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Treatment options for long-term damage of shoulder-girdle and rotator cuff muscles as illustrated by clinical cases

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Abstract
Introduction: The survey presents three clinical cases of successful treatment of chronic damage to the shoulder girdle and rotator cuff muscles with varying severity in people of working age. The patient with the most severe clinical symptoms of disorders had an episode of thromboembolism of the small pulmonary artery in past medical history. The aim of the study was to demonstrate, using the example of clinical cases, treatment options for patients with post-traumatic neuropathy of the axillary nerve associated with the rotator cuff damage, with improvement of the upper limb function and the patient's quality of life.
Materials and Methods: A comprehensive study of the outpatient and inpatient records materials, the results of clinical laboratory methods of patient work-up was carried out, a selected conservative and surgical treatment, a rehabilitation program and drug prevention of thrombus formation are described in detail.
Results: 8 months after the end of treatment, there was general, significant improvement of the damaged shoulder joint and limb function in all patients, and in the first two cases with moderate and medium deficiency, the level of complete recovery was almost achieved. The third patient, with the most adverse consequences and hemostatic comorbid pathology, underwent multi-team muscle-fascial transfer. As a result, there was a significant improvement in the right shoulder function.
Discussion: A personalized approach to the choice of treatment tactics, depending on the degree of existing clinical disorders, whether a complex conservative treatment solely, or combined with an arthroscopic technique, as well as a reasonable implementation of techniques for transfer of preserved muscles to replace the lost function of damaged muscles in the most complex case was a condition and guarantee for achieving significant progress in the patient's anatomical and functional status. Nevertheless, it seems appropriate to carry out a further search for more rational technologies of restorative reconstruction for the disorders under consideration.
Conclusion: An individualized tactical and technical approach to the rehabilitation of such a complicated cohort of patients, correctly selected, taking into account the clinical and instrumental data, allows to improve the upper limb function of and the patients' quality of life, and the reasonable tactics of clotting prevention ensures hemostasis control and the absence of vascular catastrophes.

Keywords: Long-term damage, myoparesis of the shoulder girdle, rotator cuff, myofascial transfer, pulmonary thromboembolism

Introduction

Among the injuries of the musculoskeletal system, the brachial plexus lesions associated with muscle masses myoparesis represent some of the most serious types and account for 2-3.7% of all injuries [1-3]. Myoparesis of the shoulder girdle and rotator cuff muscles are accompanied by a significant decrease in the pectoral arch function, which, when localized on the side of the dominant arm, leads to a significant decrease in the patients' quality of life [4, 5]. Taking into account the predominance of working age people in the structure of injured persons, and disability over 70% of this group, the problem of treating such patients has not only medical but also social significance [6, 7].

In the aspect of diagnosis and treatment of the injuries under consideration, a number of questions remain unresolved. In particular, this concerns the biomechanics of the joint muscular complex. Due to the anatomical features, shoulder dislocations are often accompanied by the axillary nerve damage and the deltoid muscle disability. Previously, the deltoid muscle was assigned one of the leading roles in shoulder abduction/deviation, and the rotator cuff (RC) was considered only as the humerus stabilizer.

Over the years, more and more attention was paid to the cuff; some studies appeared, stating the leading role of this complex in particular and presenting clinical observations of the deltoid muscle paralysis with preservation of the shoulder abduction/deviation function [8].

The deltoid muscle and the RC disability causes a significant limitation in the range of active movements and destabilizes the segment with further formation of its sub acromial dislocation. Treatment of this pathology requires the performance of technically complex and multi-stage operations, as well as long-term rehabilitation measures implementation [9, 10]. It is generally accepted that neurologists and neurosurgeons are mainly involved in brachial plexus injuries treatment, while orthopedists rarely deal with this pathology therapy. Nevertheless, since the beginning of the 20th century, reconstructive interventions on the tendon-muscular and bone apparatus of the pectoral arch have been developed to compensate emerging disorders. The statement of indications for their implementation is a separate and very important issue, since the unspecified residual continuity of the nerve trunks gives a perspective on greater or lesser degree of recovery in case of conservative therapy, while the failure of reconstruction will exclude hope for recovery.

