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The Nearest Treatment Result of Medical and Technical Rehabilitation of a Child After an Electrical Injury

Koryukov AA*

Multidisciplinary rehabilitation center "ReaSunMed", St. Petersburg, Russia

***Corresponding author:**

Alexander A.Koryukov,
Multidisciplinary rehabilitation center
"ReaSunMed", St. Petersburg, Russia,
E-mail: drkoryukov@yandex.ru

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1. Abstract

Electric injuries to a child can lead to amputation of the upper limbs at various levels. Often the remaining parts of the limbs, stumps, cannot be used to manipulate prostheses without preliminary surgical preparation. The presence of rough scars, deficiency of soft tissues at the ends of the stump and bone perforation, limitation of mobility in the joints, these are the basic clinical reasons requiring surgical treatment. The formation of a full-fledged stump ensures a good fit and control of the artificial limb in the child's constant daytime activities. The paper describes the rehabilitation of a 15-year-old teenager who had his right arm amputated at forearm level (below elbow stump) and left arm at shoulder level (exarticulation in elbow joint) as a result of an electric damages . With the help of a surgical operation, it was possible to eliminate medical problems of both upper limb stumps, and a month after the operation, the boy received the first prosthesis of his right hand with an external source of energy and was able to perform important self-care tasks.

2. Introduction

Injuries to the limbs in children as a result of exposure to electric current are not uncommon in the structure of childhood traumatism and, according to various burn centers, they occurred from 1 to 8% of cases [18, 22] and often caused disability and deaths [3, 4]. Preschool children were injured by contact with household electrical appliances, adolescents suffered from high-voltage currents [9, 14]. Most often, electric burns occurred in adolescents and children who do not have sufficient knowledge about the dangers of electricity [1, 2, 5, 6, 23, 24, 13, 19].

Electrical injury occurs through direct contact with an electric current conductor, contactlessly through an arc contact (high voltage currents), from a "step voltage" arising from the potential difference between two parts of the body touching the ground near the lying wire. The main factors determining the severity of electric burns are the type, strength and voltage of the electric current, the duration of its action and tissue resistance.

It is noted [3] that, depending on the physical characteristics of the electric current, an electrical injury can be:

- low voltage (when the voltage does not exceed 1000 V);
- high voltage (over 1000 V);
- ultra-high voltage (tens and hundreds of kilovolts).

Depending on the area of the electric burn, it is customary to distinguish 4 groups of victims:

- slightly injured (burns up to 1% of the body area.);
- victims of moderate severity (burns from 1 to 5%);
- victims in serious condition (burns up to 10%);
- victims in an extremely serious condition (burns more than 10%).

Indications for amputation of a part of the limb were identified in 12% of children [14]. At the same time, the choice of indications for amputation is based on the physical characteristics of the electric current, the localization of burns, the degree of disruption of trophism and innervation of the affected area of the limb.

Electric trauma is characterized by deep and widespread lesions of the subcutaneous tissue, neurovascular trunks, muscles, through which, due to the difference in the resistance of these media, the electric current passes faster than on the surface of the skin [23, 24, 25]. After overcoming the resistance of the skin, electrical energy follows the path of least resistance - along the nervous tissue and blood vessels, affecting the surrounding tissues and leading to general changes [10].

The severity of the consequences of electric trauma in children dictates strict compliance with the algorithms of medical care, depending on the severity of the child's condition and the physical characteristics of the current [16, 17, 18, 21].

With deep electrical burns in 10-15% of cases, the functional unsuitability of the limb is diagnosed, which requires a solution to the issue of amputation. The indication for this is the total necrosis of the soft tissues of the limb or its segment, the involvement of the joint or the main neurovascular bundle in the process. Late execution of amputation is fraught with the development of gangrene and sepsis. The higher the level of total death of the tissues of the limb, the more severe the patient's condition, the earlier amputation is performed (on average, from 2 to 5-6 days, and sometimes during the first two days). The death of 2/3 of the muscle tissue of two or three segments of different limbs is a direct indication for amputation. The extremely serious condition of the victim is a direct indication for early amputation with the indispensable conduct of intensive transfusion therapy [1, 4, 7, 11, 20].

If the viability of less than 1/3 of the muscle tissue, one or two segments of different limbs, especially in their distal part, is impaired, expectant tactics are advisable. The determining factor here is the degree of circular lesions and exposure of the bones of the lower third of the forearm, wrist joint, the possibility of early or late skin-plastic interventions, the total area of thermal damage and deep burns. This can reduce the frequency or rate of amputation and improve functional outcomes. After amputation, drainages are left and guide stitches are applied to the stump. Wound healing by secondary intention in the future requires the closure of the defect with an autograft. The formation of the stump for the prosthesis is performed later, during the rehabilitation period [8, 12,15].

