Evaluation of the Physical Treatment Success in Patients with Peripheral Nerve Injury Caused by Firearm

Mediha Karic Skrijelj
Medical School Sarajevo, Sarajevo, Bosnia and Herzegovina

Background: All wars bring high incidence of patients with peripheral nerve injuries, and many of today's knowledge about degeneration, regeneration and surgical treatment in this casuistry come from the period of the global world conflict. Such injuries do not endanger life, but the function of the extremities is threatened, which manifests itself in motor and sensory outbursts, as well as negative psychological implications. Objective: The aims of this article were: a) To present the method of monitoring physical treatment in a patient with a peripheral nerve injury; b) To perform a quantitative analysis of nerve lesions caused by firearms (n = 445); c) To present the effects of physical treatment for this condition; d) To analyze the time interval from injury to healing (n = 220); e) Determine the time from injury until the surgery. Results: Anatomical disruption of axons with complete Waler degeneration. The connective tissue network remains intact and the endoneurium can guide the regenerated nerve fibers to their destination. Spontaneous functional recovery can be expected in 12 to 18 months. Clinical evaluation shows a deficit in the innervation area of damaged axons with muscle atrophy and loss of sensitivity. Nerve recovery can be inhibited by scar formations at the site of injury. Complete interruption of the nerve. Functional recovery is not possible without surgical intervention. Paralysis of mm. atrophy, anesthesia and atrophic skin changes are visible. Conclusion: Rehabilitation is a delicate problem and requires long-term treatment and multidisciplinary cooperation, which is carried out in accordance with the principles of peripheral nerve repair. Factors that facilitate successful regeneration are: a) Pre and post-operative physical treatment; b) Younger age; c) Shorter time since injury (<6 months); d) More distal level of the lesion; e) Absence of factors complicating the injury (infection); and f) The first signs of nerve recovery are the return of sweating and pain.

Keywords: Peripheral nerve injury, Firearm, physical treatment.

Original paper, Received: May 22nd, 2023; Accepted: June 20th, 2023, doi: 10.5455/ijbh.2023.11.227-231, Int J Biomed Healthc. 2023; 11(2): 227-231
injury until the surgery

3. MATERIAL AND METHODS
For the purpose of this study a MS Access database containing pre-collected data with files for cross-referencing was used.

After the initial clinical evaluation, each patient is included in the physical therapy program.

Re-evaluation was carried out after 1, 3, 6... months, and the condition was recorded with scores from 0-5 which are correlated with muscle strength measured by Manual Muscle Test (MMT).

- Grade 5 - complete recovery;
- Grade 4 - full function with minimal sequelae;
- Grade 3 - satisfactory function with sequelae present;
- Grade 2 and 1 - minimal improvement, and
- Grade 0 - without improvement

If the patient had grade 4 or 5 it will end physical treatment, grade 3 - continues physical treatment after a pause, grade <3 meant consultation with surgeon for evaluation for surgery.

The results of the treatment of all patients who started and finished the treatment in the outpatient clinic for rehabilitation in the community (CBR Stari Grag), PRAXIS, in the period from January 1, 1993, until December 31, 2003 are analyzed. All patients had injuries of the peripheral nerves by a firearm, as indicated in Table 1.

From the method of physical therapy and rehabilitation are used devices for electrotherapy (TENS, DDS, interfering currents, electro stimulators, etc.), then manual massage, kinesiotherapy, hydrotherapy, thermo therapy (parafango, hydrocollator, hydrotherapy). In the Novo Sarajevo outpatient clinic, examinations, treatments were carried out by doctors specializing in physical medicine and rehabilitation, as well as senior and intermediate physiotherapists, and in the Praxis outpatient clinic, in addition to health professionals of the same qualification, other specialists participated as necessary, as consultants and consultative members of the team (orthopedics, neurosurgeon and others).

An expert in traditional medicine (acupuncture and chiropractic) also works in this outpatient clinic, who mainly applied the specific interventions of the “Praxis” method.

Standard and traditional medical procedures and therapeutic interventions are planned for each patient individually, usually at the first examination, and often after the definitive diagnosis has been determined, according to their current condition. This means that not a single case is treated stereotypically, but strictly individually.