In addition to clinical examination, the set of diagnostic procedures should include X-ray, MRI/CT of the shoulder joint and electromyography of the upper limb for choosing tactics in favor of tendon-muscle reconstruction. It is advisable to investigate the state of large vessels. Electrophysiological data must be considered as the main criterion: in the complete absence of the axillary and suprascapular nerves conduction, the possibility of rehabilitation is associated only with reconstructive surgery. The duration of the post-traumatic period is also important while making decision to carry out surgical intervention in case of conservative therapy ineffectiveness after 6 months or more [2].

The currently used reconstructive and restorative techniques are based on the necessity to insure on the one hand the humeral head centration in the shoulder blade glenoid that is conditioned by the paresis of the RC located high in the subacromial space; on the other hand – on the substitution of the lost function of shoulder abduction/deviation due to deltoid muscle damage, as well as its frontal and posterior abduction. The possibility of endoscopic surgery significantly reduces the deltoid muscle traumatization, ensuring better recovery of the damaged shoulder joint function. Today, the total number of patients undergoing arthroscopic rotator cuff reconstruction is increasing annually due to the availability of technology and significant proven experience in its effectiveness.

At the same time, the possibilities of arthroscopic reconstruction of the RC muscles are limited. Thus, muscle atrophy according to Goutalier 3-4, significant tendon retraction, a time interval of more than 4 months from the moment of avulsion impede the implementation of the arthroscopic procedure given the impossibility of moving the tendons to the footprint. At the same time, pronounced muscle atrophy does not represent prospects for their inclusion into the biomechanical process even after rehabilitation procedures, therefore the transposition of tendons from other sites might have good chances for shoulder function improvement. With furtherance the latter objective, L. Mayer developed a surgery technique (fig. 1) for the trapezius muscle transplantation to the shoulder using a fascial graft [11-13]. Subsequently, the surgery technique was changed by Bateman and by Saha lately. The first one osteotomized a segment of the shoulder bone and the acromial process, the second performed the same with the acromial end of the clavicle in the area of the trapezius muscle fixation and formed bone anchoring to the humeral head [14]. However, experience has shown, that the success of such interventions, performed without returning the humeral head to a centered position, with a common recognized risk, was problematical. And only Saha's suggestion to perform m. latissimus dorsi (or m. teres major) transfer to the lesser tubercle of humeri, greatly enhanced the results of surgery in case of the damages under consideration. Nevertheless, due to the lack of common views on the work of the muscular complex of the shoulder, treatment of patients remains a very difficult task, especially, in case of a long-term nature of the damage, it requires a personified approach and the development of new tactical and technical methods for treatment.

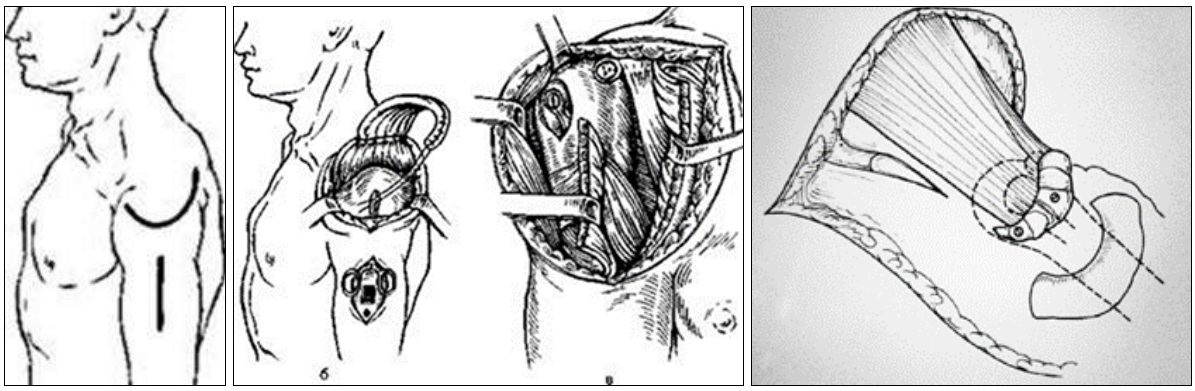

Fig 1: Trapezius muscle transfer to the shoulder bone according to L. Mayer (Bateman's modification is displayed on the right)

Purpose of the study: to demonstrate, using the example of clinical cases, treatment options for patients with post-traumatic axillary nerve neuropathy combined with the rotator cuff damage, resulting in the improved upper limb function and the patient's quality of life.

