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THE EPIDEMIOLOGY OF FOREARM NERVE INJURIES – A RETROSPECTIVE STUDY

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SUMMARY – The aim of this study was to investigate the mechanisms and etiologic factors of forearm nerve injuries. This retrospective survey included all patients treated surgically in Clinical Department of Neurosurgery, Clinical Center of Serbia, from January 1, 2000 to December 31, 2010. All relevant data were collected from medical records. Statistical procedures were done using the PASW 18 statistical package. Our study included 104 patients that underwent surgery after forearm nerve injury. The majority of admitted patients were male (n=84; 80.8%) and only 20 (19.2%) were female. Ulnar nerve injury predominated with 70 cases, followed by median nerve with 54 (51.9%) cases and radial nerve with only 5 cases. Transection was the dominant mechanism of injury and it occurred in 84.6% of cases. Injury by a sharp object was the most frequent etiologic factor and it occurred in 62 (59.6%) patients, while traffic accident and gunshot injuries were the least common etiologic factor of forearm nerve injury, occurring in 7 (6.7%) and 6 (5.8%) cases, respectively. Associated injuries of muscles and tendons, bones and blood vessels occurred in 20 (19.2%), 16 (15.4%) and 15 (14.4%) patients, respectively. The etiology and mechanism of peripheral nerve injury are of great importance when choosing the right course of treatment in each individual patient because timing and type of treatment are closely related to these factors.

Key words: *Forearm injuries – epidemiology; Median nerve – injury; Radial nerve – injury; Ulnar nerve – injury*

Introduction

Injuries of peripheral nerves are a significant cause of disability[1,2]. Forearm nerve injuries are relatively uncommon; however, they can be severe and associated with injuries of other tissues. Injury caused by fall and hard object blow is often associated with bone fracture. Sharp object lacerations due to close structural proximity are mostly associated with vascular lesions. Gunshot injuries can be associated with both bone fractures and blood vessel injuries. Vascular gunshot injuries often arise as a consequence of shock waves caused by a projectile[3-8].

As hand has essential role in everyday life, loss of its function is horrifying experience for patients. In many cases, injury of peripheral nerve leads to disability and loss of job, and since these injuries occur mostly in active population, it is a big socioeconomic problem[9-11]. According to the level of injury, they can be roughly divided into proximal and distal forearm nerve injuries. Proximal nerve injuries often have worse prognosis and poorer surgical outcome in comparison with

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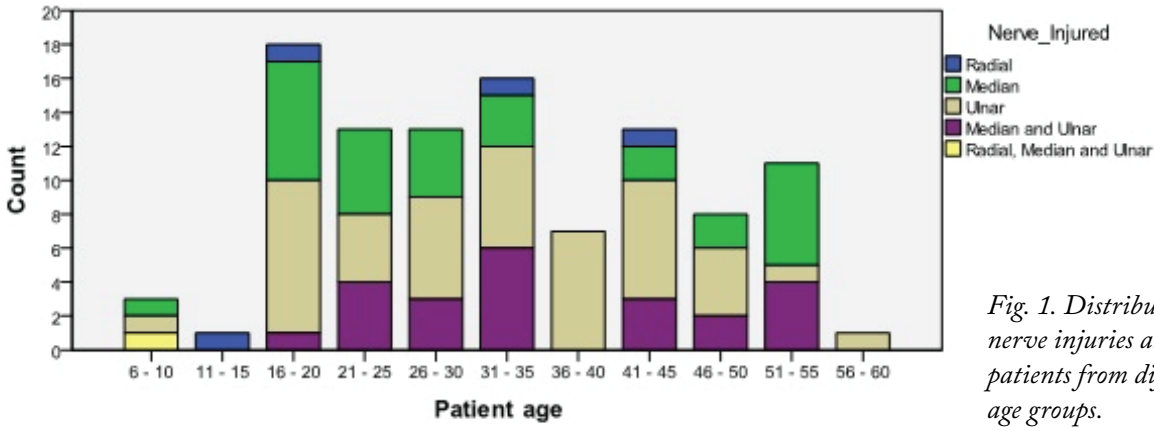

Fig. 1. Distribution of nerve injuries among patients from different age groups.

distal forearm nerve injuries[12-15]. The reason for this is a longer distance of the site of injury from the end motor organ which axon has to bridge to regenerate nerve in proximal forearm injuries. Also, proximal forearm nerve injuries affect a greater number of muscles causing a higher degree of disability.

