Chapter

Rehabilitation Therapies in Spinal Cord Injury Patients

Brenda Rodríguez-Mendoza, Paola A. Santiago-Tovar, Marco A. Guerrero-Godinez and Elisa García-Vences

Abstract

Spinal cord injury (SCI) represents a neurological life-changing condition that causes devastating physical, social, psychological, and economic consequences in the injured patient. It is due to traumatic causes that affect the motor and sensory functions, limiting daily life activities. Since rehabilitation is a fundamental process of recovery, this chapter will review diverse approaches in rehabilitation to restore or improve patients' capability. In the first section, functionality and quality of life tools will be discussed. Subsequently, rehabilitation strategies and their adoption will be explained. Ultimately, rehabilitation goals, according to the level of injury, will be reviewed.

Keywords: spinal cord injury, rehabilitation, exoskeleton, functional electrical stimulation, rehabilitation goals

1. Introduction

Spinal cord injury (SCI) is attributable to trauma caused by accidents like car crashes, falls or sports such as diving or gymnastics, and violent causes like gunshots or injuries by cold weapon [1] and also caused by nontraumatic causes like primary or metastatic tumors, compressive myelopathy such as cervical spondylotic myelopathy, neurodegenerative diseases such as motor neuron disease, autoimmune diseases like multiple sclerosis, infections such as epidural abscess, and vascular diseases such as medullary infarction, as well as genetic causes, for example, spinal muscular atrophy [2] that affect spinal cord motor and sensory function, also causing neurogenic bladder or bowel.

The global prevalence rate, including both traumatic and nontraumatic causes, is 40–80 cases per million people; however 90% of cases are due to traumatic causes, with a male-to-female ratio of 2:1, respectively [3], presenting with a bimodal age peak of young people and 60-year-old people [4]. To estimate the economic burden, the first year after injury treatment cost is estimated to be $334,170 USD rising to $1,023,924 USD [5]. The main causes of SCI are vehicle accidents, falls, violence [6], compressive myelopathy, tumors, and multiple sclerosis [2]. Most damaged anatomical regions are the lower cervical spine, cervicothoracic union, and thoracic-lumbar union [6]. Prognosis depends on the level of injury [4].

To the present day, there are no medical or surgical procedures to reverse neurological damage in SCI patients; therefore new rehabilitation strategies have been designed to avoid deterioration in many patient scopes. This process has to be coordinated by a multidisciplinary SCI expert team so that biopsychosocial impact on patients is reduced.

2. Evaluation and assessment tools in rehabilitation

There are several tools to assess the patient with SCI; some of them are the following, ASIA scale, Spinal Cord Independence Measure (SCIM) scale, Walking Index for Spinal Cord Injury II (WISCI II) scale, and Short-Form Health Survey (SF-36) quality of life test, which will be discussed in detail below. These are very useful instruments that ease decision-making on treatment and rehabilitation, taking into consideration patient capacity and expectations to integrate into society.

2.1 ASIA scale

This scale developed by the American Spinal Injury Association is considered the gold standard for SCI clinical evaluation. The scale significance relies on its capacity to determine the level of injury, whether it is a complete or incomplete injury, predict prognosis, and serve as guidance for treatment.

It consists of the examination of dermatomes and myotomes. For evaluation of sensory function, 28 key dermatomes are explored using a piece of cotton and a monofilament. For motor examination, five upper and five lower key muscle groups are evaluated. S4 and S5 dermatome evaluation is useful to determine if the injury is complete or incomplete by looking for external anal sphincter contraction and anal pressure sense.

Patients are classified from A, which means an injury is complete, to E, where patients have normal functionality (**Table 1**). This tool provides a long-term reliable prognosis, but it does not take into account pain and spasticity [7, 8].

According to this scale, an accurate prognosis can be established if a 72-h post-injury evaluation is made. 80% of patients with an A-type injury will remain in this classification; meanwhile, 10% will convert into a B-type injury and the 10% remaining will convert into a C-type injury; from the conversion percentage, only 14% of the patients will gain some aided gait capacity. Patients with B-type injury are considered to gain 33% of gait capacity, C-type injury patients will gain approximately 75% of gait capacity, and D-type injury patients will have a very good prognosis since most of them will be able to walk in 1-year post-injury [9, 10].

