



# LONG-TERM COMPLICATIONS FOLLOWING SPINAL CORD INJURY AND AGING

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## Abstract

**Purpose:** The study presents complications following spinal cord injury (SCI) in relation to aging.

**Views:** It is estimated that there are approximately 6 million SCI patients in the world who are struggling with disabilities of the locomotor system of a paraplegic or tetraplegic nature. The effects of aging in a person with SCI are due to age factors related to abnormal health behavior, environmental impact, and the presence of comorbidities and complications. SCI entails numerous complications, the most common including infections of the urinary and respiratory systems, the formation of pressure ulcers, cardiovascular disorders, sleep disorders, depression, muscle atrophy and osteoporosis. In patients who have suffered a SCI, it was found that age-related changes occur as early as 15 years following the injury, much more often than in the healthy population. The incidence of cardiovascular disease, for example, is 200% higher in people after a SCI than in the general population. It should be emphasized that SCI does occur within the young population, although recently there has been a significant increase in SCI in patients over 65, who as an age group are increasingly fit, and get involved in accidents.

**Conclusions:** The complications of SCI affect the patient's independence and limit his or her activity and functioning in social, professional and personal life. All this implies an assessment of the life quality of patients after a SCI. Also, the prolonged period of a patient's lack of independence resulting from osteoporosis, sarcopenia or cardiovascular diseases significantly increases the financial burden on the health and social care system.

**Key words:** spinal cord injury, aging, complications.

## INTRODUCTION

In people living with spinal cord injury (SCI) for long periods, causes of death are similar to those in the general population, such as cardiovascular disease (CVD), respiratory distress, and cancer [1]. The incidence of SCI, including traumatic and non-traumatic cases, is estimated to be between 40 and 83/million/year, with an absolute estimated annual number of new cases worldwide of around 250,000-500,000 [2].

## LIFE EXPECTANCY AFTER SPINAL CORD INJURY

Life expectancy of SCI patients is lower compared to the general population [3]. In fact, lower life expectancy is mainly seen in SCI people with higher-level, complete

lesions (based on Association Impairment Scale), and in the elderly population [3, 4].

Spinal Cord Injuries are classified as complete and incomplete according to the International Standards for Neurological Classification and the ASIA-American Spinal Injury Association Impairment Scale (AIS). Complete injuries are defined as AIS-A, and incomplete ones are defined as AIS-B, AIS-C, AIS-D or AIS-E depending on the severity of the motor and sensory disturbance [5]. This classification replaced the earlier, but perhaps more intuitive, classification by Frankel [6]. With this classification, a person with incomplete SCI was defined as such when any motor or sensory behavior was found at more than three levels below the injury level. In contrast, the International Standards of Neurological Classification SCI distinguishes between complete and incomplete injuries based on sensory behavior, and motor response

in segments S4/5. The injury is classified as complete if the person does not have voluntary anal contraction (indicative of S4/5 motor lesion), and sensation around the anus (indicative of S4/5 sensory lesion) [5]. The exact definitions of the different types of injury are surprisingly complex and unclear, and are still under discussion.

Based on the findings of a neurological examination (motor and sensory index), the prognosis for functional recovery can be predicted with fairly high degree of accuracy during the first 20-40 days after spinal shock following a SCI [7]. Some of the papers found in the literature examine the ability of physiotherapists, neurologists or physiatrists to predict the probability of recovery of gait function in patients (and ability to perform a number of other motor tasks) 3 months or 1 year after injury, based on the physiotherapist's assessment at the time of admission to rehabilitation. Patients were also asked to predict their own future mobility. Interestingly, but perhaps not surprisingly, there was an obvious disparity between patients' expectations of walking and end-use mobility, with them expecting to achieve a higher level of mobility than predicted by their physiotherapists, which may be related to the popular media coverage of the issue of mobility/walking after SCI which foster optimism. Significant predictors of the return of the ability to walk are: age, strength of the quadriceps muscle of the thigh, strength of the gastrocnemius muscle, sense of touch at the L3, S1 level, and the ability to walk at home up to 1 year following the injury [8].

Patients classified as AIS-A typically show no improvement in their neurological status (5% or less) within one year of follow-up. Patients classified as AIS-B have an approximately 35% chance of improving their neurological status, whereas, according to some studies, the conversion from AIS-C or AIS-D to AIS-E may not be rare. People classified to AIS-C can improve to AIS-D with a very high probability of 60-70% [9].

