

Lower extremity nerve injuries and their management at a referral center in Mexico City

Lesiones nerviosas en extremidad pélvica y su manejo en un centro de referencia en la Ciudad de México

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Abstract

Objective: To describe the management of lower extremity nerve injuries at a plastic and reconstructive surgery referral center in Mexico City. **Method:** A descriptive, transversal and retrospective study was performed, evaluating clinical records of patients with lower extremity nerve injuries managed in our center between 2010 and 2018. **Results:** Twenty-one patients were included, 14 males (66.6%) and 7 females (33.3%); mean age was 30.00 ± 8.89 years. Right-sided injuries were more prevalent (52.3%). The most common etiologies were gunshot injuries (28.5%) and motor vehicle accidents (13.6%). The most frequently affected nerves were the sciatic (38.0%) and the peroneal nerves (38.0%), followed by the tibial (9.5%), simultaneous tibial and peroneal nerve injury (9.5%) and the femoral nerve (4.7%). Nerve transfers (7 cases, 33.3%) and autologous nerve grafts (7 cases, 33.3%) were the preferred surgical techniques for injury management. **Conclusions:** Repair of lower extremity nerve injuries has not been popularized; however our study shows that several microsurgical reconstructive strategies are available in order to improve functional outcomes.

Keywords: Lower extremity. Peripheral nerve injuries. Leg injuries. Femoral nerve. Peroneal nerve. Nerve transfer.

Resumen

Objetivo: Describir el manejo de las lesiones nerviosas de extremidad inferior atendidas en un centro de referencia en cirugía plástica y reconstructiva en la Ciudad de México. **Método:** Estudio descriptivo, transversal y retrospectivo, en el que se evaluaron los expedientes clínicos de pacientes atendidos por lesiones nerviosas de extremidad inferior entre 2010 y 2018. **Resultados:** Se incluyeron 21 pacientes, 14 hombres (66.6%) y 7 mujeres (33.3%), con una edad promedio de 30.00 ± 8.89 años. Las lesiones en la extremidad derecha fueron más prevalentes (52.3%). El mecanismo de lesión más común fue por herida por proyectil de arma de fuego (28.5%) o por accidente automovilístico (13.6%). Los nervios más afectados fueron el ciático (38.0%) y el peroneo (38.0%), seguidos por el tibial (9.5%), el peroneo y el tibial simultáneamente (9.5%) y el femoral (4.7%). Las medidas de tratamiento más empleadas fueron las transferencias nerviosas (7 casos, 33.3%) y la aplicación de injertos nerviosos para el manejo de brechas (7 casos, 33.3%). **Conclusiones:** La reparación de las estructuras nerviosas de la extremidad inferior ha recibido poca atención. Sin embargo, nuestro estudio muestra

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que es posible aplicar diversas estrategias reconstructivas microquirúrgicas, buscando mejorar los desenlaces funcionales de los pacientes.

Palabras clave: *Extremidad inferior. Lesiones de nervio periférico. Lesiones en pierna. Nervio femoral. Nervio peroneo. Transferencia nerviosa.*

Introduction

Lower extremity trauma is highly common and potentially disabling. In the United States of America, the National Trauma Data Bank reported 278,100 cases in 2012, which represents 14% of all visits to emergency services^{1,2}. Similarly, the National Institute of Public Health of Mexico reports that lower extremity injuries accounted for 13% of patient visits for injuries in public hospital systems, surpassed only by upper extremity trauma³.

Treatment of these patients requires coordinated multidisciplinary management, which includes plastic surgeons collaboration. There are currently well-established treatment protocols for the reconstruction of lower extremity skin layers and bone structures, but this is not the case in the management of injuries associated with peripheral nerve damage⁴.

Nerve injuries in lower extremities cause sensitivity and mobility alterations, thus limiting people's ability to ambulate, exercise or work, which deeply affects their quality of life and social or work interactions. In Europe, it has been reported that 2% of patients suffering from lower extremity trauma may have concomitant nerve injury⁵. It is possible for the incidence to be higher because, in this group of patients, medical care priority is usually focused on the management of poly-trauma, and thus these injuries go unnoticed or are lately diagnosed. In our country, the incidence of this type of injuries is unknown; however, a report from "Dr. José Eleuterio González" University Hospital, in Monterrey, revealed that peripheral nerve injuries constituted 1.12% of total patient visits to its emergency department, out of which 15% occurred in the lower extremities (0.16% of total)⁶.

At urban environs, the main causes of injuries to lower extremities are blunt trauma associated with motor vehicle accidents, followed by falls, lacerations, and firearm projectile wounds. These injuries mainly affect men (80%) and at productive ages (16 to 59 years, 86%)⁵.

Clinical evaluation should initially focus on the principles of trauma patient stabilization, and then, once the patient is alert and able to cooperate, a thorough

neurological clinical examination should be carried out in order to identify motor and sensory alterations in the extremity, especially focusing on femoral, sciatic, peroneal and tibial nerves:

- Femoral nerve: femoral nerve injuries cause hypoesthesia on the thigh anterior aspect and weakness for hip flexion and knee extension.
- Sciatic nerve: harm to the sciatic nerve reduces sensitivity at the lateral portion of the leg, as well as on the dorsum, sole and lateral region of the foot; it is also accompanied by weakness in knee flexion and inability to move the foot.
- Peroneal nerve: its injury reduces sensitivity at first interdigital space and prevents dorsal flexion of the foot.
- Tibial nerve: its injury causes sensitivity loss on the heel and inability to perform plantar flexion of the foot⁷.

