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Missile injury of peripheral nerves: Fators affecting the prognosis & recovery.

KEYWORDS

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ABSTRACT Missile injuries to the peripheral nerves present a specific problem regarding their clinical and morphological charactericties, indications and timing of surgery, and prognosis. Our clinical retrospective study conducted at the neurosurgical department in Al-Shaek Zaed hospital for neurosurgical speciality between august 2005 and august 2007. We were studying 50 patient presented with missile injury to the peripheral nerves involving the brachial plexus, sciatic, peroneal, median, ulnar, and radial nerves. In this study, 26 patient were injured by bullet & 24 patient by shell injury, 34 patient were treated by neurolysis, 9 patient by direct end to end anastomosis and 7 patient treated conservatively. 26 patient(52%) in our study had good to fair functional recovery and 24 patient(48%)had poor surgical outcome after follow up period of 3 - 24 months. The patient age ranged from 9-54 years with male to female ratio of 5:1, most pt. present to us before 1 year of their injuries. The best functional recovery (good and fair prognosis) was for median & radial nerves. The worst prognosis was for patient of brachial plexus injury. All the cases who have functional recovery after treatment were of younger age group treated within the first 6 months after injury, while most of the cases of poor result were of older than 40 years and treated after 6 months of the injury.

Introduction

Peripheral nerve injuries participate 10% of all injuries, and in 30% of extremity injuries [1]. In recent years, the incidence of such injuries has gradually increased and the indications for surgery have been challenged. Most information on the results of brachial plexus repairs after missile injury has been derived from military reports. Brooks reported the first large series in 1954[2], followed by a few other authors reported their series.(3,4) Missile injuries of the peripheral nerves may be produced by low-velocity and high-velocity missiles that cause compressing and stretching of the nerves.(4,5) The high-velocity missile injuries are the second most common cause of brachial plexus lesions, accounting for about 25%(6) Missile wounds, particularly those causing bone fractures, increased the risk of nerve severance and irreparable damage.(7) In addition, other extensive injuries like soft tissue; visceral organ and blood vessel injuries complicate the treatment and prognosis of the peripheral nerve injuries.(4) The patient's outcome depends on the characteristics and site of injury, the coexisting lesions, time of surgery, intraoperative findings, surgical technique, and postoperative physical rehabilitation.(4)

Aim of study:

1. Evaluate the benefit of surgical intervention in management of patients with missile injury of peripheral nerves.
2. Evaluate the factors that improve surgical outcome in those patients with missile injury of peripheral nerves.

Patients and methods:

In our study, 50 patients with missile injuries to the brachial plexus, sciatic , median, ulnar, radial, and peroneal nerves were operated on between, August 2005 and August 2007 at Al-Shaek Zaed hospital for neurosurgical specialty. This number presented 50 patient, 26 (52%) of patients injured by bullet and 24 (48%) of patients by shell, 40 (80%) males and 10 (20%) females and the age of patients ranged from 9-54 years. The injured nerves included 6 (12%) brachial plexus injury, 20 (40%) sciatic nerve injuries, 2 (4%) common peroneal nerve injuries, 12 (24%) median nerve injuries, 6 (12%) ulnar nerve injuries, and 4 (8%) radial nerve injuries. The diagnosis of patients occurs according to the clinical signs and symptoms, neurophysiological and radiological studies. About 75% of patients presented to us within 6 months of their injury and 25% more than 6 months. About the treatment of patients, 43 patients treated operatively and 7 patients treated conservatively. Of the operated patients, 34 patients treated with neurolysis, 9 patients treated with direct end to end anastomosis and no patient needed nerve graft. The follow up of patients occurred over a period of 3 weeks to 24 months and the final results were classification of patients into 3 groups, according to the functional recovery and response to treatment, which are good result conistituting 22% of patients, fair results conistituting 30% of patients and poor results conistituting 48% of patients. The patient who develop good or fair result regarded as having functional recovery. During management and followup of our patient, Motor function was classified into six grades, from M0 to M5 using the widely accepted Highet's clinical scale. Sensory function was classified in five grades, from S0 to S4 (anesthesia, dysesthesia, protective sensation, two point discrimination above and below 10 mm). Functional recovery of the sciatic, median and ulnar nerves was evaluated for both motor and sensory function, and the recovery of the radial nerve was evaluated only for the motor function, because the sensory function was of no useful significance. In evaluation of the motor recovery of the sciatic, median, ulnar and radial nerves, we considered the function of the proximal and distal muscles separately. The results were classified in three groups. Cases at the lower limits M4 for proximal muscles, M3 for distal muscles, and S3 for sensory function if significant, were estimated as having good recovery. Patients at the lower limits M3 for proximal muscles & S2 for sensory function were estimated as having fair recovery, regardless of the grade of recovery for distal muscles. Finally, patients with functional grading below these limits were estimated as having bad recovery. Good and fair results were estimated as useful functional recovery. Similarly, patients at lower limits M3 for dorsal flexors of the foot were estimated as having useful functional recovery of the peroneal nerve .