The aim of this paper is to present the etiology and mechanisms of forearm nerve injuries in 104 patients treated at Clinical Department of Neurosurgery, Clinical Center of Serbia, during an 11-year period, from January 1, 2000 until December 31, 2010.

Patients and Methods

This retrospective study included 104 patients operated on for forearm nerve injury at Clinical Department of Neurosurgery, Clinical Center of Serbia, during an 11-year period, from January 1, 2000 until December 31, 2010. The study included only patients in whom nerve injury occurred as a consequence of trauma, while patients that underwent surgery due to the nerve entrapment syndrome or peripheral nerve sheath tumor were excluded from the study. All relevant data were obtained from medical records of these patients.

Statistical analysis was performed using the PASW 18 statistical package. For description of the parameters of interest, we used the methods of descriptive statistics: measures of central tendency (mean value), range, percentages and tabulation.

The study was approved by the relevant Ethics Committee and it was part of a doctoral thesis project.

Results

Out of 104 treated patients, 84 (80.8%) were male and 20 (19.2%) female. In our patient group, the most frequently injured nerve was ulnar nerve. This nerve was injured in 70 patients, however, 23 patients had both ulnar and median nerve injury and one patient had injuries of all three forearm nerves, ulnar, median and radial nerve. The least frequently injured nerve was radial nerve, which was injured in five patients, with four patients having isolated radial nerve injury. The average age of study patients was 32 years. The youngest one was 8 and the oldest 56 years old. The majority (67.3%) of injured patients were aged between 21 and 50 years (Fig. 1). There was no significant difference between injured sides; 53 patients had injury of the

Table 1. Distribution of forearm nerve injuries according to injured nerve and injury localization

Nerve	n (%)	Left/Right	Proximal/Distal
Ulnar	46 (44.2%)	25/21	12/34
Median	30 (28.8%)	11/19	7/23
Radial	4 (3.8%)	1/3	4/0
Median and ulnar	23 (22.1%)	15/8	5/18
Median, ulnar and radial	1 (1%)	1/0	0/1
Total	104 (100%)	53/51	28/76

Table 2. Distribution of the mechanism and etiology of forearm nerve injures in study patients

Mechanism of injury	
Transection	88 (84.6%)
Traction and contusion	16 (15.4%)
Etiology of injury	
Injury by sharp object	62 (59.6%)
Injury by chainsaw or grinder	11 (10.6%)
Fall	12 (11.5%)
Gunshot injury	6 (5.8%)
Traffic accident	7 (6.7%)
Other	6 (5.8%)

left and 51 of the right forearm. From the topographic point of view, injury of the distal part of the forearm was 2.7-fold more often recorded than injury of the proximal part of the forearm (Table 1).

There were two mechanisms of injury in our study: 1) transection; and 2) traction and contusion.

Transection was more than 5 times more frequent mechanism of injury than traction and contusion (Table 2). Nerve injuries of the forearm were mostly caused by sharp object (59.6%) or by fall (11.5%). Gunshot injuries and traffic accidents were not so frequent cause of forearm nerve injury in our group (Table 2). Falls, traffic accidents and gunshot injuries caused injury of the nerve by both mechanisms, while injury by sharp object, chainsaw or grinder caused only transection of the nerve in our study patients (Table 3). Of 62 patients injured by a sharp object, four were injured

Table 3. Cross-table: mechanism and etiology of forearm nerve injury

		Mechanism of injury	
		Transection	Traction and contusion
Etiology of injury	Injury by sharp object	62	0
	Injury by chainsaw or grinder	11	0
	Fall	5	7
	Gunshot injury	3	3
	Traffic accident	3	4
	Other	4	2

Table 4. Associated injuries in study patients

Associated injuries	n of patients	% of patients
Cranial injuries	1	0.96%
Thoracic traumas	3	2.88%
Abdomen traumas	1	0.96%
Vascular injures	15	14.42%
Long bone fractures	16	15.38%
Muscle and tendon injuries	20	19.23%

*Total percent of patients with associated injuries is different from the sum of percentages in the table because many patients had more than one associated injury

during suicide attempt by cutting the forearm blood vessels.

