Epidemiology of Traumatic Peripheral Nerve Injuries Evaluated with Electrodiagnostic Studies in a Tertiary Care Hospital Clinic

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Objective: To describe the etiologies and frequency of traumatic peripheral nerve injury (TPNI) seen in the electrodiagnostic laboratory of a tertiary care hospital in Puerto Rico.

Methods: The charts of patients who underwent an electrodiagnostic study for a TPNI were revised. The main outcome measure was the frequency of each injury by anatomic location, specific nerve or nerves affected, injury mechanism, and injury severity.

Results: One hundred forty-six charts were included, and in them were listed a total of 163 nerve injuries; 109 (74.7%) cases were men and 37 (25.3%) were women. The mean age was 33.6 years. The facial nerve, the brachial plexus, and the ulnar nerve were more frequently injured than any other nerve or nerve bundle. The ulnar, sciatic, median, and radial nerves and the lumbosacral plexus were more commonly injured as a result of gunshot wounds than of any other mechanism of injury. The brachial plexus was most frequently injured in motor vehicle accidents and the facial nerve injuries most commonly had an iatrogenic cause. In terms of injury severity, 84.2% were incomplete and 15.8% were complete.

Conclusion: TPNIs are common in young individuals and potentially can lead to significant disability. Further studies are needed to assess the socioeconomic impact of these injuries on our population. [*P R Health Sci J 2016;35:76-80*]

Key words: Nerve injury, Trauma, Electrodiagnostic Hispanics

Traumatic peripheral nerve injuries (TPNIs) are a major public health problem that can cause significant disability (1). Their first epidemiologic description came during the American Civil War from the neurologist S. Weir Mitchell, providing the initial insight into these injuries (2). In fact, historically wartime has provided many of the advances in the knowledge of TPNIs (2). It is estimated that the number of TPNIs observed in military personnel will increase since more soldiers are surviving previously lethal attacks, increasing the risk of residual injury (2, 3). Differentiating civilian- from combat-related cases is important because the etiologies may vary (2,3). Moreover, a population's demographic characteristics and developmental level as well as the kinds and number of natural disasters (e.g., earthquakes) generally experienced by that population all combine to influence injury distribution, cause, and severity (4,5).

The published literature about the epidemiology of TPNIs is limited. The few studies describing etiologies and electrodiagnostic findings for these kinds of cases were done in Brazil, Turkey, Canada, Pakistan, and the United Kingdom (this last with military personnel) (3, 4, 6–9). The methodologies of these studies were not homogenous, and multiple factors—such as the population studied—affected their respective findings. Nevertheless commonly described etiologic factors for TPNI include motor vehicle accident (MVA), penetrating injury, gunshot wound (GSW), crush, compression, traction, ischemia, occupational injury, sports-related injury, and explosion-related injury (1,3). In terms of anatomic location, commonly injured nerves and nerve bundles in the upper limbs include the ulnar, median, and radial nerves, along with the brachial plexus, while in the lower limbs the sciatic and deep peroneal nerves are more frequently involved (3, 4, 6–10).

Electrodiagnostic studies (EDX) that include nerve conduction studies (NCS) and electromyography (EMG) are the best methods for localizing and assessing the severity of a peripheral nerve injury (1, 2, 6). Studies performed 3 months after a given trauma has occurred have more prognostic certainty (1, 11).

The aim of this study was to analyze the data of patients with TPNIs who had been treated at a specific university

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hospital–based EDX laboratory in order to describe nerve injury distribution patterns, mechanism of injury, and the respective severity of same. This study adds knowledge about the epidemiology of TPNIs in our population.