2.2 SCIM scale

The Spinal Cord Independence Measure is a tool that assesses an SCI patient capacity to perform daily life activities. This instrument evaluates 19 areas and contains 4 subscales: self-caring (0–20 points), breathing and sphincter control (0–40 points), room and bathroom mobility (0–10 points), and interior and exterior mobility (0–30 points). Besides these subscales, feeding, bed mobility, pressure ulcer prevention, and transfer from wheelchair to the car and floor are included [11].

The maximum score to obtain is 100 points; a high score means that the patient is independent for daily life activities. This is a self-assessment tool, so there is no need for qualified personnel to evaluate it [12].

A	Complete	No motor and sensory function
B	Incomplete	Sensory function preserved. No motor function below the level of injury, including S4-S5 level
C	Incomplete	Motor function preserved below the level of injury and more than half of the key muscles below the level of injury with less than 3/5 strength
D	Incomplete	Motor function preserved below the level of injury and at least half of key muscles with strength more than 3/5
E	Normal	Normal sensory and motor function

Table 1.
ASIA scale.

2.3 WISCI II

The Walking Index for Spinal Cord Injury II is a reliable and trustworthy tool to measure walking improvement in SCI patients [13]. It comprises 21 levels that evaluate gait, considering the use of walking aids. It goes from 0 (the patient is not able to walk) to 20 (the patient walks at least 10 m without crutches or assistance) [14].

2.4 SF-36

The Short-Form Health Survey questionnaire is a nonspecific generic test broadly used to evaluate the quality of life, considering both positive and negative subjects, in patients with chronic conditions and mobility diseases [15]. It is easy to answer and takes approximately 5 to 10 min.

The test comprises 36 items, divided into 8 subscales that evaluate the following areas: physical function (10 items), role limitations due to physical issues (4 items), pain (2 items), general health appreciation (5 items), vitality (4 items), social function (2 items), role limitations due to emotional issues (3 items), mental health (5 items), and an additional item that compares actual health with previous year perception of health [16]. Many studies have found with this instrument that SCI has a negative influence on the quality of life of patients [17].

3. Rehabilitation strategies

SCI is a neurological condition that demands a long rehabilitation period, coordinated by a multidisciplinary team because of the damage that it entails. To avoid complications as much as possible, to improve function, and to achieve the most independence, numerous rehabilitation strategies have been shown in many studies to have an impact in patient recovery; some of them are the following: strength, range of movement and stretching exercises, functional electrical stimulation (FES), epidural electrical stimulation (EES) of the spinal cord, occupational therapy, dry needling, and exoskeleton.

3.1 Range of movement, strength, and stretching exercises

Range of movement refers to the normal movement of a joint; hence range of movement exercises are those that promote joint mobility and flexibility.

Studies have observed that these exercises improve function for daily life activities [18], prevent contractures, protect tenodesis effect [19], strengthen paralyzed muscles, promote nerve and cerebral remodeling, and improve spinal microenvironment and functional prognosis [20]. For protection of the joint structure and preservation of muscle tone, sandbags, pillows, or orthotics are usually used. Exercise is important for strengthening the muscles of the upper limbs, emphasizing on rotation of the shoulders for the use of crutches or wheelchair. These exercises will help in the mobilization and independence in daily life activities. In patients with incomplete SCI, walking potential is high, so sitting, parallel bars, and balance exercises should be done [19].

3.2 Functional electrical stimulation

Functional electrical stimulation is a technique that artificially activates sensory-motor systems through electrical current pulses, producing action potentials in afferent and efferent neural pathways to stimulate muscles and generate movement [21]. This procedure is added to other therapies to increase mobility, sensory feedback, and muscle activity to decrease atrophy. It also provides cardiorespiratory fitness; improves posture and trunk stability [22]; prevents contractures, pressure ulcers, and orthostatic hypotension [23]; promotes nerve restoration; and prevents peripheral nerve deterioration [24].