Concerning associated injuries, 20 (19.23%) patients had muscle or tendon injury of the forearm, but forearm bone fracture and vascular trauma were also frequent, observed in 16 (15.38%) and 15 (14.42%) cases, respectively (Table 4). The total number of patients with associated injuries was 47 or 45.2% of the total number of patients.

Distribution of nerve injuries among patients of different age groups is shown in Figure 1. A high prevalence of injury was recorded in patients aged 16-55. The mean time elapsed from injury to surgery was 4.95±3.49 months. In 74% of cases, surgery was performed in the first 6 months after injury and 37 patients (35.6% of all patients) were operated in the first 3 months. In just 3 cases, surgical treatment was performed 12 months after injury. In 48.4% of patients injured by a sharp object, surgical reconstruction was performed in the first 3 months of injury. Delayed treatment (more than three months after injury) was performed in 85.7% of patients injured in traffic accidents, 83.3% of those injured on fall and 66.7% of those with gunshot injury.

Discussion

Depending on the severity of the injury and associated injuries, forearm nerve injuries can be life threatening, especially in cases with associated vascular trauma. Although associated injuries are mainly successfully repaired, injury of the nerve itself can leave permanent consequences in terms of the ability to use the arm, hand or fingers. Most studies dealing with in-

juries of peripheral nerves, especially nerves of upper extremities, are concentrated on the results of surgery, in the form of motor and sensory recovery, and eventually the time of the recovery plateau. In previously published studies on the epidemiology of nerve injuries, forearm nerve injuries are presented just as a fragment of studies, and they are not presented in detail[16,17]. The lack of epidemiological studies of peripheral nerve injuries in general, and specifically of forearm nerve injuries, can be explained by the relatively small percent of these injuries in relation to the total number of trauma, and due to the relatively small number of specialized centers that deal with surgical reconstruction of injured peripheral nerves. In one large epidemiological study which covered a 15-year period and included 16 753 patients, 219 patients had injuries of peripheral nerves, yielding a prevalence of 1.3%. The most common location of nerve injury was forearm[18].

In another study which dealt with the prevalence of peripheral nerve injuries of upper and lower extremities in multi trauma patients, 162 of a total of 5777 patients had nerve injury, yielding a prevalence of 2.8%. One hundred and twenty-one of these 162 patients had injury of the nerves of upper extremities[19]. The prevalence of forearm nerve injuries is much higher than the prevalence of upper arm and brachial plexus nerve injuries. The higher prevalence of forearm nerve injuries can be explained by the superficial position of nerves in the forearm region, which is often in contact with or near sharp objects we handle on a daily basis[20].

In our study, there were 84 (80.8%) male and 20 (19.2%) female patients and their average age was 32 years. Distribution of peripheral nerve injuries according to gender and mean age of patients in previously published papers on the topic of peripheral nerve injuries is comparable to our study. Soheil *et al.* in their comprehensive epidemiological study had 83.1% of male and 16.9% of female patients, average age of 33 years[18]. In his retrospective study that included 456 patients with peripheral nerve injuries, Kouyoumdjian had 74% of male and 26% of female patients, mean age 32.4 years, age range from 4 to 79 years[16]. The average age of patients in the study by Ciaramitaro *et al.* was somewhat higher, 37 years, but gender distribution of nerve injuries was comparable to our study, i.e. 75% of male and 25% of female patients[21]. In our study, age range was 8-56, with the highest prevalence in active population aged 16-55 (Fig. 1). Because of the disabling effects in active population, this particular pathology carries long-term socioeconomic consequences, inability to perform previous job, or losing working ability altogether[9].

