Peripheral Nerve War Injuries

Guarantor: Veselin Vrebalov-Cindro, MD PhD
Contributors: Veselin Vrebalov-Cindro, MD PhD*; Petar Reic, MD PhD*; Marina Ognjenovic, MD PhD†; Stipan Jankovic, MD PhD‡; Šimun Andelinovic, MD PhD§; Deny Karelovic, MD†; Leonardo Kapural, MD¶; Mladen Rakic, MD‖; Dragan Primorac, MD PhD§

Objective: The purpose of this study is to evaluate peripheral nerve war injuries sustained during the war in southern Croatia and Bosnia and Herzegovina. Patients and Methods: During the war in Croatia, 713 patients (99% male and 1% female) with wounds inflicted by firearms were examined at the Laboratory of Neurophysiology, University Hospital, Split. The patients, soldiers and civilians alike, ranged in age from 6 to 73 years (average, 28 years). All patients with firearm nerve war injuries underwent detection by electromyography and plurisegmental examination of the damaged peripheral nerve (neurography). The patients were examined and controlled on three occasions: within 2 months after wounding; up to 6 months after wounding; and more than 6 months after wounding. Results: Single peripheral nerve lesions were present in 80% of the patients, and multiple peripheral nerve or plexus lesions were present in 20% of the patients. Peroneal and ulnar nerves were most often involved (20.9% and 19.8%, respectively). Associated massive injuries to the muscles, large blood vessels, or vital organs were present in 45% of the patients. Wounds were inflicted by shell fragments in 80% of the patients and by projectiles in 20% of the patients. Conclusion: According to our results, better recovery was achieved with conservative treatment and when physical therapy was initiated early with maximal patient cooperation. Electromyoneurographic findings were the most valid in the prognostic classification of war-inflicted peripheral nerve injuries.

Introduction

Peripheral nerve war injuries have been reported more often during recent wars than in previous wars.[1-4] During the war in Croatia and Bosnia and Herzegovina, these types of injuries were common, particularly as a result of the use of forbidden explosive devices.[5,6] Various forms of nerve damage were caused by traction, laceration, and transection by mine debris, hand grenades, or bullets. However, high-velocity missiles caused vast disruption of soft tissue directly or indirectly by fragmentation of projectile or bone ("secondary projectiles").[7,8] The management of peripheral nerve injuries differs depending on the mechanism of injury, the medical supplies and equipment available, and the experience of the treating physician.[9-11] In this study, we review our neurological experience in the management of peripheral nerve war injuries during the war against Croatia (1991-1995).

Departments of *Neurology, ‡Radiology, §Pathology and Forensic Medicine, and ‖Anesthesiology, University Hospital, Split, Croatia.
†Medical School, University of Split, Split, Croatia.
¶Department of Anesthesiology, Cleveland Medical Foundation, Cleveland, OH.
This manuscript was received for review in March 1998. The revised manuscript was accepted for publication in August 1998.

Patients and Methods

During the war in southern Croatia and Bosnia and Herzegovina (1991-1995), 713 patients with peripheral nerve war injuries were examined at the Laboratory of Neurophysiology, University Hospital, Split. The patients ranged in age from 6 to 73 years (average, 28 years). There were 706 men (99%) and only 7 women (1%), who ranged in age from 41 to 60 years.

Examinations were performed using the Mystro MD 87 electromyographic apparatus. Muscle electromyographic examinations and nerve conduction studies of damaged nerves and plexuses were performed on all patients. The patients were examined and controlled on three occasions: within 2 months after wounding; up to 6 months after wounding; and more than 6 months after wounding.

Results

The frequency of particular nerve and nerve plexus lesions is presented in Table I. The results of nerve and plexus treatments are presented in Table II. Surgical treatment were performed on 149 patients (end-to-end suture repair in 72 patients and neurolysis in 77 patients). However, 40 of 77 patients who showed denervation 6 months after wounding were treated surgically (Table III). The remaining 37 patients did not undergo any additional surgical procedures.

