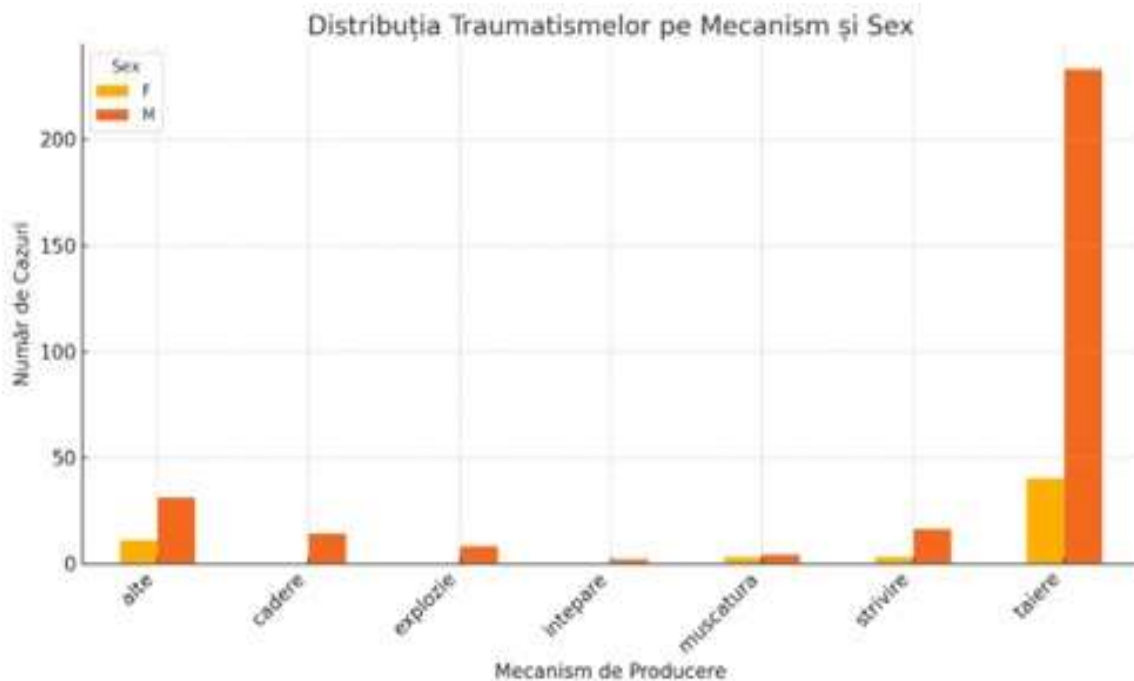
The results of the study showed significant differences between traumas suffered in rural and urban areas. In rural areas, crushing injuries were the most common, being often associated with agricultural work, while in urban areas, puncture injuries and cuts, caused by industrial or domestic accidents, predominated. Notable differences were also observed by gender and age, with males and younger patients having a higher incidence of severe trauma.