Table 1 shows Grading results for the individual peripheral nerves.

RESULT	MEDIAN	ULNAR	RADIAL	SCIATIC and PERONEAL
Good	**M4-5 forearm, M3 intrinsic, S3-4**	**M4-5 forearm, M3 intrinsic , S3-4**	**M4-5 all except M3 thumb abductor**	**M4-5 anterior tibial and peroneal, M3 extensors of digits**

Fair	**M3 forearm, M0-3 intrinsic, S2**	**M3 forearm, M3 intrinsic, S2**	**M3 all except M0-3 thumb abductor**	**M3 anterior tibial and peroneal, M0-3 extensors of digits**
Bad	**M0-2 all, S0-1**	**M0-2 all, S0-1**	**M0-2 all**	**M0-2 all**

Results:
The results were analyzed in our 50 patients with follow-up period of 3 weeks-24 months according to the following data:

Age and Gender distribution:
The age of patients ranged from 9 to 54 years

Table 2 shows the Relationship of injured nerves with the age of the patient

Injured nerve	More 40	10-40	0-10 years
median	2	9	1
Radial	1	2	1
Ulnar	1	5	0
Sciatic	2	16	2
Common peroneal	0	1	1
Brachial plexus	1	5	0
Total	7 (14%)	38 (76%)	5 (10%)

There were no effects of the gender of the patients on the outcome and prognosis.

Table 3 shows the gender of the patients according to the individual injured nerve.

Injured nerve	Female	Male
median	2	10
Radial	1	3
Ulnar	1	5
Sciatic	4	16
Common peroneal	0	2
Brachial plexus	2	4
Total	10(20%)	40(80%)

Table 4 shows Level of injury(Proximal or distal):

Injured nerve	Distal	proximal
Median	10	2
Radial	4	0
Ulnar	3	3
Sciatic	0	20
Common peroneal	2	0
Brachial plexus	0	6
Total=50	19(38%)	31(62%)

Table 5 shows the relationship between the injured nerve and the functional recovery.

Injured nerve	Bad result	Functional recovery
Median	2	10
Radial	1	3
Ulnar	3	3
Sciatic	13	7
Common peroneal	0	2
Brachial plexus	5	1
Total	24(48%)	26(52%)

Type & velocity of missile injury.

Of these injuries, 26 were gunshot wounds and 24 were caused by shell fragments. Extensive nerve and soft tissues damage associated with shell fragment injury, where 6 of 9 cases of complete nerve transaction caused by shell fragment, 4 cases of them had bad result after surgical intervention. Extensive soft tissue damage and bone fracture were found in 20 cases (10 sciatic, 4 brachial plexus, 3 ulnar, 2 median and one radial nerves). Intraoperatively complete loss of continuity was found in 9 (18%) of 50 patient. Nerve continuity was preserved at least partially in 34 (68%) of patients & 7 (14%) have neuromas in continuity and/or fibrotic nerves. Complete loss of nerve continuity was somewhat more common in injuries caused by shell fragment wounds, 6 of 9 vs. 3 of 9 cases in those caused by gunshot wounds.

Table 6 demonstrates the extent of the injured nerves according to type of missile

Type of injury	Neuroma &/or fibrosis	Partial transection	Complete transection	Total
Gunshot	4	19	3	26
Shell fragment	3	15	6	24
Total	7(14%)	34(68%)	9(18%)	50

Clinical, Neurophysiological (EMG/NCS) & radiological findings.

