

Original article

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Damage to the major limb vessels with complete disturbance of blood flow in children (results of clinical observations)

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Abstract

Background Trauma with associated damage to major arteries and veins typically occurs in adults; reports on such injuries in children are rare. In the organization of their treatment, difficulties are encountered such as formation of teams that must include angiosurgeons. The issues of restoring limb function after injuries with damage to muscle, nerve trunks or complete amputation of the limb remain relevant in children, despite their high abilities to recover. Each particular case in health care institutions has its own characteristics and difficulties for treatment, which was the reason for this communication. **Purpose** To share our clinical experience and details of providing urgent medical care to injured children with complete impairment of the main arteriovenous blood flow. **Materials and methods** Three cases with complete damage to major arteries and veins, including their defects, were studied. We describe the details of tactics and features of their surgical management. All patients underwent clinical and laboratory examination; emergency assistance was provided by orthopedic traumatologists and angiosurgeons. All patients were admitted in a state of hemorrhagic shock in stage 2 or 3. Surgical aid was provided in patients with a critical, almost terminal condition. **Results** On admission 40 minutes after the injury, one patient was diagnosed with a deep cut wound on the posterior surface of the right thigh with damage to the flexor muscles of the leg, femoral artery and vein with their defects up to 3 cm, and a cut wound on the right lower leg. Combined plasty of vascular defects with grafts from the great saphenous vein of the thigh and muscle suture were performed. An excellent result was noted after 3 months. In the second patient, there was an injury with glass in the area of the left axillary fossa with a transverse cut of all nerves, brachial artery and vein, tendons of the biceps and triceps muscles of the shoulder. An excellent result of primary reconstruction was diagnosed 1.5 years later. In the third case, the patient was admitted with a complete traumatic amputation of the right forearm in the lower third due to the use of a mechanical wood splitter; replantation began 5 hours after the cut off. Replantation was successful. It included 4 stages of treatment; the 2nd one was repeated revision and suture of the vessels 16 hours after the onset of thrombosis following the 1st operation. The next two stages included combined plastic surgery of muscles and tendons, first on the extensor and then of the flexor surface of the forearm. Movements appeared 6 months after the injury during the restoration of sensitivity. A completely satisfactory result of treatment was obtained; the patient began to use his hand in everyday life and to write after one year. **Conclusion** Damage to the main arteriovenous formations requires urgent surgical treatment, aimed at preserving the limb, restoring blood supply, nerve formations, and bone integrity. In complete amputation, restoration of muscle-tendon formations may be postponed for subsequent stages. In primary care, one should consider the need for subsequent, sometimes long-term rehabilitation, the result of which directly depends on the restoration of neurotrophic and sensitive functions.

Keywords: damage to the main arteries and veins, disorders of the nerve trunks, traumatic amputation, limb replantation, deep cut wound, hemorrhagic shock

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INTRODUCTION

Injury to the major limb vessels is an extremely dangerous condition, as it poses a threat to the life of the injured and often excludes the possibility of preserving the anatomical structures and adequate functional characteristics of the distal parts of the segment or limb as a whole. The overall mortality due to vascular injuries to the extremities, according to different authors, ranges from 8.7 to 18 % among the injured persons in the peacetime. The rate of primary amputations thereby ranges from 8 to 10.8 % [1]. Success depends on many factors, among which a huge role is played by emergency care and joint efforts of vascular surgeons and orthopedic traumatologists, and

if required of general surgeons or neurosurgeons [2, 3]. It has been established that the most critical situation is simultaneous injuries to the main arteries and veins, which requires their simultaneous restoration [4, 5, 6]. The situation becomes aggravated in the complete detachment of the limb segment, which implies a dubious result of replantation, and, moreover, functional recovery. Reports of replantation of a large limb part with its complete detachment or complete cut of blood supply are rare, and the results of such reconstructive interventions are not always satisfactory [7]. Total damage to blood vessels, more often in the upper limb, is the prerogative of the adulthood [8].