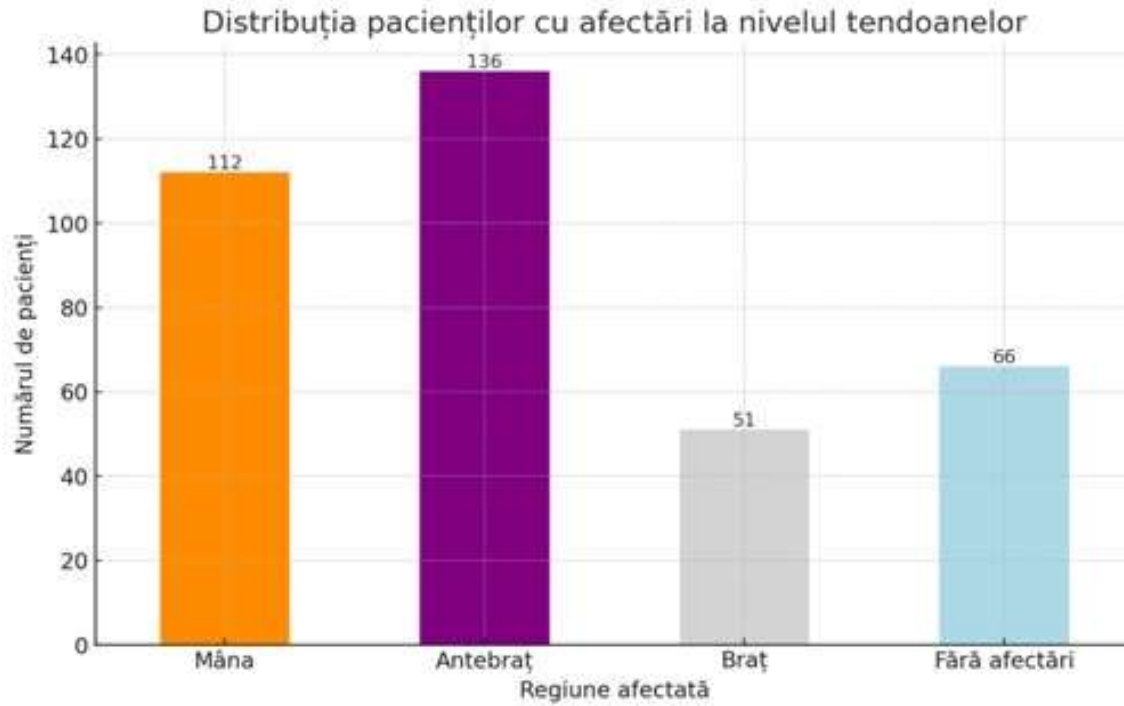
The graph presented provides a complex analysis of the distribution of patients according to age, level of trauma and type of mechanism of injury. This type of analysis is important to understand how age influences the type and severity of injuries sustained at different levels of the upper limbs, such as the finger, hand, forearm, and arm.

Detailed analysis of this graph shows that cutting is a common mechanism of injury at all levels of trauma, but is more prevalent in young and adult patients, particularly in the fingers and hands. This suggests a potential link between activities specific to certain age groups and the types of trauma they are exposed to.

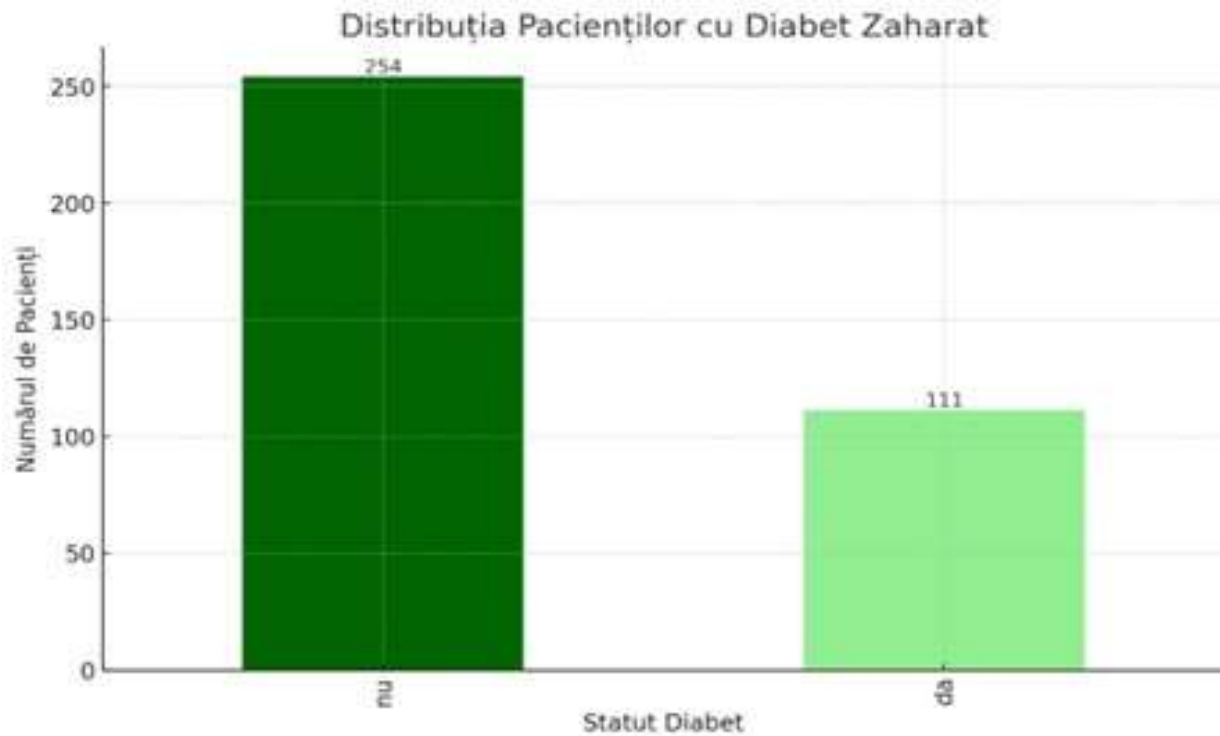
The importance of this chart lies in its ability to guide treatment customization based on age and type of trauma. By understanding how different age groups are prone to certain types of trauma and at specific levels of the upper limbs, doctors can anticipate complications and optimize medical interventions. Thus, the information extracted from this graph contributes to the development of more precise clinical guidelines, which take into account the demographic variables and traumatic mechanisms specific to each patient.