Materials, methods and results: This article displays clinical cases of post-traumatic axillary nerve injury combined with the deltoid muscle paralysis and the RC damage. In the first case, a 40-year old male patient M., had a numb feeling in the skin cover, spreading from the left

shoulder girdle to the elbow joint, after a traumatic dislocation of the left shoulder. Also, when it happened, he had a drop of the range of active movements in the left shoulder joint: flexion - 20 degrees, extension - 10 degrees, abduction/deviation - 20 degrees. On the VAS scale, the pain syndrome was 2 points, the shoulder function on the DASH scale was 75 points. After a complex examination, including the left brachial plexus ENMG and ultrasound, partial damage to the left axillary nerve was revealed, but the suprascapular nerve function preserved. Post-traumatic neuropathy manifested itself as the deltoid muscle paralysis. MRI revealed only Bankart injury but the RC complex remained undamaged. The complex conservative treatment which also included active neurotropic medication, with a complex of rehabilitation measures had a positive effect on the left upper limb function only after 4 months. After 6 months, the range of motion increased to full. The pain syndrome was relieved, the shoulder function on the DASH scale amounted to 8 points.

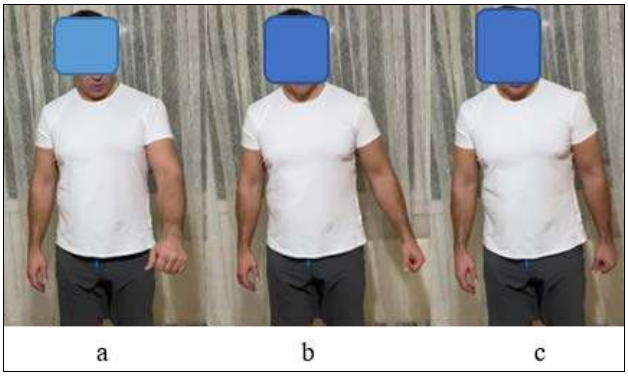

Fig 2: Range of motion in the left shoulder joint 1 month after injury. (a - flexion; b – abduction/deviation; c - extension)

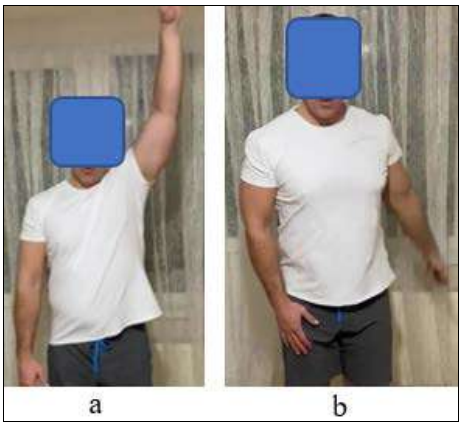

Fig. 3. Range of motion in the left shoulder joint 6 months after complex conservative therapy (a - full Dowborn arch, b - extension).

In the second clinical observation, a female patient M, 53 years old, had the shoulder dislocation. She also noted sensitivity loss in the area responsible for the axillary nerve. The patient applied for medical assistance 2 weeks after the injury. The range of motion decreased significantly: flexion, abduction, extension according to Marx amounted to 10 degrees. Pain syndrome was insignificant: 3 points according to VAS. DASH shoulder function was 78 points. Examination, including the left shoulder joint MRI, the left brachial plexus ultrasound and ENMG, revealed the RC tear, the axillary nerve damage, and the deltoid muscle paralysis. During 2 months she was receiving a course of neurotropic therapy and electromyostimulation. The pain syndrome decreased to 1 point according to VAS, sensitivity was restored, the range of motion increased: flexion - 30 degrees, extension - 40 degrees, abduction/deviation - 20 degrees (Fig. 4).