Complete nerve palsy was initially present in all cases. Partial spontaneous improvement was registered in 10 (20%) of 50 nerves prior to surgical exploration. This partially preserved function usually involved one, either motor or sensory function, and rarely exceeded grade M2 for the corresponding forearm muscles or S2 in sensory function. The approach to diagnosis depends on history, neurological examination, neurophysiological (EMG & NCS) & radiological studies including cervical & lumbar spine X-Ray.

Table 7 shows the neurophysiological and intra operative findings of the injured nerves

Nerve	Neurotemesis	Axonotemesis	Neuropraxia
Median	3	7	2
Ulnar	1	3	2
Radial	1	2	1
BR.PLEX.	0	6	0
Peroneal	0	2	0
SCIATIC	4	14	2
Total 50	9 (18%)	34 (68%)	7 (14%)

Type of treatment (operative or conservative):

In our 50 patients, 7 patients treated conservatively and 43 patients operatively, of them, 34 patient with neurolysis and 9 patient with direct end to end anastomosis.

Table 8 shows types of Surgical procedures performed on injured nerves.

Surgical procedure	number
Neurolysis	34 (68%)
Direct suture	9 (18%)
Nerve grafting	0 (0%)
Not repaired (conservative treatment)	7 (14%)
Total	50 (100%)

Intraoperative findings:
Table 9 demonstrates intraoperative findings.

Nerve	Neuroma &/or fibrosis	Partial transection	Complete transection	Total
Median	2	5	3	10
Ulnar	0	3	1	4
Radial	1	1	1	3
Peroneal	1	1	0	2
sciatic	1	13	4	18
Br. Plexus.	0	6	0	6
Total	5(11.5%)	29(67.5%)	9(21%)	43

Type of surgical treatment & correlation with recovery:
Table 10 shows Results of surgery according to the individual nerves and surgical procedures.

Nerve	Neurolysis			conservative			End to end anastomoss		
Outcome	good	fair	bad	good	fair	bad	good	fair	bad
Median	2	4	1	1	1	0	0	2	1
Ulnar	0	1	2	1	1	0	0	0	1
Radial	1	1	0	1	0	0	1	0	1
BR. PLEX.	0	1	5	0	0	0	0	0	0
Peroneal	1	1	0	0	0	0	0	0	0
SCIATIC	2	2	10	1	1	0	0	0	4
Total 50	**6(12 %)**	**10(20 %)**	**18(36 %)**	**4(8%)**	**3(6%)**	**0(0%)**	**1(2%)**	**2(4%)**	**6(12 %)**

Interval between injury and time of surgical interference:
Table 11 demonstrates the interval between injury & surgical interference & recovery

Injured nerve	More 6m.	recovery	3-6m.	recovery	0-3m.	recovery
median	2	1	3	2	5	5
Radial	1	0	1	1	1	1
Ulnar	1	0	2	0	1	1
Sciatic	3	0	7	1	8	4
Com.pero neal n.	0	0	1	1	1	1
Brachial plexus	3	0	1	0	2	1
Total=43	10	1 (10%)	15	5 (33%)	18	13 (72%)

Outcome & prognosis: The patients are followed clinically, radiologicaly & neurophysiologicaly, over a period of 3weeks - 24 months. Good functional recovery was related to early surgical intervention in radial, common peroneal, median & ulnar nerves injury, in younger age group especially in distal nerve lesion. Functional recovery achieved from surgical intervention in 4 of 6 patient treated, one patient with radial nerve injury, 2 with median nerve injury and one with common peroneal nerve injury. For brachial plexus & sciatic nerve injury, bad result was due to proximal injury and/or complete transaction, & of cases with brachial plexus injury, one patient had fair functional recovery and 5 patients had poor result. So, the total rate of functional recovery (good & fair result) was 26 of 50 cases (52%) and bad result was 24 of 50 cases (48%), all cases treated conservatively within 3-4 months were improved. **The Factors that negatively affect the outcome and prognosis:**

(1) age of patients over 40 years. (2) high (proximal) location of injury. (3) surgery after 6 months. (4) extensive nerve & soft tissues injury. (5) High velocity missile injury.