This analysis explores how the gender of the patient influences the type and severity of trauma, by studying the mechanism of production, the object involved, the level of trauma and the structures affected. Choosing this makes it easier to understand the differences in vulnerability between men and women, which can guide the development of personalized prevention and treatment strategies.



This breakdown examines the incidence of nerve damage, emphasizing its consequences on sensation and motor control. The choice of this analysis is important to develop precise surgical interventions and recovery programs that optimize functional recovery.



This assignment examines the impact of diabetes on outcomes in trauma cases, providing insight into how this comorbidity complicates treatment.

Comorbidities, such as diabetes and hypertension, complicated recovery, being associated with an increased risk of complications. Also, patients with alcohol or drug addictions had poorer clinical outcomes, largely due to delayed surgery. Severe cases required multidisciplinary interventions, and these approaches were essential to improve prognosis.

Discussions

The study emphasizes the importance of a personalized approach in the treatment of patients with severe upper limb trauma. The different distribution of injuries between rural and urban environments suggests the need for preventive and intervention strategies specific to each environment. Gender and age differences also indicate that education and prevention programs must be tailored to address the vulnerabilities of each demographic group.

Comorbidities played a significant role in complicating cases and influencing clinical outcomes, highlighting the need for careful monitoring and management of these conditions. Alcohol and drug dependence was a determining factor in delaying treatment and worsening prognosis, which underscores the importance of integrating addiction support services into the trauma patient's care plan. Multidisciplinary interventions and the use of advanced surgical techniques have proven critical in the management of complex cases. However, standardized protocols are needed to maximize the effectiveness of these approaches and minimize postoperative risks.

Conclusions

The study provided comprehensive insight into the factors influencing clinical outcomes in severe upper limb trauma. The personalized approach, which takes into account demographic variables, injury mechanisms and patient comorbidities, has proven essential to optimize treatment. The implementation of rapid therapy protocols and the use of multidisciplinary interventions have been successful in improving patients' recovery and quality of life. Future research should explore the integration of new technologies and therapeutic approaches to continue to improve outcomes in the management of severe upper limb trauma.

11. Cases for patients who had a quick recovery

Complete tear of the biceps brachii due to severe trauma

A 28-year-old man was the victim of a motor vehicle accident that resulted in a type III C humeral fracture and a complete section of the radial nerve, along with a complete tear of the biceps brachii. This was a highly complex trauma characterized by a major muscle defect of approximately 10 cm in the anterior brachial compartment. After admission, the patient developed a severe infection with *Enterococcus* spp., further complicating the treatment. Initially, the patient received humeral osteosynthesis and neurorrhaphy, but four days postoperatively, purulent discharge signaled an active infection that required urgent debridement and an aggressive antibiotic regimen.

Treatment included extensive wound washing and excision of septic tissue. Despite the severity of the infection, muscle repair was successfully accomplished using U-type sutures, and the limb was immobilized in a flexion splint to avoid excessive tension on the sutured muscles. A skin graft was subsequently applied to cover the remaining defect and maintain elbow mobility. The patient followed a strict rehabilitation regimen, including passive and active exercises to regain joint and muscle mobility and strength.