This work focuses on the medical and technical problems of rehabilitation of children with upper limb stumps after electrical injury. Features of the clinical characteristics of the upper limb stumps are of decisive importance for the forthcoming prosthetics.

3. Material and Methods

A 15-year-old child from the Republic of Kazakhstan was under observation, whose right arm was amputated at the level of the upper third of the forearm and the left arm at the level of the left elbow joint in December 2020 after a high-voltage electrical injury (exarticulation was made in it).

In the lower third of the right shoulder and on the stump of the right forearm, there were rough painful scars of the skin, and additionally, in the distal part of the right forearm stump, skin deficiency and penetration of the ends of the forearm bones were revealed (Figure 1, 2, 3). Osteophytes were determined on the bones, which had painful sensitivity to palpation They were located at the points of contact with the walls of the prosthesis socket. The same rough cicatricial lesions of soft tissues were found in the midle and lower third of the left shoulder stump (Figure 4).

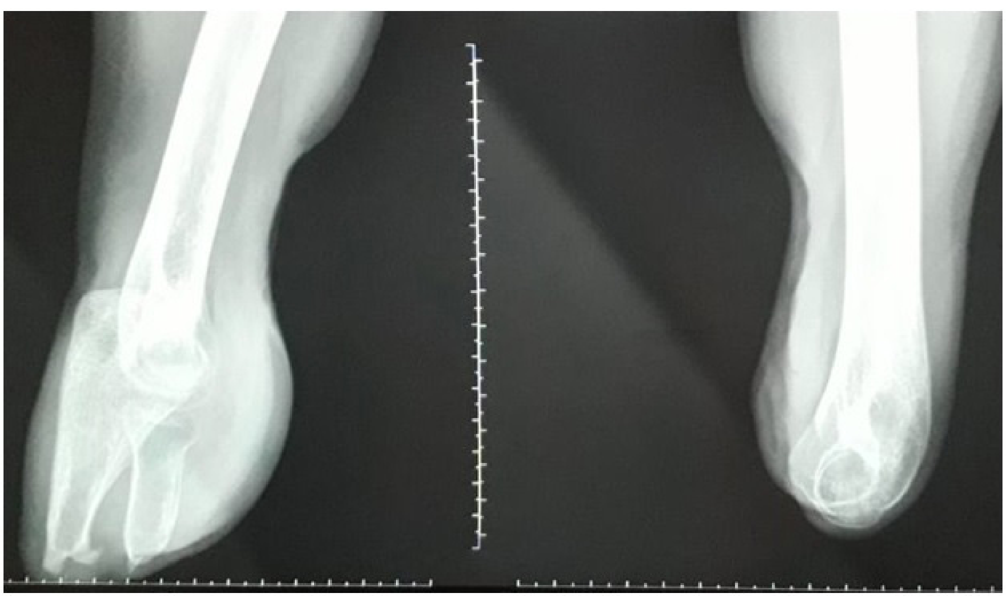

Figure 1: X-ray of the stumps of the right forearm in the upper third and the stump of the left shoulder after exarticulation in the elbow joint. Osteophytes of the ends of the forearm bones are visible

Figure 2: The maximum angle of flexion in the elbow joint of the stump of the right forearm is shown. Such flexion will not ensure the active function of the prosthetic arm

Figure 3: View of the stump of the right forearm on the operating table. Rough scars of the skin shoulder and the end of the forearm, penetration of the right radius. The use of a prosthesis is excluded

Figure 4: View of the stump of the left shoulder on the operating table. A long, rough and painful scar at the level of the middle and lower third of the stump

The depth of tissue damage by electric current was so pronounced that movements in the right elbow joint were limited and were carried out within 30 degrees (Figure 2). A defect in muscle tissue in the projection of the biceps muscle was contoured under the skin and identified with ultrasound and by the fingers restriction of movement could also be triggered by cicatricial changes within the tissues of the elbow joint itself.

It was not possible to carry out prosthetics with such clinical failure. It was decided to surgically correct the existing shortcomings of the stump: excision of rough scars and skin grafting in their area with local tissues, excision of welded scars and tenolysis of the biceps tendon of the right forearm stump, excision of rough scars in the area of the left shoulder stump.

Resection of osteophytes and skin grafting with local tissues were planned to form the end of the right below elbow stump.

4. Results and Discussion

It is well known that a stump is optimal for prosthetics, the shape and dimensions of which allow you to easily fit the prosthesis socket. The presence of full-fledged movements in the preserved joints helps to realize the natural pattern while controlling the mechanism of the artificial limb. However, the stump after electrical injury has striking clinical disadvantages that do not allow for prosthetics and require surgical correction. After the formation of a full-fledged stump, the question of making an upper limb prosthesis can be raised.