Repeated MRI examination of the shoulder joint revealed significant retraction of the RC tendon up to 2.5 cm, the muscle atrophy closer to 3rd degree according to Goutalier (about 45%). It was decided to try to re-fix the rotator cuff tendons to the footprint. An arthroscopic RC reconstruction was performed using anchor fixation (Fig. 5). The attempt was successful after the tendons release and the scars removal. There were no complications during the postoperative period. 6 months after the medical rehabilitation course combined with neurotropic therapy, a significant improvement in the left shoulder joint function was noted. The range of motion increased: flexion - 160 degrees, abduction/deviation - 150 degrees, extension - 40 degrees (Fig. 6). Function according to the DASH scale was: 10 points. Sensitivity was fully restored.

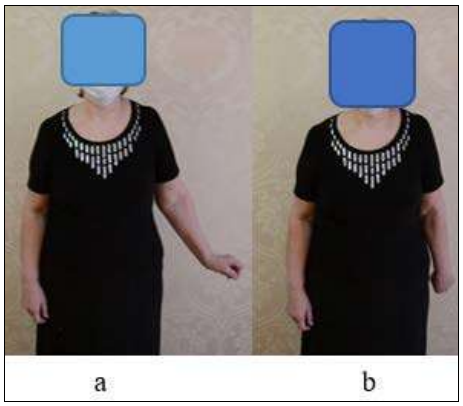

Fig 4: Range of motion in the left shoulder joint 1 month after injury (a – abduction/deviation, b - extension)

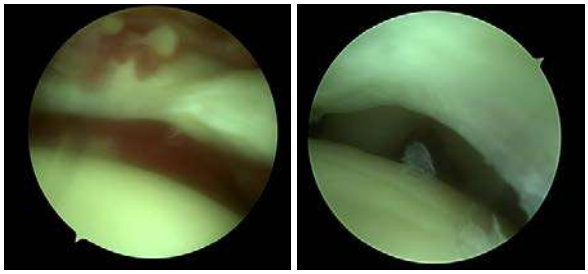

Fig 5: Arthroscopic picture of the RC tendons tear.

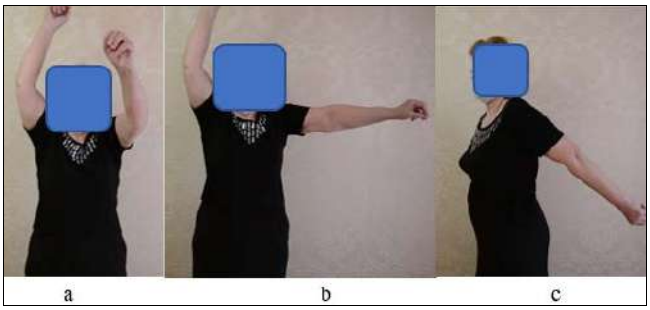

Fig 6: Range of motion 6 months after the surgery (a – abduction/deviation, b - extension)

In the third case, a 60-year old male patient T. got a multiple trauma at work in March 2019. He had multiple fractures of

the lower extremities bones, a blunt chest trauma followed by the developed small pulmonary artery thromboembolism, as well as traction neuropathy of the suprascapular and axillary nerves with innervated muscle mass paresis. The treatment of injuries to the right shoulder girdle and the RC muscles was delayed due to the severity and urgency of other damages.

After 6 months, the patient showed a significant limitation of active movements in the right shoulder joint with moderate pain syndrome. When contacting the clinic, the range of active movements (according to Marx) was: flexion - 100, extension and abduction/deviation also 100 each. The upper limb function according to the DASH scale was estimated at 80 points, the pain assessment according to the VAS was 6 points. The X-ray, ultrasound and ENMG investigations revealed: complete detachment of the tendons of the subscapular, supraspinous, infraspinous and small round muscles with their atrophy equal to 3-4 degrees according to Goutallier scale, the humeral head dislocation upward associated with the subacromial space narrowing up to 2 mm and outward (1.5 cm diastasis between the humeral head and the articular process of the scapula) with joint destabilization and an acute decrease in the suprascapular and axillary nerves conductivity.

