CASE REPORT

One-Stage Nerve Repair for Post-Ganglionic Brachial Plexus Injury by Using Ipsilateral Ruptured Ulnar Nerve as a Donor for Axillary Artery Rupture with Open Wound

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Abstract : Open axillary arterial injury is life-threatening, and upper-extremity reperfusion must be performed within approximately 6 h. We present the case of a patient who underwent reperfusion of the upper limb and nerve reconstruction of the post-ganglionic brachial plexus injury in one stage while maintaining stable vital signs. The injury was an avulsion with no fracture. Nerve grafting was necessary to reconstruct the nerves without tension. Although the sural nerve is commonly used, we decided to sacrifice the ipsilateral ruptured ulnar nerve because it was less likely to recover over a long reinnervation distance. Nine months postoperatively, the patient was able to flex the elbow and rotate the forearm, although finger function was poor. Nevertheless, the patient could use the hand to assist her in performing daily activities and return to the previous workplace as a clerk. J. Med. Invest. 71 : 332-334, August, 2024

Keywords **:** *brachial plexus injury, arterial rupture, nerve grafting, replantation, ulnar nerve graft*

INTRODUCTION

Open brachial plexus injuries can be associated with life-threatening arterial hemorrhages. Nerve grafting is indicated for infraclavicular and terminal branch injuries. The sural nerve is commonly used as it causes minimal functional loss after sacrifice. However, harvesting donors for multiple nerve injuries is invasive. In general, the functional recovery of intrinsic muscles tends to be poor. Therefore, ulnar nerve reconstruction is of lower priority.

CASE REPORT

The patient was a 39-year-old woman who underwent an incomplete axillary amputation. While working in the recycling industry, the patient's right arm was rolled in a conveyor, and she arrived at our hospital 2.5 h after the injury. On physical examination, the radial artery was unpalpable, and no muscle contraction below the elbow was observed (Figure 1). The patient was diagnosed with incomplete amputation, and the airway, breathing, and circulation were evaluated. The patient's blood pressure was 151/50 mmHg on arrival ; however, there was massive hemorrhage, and she required a total of 10 units of blood transfusion. On contrast-enhanced CT, the axillary artery was found to be disrupted, while the brachial artery showed collateral flow originating from the axillary artery. Additionally, there was no fracture. Intraoperatively, we found ruptured axillary artery and vein and median, radial, musculocutaneous, and ulnar nerves. First, vascular repair was performed with a saphenous vein graft. Reperfusion was obtained after 6 h 20 min. Laboratory data at the time revealed creatine kinase, 1,471 IU/L ; blood urea nitrogen, 22.6 mg/dL ; creatinine, 0.65 mg/dL ; and potassium, 4.0 mmol/L ; showing no evidence of replantation toxemia. As the nerve defects after debridement were 3 cm in the radial and musculocutaneous nerves and 10 cm in the median nerve, we harvested the ulnar nerve as the donor and performed nerve grafting (Figure 2). The duration of surgery was 9 h 22 min (3 h 16 min for vascular repair, and 6 h 6 min for nerve grafting). After surgery, elbow flexion gradually recovered to achieve a score of 4 on the manual muscle test (MMT) at 21 weeks. The elbow, wrist, and finger extensions achieved MMT scores of 3. Nine weeks after the injury, wrist and finger flexion remained at an MMT score of 2 (Figure 3). Palmar sensation recovered to a protective level. To date, the patient can return to the previous workplace as a clerk with some difficulty.

DISCUSSION

Major arterial injuries can cause massive hemorrhage and lead to death. Santoro *et al*. reported the case of a patient who died of axillar arterial injury (1). The ischemic period must be shorter than 6 h (2) because muscle necrosis and reperfusion toxemia can occur. Generally, the upper limbs are less susceptible to reperfusion toxemia than the lower limbs owing to collateral flow. A mangled extremity severity score ≥ 7 indicates amputation (2). In our patient, who had a score of 5 points, no evidence of reperfusion toxemia, and stable vital signs, we considered it reasonable to save the arm. Because terminal-branch injuries have some defects, we had to perform nerve grafting. We deemed it appropriate to complete nerve reconstruction simultaneously with vascular reperfusion as the injury was open and allowed for exploration of the nerve injuries through the same wound. Additionally, adhesions and scar formation could complicate our

Received for publication March 1, 2024 ; accepted August 6, 2024.