The results were favorable, with the patient recovering motor function and nerve sensitivity after a 30-month rehabilitation period. Despite severe infection and complex trauma, the careful surgical approach and effective antibiotic regimen resulted in an excellent outcome with full restoration of arm mobility and aesthetics.

Rattlesnake bite

A 30-year-old female snake and tarantula breeder was bitten on the wrist by a rattlesnake. On arrival at the hospital, the patient presented with severe erythema and edema, classic signs of a venomous bite. In the first hours after the bite, laboratory tests revealed a significant increase in creatine kinase and a decrease in fibrinogen, suggesting muscle damage and coagulopathy. Initial treatment included intravenous fluids, anticoagulants, corticosteroids, and pentoxifylline to reduce the risk of thrombosis and improve tissue perfusion.



After 12 hours, the patient developed signs of compartment syndrome, including extreme pain and loss of function in the affected limb. A surgical decompression incision was performed to prevent ischemic contracture and restore blood flow to the affected tissues. After the initial intervention, the patient required a second surgery to close the wound and repair the affected structures. Despite complications, the patient regained limb function and was discharged, albeit against medical advice.



This case highlights the importance of prompt intervention in venomous snakebites, especially in the setting of compartment syndrome, which can lead to severe functional loss if not managed properly.

12. Treatment protocol

Treatment protocol for the early rehabilitation of severe upper limb trauma

Introduction

Severe upper limb injuries represent a significant challenge in medical practice, due to their complexity and profound impact on patients' functionality and quality of life. Effective treatment of these injuries requires a multidisciplinary approach that integrates emergency surgery, medical management, and early rehabilitation. Early recovery of patients with such trauma is essential to prevent long-term complications and restore function of the affected limb.

This treatment protocol is designed as a comprehensive guide for medical professionals, providing clear directions for initial management and necessary surgical interventions, as well as implementing a structured early rehabilitation plan. The protocol emphasizes the importance of prompt intervention and rigorous planning at all stages of treatment, from hemodynamic stabilization and surgical debridement to functional rehabilitation of the upper limb.

Therefore, this guideline provides recommendations based on current best practice and clinical evidence, with the primary objective of maximizing the chances of full recovery and minimizing the risks of complications. The guidelines presented are intended to support medical teams in making critical decisions, ensuring high-quality care tailored to the individual needs of each patient. This guide not only provides solutions for immediate treatment problems, but also strategies for ensuring effective rehabilitation, thus contributing to the rapid and successful reintegration of patients into their daily activities.

What to follow

1. Ensure hemodynamic stability of the patient by fluid and electrolyte rebalancing and control of any moderate or major active bleeding. Give intravenous antibiotics to prevent infection.
2. Perform a complete evaluation of the lesion, including radiologic imaging and evaluation of the great vascular axis. Document the extent of bone, nerve, and soft tissue injuries.
3. Initial surgical debridement must be meticulous, removing all necrotic tissue and foreign material to minimize the risk of infection.
4. Use external fixators or internal fixation devices as appropriate to stabilize the fractures. Ensure that the method of stabilization allows for subsequent surgery and wound care.
5. Promptly perform microvascular repair to restore blood flow to ischemic tissues. Repair peripheral nerves using microsurgical techniques to precisely align nerve fibers.
6. Ensure soft tissue coverage of noble structures, tendons and bones. Integumentary wound closure, use skin grafts or local flaps if necessary.
7. Administer analgesics and consider regional anesthetic techniques to effectively manage pain.
8. Place the limb in a functional position using splints or casts to avoid excessive tension on sutures and repairs. Monitor the limb for signs of ischemia, infection, or compartment syndrome. The exception is cases where the patient is placed in a physiological position but with a narrower angulation of some of the joints to avoid the use of arterial and nerve grafts.
9. Follow culture-specific antibiotic protocols, adjusting them based on antibiogram results.

10. Begin planning for early mobilization even during the initial surgical phase, anticipating the need for a structured rehabilitation program.