The main complicating circumstances in the restoration of blood supply are damage to the nerve trunks or bone trauma as they require additional complex surgical interventions, correct and sufficiently effective intra- and postoperative therapy, and a long-term follow-up rehabilitation. It also equally refers to pediatric patients [9, 10, 11]. The problem is the organization of surgical management in injuries to the main vessels of the extremities in hospitals that do not have their own vascular department. This situation exists in almost all regional children's institutions, even

of the highest level. In practical healthcare, reports on successful work with the patients that sustained complete discontinuity of the main veins and arteries are rare, and especially among pediatric population [12, 13]. Therefore, each of such cases deserves attention. This was the aim for the preparation of our report.

Purpose To share our clinical experience and details of providing emergency medical care to pediatric patients with complete disintegrity of the main arteriovenous blood flow.

MATERIALS AND METHODS

Three cases of urgent care in patients with complete damage to the main veins and arteries and a complete cut of blood supply to the distal parts of the limb are presented in our report. All patients underwent clinical and laboratory examination; urgent medical care was provided by orthopedic traumatologists and angiosurgeons; blood transfusion was performed according to vital indications; it was clinically established that blood loss was half of the volume of the circulating blood or even more. All patients were admitted in a state of hemorrhagic shock in stage 2–3.

In case of damage to the main arteries and veins along with injuries to large muscle groups without damage to the nerve trunks, a more rapid recovery occurs. The method of choice is vascular plasty. In cut and torn injuries of the thigh, plasty of the defects in the femoral artery and deep vein with an autograft from v. saphena magna, primary muscle suture, and plaster immobilization.

The parents of the patients gave their consents to the study and the publication of data on the treatment of their children and the results obtained.

RESULTS

Case 1 Patient K., 9 years old, was injured with glass fragments after he broke a room door; he smashed the door with his foot and sat down on the pieces of broken glass. On admission 40 minutes after the injury, the patient was diagnosed with a deep incised wound on the posterior surface of the right thigh with damage to the muscles, flexors of the leg, femoral artery and vein with their defect of up to 3 cm, complete cut of the great saphenous vein of the thigh, incised wound of the right leg that resulted in massive blood loss. Hemorrhagic shock was stage 2. According to urgent indications and under anesthesia, revision of the wound with clipping of the vessels was performed that revealed injuries to the semimembranosus, semitendinosus, biceps femoris, gastrocnemius muscles; the sciatic nerve was intact. The surgical team with the participation of an angiosurgeon performed restoration of the femoral artery and vein with plasty of their defects with vascular grafts from the damaged great saphenous vein (Fig. 1) and suture of the thigh muscles. The vascular stage of the operation managed the defect in the femoral artery and vein up to 3.0 cm. Two grafts were harvested from the great saphenous vein that measured up to 2.5 cm and 4.0 cm. The vein taken from the first graft was reverted and used to fill the defect in the artery, the second graft was applied for plasty of the deep femoral vein; the great saphenous vein (the source of the grafts) was ligated. The second graft of a smaller diameter in relation to the common femoral vein was taken from 2 parts; the resulting rectangular venous flaps were longitudinally sutured into a cylindrical graft on a template (an insulin syringe). After six months of plaster immobilization,

physical exercises for recovery of knee joint motion were initiated. Full recovery of the limb function was achieved 3 months after the injury.



Fig. 1 Photo of the wound in the injured lower limb of patient K., 9 years old. During the intervention: after plastic reconstruction of the femoral artery and vein

The result of recovery in case of total damage to blood vessels in an anatomically unfavorable zone along with the injury to nerve trunks and muscles seems doubtful, but far from hopeless if high-quality surgical and long-term rehabilitation care are provided.