Functional electrical stimulation is a technique that artificially activates sensory-motor systems through electrical current pulses, producing action potentials in afferent and efferent neural pathways to stimulate muscles and generate movement [21]. The main elements of a FES system are the battery, an electronic stimulator, control unit, wiring, and electrodes. The controller can work through a switch, joystick, or voice. There are different types of electrodes, superficial, intramuscular percutaneous, implantable, and epimysial; however the commercially available are the superficial ones, which should be placed over the skin above the nerves to be stimulated; the rest of the electrodes are for research purpose only. The electrodes must be of low-impedance, flexible, and easy to don and doff [22]. The electrical parameters of these systems are waveforms, amplitude, pulse width, reciprocity, ramp, and duration; all of these are combined to generate an electrical current and must be adjusted to achieve the desired response [22, 23].

It is important to evaluate the patient to determine if he or she is a candidate for this therapy. Some exclusion criteria for FES are the following: if the patient has an electrical implantable device, history of cancer, osteomyelitis, epilepsy, and thrombosis [23].

FES systems can be applied to different sites. In patients with cervical SCI, hand function recovery is the main priority, so there are FES systems developed for the upper limb that work through neuroprosthetics with a stimulator for forearm and hand muscles; patients with injuries at C5-C6 level can benefit with this therapy. The only commercially available systems for the upper limb are NESSH200 and Compex. NESSH200 consists of an adjustable wrist prosthetic with five electrodes for finger flexors and extensors, allowing handgrip [24, 25]. There are FES systems for lower limbs that allow sitting and mobility. The best candidates for this therapy are patients with injuries at T4-T12 level, which have more impact in patients with incomplete injuries. The FES neuroprosthetics for the lower limbs stimulate the knees and hips [24]. A commercially available FES system in the USA is the Parastep, which works through 4–6 channels to stimulate the quadriceps and gluteal muscles. Battery is placed on the waist and controls are over a walker [25]. FES cycling systems are also commercially available; one of them is developed by Restorative Therapies, Inc. [24] and the other one, ERGYS, developed by

Therapeutic Technologies, Inc. which has six electrodes to stimulate the quadriceps, hamstrings, and gluteal muscles [22].

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3.3 Epidural electrical stimulation of the spinal cord

This strategy requires a device to be implanted through a laminectomy over the dura mater of the spinal cord [25]. The device delivers a rhythmical afferent electrical current to posterior nerve roots to activate central circuits that regulate movement, pain, and the cardiorespiratory system [22].

It is believed that EES activates two pathways: The first one stimulates afferent dorsal pathways that synapse with motor neurons; the second pathway directly stimulates motor neurons through stimulation of efferent motor nerves [26].

Studies in SCI patients have shown that this strategy decreases fatigue [25], improves cardiovascular and respiratory fitness, increases lean body mass, and improves bladder voiding [26]. The main disadvantage of EES is that it requires surgery for device insertion, which implicates the risk of infection, hematoma, or injury because of the device [25].

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Studies in SCI patients have shown that this strategy decreases fatigue [29], improves cardiovascular and respiratory fitness, increases lean body mass, and improves bladder voiding [30]. The main disadvantages of EES are that it requires surgery for device insertion, which implicates the risk of infection, hematoma, or injury because of the device [29], it is expensive, and it does not yet establish a standard number of sessions and parameter configurations since multiple studies have shown that outcomes vary in each patient due to SCI heterogeneity [30].

It is worth mentioning that this technique is used merely for research purpose only and it is not approved by health authorities. The evidence that exists to date is not enough to justify its use, since it has been studied only in specific small cohorts of patients or single patients with SCI and there are no clinical trials with this method [29, 30].

3.4 Transcutaneous electrical nerve stimulation (TENS)

TENS is a high- and low-frequency electrical current therapy. It is used for pain management, but many other benefits have been observed, such as balance and proprioception improvement and spasticity decrease [31]. To date, its mechanism of action is unknown; however, different theories assume it works by modulating inhibitory spinal circuits, by activating afferent neurons, or by inducing central nervous system plasticity [32]. When applying it, it is necessary to consider electrode positioning, frequency, and pulse intensity; though, there is not a consensus on how long sessions should last and how much frequency has to be applied. The main advantages of this therapy are that it is low cost, it is easy to apply since the patient can do it by himself/herself, and there are no side effects reported yet [31, 33].

