Injury, Int. J. Care Injured 41 (2010) 312–318

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Shoulder reanimation in posttraumatic brachial plexus paralysis

Marios D. Vekris [a,*], Alexandros E. Beris [a], Dimitrios Pafilas [a], Marios G. Lykissas [a], Theodoros A. Xenakis [a], Panayotis N. Soucacos [b]

[a] Department of Orthopaedic Surgery, University of Ioannina, School of Medicine, Ioannina 45110, Greece
[b] Department of Orthopaedic Surgery, University of Athens, School of Medicine, Athens, Greece

ARTICLE INFO

Article history:
Accepted 4 September 2009

Keywords:
Brachial plexus palsy
Shoulder reanimation
Suprascapular nerve
Axillary nerve
Extraplexus donor
Intraplexus donor

ABSTRACT

Introduction: Posttraumatic brachial plexus paralysis invariably involves the upper roots leading to paralysis of the shoulder region musculature. Early neurotisation of the suprascapular and the axillary nerve should be one of the priorities in plexus reconstruction in order to reanimate the shoulder.

Patients and methods: From 1998 to 2007, 78 patients with posttraumatic brachial plexus palsy were operated in our department. Forty-three patients presented with supraclavicular lesions with involvement of C5 and C6 roots in all cases. Reconstruction of the shoulder function was achieved with neurotisation of the suprascapular nerve in 41 patients. Extraplexus donors were utilised in 34 patients, while intraplexus donors via nerve grafts in 7 patients. Neurotisation of the axillary nerve was performed in 25 patients, utilising intraplexus donors in 16 patients, extraplexus donors in 4, and combination of intraplexus and extraplexus donors in 5 patients.

Results: Suprascapular nerve neurotisation gave good or excellent results (supraspinatus > M3+ or shoulder abduction > 40°) in 35 patients. Intraplexus donors regained good or excellent function in 5 out of 6 patients (83%), while extraplexus neurotisations achieved good or excellent function of the supraspinatus in 30 out of 34 patients (88%). Axillary nerve neurotisation offered good or excellent results (deltoid > M3+ or shoulder abduction > 60°) in 14 patients (58%). Direct neurotisation of the axillary nerve via the motor branch for the long head of the triceps gave shoulder abduction of >110°, as well as external rotation of >30° in 3 out of 5 patients. Combined neurotisation of suprascapular and axillary nerves gave the best outcome achieving shoulder abduction of >60° as well as external rotation of >30°.

Conclusions: Shoulder reanimation should be one of the first priorities in brachial plexus reconstruction. Early neurotisation of the suprascapular, and if possible the axillary nerve offers the best outcome.

Introduction

Posttraumatic brachial plexus paralysis invariably involves the upper roots leading to paralysis of the shoulder region musculature. The severity of the injury is higher when avulsion of roots and involvement of the hand are present. The prognosis for these unfortunate young patients is grave. The lack of shoulder motion is a major handicap for the overall upper extremity function, even if the hand is intact, because the ability to move the arm in space and therefore to place the hand in the appropriate position for a specific function is not possible.

The reanimation of the shoulder should be one of the primary goals in the reconstruction of the injured plexus.[58] The most important targets to be reanimated are the complex of supraspinatus and infraspinatus by neurotisation of the suprascapular nerve, and the deltoid and terres minor by neurotising the axillary nerve.[58] In global palsies, where avulsion or very high rupture of C5, C6, C7 roots are present, long thoracic nerve should be reconstructed to achieve scapula stabilisation and therefore enhancement of shoulder abduction and external rotation.[53] If feasible, thoracodorsal nerve should be neurotised (usually with intercostal nerves) to achieve shoulder adduction and internal rotation. In addition, the reanimated latissimus dorsi could be transferred to act as a shoulder external rotator and abductor in a secondary procedure.

We present our experience in shoulder reanimation via various neurotisations in patients with posttraumatic brachial plexus palsy operated in our clinic.

Patients and methods

Over a 9.5-year period (1998–2007), 78 adult patients with posttraumatic brachial plexus palsy were operated on in our center. Their mean age was 28.5 years, and the majority of patients

* Corresponding author. Tel.: +30 26510 97472; fax: +30 26510 97018.
E-mail address: vekrismd@otenet.gr (M.D. Vekris).

0020–1383/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.injury.2009.09.009

were male (13 males/1 female). The most common cause of injury was motor-vehicle accident and specifically accidents with motorcycles (87%). The rest of the patients sustained brachial plexus injury after a gunshot or after a working accident.

Twenty-one patients presented to our department late after the plexus injury (denervation time > 2 years). Due to loss of muscle mass after this prolonged denervation, only secondary procedures were performed in this late group, and involved muscle transfers, tendon transfers, and bone procedures, e.g. wrist fusion.[59] For shoulder reanimation, in the majority of these patients, trapezius transfer was performed to act as an abductor and external rotator, as well as rotational osteotomy of the humerus was applied to achieve an amount of external rotation. In 4 of these patients the shoulder was totally flail and subluxated. In these patients, capsulodesis (joint capsule plication) was performed in addition to trapezius transfer.

Exploration of the brachial plexus was performed in 57 patients, who presented for surgery earlier than 12 months after injury. The mean denervation time was 4.7 months (range, 1–12 months). Fourteen patients had an extended infraclavicular lesion and 43 sustained supraclavicular lesions. In 38 patients the element of root avulsion was present (3 with global avulsion, 13 with four-root avulsion, 12 with three-root avulsion, 4 with two-root avulsion, and 6 with one-root avulsion). In all cases, intraoperative findings were expressed by the total severity score of the injured roots, according to the following scoring system per root: 0, avulsion; 1, rupture/avulsion; 2, rupture; 3, rupture/traction; 4, traction; and 5, normal.[58] Therefore, a normal brachial plexus had a score of 25, while global avulsion was rated as 0. The mean severity score in our population was 5.4, indicating severe injury involving avulsion of 3 or 4 roots.