Case 2 Patient V., 7 years old, was admitted on 26.10.2018 one hour after the injury sustained with glass pieces of a broken room door, 10-cm long wound in the area of the left axillary cavity. The child was transported with blood vessels pressed by fingers

and tamponade, which did not prevent much blood loss. Hemorrhagic shock was of grade 3. The state at admission was terminal. Upon admission, hemoglobin was 56 g/l, erythrocytes count 1.9×10^{12} , blood pressure was 97/62 mm Hg, and pulse of 132 beats per minute. The patient was taken to the operating room and diagnosed with complete transverse cut of the brachial artery and vein, trunks of the radial, ulnar, median, musculocutaneous nerves, damage to the tendons m. biceps and m. triceps; the distal part of the limb hanged on soft tissues, was cold and unviable. Anti-shock measures were carried out simultaneously with the restoration of all the formations listed above. During the operation, 1005 ml of erythrocyte mass, 480 ml of plasma, and 2200 ml of saline were transfused.

Features of the operation: the artery diameter 2.5 mm, vein diameter 3.5 mm. An end-to-end oblique anastomosis of the brachial artery was performed (propylene 6.0). Proximal to the anastomosis of the artery, there was a marginal transverse wall defect of 1.5 mm; the marginal defect was sutured. An end-to-end anastomosis was performed between two ends of the brachial vein. During the same operation, sequential epineural suture of all nerve trunks was done. After lengthy rehabilitation measures, the sensitivity of all nerve trunks was restored after 14 months. The patient was followed and examined 1.5 years after the injury. The function of the limb recovered, the full range of motion was achieved in all joints of the limb: there was a slight (10°) limitation of finger extension compared to the right hand (Fig. 2, 3, 4). There was no nerve disorder. The patient and doctors are completely satisfied with the result of treatment. The patient leads a normal life for a child.

The most critical situation occurs when a limb is completely amputated. The mechanism of a chopping wound with crushed tissues makes the result of treatment extremely doubtful. The remote from the clinical facility residence of the injured person exacerbates the consequences. However, even in such situations, replantation can lead to a satisfactory result of treatment. A terrible accident happened to a patient in our practice.



Fig. 2 Patient's (8.5-year old) photo at follow-up demonstrating the surgical scar in full shoulder extension



Fig. 3 Patient's (8.5-year old) photo at follow-up demonstrating finger flexion



Fig. 4 Patient's (8.5-year old) photo at follow-up demonstrating finger extension

Case 3 Patient L., 14 years old, from one of the districts of the Perm Territory was admitted on July 21, 2019 being delivered by air ambulance five hours after the injury. He chopped off his right forearm in the lower third working with a mechanical wood splitter. The wound was treated on the spot, bandages and a tourniquet were applied. The patient and the amputated part of the limb were delivered to the surgical department of the regional children's clinical hospital (Fig. 5).



Fig. 5 Radiographs of the severed forearm fragments of patient L., 14 years old

Simultaneously with resuscitation measures, a combined team of traumatologists and vascular surgeons was organized. The patient underwent replantation of the right forearm and hand including osteosynthesis of the right forearm bones with plates after resection of the damaged bone ends up to a total of 2.5 cm along with autovenous

grafting of the right radial and ulnar arteries, medial and lateral saphenous veins of the right forearm, epineural suture of the ulnar, median and superficial branch of the radial nerve of the right forearm. Muscles and tendons were initially sutured in a single bundle. The duration of the operation was 8 hours. Eight hours after the completion of the first surgical intervention, vascular thrombosis occurred, and the patient was urgently taken to the operating room. A revision and repeated vascular plasty, decompression with excision of part of the tendons due to edema and their partial corrugation were performed. Initially, the tendons were not restored due to the critical condition of the limb. Vascular therapy was carried out with high doses of heparin under the control of coagulation for three weeks. The replantation resulted in success. On August 20, 2019, the patient underwent revision, plastic reconstruction of the extensor and on September 6, 2019 flexor muscle-tendon apparatus of the right forearm and hand. The problem was that initial surgical interventions required resection of the tendons and the muscular part, which was additionally performed during the second revision 16 hours after in order to avoid compression of the vessels in critical condition. Nerve conduction restored at the end of December 2019. Stable fixation led to consolidation, however, the question of removing the plates was not raised (Fig. 6).