3.5 Occupational therapy

Occupational therapy is a crucial process in rehabilitation since it eases societal role finding [19]. It focuses on enhancing daily life activity execution and fine movement, by searching for total independence or performing compensatory strategies to adapt [34–36] as well as patient's environment adaption (home, transportation, or workplace) to achieve total inclusion with its remaining abilities.

It demands equipment and techniques for transferring from one surface to another, dressing, bathing, grooming, feeding, cooking, respiratory exercises, and vesical and intestinal control. Besides, it also trains on wheelchair use and provides counseling for house modification like ramp addition, bath chair incorporation, and current insulation [34, 37].

3.6 Dry needling

Dry needling is an invasive procedure that consists of reaching muscle myofascial trigger points (MTPs) with a needle [38]. MTPs are small, tense muscle nodules that cause pain, cause weakness, and limit range of motion [39].

It is considered that dry needling stimulation inhibits spontaneous electrical activity in MTPs by diminishing the availability of acetylcholine in the motor end plate (it is believed that MTP originates here); consequently, muscle fiber relaxes, promoting pain and spasticity reduction and improving gait speed and stability in patients with incomplete injury [39, 40]. It is worth mentioning that more studies have to be made to set the frequency, duration, and intensity of sessions to obtain desirable outcomes [41].

3.7 Exoskeletons

Exoskeletons are battery-powered robotic devices that adjust to the patients' limbs; it can be operated with manual or oral control or micromovement detector to ease mobility and gait [26, 34].

Two main objectives of exoskeletons are promoting recovery through repeated movements to increase neural plasticity and assist mobility [42]. ReWalk™ and Indego™ are two community use exoskeletons [43] that enable walking, sitting, and climbing stairs up and down [44, 45]. Their use has shown improvements in quality of life, body composition, bone density, neuropathic pain, and spasticity [42] and an increase in gait speed [43], number of steps, and distance test before and after 90 days of training [34]. Restraints for certain users are height, weight, articular rigidity, and high cost ($80,000 USD) [43].

4. Electrical stimulation outcome measurement

Electrical stimulation outcome measurement can be performed through different methods, depending on the evaluated function. After FES, cycling outcomes can be measured by tridimensional analysis of the gait, estimation of oxygen consumption by indirect calorimetry, and muscle tone evaluation with Modified Ashworth Scale [46]. To evaluate outcomes after EES, the following methods can be applied: Motor activity can be evaluated by electromyography and motor tasks, the cardiovascular status might be evaluated by blood pressure measurement after tilt table testing; sexual performance can be assessed by the achievement of orgasm, and for bladder control evaluation, the Neurogenic Bladder Symptom Score (NBSS) can be applied, or post-void residual volume and voluntary urination capacity can be evaluated [47]. In other studies, the outcomes have been measured through motor task performance such as sitting and balance, body fat mass measurement, and respiratory function or inspiratory function by coughing; all cases are compared before and after therapy application [30].

5. Cardiovascular rehabilitation

Cardiovascular rehabilitation is critical because daily life activities are not enough to preserve cardiovascular health. It is estimated that the prevalence of cardiovascular diseases in patients with SCI is 60–70% and these represent, just as in able population, the main cause of death [48]. Besides, if the level of injury is higher, so will be the sedentarism and risk [49]. Another detail to consider is that SCI patients have a higher risk of complications such as thromboembolism, autonomic dysreflexia (AD), orthostatic hypotension, pain, and cardiac atrophy [34].

5.1 Cardiovascular health

For cardiovascular status enhancement in the SCI patient, it is suggested to: (1) do body weight-supported training for it has advantageous effects on cardiac rhythm and blood pressure; (2) do upper limb exercise with moderate to strenuous intensity 3 days a week for at least 6 weeks; and (3) train with functional electrical stimulation 3 days a week for at least 2 months. This kind of training improves the patient lipid profile because it reduces triglycerides and LDL cholesterol [48].

5.2 Orthostatic hypotension

After a long resting period, patients may suffer orthostatic hypotension. Training with a tilt table can be useful to get patients used to a vertical position, with a gradual beginning until tolerance of position is achieved. Afterward, patients should sit on the border of the bed by their own 3 or 4 times a day to keep balance. This is important because the position is needed for wheelchair use [19].