Discussion:
In surgery of peripheral nerves, it should be remembered that magnification, delicate instruments and less reactive suture material are essential for better outcome and prognosis. In our study, 52% (26) of patients had functional recovery after surgical and conservative management, while 48% (24) of patients had poor result. For median nerve injury, we have 83% (10 of 12) of patients had functional recovery, 75%(3 of 4) of patients with radial nerve injury had functional recovery, 50% (3 of 6) of patients with ulnar nerve injury had functional recovery and 17% (1 of 6) of patients with brachial plexus injury had functional recovery. For sciatic nerve injury, we have 35% (7 of 20) of patients had functional recovery, and for common peroneal nerve injury the 2 operated patients had functional recovery.

On the basis of his series from the World War I, Delageniere concluded that results in 113 neurolysed cases were fairly recovered, & in 142 correct sutures, resulted in 122 (85,9%) fair & good results, 16 partial successes, and four failures.[8] Pollock in 1932 reported success rate of 72% for radial, 69% for median and 57% for ulnar nerve repairs. Use of nerve grafts was largely unsuccessful in this period.[9] Reviewing British experiences from the World War II Seddon indicated that radial nerve injuries have more satisfactory outcome than median and ulnar nerve injuries. He noted that 36,9% of 114 radial nerve repairs achieved grade M4-M5. Furthermore, he noted that only 8,6% of median nerve injuries achieved a satisfactory level of sensory function and 4,9% ulnar nerve injuries achieved a satisfactory level of motor function.[10]