According to the published literature, number one cause of peripheral nerve injury is traffic accident[16,17,19,21]. When it comes to the etiology of peripheral nerve injuries of the forearm, the dominant etiologic factor is cutting, mostly by sharp or broken objects that we use in everyday life[22,24]. In our study, also, the dominant etiologic factor was cutting by a sharp object, which was the cause of 59.6% of all injuries of forearm nerves. The remaining 40.4% of injuries were caused by fall (11.5%), chainsaw or grinder (10.6%), gunshot injuries (5.8%), traffic accidents (6.7%) and other (5.8%) (Table 3). In our study, four of 62 patients injured by sharp object were injured during suicide attempt.

Injuries of forearm nerves can be roughly divided into injuries of proximal and of distal forearm. This topographic division has practical importance from the perspective of potential nerve recovery and functionality of the hand, since it has already been shown that distal injuries have better prognosis of recovery[12-15]. Patients with proximal nerve injuries of the forearm have significantly less chances to return to their previous job as compared with patients with distal forearm nerve injuries[9]. In our study, distal forearm nerve injuries occurred more frequently in comparison to proximal forearm nerve injuries, 76 to 28 patients. The exception was radial nerve, which was more often injured in the proximal part of the forearm (Table 1). Other studies assessing injuries of the median and ulnar nerve of the forearm also showed a higher frequency of injuries of these nerves in distal forearm[22,23]. The explanation for different prevalence in topography of median and ulnar nerves in comparison to radial nerve and its branches lies in their anatomical location and etiology of injury. In contrast to radial nerve, median and ulnar nerves are located anteriorly, and as a consequence handling with sharp objects is more likely to injure these nerves than the one located posteriorly.

Associated forearm nerve injuries are common and almost every other patient in our study had it. As-

sociated injury in our study included injury of forearm muscles and tendons, bone fracture and vascular trauma. Head and body injuries occurred only in 5 (4.81%) cases (Table 4). The etiology and mechanism of the most frequent type of injury in our study, injury by a sharp object, may explain the high frequency of associated injuries of the surrounding muscles, tendons and blood vessels.

In 74% of cases, surgery was performed in the first 6 months and 37 patients (35.6% of all patients) were operated in the first 3 months after injury. In just 3 cases, surgical treatment was performed after 12 months of injury. Opinions about timing of the surgery are divided among experts in peripheral nerve surgery. Some experts believe that patients with evident nerve transection should be operated immediately. Others, however, believe that it is better to wait for 3 weeks, when the process of Wallerian degeneration is over. The majority of surgeons agree that nerve reparation procedure should be executed within the first 6 months after injury, at the latest within a year. After that period of time, results of surgical treatment are poorer. However, in the last years, ever more in peripheral nerve surgery advise additional examination for late referrals. The claim is that if there are fibrillations present in the muscle, surgical treatment is indicated even one or more years after injury, and the results are satisfactory[27].

The etiology and mechanism of injury are among the most significant factors in treatment modality decision making. Timing of the surgery is determined by it, as previously explained. Also, the choice of treatment depends on these factors. In transection injuries, and especially in cases where the injury of the nerve is evident from the moment of injury, surgery will be performed earlier. With this in mind, nerve tissue will not be contracted, so direct suture of the nerve usually can be accomplished. And with this, chances for full recovery are high. However, in traction and contusion injuries, although continuity of the nerve is macroscopically intact, a larger portion of the nerve is affected. Surgery is usually performed between 3 and 6 months after injury, and in this period nerve stumps are retracted. During the surgery, particular portion of the nerve is found "empty", so together with retraction of nerve stumps and resection of the damaged nerve, a large defect is present. There is no possibility for direct suture, so nerve grafting or neurotization must be performed. Results of these types of treatment are usually poorer[28].