Methods

This study was approved by the Institutional Board Review (IRB) of the University of Puerto Rico Medical Sciences Campus. The medical charts of patients who had undergone EDX studies at the Department of Physical Medicine and Rehabilitation (PM&R) in the University District Hospital from 2004 to 2014 were reviewed. This is a tertiary care university teaching hospital in the largest medical center in San Juan, Puerto Rico. Patients were referred from PM&R clinics as well as from other specialists within the medical center and from all the regions of the island. An experienced PM&R attending physician directly supervised the residents in training who performed each study (and did so using the same equipment, techniques, and normative data). In patients with multiple studies, only the first EDX study, performed at least 10 days post-injury, was included for analysis. Exclusion criteria included incomplete patient information (demographics or trauma mechanism), presence of concomitant central nervous system injury (brain injury, spinal cord injury), and technical limitations that resulted in the inability to rule out other pathologies.

TPNI was defined as an acute injury to a major peripheral nerve distal to the root. The facial nerve was the only cranial nerve included along with the brachial and lumbosacral plexus and the upper and lower limb peripheral nerves. Demographic information (age and gender) was collected from each chart. The main outcome measures were the frequency of each injury by anatomic location, specific nerve, mechanism or cause, and severity. Severity was divided into 2 categories: complete (total) and incomplete (partial). An individual was considered to have a complete injury when he or she showed the absence of both sensory nerve action potential (SNAP) and compound motor action potential (CMAP) after undergoing distal and proximal stimulation of the affected nerve with NCS, abundant spontaneous activity (fibrillations and/or positive sharp waves), and the absence of voluntary recruitment of motor unit action potentials (MUAPs) on EMG. An injury was considered incomplete when it had nerve conduction continuity on NCS, with normal or reduced SNAP and CMAP when stimulating proximal to the lesion, and normal or reduced SNAP and CMAP when stimulating distal to the injury; minimal spontaneous activity (fibrillations and/or positive sharp waves); and normal or decreased recruitment on EMG. The morphology of the MUAPs was not taken into account when categorizing severity.

The data were analyzed with the Microsoft Excel program. The frequencies of the injury patterns were described; a student's t- test for gender differences was performed.

Results

A total of 1070 charts were reviewed, of which 156 (14.5% of all studies) were from patients with TPNI; 10 studies were excluded from the data analysis. The patient population (n = 146) included 109 (74.7%) men and 37 (25.3%) women. The mean age was 33.6 years (Figure 1), with a statistically significant gender-based age difference (32.2 men and 37.8 women; p = 0.049). The anatomic areas affected were the upper extremities (73 cases; 50%), lower extremities (40 cases; 27.4%), and facial area (33 cases; 22.6%). The left side was affected in 79 (54.1%) cases, the right side in 64 (43.8%) cases, and both sides in 3 (2.1%) cases. A total of 163 injured nerves were studied from 131 patients that suffered a single nerve injury; 13 injured 2 nerves, and 2 injured 3 nerves. Most injuries were to the facial nerve and the brachial plexus, followed by the ulnar nerve (Figure 2). Injuries to more than 1 nerve often involved the median and ulnar nerves. In men the most commonly injured nerve was the ulnar nerve, while the facial nerve was injured the most often in women (Figure 3). The etiologic factors were classified by injury mechanism (Table 1). The ulnar, sciatic, median, and radial nerves, along with the lumbosacral plexus were most commonly injured as a result of GSWs, the brachial plexus as a result of MVAs, and the facial and accessory nerves secondary to iatrogenic causes, specifically complications of tumor-excision surgery (Figure 4). In terms of severity, there were 123 (84.2%) incomplete injuries and 23 (15.8%) complete injuries, without a significant difference between genders. For purposes of comparison, our sample population was divided into the following 3 age groups: 13 to 25 years, 26 to 40 years, and older than 40 years (Table 2). The most common mechanisms of injury in patients younger than 40 years were GSW and MVA, while patients who were over 40 years of age were most frequently injured secondary to iatrogenic causes, with the facial nerve being the nerve most often involved.