Similar findings were registered by Woodhal and Beebe. They registered good motor function in 21,3% of 127 radial nerve repairs. Poor results of nerve grafting in the World War II cases have been attributed to the severity of nerve injuries with large nerve gaps and the use of trunk graft technique without magnification.[11] In the largest series of nerve injuries from the Vietnam War Omer reported total rate of recovery of 55% for cases with performed external neurolysis, or 37,5% for high velocity, and even 76,2% for low velocity gunshot wounds. Additionally, he noted total rate of recovery of 25% in cases with epineurial suture, or 20% for high velocity and 31,2% for low velocity gunshot wounds.[12] Omer reported that 80% of the cases operated above 40 years had poor functional recovery.[12] These results indicated that the best functional recovery was achieved below the age of 30 years regardless of gender. The best functional recovery in our study was achieved in median (83%), radial (75%) and common peroneal nerve (only 2 cases studied) injuries, whereas poor recovery in the brachial plexus (17%) and sciatic nerve (35%) injury achieve poor result and finaly the ulnar nerve give us a result in between(50%). Pollock reported that Surgical treatment (neurolysis) was successful in all cases with median, radial & peroneal nerve injuries & in 60% of ulnar nerve injuries. Split repairs were successful in all cases with radial and peroneal nerve injuries and in 5 (83,3%) of 6 median nerve injuries.[9] These results indicate that the proximal the site of nerve injury (brachial plexus and sciatic nerves), the worse the surgical result and prognosis. Whereas distal site of injury represented by median, radial and common peroneal nerves gave us better results. From our study, the best functional recovery was for the cases who were presented to us and treated during the first 6 months of injury & in those patients treated with neurolysis rather than direct end to end anastomosis, where from 34 patients treated with neurolysis, 28 patients (83%) had functional recovery and 6 patients (17%) had poor result. For the 9 patients treated with direct end to end anastomosis, 3 patients had functional recovery and 6 patients had poor result. No patient were treated with nerve graft. Pollock decided that the total rate of functional recovery for neurolysed nerves was 92,8% (26 of 28 nerves). Neurolysis was successful in all cases with median, radial and peroneal nerve injuries and in 10 (83,3%) of 12 ulnar nerve injuries.[9] The best result of nerve repair in our study achieved during the first 6 months from time of injury, where from 19 patients having useful functional recovery, 18 (95%) of patients treated within the first 6 months while only one patient (5%) treated after 6 months from time of injury had functional recovery. Omer G. has been accepted that nerve repair in cases of missile injuries should be delayed, since these injuries usually involve multiple contaminated wounds. A clean wound, fracture stability, adequate circulation and skin closure takes priority over any nerve repair. However, possibilities for spontaneous recovery and significant number of nerve lesions in continuity are additional reasons for delayed surgery, usually two to three months when negative nerve action potential recordings are indication for resection of the lesion in continuity.[13] In an emergency situation when a brachial plexus lesion is associated with injury to major vessels, the question arises, whether in the same stage the brachial plexus repair should be performed to deal with the whole injury immediately. If not only a vascular surgeon, but also a surgeon experienced in brachial plexus surgery is available, and if the patient's state is well enough that he can sustain approximately an 8 hour surgery, then an attempt to repair the brachial plexus may be undertaken. However, in most of the times, it is much better to concentrate at this stage on the vascular repair, and leave the brachial plexus for an early secondary repair.[14] In our study, we had 6 cases of brachial plexus injury (12%), only 17% of them (1 of 6) had functional recovery. In recent military conflicts brachial plexus injury have made up 2.6% to 14% of all peripheral nerve injuries treated.[15,16,17] Missile injuries of the brachial plexus were considered to have a poor, almost hopeless prognosis and a non-operative approach of waiting for spontaneous recovery was advocated.[18,19,20,21] Seddon[22] classed nerve injuries as neurapraxia, axonotmesis & neurotmesis. He later emphasised[23] that a nerve trunk, apparently in continuity, might have sustained such a level of internal damage that the lesion was, in fact, a neurotmesis not an axonotmesis. Kline[5] reported a series of 141 missile wounds of the brachial plexus treated over 18 years. Of the 90 patients operated on 75 were followed for two years or more. The indication for surgery was a deficit in one or more elements of the plexus, with failure to improve within 2-4 months of injury. Other reasons included pain and the formation of a false aneurysm. Intraoperative recording of compound nerve action potentials (CNAP) traversing the lesion was seen in 48 of 166 such lesions. Neurolysis of damaged elements produced good or useful results in 44 of these (92%). When no CNAP was found to traverse the lesion, it was resected and grafted. Of 98 lesions, 55 were repaired by grafts, and 18 of 26 wounds in which direct suture repair was undertaken, recovered useful function or better.[24] However, we think that functional recovery following brachial plexus neurotmesis is doubtful even after direct end to end anastomosis & repair. The best outcome was achieved in lesions of the upper trunk and in the lateral and posterior cords, but recovery occurred with some repairs of C7 to the middle trunk and medial cord to the median nerve. The results in lesions of the lower trunk and the medial cord were mostly poor. Neurolysis or resection of the injured element was of value in severe non-causalgic pain, unresponsive to physiotherapy and medication, in about half of the cases.[24] M. P. M. Stewart et al. considered the violence of the injury and the extent of damage to nerves and adjacent soft tissues to be the single most important determinant of outcome, closely followed by the delay between the injury and repair.[24] Surgical intervention is indicated by pain, in which causalgia & neurostenalgia predominate, when there is failure to progress or deepening of the lesion under observation. M. P. M. Stewart et al. consider that there is cause for optimism after nerve repair, particularly of the roots of C5, C6 & C7 and the lateral & posterior cords, although the prognosis in complete lesions of the plexus associated with damage to the cervical spinal cord is particularly poor.[24]

Conclusions: Surgical intervention in missile peripheral nerve injury is indicated if there are no signs & symptoms of recovery after 2-3 months of conservative management or there was poor recovery or complete functional loss. Many low velocity missile injuries by hand guns or revolvers recover on expectant approach in weeks to months unless the missile injuries has directly damaged the neural elements. High velocity missiles produce extensive damage to soft tissues, blood vessels, bones & may divide the peripheral nerves & brachial plexus. After 4-6 weeks the patient should undergo radiological & electrophysiological studies. Results are poor in late intervention, more than 6 months because the motor end plates undergo degeneration. For brachial plexus injury, timely repairs of C5, C6 and C7 roots, & the lateral and posterior cords produce the most gratifying results if there is no neurotmesis. While C8 and T1 root injury or neurotmesis produce the worst results.

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