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Figure 1. Macroscopic appearance of the right arm on arrival. A laceration is observed on the arm pit with ruptured nerves exposed.

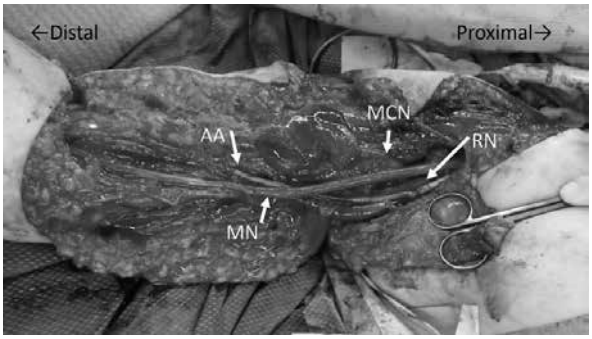

Figure 2. After reconstruction. Median, radial, and musculocutaneous nerves were repaired by nerve grafting using the ulnar nerve (AA, axillary artery ; MN, median nerve ; MCN, musculoutaneous nerve ; RN, radial nerve).

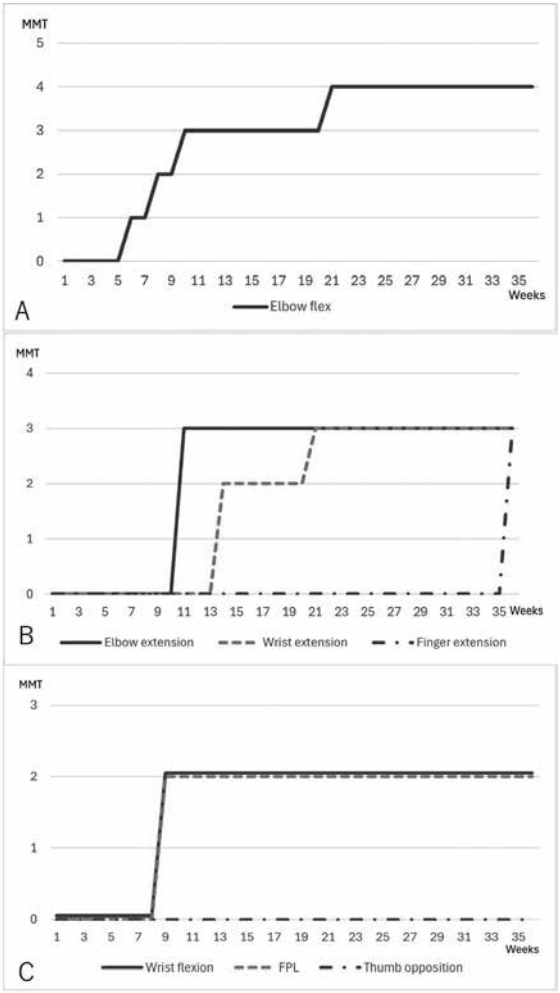

Figure 3. Recovery of muscle strength. A) Innervated by musculocutaneous nerve, B) radial nerve, C) median nerve (FPL, flexor pollicis longus ; MMT, manual muscle test).

procedure in the second operation days later once perfusion was stable. We anticipated a relatively short operative time by using the ulnar nerve as a donor. In cases of closed injuries or unstable vital signs, nerve reconstruction would need to be performed at a subsequent day.