Conclusion

Traumatic injury of peripheral nerves is a worldwide problem and it is particularly important because it affects younger population and can result in significant disability. Our study showed that transection was more than 5-fold more frequent mechanism of injury than traction and contusion, and that it was mostly inflicted by a sharp object. For this reason, this pathology is also a great socioeconomic problem. The importance of etiology and mechanism of peripheral nerve injury is great when selecting the right course of treatment for each individual patient because timing and type of treatment are closely related to these factors.

References

1. Rivara FP, Grossman DC, Cummings P. Injury prevention. First of two parts. N Engl J Med. 1997;337:543-8.
2. Robinson LR. Traumatic injury to peripheral nerves. Muscle Nerve. 2000;23:863-73.
3. Shaw AD, Milne AA, Christie J, Jenkins AM, Murie JA, Ruckley CV. Vascular trauma of the upper limb and associated nerve injuries. Injury. 1995;26(8):515-8.
4. Vlsser PA, Hermreck AS, Pierce GE, Thomas JH, Hardin CA. Prognosis of nerve injuries incurred during acute trauma to peripheral arteries. Am J Surg. 1980;140(5):596-9.
5. Chemnitz A, Björkman A, Dahlin LB, Rosén B. Functional outcome thirty years after median and ulnar nerve repair in childhood and adolescence. J Bone Joint Surg. 2013;95 (4):329-37.
6. Bowyer GW, Rossiter ND. Management of gunshot wounds of the limbs. J Bone Joint Surg Br. 1997;79(6):1031-6.
7. Hull JB. Management of gunshot fractures of the extremities. J Trauma Acute Care Surg. 1996;40 Suppl 3:S193-7.
8. Xinan L, Yinqiu L, Lei C. The effect of indirect injury to peripheral nerves on wound healing after firearm wounds. J Trauma Injury Infect Crit Care. 1996;40 Suppl 3:S56-9.
9. Jaquet JB, Luijsterburg AJ, Kalmijn S, Kuypers PD, Hofman A, Hovius SE. Median, ulnar, and combined median-ulnar nerve injuries: functional outcome and return to productivity. J Trauma. 2001;51(4):687-92.
10. Dias JJ, Garcia EM. Hand injury costs. Injury. 2006; 37(11):1071-7.

11. Rosberg HE, Steen Carlsson K, Dahlin LD. Prospective study of patients with injuries to the hand and forearm: costs, function, and general health. Scand J Plast Reconstr Surg Hand Surg. 2005;39(6):360-9.
12. Ruijs AC, Jaquet JB, Kalmijn S, Giele H, Hovius SE. Median and ulnar nerve injuries: a meta-analysis of predictors of motor and sensory recovery after modern microsurgical nerve repair. Plast Reconstr Surg. 2005;116(2):484-94.
13. Sakellarides H. A follow-up study of 172 peripheral nerve injuries in the upper extremity in civilians. J Bone Joint Surg (Am). 1962;44(1):140-8.
14. Millesi H. Factors affecting the outcome of peripheral nerve surgery. Microsurgery. 2006;26(4):295-302.
15. Secer HI, Daneyemez M, Gonul E, Izci Y. Surgical repair of ulnar nerve lesions caused by gunshot and shrapnel: results in 407 lesions. J Neurosurg. 2007;107:776-83.
16. Kouyoumdjian JA. Peripheral nerve injuries: a retrospective survey of 456 cases. Muscle Nerve. 2006;34(6):785-8.
17. Eser F, Aktekin LA, Bodur H, Atan C. Etiological factors of traumatic peripheral nerve injuries. Neurology India. 2009;57(4):434.
18. Soheil S, Eslami V, Rahimi-Movaghar V. The incidence of peripheral nerve injury in trauma patients in Iran. Ulus Travma Acil Cerrahi Derg. 2011;17(6):539-44.
19. Noble J, Munro CA, Prasad VS, Midha R. Analysis of upper and lower extremity peripheral nerve injuries in a population of patients with multiple injuries. J Trauma Injury Infect Crit Care. 1998;45(1):116-22.
20. Civil ID, Schwab CW. The Abbreviated Injury Scale, 1985 revision: a condensed chart for clinical use. J Trauma Acute Care Surg. 1988;28(1):87-90.
21. Ciaramitaro P, Mondelli M, Logullo F, Grimaldi S, Battiston B, Sard A, *et al*. Traumatic peripheral nerve injuries: epidemiological findings, neuropathic pain and quality of life in 158 patients. J Peripher Nerv Syst. 2010;15(2):120-7.
22. Galanakos SP, Zoubos AB, Ignatiadis I, Papakostas I, Gerostathopoulos NE, Soucacos PN. Repair of complete nerve lacerations at the forearm: an outcome study using Rosen-Lundborg protocol. Microsurgery. 2011;31(4):253-62.
23. Gaul SJ. Intrinsic motor recovery – a long-term study of ulnar nerve repair. J Hand Surg. 1982;7(5):502-8.
24. Chemnitz A, Dahlin LB, Carlsson IK. Consequences and adaptation in daily life – patients' experiences three decades after a nerve injury sustained in adolescence. BMC Musculoskel Disord. 2013;14(1):1-9.
25. Bruyns CN, Jaquet JB, Schreuders TA, Kalmijn S, Kuypers PD, Hovius SE. Predictors for return to work in patients with median and ulnar nerve injuries. J Hand Surg. 2003;28(1):28-34.
26. Terzis JK, Konofaos P. Radial nerve injuries and outcomes: our experience. Plast Reconstr Surg. 2011;127(2): 739-51.
27. Bergquist ER, Hammert WC. Timing and appropriate use of electrodiagnostic studies. Hand Clin. 2013;29(3):363-70.
28. Sunderland SS. A classification of peripheral nerve injuries producing loss of function. Brain 1951;74(4):491-516.