What not to follow

1. Avoid delays in initial debridement and wound cleansing, as this can significantly increase the risk of infection.
2. Don't overlook vascular assessments. Failure to restore adequate blood flow can lead to tissue necrosis and further complications.
3. Don't ignore the risk of infection. Prompt initiation of antibiotic therapy and strict aseptic techniques during surgery are crucial.
4. Avoid insufficient stabilization of fractures, as this may compromise the healing process and the success of subsequent surgery.
5. Do not underestimate the importance of psychological therapy as an important part of case recovery, this can lead to unexpected events and reactions of patients suffering from functional impotence of the limb.
6. Avoid immobilizing the limb in positions that could lead to contractures or excessive tension on repairs.
7. Do not neglect consistent follow-up and monitoring, which are important for early detection of complications.

Early rehabilitation phase

What to follow

Begin passive range of motion exercises within 72 hours after surgery to prevent joint stiffness and adhesions. Movements should be gentle and within the pain threshold.

Develop a detailed physiotherapy plan that includes gradual progression from passive to active and finally active exercises.

Emphasize exercises that maintain and improve joint mobility, especially at the shoulder, elbow, and wrist.

Use lifting garments, compression and manual lymphatic drainage techniques to manage and reduce inflammation.

Continue appropriate pain management strategies, including NSAID use, to facilitate patient participation in rehabilitation.

Implement techniques such as nerve gliding exercises to promote nerve regeneration and prevent neuromas.

Maintain the limb in functional positions during immobilization to prevent contractures. Splints should be used as needed.

Gradually introduce strengthening exercises, starting with isometric contractions and progressing to isotonic exercises as healing allows, all the while considering isometric exercise correlation with hypertensive patients.

Monitor the patient regularly for signs of complications such as infection, nerve and vascular damage.

Educate the patient about the importance of following the rehabilitation program, proper limb positioning, and signs of complications to watch for.

What not to follow

Avoid aggressive movements or excessive force during early rehabilitation, as this can disrupt surgical repair and worsen injuries.

Do not ignore the patient's complaints of pain. Pain is an indicator of potential problems and should be managed and investigated appropriately.

Neglecting to manage edema can lead to increased pain, decreased mobility, and delayed healing.

Do not allow gaps in the rehabilitation program. Consistency is the key to successful recovery.

Prolonged immobilization without gradual introduction of movements can lead to joint stiffness and muscle atrophy.

The intermediate phase of rehabilitation

What to follow

Gradually increase the intensity of the exercises, as healing progresses, increase the intensity and range of exercises. Focus on functional activities that replicate daily tasks.

Introduce activities that improve coordination, dexterity, and functional use of the limb, such as grasping, lifting, and fine motor tasks.

Use therapeutic modalities such as ultrasound, TENS, and heat therapy to facilitate tissue healing and pain relief.

Use joint mobilization techniques to improve range of motion and prevent joint contractures.

Implement scar management techniques including massage, silicone gel sheets, and pressure garments to improve scar flexibility and appearance.

Provide psychological support to address any anxiety or depression related to the injury and rehabilitation process.

Conduct regular assessments to track progress and adjust the rehabilitation plan as needed.

Promotes patient independence in performing daily activities and self-care tasks.

Ensure the patient maintains a balanced diet to support overall health and tissue repair.

What not to follow

Don't overlook the psychological impact of injury. Mental health is important for motivation and participation in rehabilitation.

Failure to manage scar tissue can lead to decreased flexibility and cosmetic problems.

Avoid overloading the patient, which can lead to failures or re-injury.

Do not underestimate the importance of functional training in the rehabilitation process. Practical skills are important for everyday life.

Poor nutrition can affect healing and overall recovery.

Late phase of rehabilitation

What to follow

Advanced Strength Training Implement advanced strength training exercises targeting both the affected and contralateral limb to restore symmetry and overall strength.

Include cardiovascular and endurance training to improve overall fitness and limb endurance.

Focus on exercises that improve fine motor skills and accuracy, crucial for tasks that require dexterity.

Include activities that simulate the patient's work environment to prepare for return to work.

Maintain access to psychological support services to address any ongoing mental health issues.

Schedule regular follow-up appointments to monitor long-term results and address any late-onset complications.

Provide training in the use of adaptive equipment, if necessary, to facilitate independence in daily activities.

Support the patient's reintegration into the community through social activities.

Regularly assess the patient's goals and modify the rehabilitation plan to align with the patient's progress and aspirations.

What not to follow

Do not stop psychological or medical care prematurely. Long-term recovery often requires prolonged care.