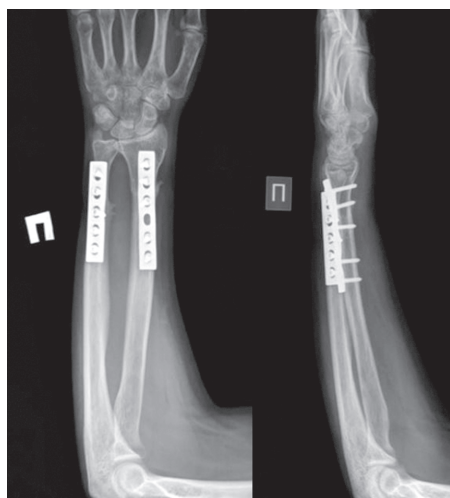


Fig. 6 Radiographs of the forearm of patient L. seven months after amputation, consolidation of the radius and ulna

The gripping function of fingers and their independent movements of a limited range recovered at the end of February 2020. After one year, the patient began to actively use the hand, to write with this hand and perform the necessary household activities (Fig. 7–9). He continues rehabilitation.



Fig. 7 Photo of the hand of patient L., one year after the injury



Fig. 8 Photo of the hand of patient L., extension function after one year

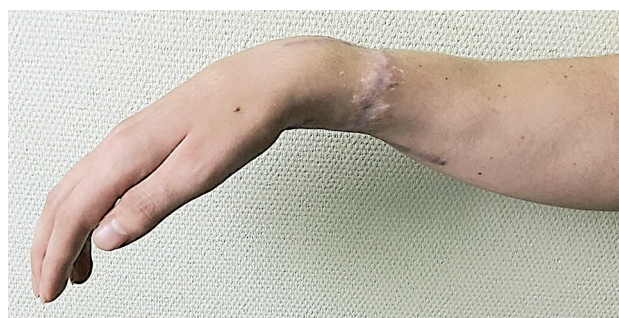


Fig. 9 Photo of the hand of patient L., flexion function one year after complete amputation

DISCUSSION

In injuries to major vessels, the only way to save the limb and life of the patient is to involve vascular surgeons in combined surgical teams. Long-term intensive care treatment and rehabilitation are required. Surgical interventions are carried out simultaneously with resuscitation measures. In our cases, we managed to preserve the viability of the limbs. In one of them, there was a technical need to postpone the surgical interventions aimed at reconstruction of the tendon apparatus in complete amputation of the forearm saved by delayed replantation. Excellent results were obtained in two cases. In the third case, the result is good and

rehabilitation still continues. The severed at the level of the forearm limb was preserved, and a satisfactory function of the hand was achieved.

We believe that the possibility of successful management in such patients in city and regional children's medical institutions directly depends, first of all, on the short time period from injury to the patient's admission to the hospital and fast organization of combined teams of specialists, what is emphasized by almost all authors [1, 6, 7, 9, 12, 13]. In all such cases, the struggle for the life of the patient with damage to the main vessels is carried out simultaneously with

reconstructive interventions to restore blood flow, the integrity of the bone, nerve formations, muscles and their tendon part [2, 4, 8]. The possibility of restoring blood flow in large vessels, and in the presented cases with damage to arteries and veins associated with defects in the wound area, always exists in childhood, even in very complicated conditions with complete amputation of the limb with crushed bone segments. To save the limb, it is necessary to resect the damaged ends of the bones to

shorten them as minimally as possible, to ensure primary consolidation by stable fixation. There is always a risk of vascular complications such as of thrombosis. Therefore, long-term conservative treatment with dynamic clinical and laboratory control is required [1, 2, 6, 11]. Clinical reports presenting similar to our observations in children are not common, therefore, we opine that the details of the treatment and the results of such cases might be interesting for specialists.

COCLUSION

In all cases of damage to large arteries and veins along with nerve injuries, the restoration of these structures should be immediate and simultaneous with resuscitation measures. The nerves should be sutured simultaneously with the restoration of the integrity of

the vessels. Replantation of a severed limb should be performed and based on the nature of damage to soft tissues and bone. Bone resection with shortening of the limb may be necessary for the purpose of qualitative adaptation.

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