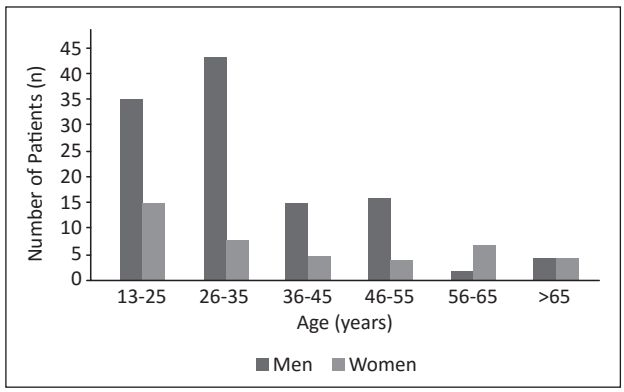

Figure 1. Age and gender distribution of PNIs (n = 146)

Discussion

TPNIs (specifically lesions to the brachial plexus and the ulnar nerve secondary to MVAs and GSWs, respectively) were

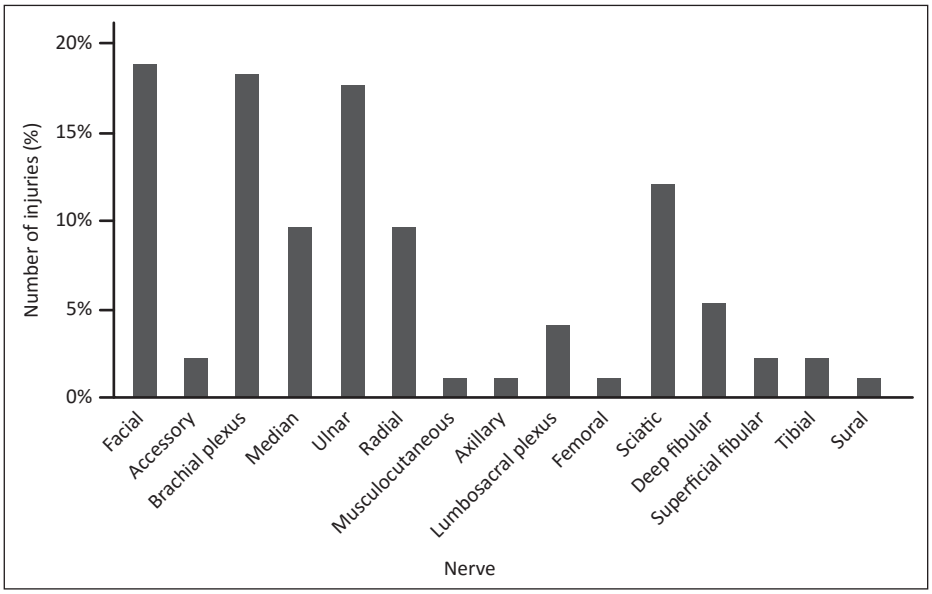

Figure 2. Number of injuries by nerve (n = 163)