Under general anesthesia, the child consistently performed elimination of the defects of both stumps of the upper extremities. At the first stage, coarse scars were excised on the left arm in the area of the lower third of the right shoulder and the end of the stump. The osteophytes of the radius and ulna were resected. The ends of the forearm bones were rasped and smooth. Scars were excised in the area of the biceps muscle of the right shoulder, which limited mobility in the elbow joint. After excision, it was possible to bend the stump at the elbow to an angle almost of 90 degrees. Performed skin grafting with local tissues (Figure 5, 7).

The forearm stump was immobilized in a corrected position for 3 weeks with a plaster splint. The next stage was performed by excision of rough and painful scars of the left shoulder stump and skin grafting in the area of damage (Figure 6). Healing of the wounds of both hands took place by first intention, without complications. The stitches were removed on day 10. But a week after the operation, the child began to receive physiotherapy and physiotherapy exercises.

Prosthetics became possible 4 weeks after the operation. The stumps of the forearm and upper arm of the optimal size and shape after surgical treatment did not cause difficulties in taking the impression and fitting the socket of the prosthesis.

The patient received an active bionic prosthesis from Motorika, Russia (Figure 8, 9, 10, 11), Which he successfully began to use in his daily activities.

Figure 5: The stump of the right forearm immediately after eliminating the shortcomings

Figure 6: The stump of the left shoulder after elimination of the scar and skin grafting. During the operation, the shoulder condyles were resected, which will allow in the future to produce an active shoulder prosthesis with an artificial elbow joint and the same length of both arms

Figure 7: Possible flexion in the right elbow joint 3 weeks after surgery

Figure 8: The patient is in the first below elbow prosthesis, which was made 4 weeks after the operation

Figure 9: Some examples of the first skills of using a russian bionic below elbow prosthesis of the "Motorica"

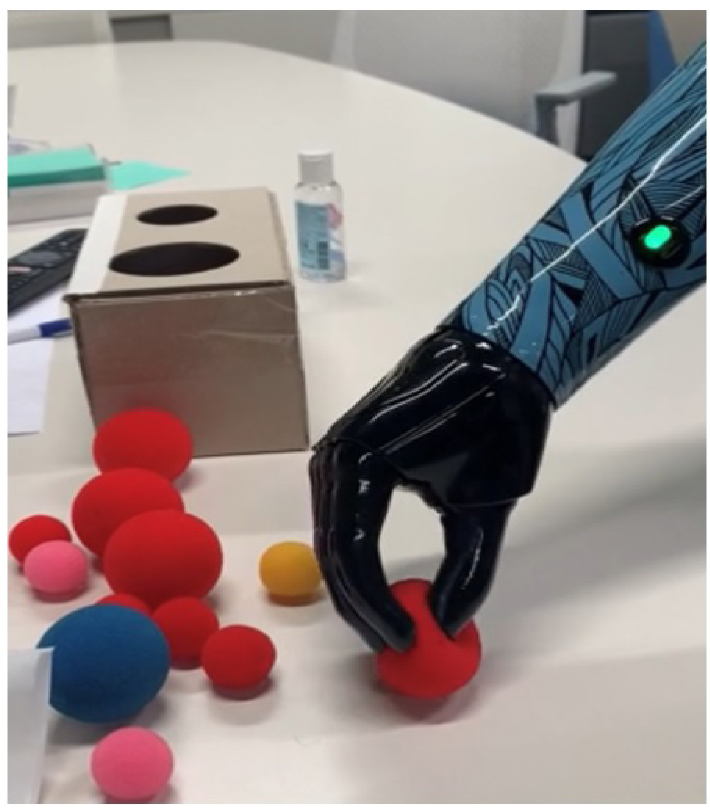

Figure 10: Some examples of the first skills of using a russian bionic below elbow prosthesis of the "Motorica"

Figure 11: Some examples of the first skills of using a russian bionic below elbow prosthesis of the "Motorica"

5. Conclusion

The type of electrothermal injury in children depends on age and social activity. Electric shock, lead to severe injuries, high disability and mortality. Combined and combined lesions are often noted. A serious complication of electrical injury is the amputation of a limb, especially the upper one. It becomes very important not only to form the stump itself for high-quality prosthetics, but also other skin integuments of the injured limb, especially those located in the zone of contact with the details of the prosthesis. The presence of soft tissue deficiencies in the form of scars, bone deformities and limitation of mobility in the joints are the need for preliminary surgical treatment before the manufacture of a prosthesis. The functional result of prosthetics is much higher if the stumps are mobile, have a favorable size and shape.

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