Reanimation of the shoulder was achieved with reconstruction of the suprascapular nerve primarily, since supraspinatus function (rotator cuff) is of great importance in the shoulder arc of motion and stabilisation. Neurotisation of the suprascapular nerve was performed in 41 patients, while in the other 2 patients with supraclavicular lesions the suprascapular nerve was in continuity with the upper trunk, and therefore neurolysis was adequate. Neurotisation of the axillary nerve was performed in almost half of the cases (25 patients).

For the reconstruction of the suprascapular nerve extraplexus donors were used in the majority of the plexuses (34 patients). In 30 patients the terminal branch of the accessory nerve was coapted directly, in 3 patients cervical plexus motor donors were used, while in 1 patient the phrenic nerve was utilised. The later neurotisations were performed via nerve grafts. Intraplexus donors (C5, C6) via nerve grafts were used in 7 patients: the C5 root was utilised as the only one spared or the one with the best axonal density in 6 patients, while in 1 patient the C6 root was the axon donor for neurotisation.

For the reconstruction of the axillary nerve intraplexus donors were used in 16 patients: the C5 root via nerve grafts was used in most of the cases (11 patients), while in 5 patients with upper plexus palsy, where the triceps function was spared, the motor branch to the long head of triceps was coapted directly to the axillary nerve. Extraplexus donors were used in 4 patients: the phrenic nerve in 3 patients and cervical plexus motor donor in 1 patient. In order to ensure best results when the donor root presented with scar formation, combined neurotisation utilising both intraplexus donor (C5 root) and extraplexus donor (cervical plexus motor branch or phrenic nerve) was performed in 5 patients. In all cases care was taken to reconstruct the branch of terres minor, in order to achieve external rotation.

In cases where C5 and/or C6 roots were not avulsed, usually long thoracic function was guaranteed, even if the intraoperative electrical stimulation of the nerve was not adequately strong. Despite that neurotisation of the long thoracic nerve was not a routine in our series, the nerve was reconstructed in 2 patients from the dorsal scapular nerve.

The thoracodorsal nerve was reconstructed in 3 patients utilising 2 intercostals. In 1 of these patients the achieved muscle strength was M4−, and the latissimus dorsi was transferred to enhance elbow extension.

Postoperatively, the arm was immobilised in an abduction prefabricated splint for 6 weeks. After this period, the patient was urged to start physiotherapy, including kinesiotherapy with passive motion of all joints and electrical muscle stimulation using a slow-pulse electrical stimulator.

All patients were followed-up and evaluated every 4 months till the reanimated muscles achieved useful function (mean follow-up time, 28 months). A modified muscle-grading scale was utilised, based on the British Medical Research Council Grading System with intermediate gradings of M+ and M−, i.e. M2, M2+, M3−, M3, M3+, etc.[58] A grade of M0 to M2 was considered as poor result, M2+ to M3 as fair, M3+ to M4− as good, and M4 or M4+ as excellent. In addition, the range of abduction and external rotation was measured. The results of muscle grading were also expressed in pure numbers in order to perform statistical analysis, e.g. M3 = 3, M3+ = 3.33, M4− = 3.66, and M4 = 4.

Statistical analysis of the results was performed using ANOVA. In all instances, $P < 0.05$ was regarded as statistically significant.

Results

Preoperative muscle strength and range of motion significantly improved after surgery ($P < 0.05$). The mean postoperative abduction muscle grading was 3.48 ± 0.5, and the mean range of motion was for abduction $60 \pm 20^\circ$ and for external rotation $30 \pm 10^\circ$ in cases where both suprascapular and axillary nerves were reconstructed. The best results were obtained in young patients who were operated on less than 6 months after the injury, when both the suprascapular and the axillary nerves were neurotised and when a healthy intraplexus donor was utilised for neurotisation. Usually, supraspinatus reinnervation occurred in 4–6 months postoperatively. The first clinical sign was the relocation of the inferiorly subluxated humeral head. After this initial stabilisation, a progressive increase of abduction strength and range of motion was noticed, enabling the patient to perform arm abduction needed for various daily activities. The final range of motion was obtained in a time interval ranged from 8 to 12 months after the initiation of muscle contraction.

The overall outcome of suprascapular nerve neurotisation showed good or excellent results of supraspinatus reinnervation (muscle strength of >M3+ and shoulder abduction of $>40^\circ$) in 88% of the cases (36 patients). Despite this optimal response of supraspinatus reinnervation, suprascapular neurotisation did not offer return of infraspinatus function, and therefore useful external rotation in the majority of these patients (external rotation of $<20^\circ$). Intraplexus donors regained good or excellent function of the supraspinatus in 6 out of 7 patients, while 1 patient regained muscle strength M2+ and was able to stabilise the humeral head in the glenoid, but he could not abduct the arm more than 20°. Extraplexus neurotisation of the suprascapular nerve directly through the terminal branch of the accessory nerve gave good or excellent function of the supraspinatus in 27 out of 30 patients (90%) (Fig. 1a and b). The same satisfactory result was achieved in 2 patients with cervical plexus motor donor and the patient with the phrenic nerve neurotisation. The only clinical difference that we could notice was a delay of these nerve donors to gain a powerful and longstanding abduction. In 3 patients with accessory nerve neurotisation, and the 1 patient with cervical motor donor neurotisation fair results (muscle strength M3− to M3 and shoulder abduction of $<40^\circ$) were obtained. These patients were