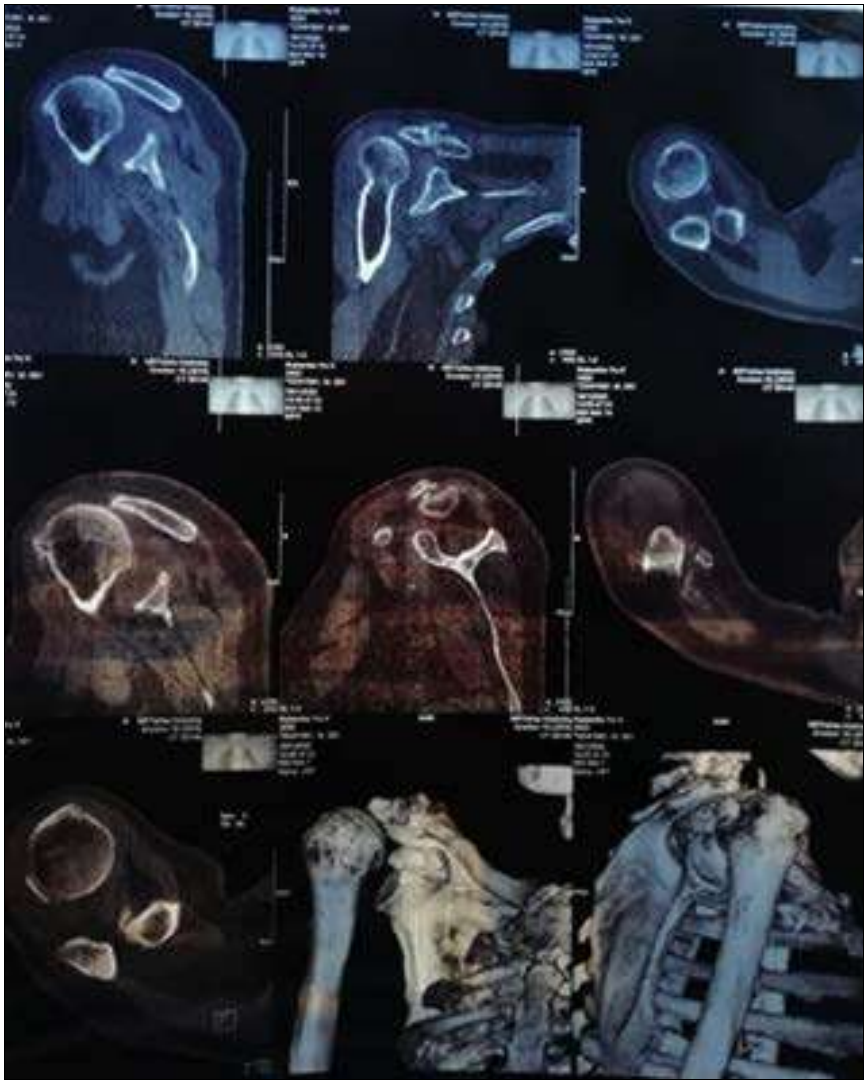

Fig 7: The right shoulder joint CT of the patient T. at admission

Thus, it was acknowledged that irreversible loss happened to the main muscle groups-antagonists, ensuring the shoulder joint motions of the right, leading arm. The chance of improving the shoulder function was associated exclusively with an attempt to replace the "levers" by transferring the undamaged muscles tendons. In this sense, the transfer of the trapezius muscle segment to the area of fixation of the paretic deltoid muscle and the latissimus dorsi tendon to the lesser tubercle of humeri, created conditions for restoring centration of the humeral head at the point rotation. At the same time, as for the method of the trapezius muscle release, we chose the combined Mayer-Bateman-Saha method with bone fixation.

On 12.05.2020 we performed a simultaneous transfer surgery of the trapezius muscle tendon segment to the place of the deltoid muscle insertion onto the shoulder tuberosity (by one team). In parallel, the second team, performed the transfer surgery of the latissimus dorsi muscle to the lesser tubercle of the right humeral trough two approaches. The patient was positioned on his side. Through the "epaulette" incision, we accessed to the distal trapezius muscle. Then, the access from the "epaulette" apex was extended outward and distally (Fig. 8). Using blunt and sharp dissection we released the tubercular region of the humeral head and the zone of delta insertion on the segment superficies. A significant distal part of the m. trapezius tendon was taken

with bone fragments of the clavicle acromial end, the scapula acromion and spine, released and sutured with a transosseous suture to the tuberosity of the right humeri keeping the shoulder abducted by 90 degrees.