5.3 Glycemic control

For optimal glycemic control, aerobic exercise and EES 30 min a day for at least 3 times a week for 8 weeks is recommended [48].

5.4 Autonomic dysreflexia

Autonomic dysreflexia consists of a sudden blood pressure elevation caused by stimuli such as bladder overdistension or lack of bowel voiding, tight clothes, or pressure ulcers.

AD is considered when systolic blood pressure increases to 20–40 mmHg over the baseline. This usually occurs in patients with injuries in or over T6 level. AD happens because the previously mentioned stimuli start an uncontrolled adrenergic response due to an abnormal supraspinal regulatory signal, causing blood pressure elevation and bradycardia as a compensatory response.

AD is an emergency since it can cause serious complications such as hypertensive encephalopathy, seizures, cardiac arrest, or even death. To prevent patients from

AD, stimuli should be avoided. Some pharmacological treatments used are nitrates, nifedipine, prazosin, capsaicin, and botulinum toxin for refractory cases [50, 51].

6. Pulmonary rehabilitation

Pulmonary rehabilitation is critical in the acute and chronic phases of SCI, particularly in patients with high-level injuries because there are respiratory muscle paralysis limiting thoracic expansion, low pulmonary volumes, and weak cough [52]. Previously mentioned issues cause hypoventilation, mucus plugs, surfactant decrease, pneumonia, atelectasis, or respiratory failure that may result in death if not properly cared [53].

Additionally, due to respiratory mechanics compromise, certain voice characteristics are affected such as less syllable production per breathing, less volume, and more roughness [54].

The next section discusses the strategies to improve pulmonary function: (1) postural changes and early mobilization; (2) breathing techniques, spontaneous cough, and cough aid; (3) secretion management and respiratory muscle training [19, 34, 53]; and (4) pulmonary percussion and vibration therapy [26].

7. Neurofacilitation techniques

Neurofacilitation techniques are frequently used in patients who suffered a stroke but these can also be applied to patients with SCI. It consists of a group of techniques whose main objectives are functionality recovering through noninvasive neuropsychological stimulation, promoting nerve regeneration, and neural systems reorganization [55]. Some of these techniques are mentioned below.

7.1 Constraint-induced movement therapy

It is useful for upper limb rehabilitation. It consists of repeatedly training the limb mobility; meanwhile the contralateral limb is immobilized. However, there has to be some mobility remaining to be applied [55].

7.2 Body weight-supported treadmill training

This is a functional movement training in which the patient stands over a treadmill with a harness, aided by therapists to move the legs and keep balance. It can be beneficial since it is an aerobic exercise [55].

7.3 Bobath method

Bobath method consists of a group of complex, specific, and individualized techniques based on postural control and task execution, taking advantage of neuromuscular plasticity to achieve problem-solving in people with movement disorders. It is possible to control posture, reduce spasticity, increase muscle tone, and improve standing ability through this method [56, 57].

8. Neurogenic bladder

Up to 80% of patients with SCI suffer neurogenic bladder as a result of detrusor hyperactivity disorder, sphincter dyssynergia, or detrusor areflexia; they have an increased risk of urinary incontinence, recurrent infections, vesicoureteral reflux, and renal and bladder lithiasis [58].

Most of the patients will need management for dry, incomplete voiding, to ensure the low-pressure reservoir function of the bladder. This management begins with anticholinergic medication and intermittent catheterization; patients who failed these treatments need more invasive treatments such as sphincterotomy, botulinum toxin applications, and stent insertion [59].

Imaging and urodynamic studies should be performed for the initial evaluation of the patient [60]. Catheterization techniques are detailed below.

8.1 Clean intermittent catheterization

This is the most used method for bladder drainage without the need for a permanent catheter. A catheter is inserted in an interval of 4–6 h. It prevents complications such as hydronephrosis and kidney and bladder stones. It must be done by patients who have enough manual ability (writing and feeding) or a caregiver willing to do it [60].

8.2 Permanent catheterizations

It consists of the insertion of a suprapubic or urethral catheter. This catheterization is suggested for patients with poor manual ability, cognitive deficits, and limited assistance [60].

8.3 Credé method

It is the application of suprapubic pressure for drainage of the bladder. It is used when the bladder is flaccid or when it is necessary to increase the contraction; the Valsalva method is also used to drain the bladder [60].