4. RESULTS
NEUROPRAXIA is the lightest nerve injury with a physiological block of conduction without breaking the continuity of the nerve sheath and Waller's degenera-

<table>
<thead>
<tr>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. ulnaris</td>
<td>74</td>
</tr>
<tr>
<td>N. medianus</td>
<td>7</td>
</tr>
<tr>
<td>N.radialis</td>
<td>39</td>
</tr>
<tr>
<td>Naxillaris</td>
<td>6</td>
</tr>
<tr>
<td>Sensory-cutaneous branches</td>
<td>3</td>
</tr>
<tr>
<td>Combined injuries</td>
<td>24</td>
</tr>
<tr>
<td>Plex.brachialis</td>
<td>37</td>
</tr>
<tr>
<td>Total upper extremities injuries</td>
<td>230</td>
</tr>
<tr>
<td>N.ischiadicus</td>
<td>98</td>
</tr>
<tr>
<td>N.femoralis</td>
<td>22</td>
</tr>
<tr>
<td>N. tibialis</td>
<td>13</td>
</tr>
<tr>
<td>N.peroneus</td>
<td>53</td>
</tr>
<tr>
<td>Sensory-cutaneous branches</td>
<td>13</td>
</tr>
<tr>
<td>Combined injuries</td>
<td>7</td>
</tr>
<tr>
<td>Plexus L/S</td>
<td>18</td>
</tr>
<tr>
<td>Total lower extremities injuries</td>
<td>224</td>
</tr>
<tr>
<td>TOTAL</td>
<td>454</td>
</tr>
</tbody>
</table>

Table 1. Review of peripheral nerve injury treated in the PRAXIS clinic

The clinical picture includes sensory and motor deficits. Complete spontaneous recovery is within 3-6 weeks.

AXONOTMESIS - Anatomical disruption of axons with complete Waller degeneration. The connective tissue network remains intact and the endoneurium can guide the regenerated nerve fibers to their destination. Spontaneous functional recovery can be expected in 12 to 18 months. Clinical evaluation shows a deficit in the innervation area of damaged axons with muscle atrophy and loss of sensitivity. Nerve recovery can be inhibited by scar formations at the site of injury

NEUROTMESSIS - Complete interruption of the nerve. Functional recovery is not possible without surgical intervention. Paralysis of mm. atrophy, anesthesia and atrophic skin changes are visible.

Sudden gradation
- First degree - neuropraxia - segmental demyelination without loss of nerve continuity – neuropraxia
- Second degree - axonotmesis - damage to the axon, but intact endo neural tissue
- Third degree - involves discontinuity of axons with discontinuity of endoneural tubes and incomplete recovery
- Fourth degree - complete disorganization of nervous structures, formation of neuroma
- Fifth degree - complete interruption of the nerve - neurotmesis

Response to the injury
The stimulus of the human organism causes a response. If the stimulus is an injury to human tissue, the body’s response is reparation. Reparation is a pro-
cess of degeneration followed by regeneration. Waller's degeneration occurs in the peripheral nerves, and it is named after the author who described these changes back in 1850. This is the process of phagocytosis of the damaged nerve segment. Many different growth factors (NGF) influence the process of degeneration and regeneration. Waller’s degeneration also occurs in the segment above the injury, 2-3 nodes of Ranvier. Some injuries result in the death of the cell body.

The approximate rate of regeneration of the peripheral nerve is 1 mm per day (Colohan, 1996; Grant, 1999; Greenfield 1997, Ristić, 2000). In the case of proximal injuries, there will be no evident improvement for months. At the level of the injury, the axons will bud into regeneration units, the shoots of the proximal segment consist of groups of intertwined regenerated buds towards the axon and associated Schwann cells surrounded by the perineurial sheath. According to Thomas (1966) the shoots of the distal segment consist of interfascicular columns of Schwann cells, Bungner band and endo neural-type connective tissue, and these bands are the longitudinal guide through which regenerated axons grow. When the regeneration unit reaches the distal receptors, functional recovery is possible. If it is lost in the extraneural environment, then a NEUROMA will be formed. It will represent a potential loss of function and may be a source of neuromatous pain.

Axonal regeneration is guided towards the distal end of the nerve by a gradient of diffusible substances, and this process is called neurotropism (Trumble 2000).

Factors involved in nerve healing

In the literature, there are numerous reports on attempts to assess the factors that contribute to the healing of an injured nerve (13-17). They are described as internal and external. Internal factors include species, age, tissue nutritional status, type and level of injury. This information can be gathered from medical history and clinical examination and can help in prognostic evaluation. All factors influence the management of nerve lesions. The success of the surgical treatment depends on the selection of the technique, instruments, material for the suture, as well as the optimal time for the operation. Postoperative management is of great importance in restoring lost function.

Assessment of peripheral nerve damage

It begins with a careful examination and documentation, and the diagnosis should include the following:

- Injured nerve or nerves
- Anatomical level of injury
- Pathological type of injury; Neuropraxia, Axonotmesis, Neurotmesis
- Combined injuries of bones, tendons, blood vessels
- Secondary deformities and contractures
- Record of recovery of a paralyzed nerve

Neurological status: Nerve injury manifests as motor weakness, sensory and autonomic dysfunction. Motor signs: Note the paralyzed muscles distal to the injury, and the muscle strength is assessed with a manual muscle test and expressed on a gradation scale from 0 to 5.