The interest in performing lower extremity nerve reconstructions has not spread, first of all because sensitivity and mobility of the lower extremity traditionally are not considered to be as critical and necessary as in the upper extremity and, in the second place, because the larger length of the limb delays target organs re-innervation, which can lead to unfavorable results. Traditional management of these injuries has mainly corresponded to the area of orthopedics, focusing on the use of orthotics or on the performance of static procedures, such as ankle arthrodesis and tendon or muscle transfers⁸.

Peripheral nerve surgeons currently have a vast therapeutic arsenal for the management of nerve injuries, which ranges from simple neurorrhaphies to the construction of complex nerve transfers:

- Neurorrhaphy: approximation of the injured nerve stumps and coaptation with 8 to 10-0 nylon sutures is the reference method for nerve reconstruction. Two techniques are currently used, epineural sutures and fascicular group repair, and both have been shown to be equally effective as long as the stumps contain viable fascicles and the repair is carried out free of tension^{9,10}.
- Nerve graft: it is indicated when performing a primary repair without tension is not possible,

especially in gaps larger than 3 cm. Donor nerves should be easily accessible and cause low morbidity; the most commonly used are the sural (30-40 cm), internal saphenous (40 cm), lateral femoral cutaneous (30 cm) and medial antebrachial cutaneous nerves (20 cm). Postoperative results are unsatisfactory in case of nerve gaps larger than 6 cm and in very proximal injuries¹¹.

- Vascularized nerve graft: extensively described by Dr. Julia Terzis¹². It is indicated when there is a poorly vascularized receptor bed or a nerve graft that is too long (> 6 cm) is required. The most commonly used is the ulnar nerve, although others have also been used, such as sural and saphenous nerves. It has the advantage that it accelerates the rate of axonal growth to 3 mm per day¹³.
- Nerve transfer: it sacrifices nerves with redundant motor or sensory function to convert a proximal injury on the recipient nerve into a distal injury on the donor nerve. Its main indications are very proximal lesions, late repairs, nerve root avulsion or presence of extremely broad nerve gaps. The ideal donor nerve must be close to the target organ, have a synergistic function with the muscles that are to be re-innervated and have an axonal load similar to that of the receptor nerve¹⁴.

As in the case of brachial plexus reconstruction, there are functional priorities when lower extremity nerve reconstruction is carried out. Stability and extension of the knee are the first goal (vastus medialis re-innervation), followed by foot plantar flexion, which is accomplished by the tibial nerve, as well as plantar sensitivity restoration. Finally, recovery of foot dorsiflexion by the deep peroneal nerve will allow to improve ambulation, thus preventing foot drop¹⁵.

It is important to note that international literature on this subject is mainly composed of case reports, small case series, cadaveric dissections, and reviews on the subject based on the experience of renowned authors¹¹.

“Dr. Manuel Gea González” General Hospital is a national and international referral center for plastic surgery, especially within the fields of craniofacial surgery, microsurgery, and peripheral nerve reconstruction¹⁶. The purpose of this work is to describe the lower extremity nerve injuries cared for in our department.

Method

Observational, descriptive, cross-sectional, retrospective study, in which medical records of patients

looked after for lower extremity nerve injuries were evaluated at Dr. Manuel Gea González General Hospital plastic and reconstructive surgery division, within the period comprised between January 2010 and December 2018.

The information was collected in a Microsoft Excel database, including age, gender, injured nerve, injury mechanism and type of treatment provided.

Descriptive statistics were used to evaluate patient demographic and clinical characteristics. Continuous variables are presented as measures of central tendency, and categorical variables as total values and percentages.

Results

During the study period, 21 patients with lower extremity nerve injuries were provided care, which represents 0.002% of total operated patients and 13% of lower extremity injuries cared for in our department within said period. Fourteen patients (66.6%) were males and 7 (33.3%) were females, resulting in a male: female ratio of 2:1.

Average age of presentation was 30.00 ± 8.89 years, and age distribution was as follows: 3 patients (14.2%) were younger than 15 years; 10 (47.6%), were between 16 and 30 years of age; 4 (19.0%), were between 31 and 45 years; and 4 (19.0%), were between 46 and 60 years of age.

Right extremity injuries were slightly more prevalent than on right extremity (52.3% vs. 47.6%). The most common injury mechanism was gunshot wounds, with 6 cases (28.5%), followed by car accidents in 3 (13.6%), nerve tumors resection in 3 (13.6), and iatrogenic in 2 (9.5%); the rest (33.3%) of trauma mechanisms were unknown.

Affected nerves, in decreasing order, were the sciatic nerve in 8 cases (38.0%), peroneal nerve in 8 (38.0%), tibial nerve in 2 (9.5%), peroneal and tibial nerves simultaneously in 2 (9.5%), and femoral nerve in 1 (4.7%) (Table 1).