Discussion

Recent results suggest that peripheral nerve war injuries are very common, being second only to musculoskeletal injuries.[1,2] In our work, single peripheral nerve injuries were present in 80% of all patients, whereas multiple peripheral war nerve injuries and plexus lesions were found in 20% of all patients. Peroneal and ulnar nerves were most commonly involved (20.9 and 19.8%, respectively). Furthermore, war injuries of facial nerves were relatively rare (2.7% of all peripheral nerve war injuries). Nerve lesions were combined with severe injuries of the muscles, large blood vessels, or other organs such as lungs, with penetrating abdominal injuries, and with head and neck injuries. The same results have been reported by other authors.[3,4] Multiple injuries inflicted by shell fragments and mines were observed in 80% of the patients, whereas the rest of the patients (20%) sustained gunshot wounds inflicted by projectiles. One-fifth of the patients were wounded by explosive devices forbidden by international conventions (cluster bombs and dumdum bullets).

Results of clinical and electromyoneurographic (EMNG) testing of the involved nerves showed the same pattern. When EMNG recovery was recorded as early as 3 to 5 months after wounding, clinical recovery was also satisfactory. When EMNG

TABLE I

FREQUENCY OF INJURIES TO PARTICULAR NERVES OR PLEXUS

Nerve/Plexus	No. of Patients	Percent
Musculocutaneus nerve	14	1.9
Radial nerve	96	13.5
Median nerve	83	11.6
Ulnar nerve	141	19.8
Lumbosacral plexus	44	6.2
Ischiatic (sciatic) nerve	34	4.8
Femoral nerve	25	3.5
Peroneal nerve	149	20.9
Tibial nerve	28	3.9
Facialis nerve	19	2.7
Total	713	100.0

TABLE II

RECOVERY OF PARTICULAR NERVES AND PLEXUSES 6 MONTHS AFTER WOUNDING (PERCENTAGE OF RECOVERY IS GIVEN IN PARENTHESES)

Nerve/Plexus	Good	Partial	Poor
Cervicobrachial plexus	7 (13.2)	22 (41.5)	24 (45.3)
Axillary nerve	10 (37.0)	15 (55.6)	28 (7.4)
Musculocutaneus nerve	7 (50.0)	6 (42.9)	1 (7.1)
Redial nerve	74 (77.1)	21 (21.8)	1 (1.1)
Median nerve	9 (10.8)	62 (74.7)	12 (14.5)
Ulnar nerve	48 (34.9)	76 (53.9)	17 (12.1)
Lumbosacral plexus	2 (4.5)	15 (34.1)	27 (61.4)
Ischiatic nerve	5 (14.7)	27 (79.4)	2 (5.9)
Femoral nerve	4 (16.0)	18 (72.0)	3 (12.0)
Peroneal nerve	50 (33.6)	92 (61.7)	7 (4.7)
Tibial nerve	15 (53.6)	11 (39.3)	2 (7.1)
Facial nerve	12 (63.1)	6 (31.6)	1 (5.3)
Total	243 (34.1)	371 (52.0)	99 (13.9)

TABLE III

RESULTS OF SURGICAL TREATMENT PERFORMED 6 MONTHS AFTER INJURY TO THE NERVE OR PLEXUS

Nerve Plexus	No. of Patients	Improvement
Cervicobrachial plexus	2	0
Upper extremities	19	1 (5.3%)
Lumbosacral plexus	1	0
Lower extremities	17	1 (5.9%)
Facial nerve	1	0
Total	40	2 (5.0%)

recovery was observed later or denervation persisted, clinical recovery was less satisfactory or failed to occur.

In addition to the severity and type of lesion, the peripheral nerve structure also appears to play a role in the recovery of injured nerve or nerve plexus. Recovery is probably less likely in the nerves that contain a greater amount of vegetative fibers. Thus, the nerve plexus with a significant autonomic component is less likely to recover after injury. For a similar reason, recovery is quite poor in the median nerve, whereas the radial nerve, containing a small amount of vegetative fibers, achieves relatively good recovery.