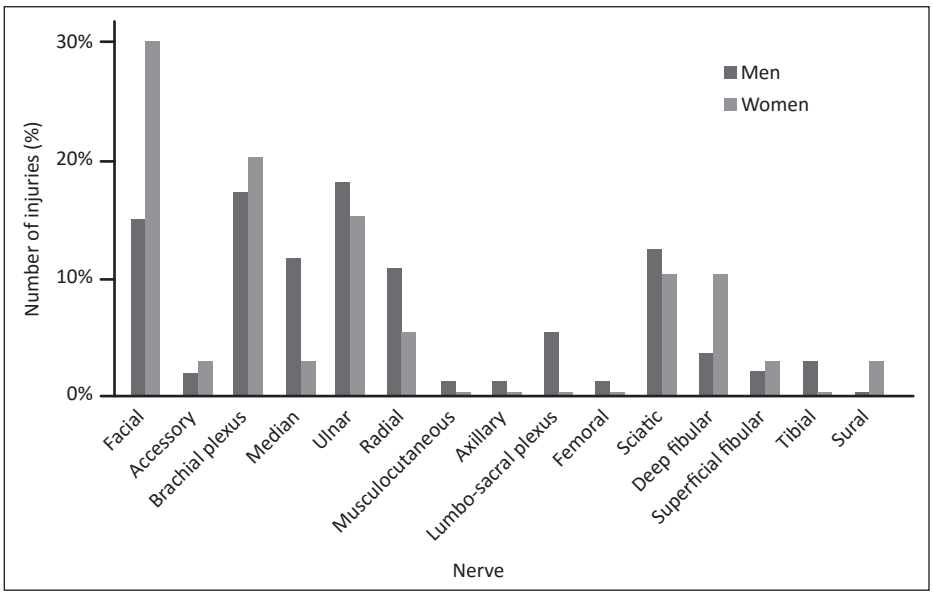

Figure 3. Nerve injuries, classified by gender (n = 163)

Table 1. Mechanism of TPNI

Mechanism	Number (n)	Percentage (%)
GSW	51	34.9
MVA		
Motorcycle n = 15	35	24.0
Iatrogenic	21	14.4
Fall	17	11.6
Penetrating		
Violent n = 5		
Non-violent = 7	12	8.2
Occupational/Sports	7	4.8
MVA/Pedestrian	2	1.4
Fight	1	0.7

GSW = Gunshot wound; MVA = Motor vehicle accident

observed most frequently in young adult men. Nevertheless, injuries to the facial nerve were very common in an older sub-group of individuals, as well, mostly as a result of surgical complications. In our population, TPNIs were very common, being present in 14.5% of all the EDX studies reviewed. The incidence of TPNI in our laboratory may in fact be higher if all neuromuscular pathologies are taken into consideration, since only 45 to 59% of patients referred for an EDX study presented abnormal findings (12,13).

Young male adults appear to be at the highest risk of sustaining a TPNI. Men are affected in 71 to 92% of all cases (4, 6–9). The mean age in our population was 33.6 years, which is consistent with other studies, (6–9) except when considering TPNIs in military personnel, in which group of individuals the mean age is 26.3 years (3). It has been consistently reported that the majority of injuries occur in the most productive age group (18 to 35 years), therefore potentially adding to a country's socioeconomic burden by decreasing its workforce (4,6–9).

Although the upper limbs were the most commonly affected body area in our sample, they accounted for only half (50%) of the injuries. This percentage is different from those of other series: 73% in Italy, 77% in Turkey, 80% in Brazil, and 61% in Canada.(6–9) The main reason for this difference is that we included facial injuries in the anatomic area category, and they accounted for a high percentage (22.6%) of all the injuries, which percentage is significantly higher than was previously reported in one series (5%) (8). In terms of body side, the occurrence of left- or right-side lesions varies with the reported series. We found a higher incidence on the left side, but other reports show similar rates on either side (3,7–9).

The frequency of the specific location and the injury mechanism of TPNIs may be influenced by several factors. The socioeconomic levels of the population and its involvement in war-related conflict are among these factors (3, 4, 7). Different