8.4 Surgery

Transurethral sphincterotomy, stent colocation, or ileocystoplasty can be done.

9. Neurogenic bowel

Neurogenic bowel dysfunction occurs 95% of the time as constipation and 75% as fecal incontinence. Hemorrhoids, abdominal pain, prolapse, rectal bleeding, and anal fissures also occur and can trigger episodes of autonomic dysreflexia.

The management of this dysfunction requires a history of bowel habits in addition to a complete physical examination [61]. It is recommended to establish a schedule to defecate in a comfortable position, implementing changes in diet and lifestyle before using laxatives or suppositories. The caregiver must perform an examination or digital stimulation; manual removal of feces is also preferable [60, 61]. Enemas are another treatment [62].

10. Sexual rehabilitation

After SCI, sexual function is affected since it alters the motor, sensory, and autonomous functionality, and its importance relies in the fact that the number of patients with SCI is young in a childbearing age. There is damage to male fertility, vaginal lubrication, erection, and ejaculation [63].

The causes of sexual dysfunction are multifactorial: altered sensitivity, erectile dysfunction, and side effects of medical therapy.

In men with SCI, some dysfunctions can present as a delayed orgasm, erectile or ejaculatory disorder, seminal abnormalities such as hypomotility, or low sperm viability [64].

10.1 Male sexual quotient (MSQ)

It is a questionnaire designed to assess the sexual function and satisfaction in men. This instrument includes 10 questions where physical and emotional aspects are considered; scores go from 0 to 100 points [65].

10.2 Medical management for erectile dysfunction

Administration of phosphodiesterase-5 inhibitors is helpful in inhibition of guanosine monophosphate degradation causing smooth muscle relaxation. Other methods are intracavernous application of phentolamine, papaverine, and alprostadil or intraurethral application of alprostadil [64].

10.3 Management for ejaculatory dysfunction

Vibratory stimulation can be done until antegrade ejaculation is achieved. Another method is electroejaculation, which electrically stimulates prostatic nerves and muscles and seminal vesicles; if retrograde ejaculation occurs, a catheter is needed to collect residual semen from the bladder [64].

In women, sexual function after SCI has not been sufficiently studied as in male dysfunction. Sexual rehabilitation in women focuses on psychological matters and sphincter control during sexual activities. In addition, vaginal lubrication depends on neurological factors and vascular factors [66, 67].

11. Skin care

SCI causes an alteration in the microenvironment of the skin, causing excessive sweating, thinning, onychogryphosis, paronychia, tinea, seborrheic dermatitis, and cellulitis [68, 69]; besides, keeping the same position for a long time damages the integrity causing pressure ulcers [70].

Pressure ulcers are the result of applying pressure to tissue over a bone prominence, exceeding the 12–32 mmHg capillary pressure collapsing the capillaries and causing ischemia. Pressure ulcers represent a major problem for patients with SCI in the acute and chronic stages, also considering the cost involved in treatment [71]. For correct management, pressure must be decreased, and special mattresses, heel protectors, and turns and transfers are recommended. Regarding turns, these must be done in intervals of 2–4 h. Lateral positioning should be limited to minimize pressure on bony prominences. When the patient is in supine position, the bed must incline less than 30° or the limbs must be elevated. Patients using a wheelchair should be trained to distribute pressure by tilting at intervals of 15–30 min [62].

12. Nutritional support

Since life expectancy in patients with SCI has been prolonged, the incidence of metabolic syndrome, diabetes, cardiovascular diseases, but also malnutrition has increased substantially; therefore, it is important to make a nutritional plan.

There are no nutritional guidelines for patients with SCI; however, the following general measures are suggested:

1. Abundant consumption of fruits and vegetables to obtain fiber and avoid constipation; it is recommended to adjust the amount of it to avoid bloating and diarrhea.

2. Plenty intake of water (minimum 1.5 l).

3. Protein consumption of 0.8 g/kg per day is recommended, and if a pressure ulcer is present, this amount can be 1.2 g/kg, rising up to 2 g/kg if the ulcers are grade III or IV. The purpose of increasing protein consumption is to decrease the negative nitrogen balance, which is greater in acute stages of the disease; it is also helpful in preserving muscle mass and avoiding glucose intolerance. Liquid protein supplements that contain leucine may be recommended.