Ignoring the development of fine motor skills can limit the patient's ability to perform detailed tasks.

Failure to support community reintegration can lead to isolation and reduced quality of life.

Do not ignore the patient's feedback on their progress and any difficulties they are experiencing.

Goals should be flexible and adjusted based on patient progress. Rigid goals can lead to frustration and decreased motivation.

13. The role of early rehabilitation

Following surgery, the role of early and structured rehabilitation cannot be overstated. Recovery of upper limb function is strongly influenced by the timing and intensity of rehabilitation efforts. Studies have consistently shown that initiating passive range of motion exercises within the first 48 hours after surgery can significantly reduce the risk of joint stiffness and promote faster functional recovery. The case studies reviewed emphasize the critical importance of a well-coordinated rehabilitation plan that progresses from passive to active exercises, gradually increasing the load on the affected limb as healing progresses.

In cases where extensive soft tissue damage and nerve damage are present, the rehabilitation plan must be carefully calibrated to balance the need for mobility with the protection of delicate surgical repairs. The use of physical therapy modalities such as ultrasound and electrical stimulation has been shown to improve tissue healing and muscle re-education, further supporting functional recovery of the limb. Furthermore, the involvement of a multidisciplinary team – including physiotherapists, occupational therapists and surgeons – ensures that all aspects of the patient's recovery are addressed, from pain management to the restoration of fine motor skills.

14. Management of Complications

Complications such as infections, delayed or nonunion of fractures, and chronic pain are common in the treatment of severe upper limb injuries. Management of these complications requires a proactive approach involving both surgical and pharmacological strategies. In the context of infection control, the use of targeted antibiotic therapy, as demonstrated in an *Enterococcus* spp. infection following a humerus fracture, is important. The success of treatment in this case was based on early identification of the pathogen and implementation of an aggressive antibiotic regimen combined with meticulous wound debridement.

Similarly, management of chronic pain, which can seriously hinder the rehabilitation process, must be integrated into the overall treatment plan. The use of regional anesthetic techniques and careful titration of analgesic medications are crucial to maintaining patient comfort and ensuring adherence to rehabilitation protocols. The reviewed cases suggest that early and aggressive pain management not only improves patient outcomes, but also improves overall quality of life during the recovery period.

15. Multidisciplinary approach and long-term results

The importance of a multidisciplinary approach in the management of severe upper extremity trauma cannot be overstated. Coordination between surgical teams, rehabilitation specialists, and other healthcare providers is important to ensure that all aspects of the patient's recovery are addressed. Case studies highlight the benefits of this approach, particularly in the context of complex injuries that require ongoing monitoring and adjustment of treatment plans.

Long-term outcomes for patients who have undergone treatment for severe upper limb injuries are influenced by several factors, including the initial severity of the injury, the effectiveness of surgical and rehabilitation interventions, and the patient's adherence to the prescribed treatment regimen. Regular follow-up and continuous adjustment of the rehabilitation plan is necessary to address any emerging problems, such as the development of neuromas or recurrence of contractures. The success of these interventions is ultimately measured by the patient's ability to return to normal daily activities and, in many cases, to their previous level of occupational function.

Integrating patient education into the treatment plan is also a critical component of long-term recovery. Educating patients about the importance of adhering to rehabilitation protocols, recognizing early signs of complications, and managing chronic conditions such as pain and stiffness can significantly improve long-term outcomes. The role of psychological support should also be considered, particularly in cases where the injury has had a profound impact on the patient's mental health and general well-being.

16. Future Directions and Research

Treatment of severe upper limb injuries is continually evolving with advances in surgical techniques, rehabilitation protocols, and management of complications. Research focuses on integrating new technologies, such as advanced prosthetics and regenerative medicine, alongside new pharmacological agents and rehabilitation techniques to improve patient recovery.

The case studies reviewed highlight current technological progress in the management of severe upper limb trauma, but also emphasize the need for continued research to understand long-term outcomes and standardize clinical practices. The multidisciplinary approach and the integration of new technologies will remain essential to improve the treatment of these complex injuries.