Nerve grafting is contraindicated if the surgery is performed late, the muscle targets are very distal, or the graft length is > 10 cm (3). The problem is determining which nerves should be used. The sural nerve is commonly used as a donor, and up to 35-40 cm can be harvested from each leg (3). The medial and lateral antebrachial cutaneous nerves can be another choice (4). Generally, the recovery of muscle strength after nerve grafting or transfer in lower brachial plexus injuries is poor ; therefore, tendon transfer should be considered as far as possible (5). The ulnar nerve is often used as a graft after non-repairable lower plexus avulsion injury (4), contralateral C7 transfer (6), and the Oberlin procedure. However, their use during the initial surgery for injuries is uncommon. Because the ulnar nerve has almost the same diameter as other nerves, it is not necessary to form it into cables or harvest a graft several times longer than the length of the defect. Spinner *et al*. showed the priority of the repair as follows : 1) elbow flexion ; 2) shoulder stabilization, abduction, and external rotation ; 3) hand sensation ; 4) wrist and finger flexion ; 5) wrist and finger extension ; and 6) intrinsic hand muscle function (3). Lanier *et al*. reported that finger extension, intrinsic function, and sensation were not prioritized (7). Tsuchida *et al*. recommended achieving elbow flexion, palmar sensation, and hook grip as the minimum goal for patients with arm amputations (2). For our patient, we decided to sacrifice intrinsic muscle function by harvesting the ulnar nerve, with obtaining the function described earlier as the goal. The flexor digitorum superficialis (FDS) and radial side of the flexor digitorum profundus (FDP) are innervated by the median nerve, and the ulnar side of the FDP is innervated by the ulnar nerve. The patient lost function of the ulnar side of the FDP because of the sacrificed ulnar nerve. We believe that it was disadvantageous for the median nerve to regenerate as the defect was 10 cm (defects of the radial and musculocutaneous nerves were both 3 cm), and the target muscles were more distant than those of the other nerves. The amount of debridement required should be minimized. Both may be causes of the insufficient function of the hook grip. The duration of surgery was 9 h 22 min ; however, harvesting bilateral sural nerves as donors for multiple nerve grafts and making them into cables might require longer duration and might be more invasive. Shorter surgery time can prevent blood loss that results in hypothermia, coagulopathy, and metabolic acidosis and thus is

more advantageous for lifesaving in patients with severe trauma. Takahashi *et al*. reported that 11 of 19 major arterial injuries to the proximal arms were accompanied by nerve injuries (8). Regarding postoperative prognosis according to Chen's criteria (9), grade IV (almost no function of the surviving limb) was observed in seven patients. They showed that blunt force injury, nerve injury, fracture, and muscle rupture were significant risk factors for a poor prognosis. Our patient with arterial and nerve injuries was classified as grade III (function for activities of daily living) and had some difficulties.

Nerve grafting is not appropriate for lesions high on the ulnar nerve because of the long reinnervation distance. Although some surgeons perform nerve transfer, the results of this procedure have not been firmly established (3). We considered performing a free muscle transfer to reconstruct the FDP. However, Doi *et al*. defined "satisfactory prehension" as the ability to flex fingers > 30 degrees and reported that it was restored in 17 of 26 patients with brachial plexus injuries who underwent free double muscle procedures (65%) (10). It may have been difficult to obtain stronger finger flexion in our patient if we had performed a free muscle transfer. Therefore, we plan to perform capsulodesis of the metacarpophalangeal joint to prevent claw deformity and carpometacarpal arthrodesis to maintain the thumb in an oppositional position. Currently, the patient can flex the elbow, rotate the forearm, and hold objects with the hand. We believe that ulnar nerve grafting is beneficial for patients with major arterial injury, not only to reconstruct function but also to save lives.

DECLARATION OF CONFLICT OF INTEREST

The authors do NOT have any potential conflicts of interest with respect to this manuscript.

DECLARATION OF FUNDING

The authors received NO financial support for the preparation, research, authorship, and/or publication of this manuscript.

DECLARATION OF ETHICAL APPROVAL FOR STUDY

Ethical approval for this case was obtained from the Ethics Committee of Tokushima Prefecture Naruto Hospital. Approval Number ; 2024-01, the date of approval ; February 14th, 2024.

DECLARATION OF INFORMED CONSENT

There is no information (name, initial, hospital identification number or photographs) in the submitted manuscript that can be used to identify the patient.

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