Fig 8: Access for transfer of the trapezius muscle musculoskeletal block

At the same time, an S-shaped incision was made along the lateral edge of the scapula, the tendon of the latissimus dorsi was released, dissected from the insertion site (Fig. 9)

Fig 9: Access for the latissimus dorsi muscle transfer to the lesser tubercle of the humerus (in the left picture) and the latissimus dorsi muscle release for subsequent transfer (in the right picture)

The tendon was lengthened by 5 cm with a fragment of the broad fascia of the upper leg taken from the right side, and fixed to the lesser tubercle of the right humerus with transosseous sutures. The wounds were closed in layers and drained. The right upper limb was immobilized on the abduction splint at 30° abduction and 30° flexion for 6 weeks. Taking into account the severe hemostatic complications of the injury and its surgical treatment in the patient's history, it is necessary to talk more specifically about the tactics of thromboprophylaxis in this case. Let us clarify that small-branch pulmonary embolism that developed soon after injury in the postoperative period during the emergency stage, the treatment was carried out by means of LMWH administration in the form of one of the domestic generic analogues of enoxaparin. On the 4th day of its use, an abundant serous-hemorrhagic wound fluid was noted; laboratory control diagnosed a suspected adverse reaction in the form of HIT with a decrease in the number of platelets below 70×10^9 / L. In this regard, the LMWH was replaced by fondaparinux, followed by crossover to warfarin intake for 4 months.

At the appointment with the patient, we evaluated the amount of surgery to be performed taking into account the circumstances that have been mentioned, as well as the direct OACs available on the pharmaceutical market, so we decided to conduct thromboprophylaxis using rivaroxaban 10 mg, i.e. in a prophylactic dosage. The choice was based on a compromise between two arguments: on the one hand, the lack of clinical guidelines on the need to prevent thromboembolia in the upper limb surgery, and the PATE development in the patient six months ago, on the other. The duration of the new OACs intake was chosen during the period of immobilization of the limb after surgery. The postoperative period did not reveal any complications, as for wounds and hemostasis. Healing was achieved by primary intention, postoperative blood loss did not exceed 100 ml. No coagulation disorders were observed during laboratory control. A comprehensive course of rehabilitation treatment was carried out in accordance with the rehabilitation protocols.

The developed rehabilitation program, was divided in three periods of physical rehabilitation, subject to characteristics of the performed surgical treatment: early and late postoperative periods, and recovery one. In the first (motion mode - general), the following means of medical rehabilitation were used: physical exercises to relax muscles for small and medium muscle groups, general developing exercises for all healthy joints, exercises to maintain full range of motion in the elbow and wrist joints of the upper limb.

In the second period (sparing motion mode), the means of medical rehabilitation were expanded and included passive and active/passive movements in the shoulder joint, assisted pendulum exercises, isometric, isotonic and rhythmic stabilization exercises, the upper limbs massage, physiotherapy (magneto therapy), kinesio taping.

In the third period (sparing training motion mode) PNF techniques, post-isometric and post-reciprocal muscle relaxation, Mulligan's concept, active movements in the right shoulder joint with increasing the maximum possible range of the upper limb motion without weight, exercises for the shoulder muscles stretching, training to improve humeral-scapular rhythm, coordination of movements, dynamic stereotype, maintenance of the scapula function and its mobilization. The movements were performed on all planes in terms of pain sensations.

After 8 months, the patient showed an improvement in the right shoulder function. The range of active movements according to Marx significantly increased: abduction - 45°, flexion - 55°, extension - 45°. The DASH scale indicators decreased to 25 points, pain syndrome decreased to 3 points on the VAS. The level of independent living skills increased significantly. Thus, the patient noted the ability to lean on his hand, which allowed him to take food, take a shower, wash, brush his hair, brush his teeth, etc. on his own. Subjectively, the patient regards the treatment result as good.