4. High-fat diets should be avoided since the patient lipid profile is altered and predisposes to metabolic syndrome.

5. Omega-3 is recommended because of its neuro- and cardioprotective effects; however more studies are required.

6. Micronutrients such as vitamins A, B5, D, E, and C and biotin and minerals such as calcium, chlorine, magnesium, and potassium are usually low consumed, so their intake should increase to improve glucose metabolism.

Nutritional plans must be individualized according to the objectives, the age of the patient, and the level of the injury [72, 73].

13. Psychological management of the patient with SCI

Psychological management after SCI is essential for the patient in order to return to activities of daily living. After an injury, there are many psychological stages in the readjustment process: shock and denial, depression, anxiety, anger, negotiation, and adaptation.

Psychological rehabilitation should start in the intensive care unit because the patient can experience disorientation, depression, anxiety, and sensory and sleep deprivation.

Psychotherapy groups are helpful to provide emotional support, educate in the development of new skills, and minimize social aversion. Similarly, family psychotherapy groups make it easier for the family to adjust to the new situation since similar emotional reactions also occur in them [74].

14. SCI patient rehabilitation stages through time

14.1 Acute phase

This rehabilitation begins since the patient is admitted to the hospital until the stabilization. It can be a period of 6–12 weeks, depending on the existence of complications. Rehabilitation in the acute phase is important to increase the patient strength and stability for postural adaptation and orthostatic hypotension [19, 28].

Passive exercises have been observed to decrease the risk of spasticity [43]. Other early interventions in rehabilitation are bed mobility with rotation at 2–3-h intervals to prevent pressure ulcers [19, 34].

14.2 Chronic phase

This rehabilitation is focused on the patient capacity to reintegrate into society. The goals are aimed to develop motor skills such as walking, transferring using the upper limbs, and wheelchair use [28], restore psychological status as much as possible, and perform occupational therapy [19].

15. Goals in rehabilitation

Despite the fact that most of the patients with SCI want to be able to walk again, the goals of rehabilitation are mainly focused on restoring quality of life [75], and these should be individualized according to the ASIA classification.

The following functional goals can be considered in the first 5 months according to the level of injury (time may vary depending on the patient ASIA classification he/she has):

- C4: independence with a motorized wheelchair, partial or assisted ventilation, and dependence on activities of daily living.

- C5: independence with a motorized wheelchair with hand control; may require extra respiratory care, performance of some activities of daily living, adapted driving is possible.

- C6: independence with a manual wheelchair, assistance in transfer with a sliding table, control of supporting points, can do certain activities of daily life; extension of the wrist is possible; adapted driving is possible.

- C7: this is a key level for wheelchair mobility, independent transfers without sliding board support.

- C8-L2: advanced wheelchair skills, independent daily life activities, driving with adaptations.

- L3 and lower: home and community ambulation with aid devices, independence in daily life activities [19, 34].

16. Conclusion

SCI is a relevant health issue because of the impact it has on the patient, his/her family, and health system. Even though there is active research for treatment development, being surgical or medical, in order to achieve motor recovery, in the present time, there are only treatments to reduce the damage after SCI and prevent future damage so none of this therapies are curative; one of this treatments is rehabilitation, which must be coordinated by a multidisciplinary team to reduce possible complications that may arise.

To achieve better outcomes at clinical level, it is recommended to perform an integral rehabilitation therapy that combines different strategies, for example, functional, transcutaneous, or epidural electrical stimulation in addition to musculoskeletal rehabilitation exercises to decrease complications associated with this pathology. It is important to emphasize that some rehabilitation strategies have not yet been approved by health authorities for commercial use and to date have only shown results in very small populations with very particular characteristics, which impede their general application in patients with SCI, in addition to the heterogeneity of spinal cord injuries due to the level of injury, age, treatments used before, or time since injury.

The ultimate goal of these interventions is to achieve patient's societal reintegration and become independent in most of the activities according to the severity of their condition; therefore improving and updating these strategies create opportunities for novel innovative research, as well as implementing rehabilitation strategies as a complement for regenerative pharmacological and non-pharmacological strategies for the SCI patient.

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