All patients were operated on using intraoperative neurophysiological monitoring¹⁷. The most commonly used therapeutic measures were nerve transfers (7 cases, 33.3%) and application of nerve grafts for the management of gaps (7 cases, 33.3%). Nerve exploration and neurolysis were carried out in 4 patients (19.0%), and 2 (9.5%) were managed only with rehabilitation. Two patients (9.5%) chose not to receive treatment at the institution.

Table 1. Demographic characteristics of the population

	n	%
Gender		
Males	14	66.6
Females	7	33.3
Age groups		
< 15 years	3	14.2
16-30 years	10	47.6
30-45 years	4	19.0
45-60 years	4	19.0
Affected side		
Right	11	52.3
Left	10	47.6
Affected nerve		
Femoral	1	4.7
Sciatic	8	38.0
Tibial	2	9.5
Peroneal	8	38.0
Tibial and peroneal	2	9.5

On follow-up, 71.4% of patients with nerve transfers were observed to achieve an M4 recovery, and 28.5% reached M3, while in the autograft group, 42.8% achieved M3 and only 28.5% achieved M4.

Discussion

Peripheral nerve injuries are a common problem that causes extremity dysfunction, which results in a negative impact on patient quality of life, as well as significant social and economic burden. The repair of nerve injuries is a complex pathophysiological process in which Wallerian degeneration, axonal regeneration and neurotrophic and neurotropic factors are involved, all this in order to avoid neuromotor and muscle plate atrophy. The goal of any nerve reconstruction is to achieve target organs re-innervation through a careful surgical technique, free of tension and with the least loss of nerve fibers in the suture lines¹⁸.

Despite the boom peripheral nerve surgery has experienced in recent decades in the fields of brachial plexus and facial nerve reconstruction, with reliable and predictable results being achieved¹⁵, lower extremity nerve reconstruction has been poorly studied, which is why patients are often managed with orthotics, tendon transfers, arthrodesis and even amputations^{19,20}.

The first cases of lower extremity nerve reconstruction were reported during World War II, with little

encouraging results²¹. It was by the end of the 1980s when interest in repairing lower limb nerve injuries emerged again, with autograft applications being expanded and, subsequently, novel techniques being developed, such as the use of vascularized nerve grafts and nerve transfers¹¹.

The main limitation for recovery in this type of injuries is the distance the nerve fibers must travel to reach the target muscles, which results in prolonged re-innervation times, especially in proximally located injuries¹⁴. Other important causes are evolution time and presence of nerve gaps; patients with more than 1-year evolution or with gaps larger than 6 cm usually have poorer results¹¹.

Epidemiological studies on the prevalence of lower extremity nerve injuries report that it ranges from 0.8% to 1.8%, predominantly affecting men (80 to 83%) and most often the peroneal nerve (approximately 50%). Trauma mechanisms vary depending on the origin of reports, but the most common are car accidents and lacerating wounds^{5,22}. In our country, epidemiology of this type of peripheral nerve lesions is limited. The only existing report is that published by Castillo-Galván et al.⁶, who inform of 21 injuries, most of them secondary to puncture wounds and most often in the plantar nerve.

In comparison with the aforementioned series, in our patients we found a higher proportion of women and of injuries caused by firearm projectiles, and that the most often injured nerves are the sciatic and peroneal nerves. These results may differ because our institution is a referral center for reconstructive surgery, and our statistics may therefore not be consistent with those of specialized trauma centers.

So far, there is no single technique of choice for nerve repair. The results between different techniques have been compared, but existing reports are usually limited to relatively small series. Each case should be individualized in order to for anatomical reconstruction to be carried out, considering factors such as the affected nerve, evolution time and presence of gaps. All patients must be comprehensively evaluated with a sensory and motor clinical examination, with electrophysiological and imaging findings being taken into account²⁰.

Perioperative neurophysiological evaluation is now an integral part of peripheral nerve evaluation and reconstruction. Its main purpose is to locate and characterize injury sites, verify nerve stumps viability and identify donor nerves for reconstruction, thus allowing

the surgeon who is familiar with the technique to objectively support reconstructive decision-making²³.

The treatment modalities that were most commonly used in our center were non-vascularized grafts and nerve transfers. In our series, we observed a change in treatment strategies: before 2014, patients used to be managed with nerve bridges, but, currently, the use of transfers is preferred due to donor nerves anatomical proximity and to the possibility of better results to be obtained in proximal lesions or with long evolution times. No direct neurorrhaphies were carried out because patients are often lately referred.

The main limitations of this work are its retrospective nature and small sample size. However, this is the first report focused on the management of lower extremity nerve injuries in our country, and sets a precedent for the development of management guidelines for this type of patients. Our future lines of research will focus on studying patients' long-term clinical outcomes and on comparing the results of each treatment modality, especially of the use of grafts vs. transfers.

Conclusions

Repair of lower extremity nerve structures has received little attention. Our study has shown that it is possible for various microsurgical reconstructive strategies to be applied, seeking to improve patient functional outcomes.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this research.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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