An important innovation in treatment is the creation of custom orthotics using 3D scanning technology and 3D printing. They offer a more accurate and comfortable alternative to traditional methods. The process begins with a 3D scan of the patient's hand, followed by design customization in SolidWorks software, where a model optimized for comfort and functionality is created. The model is then 3D printed, providing a durable and effective orthosis tailored to the patient's individual needs. This modern approach promises more efficient recovery and increased comfort for patients with upper limb injuries.

17. Final conclusions and my contribution

The conclusions of this doctoral thesis, dedicated to the therapeutic conduct and management of postoperative recovery in severe trauma of the upper limb, reflect the complexity and importance of these injuries in plastic and reconstructive surgery. In the context where these traumas involve not only the loss of functionality, but also, in many cases, the loss of the limb itself, the therapeutic approach must be holistic, integrating both surgical and recuperative aspects. This work aimed not only to analyze and optimize existing treatment protocols, but also to propose new strategies aimed at significantly improving patient prognosis.

The research carried out confirmed the initial hypotheses regarding the benefits of a rapid and personalized recovery protocol, which is initiated only 72 hours postoperatively. This protocol has been compared to traditional recovery methods, which involve a later onset of rehabilitation and, although effective, fail to provide the same functional and quality of life outcomes. Clinical studies have shown that patients who followed the rapid protocol benefited from an accelerated recovery of limb functionality, a significant reduction in postoperative complications, and better socio-professional reintegration.

An important aspect of the research was to assess the complexity of severe upper limb trauma from a multidisciplinary perspective. The need for collaboration between specialists in the field of plastic surgery, reconstructive microsurgery, physiotherapy and psychology was emphasized, in order to offer patients a complete and integrated therapeutic approach. The complexity of these injuries, which frequently involve multiple structures such as bones, nerves, blood vessels and soft tissues, requires a coordinated and synchronized intervention between these disciplines.

The conclusions drawn from this research indicate that the success of effective rehabilitation depends not only on the surgical intervention, however complex it may be, but also on the quality and promptness of the postoperative interventions. Fast recovery, careful monitoring of the postoperative evolution and constant adjustment of the therapeutic protocol according to the individual response of the patient are basic to achieve an optimal result. Studies have also shown that psychological factors, such as the patient's level of trust in the medical act, emotional support and motivation for recovery, play a crucial role in the final outcome.

The work also made a significant contribution to the understanding of the importance of a personalized approach in postoperative recovery. Through the careful analysis of individual factors, such as the type and severity of the injury, the age of the patient, the general state of health and the presence of comorbidities, we have been able to develop protocols adapted specifically to each case. These protocols were tested and validated in a clinical study conducted at the "Floreasca" Bucharest Emergency Clinical Hospital, under the guidance of Prof. Dr. Emeritus Ioan Lascăr, the results being published in specialized journals, thus contributing to the consolidation of the scientific base in the field.

In addition to the direct medical benefits, these results also have a significant impact on the socio-professional reintegration of patients. Fast and quality functional recovery not only reduces the period of inactivity and dependence of patients, but also gives them the chance to return more quickly to their daily and professional activities, thus contributing to a faster and more efficient reintegration into society. This

aspect is particularly important, considering that severe trauma to the upper limb can drastically affect the patient's quality of life and autonomy.

Regarding my personal contribution to this thesis, I had the opportunity to integrate and coordinate a complex research effort, which involved not only the review and analysis of the specialized literature, but also the development of a robust methodological framework for evaluating the effectiveness of different treatment protocols. recovery. I actively participated in the collection and analysis of clinical data, as well as in the development of conclusions that formed the basis of the proposal of new practice guidelines in the field of postoperative recovery for severe trauma of the upper limb.

I was also involved in the publication of the intermediate results of the research, thus contributing to the dissemination of the knowledge obtained in the scientific community. This activity was important for the validation and international recognition of the research carried out, as well as for the practical implementation of the thesis conclusions within clinics specialized in plastic surgery and recovery.

In conclusion, the present thesis not only makes a significant contribution to the knowledge and management of severe upper limb trauma, but also sets a new standard in the approach to postoperative recovery. By integrating embryological and anatomical knowledge with advanced surgical techniques and personalized recovery methods, we have been able to develop a therapeutic model that can be effectively applied and adapted to the specific needs of each patient. This research thus opens up new directions of exploration in the field of plastic surgery and rehabilitation, while also providing valuable support for the training of future specialists in this field.

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