If electromyography fails to detect any spontaneous activity in a particular muscle, and no evoked potential is obtained by maximum nerve stimulation 6 or more months after wounding, it is quite certain that the nerve lesion will not recover with further conservative therapy.

In an attempt to achieve the maximum possible recovery, some of these patients underwent surgical treatment. The surgical treatments were different (neurolysis, nerve grafting, suture, split repair, and interfascicular graft repair), but the results were very poor (only 5% of patients showed improved clinical signs). Therefore, the outcome is generally better in distal nerve lesions than in proximal nerve lesions. Other researchers have reported the same results.[10] According to the literature, the results of surgical treatment of war injuries to peripheral nerves are considerably better if the treatment is performed immediately after wounding.[11,12] Unfortunately, the treatment of nerve injuries often occurs later because the patients must be treated for more life-threatening conditions (vascular injuries, musculoskeletal treatment, or other organ repair). Our results support the findings of Kline,[13] who showed that more complete recovery was achieved when conservative and physical therapy was initiated earlier along with the patient's cooperation.

Accordingly, the factor of time appears to be of paramount importance in both conservative and surgical treatment. Delayed surgical treatment in cases of denervation has a prognosis of modest recovery. EMNG was found to be an important indicator for the prognosis of recovery of nerve lesions. In cases in which both clinical and EMNG findings indicate an unfavorable course, surgical treatment should be performed without delay to improve the chance of recovery of the injured nerve

References

1. French RW, Callender GE: Peripheral nerve ballistic injuries. In Wound Ballistics in World War II, Supplemented by Experiences in the Korean War, pp 91–141. Edited by Beyer JC. Washington, DC, Office of the Surgeon General, Department of the Army, 1962.
2. Hardway RM: Viet Nam wounds analysis. J Trauma 1978; 18: 635–9.
3. Fosse E: The siege of Tripoli 1983: war surgery in Lebanon. J Trauma 1988; 28: 660.
4. Dilingham TR, Spellman NT, Braverman SE, Zeigler DN, Belandres PV, Bryant PR, Salcedo VL, Schneider RL: Analysis of casualties referred to Army physical medicine services during the Persian Gulf conflict. Am J Phys Med Rehabil 1993; 72: 214–28.
5. Luetić V, Šoša T, Tonković I, Petrunić M, Rohandić E, Lončarić L, Romić R: Military vascular injuries in Croatia. Cardiovasc Surg 1993; 1: 3–6.
6. Janković S, Sapunar D, Jurisić Z, Majić V: Medical support to a nonprofessional brigade during the Croatian Operation Storm. Milit Med 1997; 162: 37–40.
7. Perić M, Gopčević A, Mazul Sunko B, Ivanec Z, Kelečić M, Bekavac Bešlin M, Trnski D: Clinical course in 52 severely wounded patients treated in the intensive care unit during war in Croatia. Injury 1995; 26: 506–13.
8. Radonić V, Baric D, Petričević A, Kovačević H, Sapunar D, Glavina-Durdov M: War injuries of the crural arteries. Br J Surg 1995; 82: 777–83.
9. Dubuisson A, Kline DG: Indications for peripheral nerve and brachial plexus surgery. Neurol Clin 1992; 10: 935–51.
10. Ehni BL: Treatment of traumatic peripheral nerve injury. Am Fam Physician 1991; 43: 897–905.
11. Gousheh J, Razian M: War injuries of the femoral nerve: series of 27 cases. Ann Chir Plast Esthetique 1991; 36: 527–31.
12. Samardžić MM, Rasulić LG, Gjurčić DM: Gunshot injuries to the brachial plexus. J Trauma 1997; 43: 645–9.
13. Kline DG: Surgical repair of peripheral nerve injury. Muscle Nerve 1990; 13: 843–52.