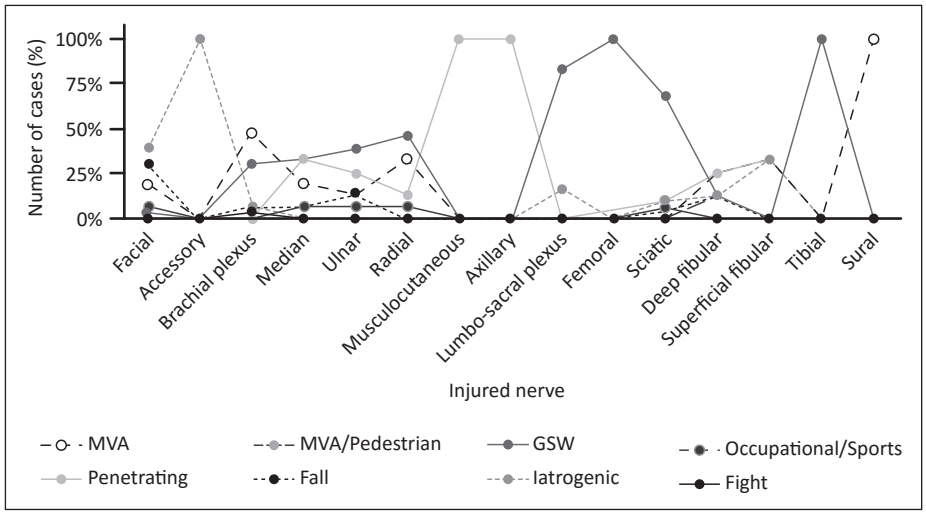

Figure 4. Injury mechanism, classified by nerve (n = 163)

reports agree that the brachial plexus is commonly injured in MVAs, (6, 8, 10) while the ulnar nerve is involved in penetrating injuries, falls, GSWs, and pedestrian accidents (8). GSWs were responsible for the highest number of lesions in our population, similar to what was reported by Babar in Pakistan (4). Gunshot wounds present a dual threat of injury: direct trauma or indirect injury caused by the cavitation effect (14). Unfortunately our population lives with a very high crime rate (homicide count = 26.5/100,000 inhabitants), (15) which explains why GSW-related trauma causes such a high number of nerve injuries in it. Meanwhile, MVAs, though the second most frequent cause of TPNIs in our sample, were the most common injury mechanism in multiple reports (7–9). The brachial plexus seems to be at a higher risk of injury with this type of trauma (6, 8, 10). Additionally, the ulnar nerve is most frequently affected by GSWs and direct penetrating injuries (7,8). In the lower limbs, GSWs were the most frequent cause of injury to the sciatic nerve, but in other series, MVAs and iatrogenic causes were the main mechanisms of injury (7). Additionally, multi-nerve injuries most commonly involved either the median and ulnar nerves or the median, ulnar, and radial nerves (7,8).

Few studies have addressed iatrogenic causes of injury. Ciarmitaro et al (6) and Eser et al (7) revealed that iatrogenic trauma accounted for 11.2% and 15% of all PNIs, respectively; which is similar to our finding of 11.1%. The most common iatrogenic cause of injury in our sample was tumor-excision surgery affecting the facial nerve, while other reports have noted that intramuscular injections and orthopedic surgeries were the most common, mostly involving sciatic nerve injury (6,7).

The majority of injuries in our sample were incomplete, in terms of severity. However, since the EDX study of each patient was performed at variable post-traumatic time intervals and no follow-up studies were included, the severity may have been underestimated. The systems for classifying nerve-injury severity that were proposed by Seddon (16) and Sunderland (17) are universally accepted, but only the former is often utilized in epidemiologic studies. It classifies a given nerve injury, in terms of increasing severity, as neuropraxia, axonotmesis, or neurotmesis; however, most cases present the electrophysiological characteristics that are associated with mixed lesions. Therefore, we used a scale similar to that employed by Eser et al, (7) which scale classifies injuries as being total (complete) or partial (incomplete). Most of the incomplete injuries in our study were consistent with pure or mixed neuropraxia and partial axonotmesis, while complete injuries represented complete axonotmesis and neurotmesis. The latter was less common in our population and probably represents those injuries with the worst prognosis. In order to accurately classify nerve injuries, the EDX evaluation needs to include ipsilateral proximal and distal nerve stimulation and contralateral evaluation, as well as a complete EMG examination.(1) The importance

Table 2. Most common injury mechanisms as well as injury distribution and severity