## PRINCIPLES OF REHABILITATION

One of the key principles of rehabilitation, comprehensiveness, relates to the patient collaborating with a rehabilitation team, which in the case of patients after SCI should consist of doctors, nurses, physiotherapists, occupational therapists, social workers, a psychologist, and a peer mentor. The team should work closely with other specialists such as urologists, because bladder dysfunction is a very important problem, upper limb and hand reconstructive surgeons for nerve and tendon transplantation, and/or specialists in pressure ulcer treatment.

Intensive rehabilitation after SCI begins when the patient is in a stable general condition, and may last for many weeks, depending on whether they suffered other injuries during the accident, or developed other medical complications later. Rehabilitation includes many team activities

to be tailored to the patient's needs. The main long-term goal is to enable the patient to recover as much as possible, so as to achieve a satisfying life and social role [10, 11]. However, it should be emphasized that the meaning of this statement is perceived differently by various people. Some people attach great importance to independence and/or walking, while others have completely other priorities. There are studies in the literature that cover attempts to define the priorities of people after their SCI. A widely cited study from a sample of more than 650 people in the US showed that people with tetraplegia gave the highest priority to recovery of hand and upper limb function, and with paraplegia to the restoration of their sexual function [7]. Regaining the ability to walk was also an important priority for both groups of people, but contrary to what is often assumed, it was not the highest priority. Overall, physiotherapy focuses on the following stage goals: gaining and improving gait function, learning to drive a wheelchair, learning to transfer from wheelchair to bed, improving upper limb function, improving respiratory function, improving quality of life, improving bladder and bowel function, improving sexual function, and others [10, 11].

The International Classification of Functioning, Disability and Health (ICF) [12] is the standard framework for guiding the patient through the rehabilitation process. According to ICF, functioning and disability result from the interaction between health status and contextual factors (i.e., personal and environmental factors). Disability is a generic term for impairment (i.e., problems in body functions and structures), activity limitations (i.e., difficulty in completing a task), and participation limitations (i.e., problems experienced in engaging in life situations). Personal factors in the background are not part of the health condition, but very often play an important role; examples are gender, behavior, and coping strategies. Environmental factors can be facilitators or impediments to functioning, and include the surrounding physical, social and postural environment.

"Healthy aging" is important for people with SCI. The term refers not only to the absence of disease or disability, as it is rather a subjective experience. The WHO definition of healthy aging is based on the ICF [12, 13], and has many similarities with the overarching goal of rehabilitation. In patients after SCI, long-term rehabilitation should enable healthy aging.

## AGE AND SPINAL CORD INJURY

Changes and a slowing down of activities in all body systems, but also in social roles and self-fulfillment are all part of the aging process [14]. The links between aging and disability include secondary consequences of disability, factors related to aging and long-term exposure to environmental hazards, or poor health behavior, and

the presence of comorbidities (heart disease, diabetes, obesity, etc.) [15].

Menter and Hudson [16] developed a model of aging after SCI, in which the physical abilities and functioning of these people were presented in three phases:

- phase I (restoration of function) – immediately after SCI, lasting about 1.5 years, the phase of maximum possible restoration of functionality, depending on the level of damage and rehabilitation;
- phase II (supportive) – lasting many years, maintaining the scope of the patient's capabilities and functionality at a specific, stable level;
- phase III (functional deterioration) – associated with a decrease in the patient's functionality, changes resulting from the patient's age.

### Problems specific to elderly spinal cord injury patients

In each of the European Union countries the share of the population aged 65 and above is growing. Forecasts show that in 2032 it is people over the age of 70 who will be the most frequent patients with a fresh SCI [17]. SCI at a young age differs from that experienced by elderly patients. The most common causes of SCI at this age are falls and car accidents. People who have had a SCI over 55 have a period of 5-7 years of relatively stable functioning [18]. The predominant injuries in this group of patients are low-energy fractures, which cause the relatively frequent incidence of incomplete AIS-C, AIS-D injury in the cervical region. Young people on the other hand, have more often high-energy fractures causing complete SCI damage [19].