- M0 - complete paralysis
- M1 - palpable muscle contraction, no strength to move the joint
- M2 - active movements of the joint in the anti-gravity position
- M3 - full motion of the joint against the force of gravity
- M4 - muscle power moves the joint against gravity and partial resistance
- M5 - normal muscle contraction

Special tests

Special test are performed to facilitate the assessment of the degree of nerve injury, as well as to record signs of recovery. Electrodiagnostic tests: They are based on recording the damaged neurophysiological function of nerves and muscles. Electromyography (EMG) has value after 2-3 weeks after the injury (13).

Nerve conduction study - MRI: It has been reported that MRI detects changes in the muscle signal as early as 4 days after nerve injury, which is much earlier than other procedures. The presence of metal is a contraindication for this test.

5. DISCUSSION

Surgical repair of peripheral nerves

History of the procedure: The concept of surgical nerve repair is very old. Saliceti from Bologna published a text on surgical nerve repair in the 13th century called Chirurgia. Gabriele Ferrara (1543-1627) was the first to publish the technique of suturing a severed nerve. The principle of wound debridement was adopted by DeSault in the 18th century. In the 19th century, Bauden performed the first “modern” epineural suture in 1836, the first human allograft was described by Albert Sherren. In 1891, Gardener performed transposition of the ulnar nerve. Wars provided researchers with abundant materials, so research from the period of World War II is the basis of today’s knowledge about nerve injuries. /Tinel,Seddon,Sunderland/ After the introduction of the microsurgical technique, Bora published a paper on fascicular nerve sutures, and in 1972, Millesi developed interfascicular nerve grafting (12-16).

Surgical treatments

Treatment of peripheral nerve injuries caused by firearms begins immediately after the injury. Surgical treatment of the wound is necessary, with an emphasis on hemostasis, debridement (excision of dead tissue, evacuation of the hematoma, extraction of foreign bodies from the wound, and macroscopic examination of the wound, including the nerve. In the treatment of nerve injury microsurgical techniques are used. The aim of the surgical treatment is to ensure the order of the nerve fascicles, with the mandatory avoidance of tension at the suture site. Correct indication and timeliness of the surgical intervention are very important.
for the success of the treatment.

**Time for surgery**

Primary nerve repair (up to 24 hours) is not performed in the case of firearm injuries.

Wounds caused by projectiles are primarily infected and are treated with:
- Early secondary repair - within three months of the injury. The optimal time for neuron regeneration is 3-8 weeks after the injury.
- Late secondary repair - after three months.

**Types of surgical nerve repair**

During the surgery, combinations of several types of surgical techniques are possible.

NEUROLYSIS: release of nerves from adhesions
- Neurolysis externa
- Internal neurolysis

NEURORAPHY - the technique of directly joining the ends of a severed nerve is done in two ways. For example, after neuroma excision.
- Epineural "end to end" repair.
- Fascicular "end to end" repair.

**Nerve grafting**

NERVE GRAFTING - technique of inserting a graft if the ends of the injured nerve are more than 2 cm apart. The graft is taken from the sural nerve or from the cutaneous nerves on the inside of the arm.

**Reconstructive surgery**

In some patients, it will not be possible to restore the continuity of the nerve. In such situations, the function of the limb can be improved by reconstructive operations such as tendon transfer and arthrodesis.

**Post operative treatment and rehabilitation**

Physical treatment is carried out immediately after the beginning of wound healing and can last for months. Grant (1999) does not recommend traditional immobilization of several weeks. Postoperative clinical and electrodiagnostic evaluation is applied every 3 months in the first two years after surgery, and every 6 months thereafter (14, 17).

6. CONCLUSION

All wars record a high incidence of patients with peripheral nerve injuries, and many of today’s knowledge about degeneration, regeneration and operative treatment in this casuistry come from the period of the global world conflict. Such injuries do not endanger life, but the function of the extremities is threatened, which manifests itself in motor and sensory outbursts, as well as negative psychological implications. The ability to regenerate the peripheral nerve provides the possibility for an extraordinary recovery, and microsurgical techniques are reserved for the most difficult cases. Rehabilitation is a delicate problem and requires long-term treatment and multidisciplinary cooperation, and is carried out in accordance with the principles of peripheral nerve repair.

Factors that facilitate successful regeneration are:
- Pre and post-operative physical treatment
- Younger age
- Shorter time since injury (<6 months)
- More distal level of the lesion
- Absence of factors complicating the injury (infection)

The first signs of nerve recovery are the return of sweating and pain.

**Authors contribution:** The author was included in all processes of preparing this article including final proof-reading.

**Conflict of interest:** None declared.

**Financial support and sponsorship:** Nil

REFERENCES