Age (years)	Number of patients (n, %)	Mechanism (n, %)	Nerve (n, %)	Severity (n, %)
13–25	48 (32.8%)	GSW 23 (48%) MVA 15 (31%) Fall 4 (8%) Iatrogenic 4 (8%) MVA/Pedes 1 (2%) Penetrating 1 (2%)	Sciatic 10 (18%) Brachial Pl 10 (18%) Facial 9 (16%) Ulnar 8 (14%) Radial 7 (13%) Median 6 (11%) Others 6 (11%)	Complete 7 (15%) Incomplete 41 (85%)
26–40	58 (39.7%)	GSW 22 (38%) MVA 14 (24%) Penetrating 9 (16%) Fall 5 (9%) Iatrogenic 4 (7%) Occu/Sports 3 (5%) MVA/Pedes 1 (2%)	Ulnar 15 (23%) Brachial Pl 11 (17%) Facial 9 (14%) Radial 7 (11%) Median 6 (9%) Sciatic 4 (6%) Others 12 (19%)	Complete 13 (22%) Incomplete 45 (78%)
>40	40 (27.4%)	Iatrogenic 13 (33%) Fall 8 (20%) GSW 6 (15%) MVA 6 (15%) Occu/Sports 4 (10%) Penetrating 2 (5%) Fight 1 (3%)	Facial 12 (28%) Ulnar 5 (12%) Brachial Pl 5 (12%) Sciatic 5 (12%) Deep Fib 4 (9%) Others 12 (27%)	Complete 3 (8%) Incomplete 37 (92%)

GSW = Gunshot wound; MVA = Motor vehicle accident; MVA/Pedes = Motor vehicle accident/Pedestrian; Occu/Sports = Occupational &Sports; Brachial Pl = Brachial plexus; Deep Fib = Deep fibular

of injury severity classification lies in its prognostic and its effectiveness at ensuring that a given therapeutic intervention has a positive outcome. Therefore differentiating between neuropraxia, axonotmesis, and neurotmesis is essential, but it is time dependent and requires follow-up EDX studies as well as histologic evidence.

This study has several limitations. First, the study is a retrospective chart analysis. Second, the classification of injury severity was not done using the current universal scales (Seddon and/or Sunderland), although, as described earlier, in order to coincide with such scales, follow-up studies were done. Additionally, the timing after the trauma of the studies varied from patient to patient and was not consistently documented. Last, the EDX studies were performed by physicians-in-training, although there was always direct supervision from an attending physician.

Conclusion

TPNIs generally occur in young, productive individuals. Such injuries potentially can lead to significant disability and have a negative socioeconomic impact on the population. EDX studies are very useful in detailing the extent and nature of these injuries so that prompt clinical decisions can be made and a prognosis characterized. In the literature, the reported etiologies of these injuries vary according to a given population's sociodemographic characteristics. However, further investigation is needed to better understand this kind of injury and, more specifically, to measure disability and gauge its socioeconomic impact.

Resumen

Objetivo: Describir las etiologías y frecuencia de las lesiones traumáticas a nervios periféricos en un laboratorio electrodiagnóstico de un hospital supraterciario. Metodología: Se revisaron los reportes de estudios electrodiagnósticos de pacientes con lesiones traumáticas a nervios periféricos. Las medidas principales fueron la frecuencia de cada lesión por su localización anatómica, el nervio afectado, el mecanismo y la severidad de la lesión. Resultados: Se incluyeron 146 reportes para un total de 163 lesiones a nervio periférico; 109 (74.7%) hombres y 37 (25.3%) mujeres. La edad promedio fue de 33.6 años. El nervio facial, el plexo braquial y el nervio ulnar fueron más frecuentemente afectados. Los nervios ulnar, ciático, mediano, radial, y el plexo lumbo-sacro se lesionan comúnmente por heridas de bala, el plexo braquial por accidentes de vehículos de motor y el nervio facial por causas iatrogénicas. El 84.2% fueron lesiones incompletas y el 15.8% completas. Conclusión: Lesiones traumáticas a nervios periféricos son comunes en individuos jóvenes y potencialmente pueden llevar a discapacidad. El impacto socioeconómico de dichas lesiones en nuestra población debe ser estudiado en el futuro.

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