Older people with SCI have a number of disorders and complications. The most common of these are venous thromboembolism, pressure ulcers, disorders of the autonomic system (orthostatic blood pressure disorders, bradycardia, and autonomic dysreflexia), neurogenic bladder, sexual dysfunction, defecation disorders, depression, spasticity, and heterotopic periarticular ossification [20]. These age-related problems influence therapeutic decisions in SCI patients and hinder their functioning. The injury itself, and the level of injury obviously contributes to this situation, is often just the beginning of the problems that may accompany the patient. In the over-70s, comorbidities (such as arterial hypertension, osteoarthritis, obesity or diabetes), make it much more difficult to regain the correct pattern of locomotion, and it is more difficult to improve the function of the bladder, intestines and overall efficiency. It has also been shown that in case of the elderly patients, the waiting time between admission and surgery was twice as long as the equivalent time in case of younger people with SCI [19]. Such a delay may increase the risk of perioperative complications and death in these patients.

In addition to the medical problems of SCI patients, a very important economic aspect is the return to work. In Poland there are no registers of how many people return to work after suffering a SCI. In contrast, in the Scandinavian countries the employment rate of people of working age five years after an injury is approximately 50% [21].

Factors which significantly impact the deterioration of the long-term functioning of patients after SCI are described below.

### Pain

Pain is one of the major and difficult-to-treat problems in patients after SCI. Recently, a paper has been published in which the authors indicate that this type of problem may occur in up to 60% of patients [22, 23]. Chronic pain in these patients may have a negative impact on functioning and the quality of sleep, mood, and become a cause of dissatisfaction with life. In one of the latest studies on pain in patients with SCI, it was found in 67% over 5 years after the injury [23]. According to the International Spinal Cord Injury Pain (ISCIP) classification, 58% of patients reported nociceptive pain (musculoskeletal pain), and 3% reported visceral pain. Neuropathic pain at or below the damage level, or other neuropathic pain, was observed in 53%, 42%, and 5% of patients, respectively. An unknown type of pain was found in 8% of patients. In patients with complete damage, neuropathic pain was much more frequent at the level of damage than in patients with incomplete damage. Patients with complete SCI and paraplegia were more likely to experience pain at the injury level, while patients with tetraplegia were more likely to report pain below this level. The intensity of this pain was significant (mean intensity:  $8.2 \pm 1.6$  on a scale from 0 to 10) [23].

Pain treatment depends on its type. In the treatment of receptor pain, the following are used: non-steroidal anti-inflammatory drugs and physical methods (massage, physiotherapy, transcutaneous electrical nerve stimulation (TENS), thermotherapy, cryotherapy). Neuropathic pain is treated primarily pharmacologically: pregabalin and gabapentin, as well as serotonin norepinephrine reuptake inhibitors (SNRI) [24-26]. Additionally, cognitive-behavioral therapy is used. The following potential methods remain in the research phase: transcranial magnetic stimulation (TMS), and transcranial direct current stimulation (tDCS) [24-26].

### Spasticity

Spasticity is characterized by increased muscle tone, excessive tendon reflexes, and involuntary muscle contractions. These contractions can be painful for the patient. In the rehabilitation process, spasticity can be of benefit to the patient as it can support the ability to stand, walk, prevent muscle wasting and increase peripheral

blood circulation. However, its other side, which is unfavorable for the patient, is its contribution to the formation of contractures, which may cause difficulties with dressing or caring for the patient. Spasticity also contributes to the intensification of pain, the development of bedsores, and the difficulty in treating urinary or intestinal disorders [27].

The first step in the treatment of spasticity is prevention, as well as elimination of pain, constipation, infection, pressure ulcers and the wearing of tight clothes. The treatment plan includes a possible, individualized combination of treatment methods: oral medications (baclofen, tizanidine, dantrolene, tolperisone, cannabinoids, diazepam), chemodenervation with botulinum toxin, therapeutic nerve block with ethyl alcohol or phenol, intrathecal baclofen pump, physiotherapy (passive exercises, stretching), body weight-supported treadmill training, exoskeletal assisted walking, TMS, ultrasounds, cryotherapy, vibration therapy, hydrotherapy, TENS and functional electrical stimulation (FES). Surgical procedures include tendon lengthening, tenotomy, tendon transfer, neurotomy, selective rhizotomy [28].

### The influence of age and aging on patients with spinal cord injury

The lifespan of SCI-affected patients has lengthened considerably over the years. The average age of their survival after the injury is about 30-40 years [19]. In the case of SCI, it was found that age-related changes occur as early as 15 years after the injury. Identification of the natural course of the disease with the age process is an important area of research with important implications for clinical practice.