Sažetak

EPIDEMIOLOGIJA OZLJEDA ŽIVACA PODLAKTICE – RETROSPEKTIVNA STUDIJA

L. Rasulić, V. Puzović, K. Rotim, M. Jovanović, M. Samardžić, B. Živković i *A. Savić*

Cilj ovoga rada bio je procijeniti mehanizme i etiološke čimbenike ozljeda perifernih živaca podlaktice. Ova retrospektivna studija je obuhvatila sve bolesnike kirurški liječene u Klinici za neurokirurgiju Kliničkog centra Srbije u razdoblju od 1. siječnja 2000. do 31. prosinca 2010. godine. Svi relevantni podaci su dobiveni iz medicinske dokumentacije. Statistička obrada podataka je načinjena primjenom statističkog paketa PASW 18. U našoj studiji koja je uključivala 104 bolesnika operirana zbog povrede perifernog živca podlaktice većinu su činili muškarci (n=84; 80,8%), dok je bilo samo 20 (19,2%) žena. Najčešće ozlijeđeni živac bio je ulnarni živac u 70 slučajeva, potom medijani živac u 54 (51,9%) slučaja, dok je najrjeđe bio ozlijeđen radijalni živac i to u 5 slučajeva. Transekcija živca je bila dominantni mehanizam ozljede živca, a utvrđena je u 84,6% bolesnika. Lezija živca oštrim predmetom je bila najčešći etiološki čimbenik utvrđen kod 62 (59,6%) bolesnika, dok su prometni traumatizam i ozljeda vatrenim oružjem bili najrjeđi etiološki čimbenici ozljede perifernog živca podlaktice i javili su se u 7 (6,7%) odnosno 6 (5,8%) slučajeva. Udružene ozljede mišića i tetiva, kostiju i krvnih žila nađene su u 20 (19,2%), 16 (15,4%) odnosno 15 (14,4%) slučajeva. Etiologija i mehanizam ozljede perifernih živaca veoma su važni za odabir pravog načina liječenja kod svakog pojedinog bolesnika, jer su vrijeme i vrsta kirurške operacije usko vezani za ove čimbenike.

Ključne riječi: *Podlaktica, ozljede – epidemiologija; Nervus medianus – ozljeda; Nervus radialis – ozljeda; Nervus ulnaris – ozljeda*