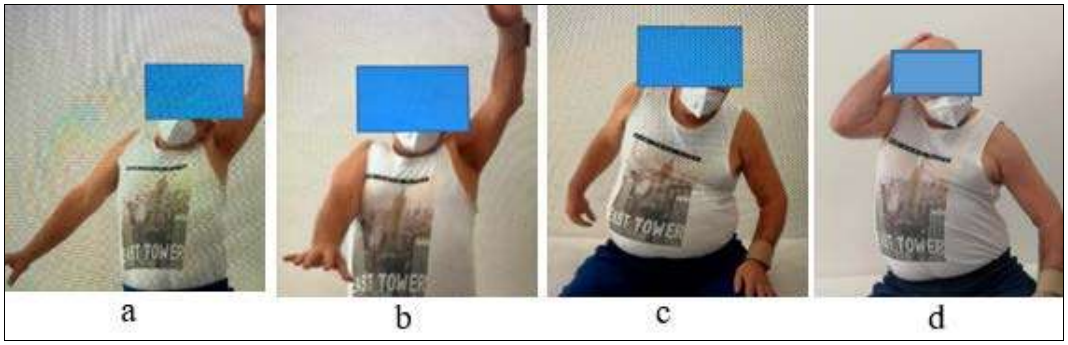

Fig 10: Long-term result of patient T. treatment after 7 months (a - abduction; b - anterior deviation; c - posterior deviation; d - independent living skills)

Discussion

The above mentioned clinical cases and undertaken tactics of treatment methods demonstrate, on the one hand, different degrees of traumatic injuries of the shoulder girdle accompanied with the axillary and suprascapular nerves neuropathy, on the other hand, a personalized approach to each patient, depending on the revealed clinical picture. Given the obvious differences, the general period in the rehabilitation tactics should certainly be called the period of complex therapy, including neurotropic rehabilitation treatment, with minimum length of 5-6 months, observed in all three cases. In the first case, the least severe from the clinical point of view, this tactical technique was enough to achieve almost complete restoration of the injured limb functionality.

In the second observation, complex rehabilitation measures made it possible to only partially restore the lost functions of the injured arm. Residual deficits, largely due to the RC traction and release, justified a decision on a minimally invasive surgical technique - arthroscopic reconstruction with anchor refixation of the cuff. This technique, given subsequent rehabilitation efforts during several months, as well as in the first case, was sufficient to achieve almost complete recovery of the injured shoulder joint function and of the limb in general.

In our opinion, the last case certainly deserves a more serious discussion. The case is characterized by the severity of the clinical picture of post-traumatic disorders of the function of the right (leading) shoulder girdle in a patient of working age with a history of a very formidable hemostatic comorbid. The treatment of such patients is a difficult task and remains a subject of discussion both in relation to the term and technology of the surgical aid, and rehabilitation and recovery measures in the postoperative period. As a result of analysis of clinical, instrumental and laboratory data, we have chosen an active surgical tactic 6 months after injury, besides the work of two surgical teams was organized to reduce the surgery duration, blood loss and other risks. Combined simultaneous myo-fascio-osteoplastic techniques of intact muscles transfer aiming to replace the lost function of damaged muscles carried out with adequate control and prevention of thromboembolic complications was a condition and guarantee of significant progress in the patient's anatomical and functional status. The long-term positive result was achieved by the implementation of a personalized rehabilitation scheme during the outpatient care, developed for a specific case, given the absence of a standard rehabilitation protocol for the contingent in question. Nevertheless, further search for rational technologies of restorative reconstruction and rehabilitation for the disorders under consideration seems appropriate.

Conclusion

Thus, the selected treatment tactics based on clinical and instrumental data were individualized, namely: the comprehensive conservative rehabilitation exclusively in the first case, arthroscopic support for the RC reconstruction combined with restorative efforts applied by multi-profile specialists in the second, and, finally, the transfer of the tendons of the acting muscles in the shoulder joint area, in order to replace the shoulder antagonists (the deltoid muscle and the rotator cuff muscles) irretrievably damaged because of neuropathy, along with an individual rehabilitation program - in the third case, allowed to improve the upper limb function and the quality of life in such a complicated patient population, and reasonable tactics of clotting prevention that ensured the hemostasis control and the absence of vascular accidents.

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