#### The effect of aging on the cardiovascular system

Cardiovascular disease is now a main cause of death in persons 30 years post-SCI and older than 60 years [29]. One of the causes of such a situation can be the fact of altered sensory pattern, predisposing the patient to atypical symptoms that might warn about an urgent situation. The incidence of CVD is 200% higher in patients after SCI than in the general age-matched population [30]. The risk of CVD is associated with the level of injury, and patients with tetraplegia are at a 16% greater risk of CVD compared to those with paraplegia [31]. This fact can be partially connected with a decentralization of the sympathetic nervous system and immobilization of tetraplegic patients. Immobilization leads to diabetes, dyslipidemia, obesity etc., the problem being the decreased baseline exercise capacity of these patients [32]. Elderly patients experience drops in blood pressure during exercise, bradycardia, and many other problems affecting their ability to exercise after SCI [33]. Patients with tetraplegia in chronic stages have cardiac atrophy and impairment in systolic

cardiac performance [34, 35]. In paraplegic patients after SCI higher heart rate compared with healthy subjects was diagnosed [35]. Nash *et al.* stated that in a high percentage of young patients, healthy paraplegics qualify for lipid therapies based on the guidelines of the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) [36]. This is very practical information for doctors who take care of SCI patients, signaling that they should also place emphasis on early risk assessment in this population. Therefore, the prevention of CVD is very important. Exercise is an important therapeutic intervention to improve cardiac function and reduce CVD risk profiles in patients with SCI. Individuals with paraplegia mostly exercise their upper body, often neglecting lower limb therapy [37]. However, it has been proved that passive lower-limb cycling is also very important, and represents an elegant, cost-effective and widely accessible therapeutic strategy that may reduce the clinical cardiovascular burden imposed by SCI, and other neurological disorders [38, 39].

Disturbances in the autonomic system can result in disturbances in the regulation of blood pressure, body temperature, and heart rate. Individuals with an injury level equal to or greater than Th6 may experience a potentially life-threatening increase in blood pressure in response to stimuli below the level of injury known as autonomic dysreflexia (AD) [40]. Therefore, education in the care of the bladder, intestines and skin as well as a thorough knowledge of the factors contributing to the development of AD are of the utmost importance in its prevention. Treatment includes non-pharmacological management: positioning the patient upright, loosening tight clothing, and eliminating any precipitating stimulus, and pharmacotherapy with prazosin, nifedipine and prostaglandin E2 [40, 41].

#### The effect of aging on changes in the respiratory system

Respiratory complications after SCI are associated with a reduction in lung volume and changes in surfactant [42]. In complete SCI from the C2 level and below, there is a 20-50% reduction in vital capacity (VC), ventilation ineffectiveness, and severely impaired cough due to changes in lung compliance, deformity of the chest wall, and impairment of the inspiratory and expiratory muscles [43]. The reduced lung function is a consequence of a restrictive disease that occurs because of the paralysis of the respiratory muscles after SCI. The higher the level of SCI, the greater the restrictive ailment. Additionally, the development of kyphosis, scoliosis or increasing spasticity, which may occur over the years following SCI, may cause further restrictive lung progression [14]. It has been observed that during hospitalization SCI patients develop respiratory system infection twice as often as others [44].



Respiratory disorders occurring in the acute phase after SCI require the use of mechanical ventilation, sometimes even for an extended period of time. People over 50 years of age with SCI, with mechanical ventilation dependence, are more likely to die, and less likely to be disconnected from ventilators than younger people [45]. Phrenic nerve and diaphragm stimulators are an alternative to this treatment [46].

The incidence of obstructive sleep apnea in patients after SCI is twice as high [47], and this disease may increase or persist with the aging process [48].

In order to minimize the aging of the respiratory system in patients after SCI, it is recommended not to smoke, minimize exposure to polluted air, and control body weight [49].

#### Musculoskeletal changes in the aging process after spinal cord injury

Age-related changes in the musculoskeletal system in patients after SCI may lead to pain in the upper limbs, decreased strength due to muscle atrophy, and an increased risk of fractures, with serious consequences in terms of the functionality [1].

There is evidence of an increased development of osteoporosis after SCI. The literature describes a 22% reduction in bone mineralization in the first 3 months after SCI [50], and a continuous loss of bone mass following the injury [51]. Thus, in such patients the degree of osteoporosis is much more severe because they have lower skeletal mass at the beginning of the typical age associated with decreases in bone mass. People with SCI are more likely to develop osteoporosis if they are older, women, or have lived for a longer period since their injury [52]. The development of rapid and severe osteoporosis is only observed in the paralyzed part of the body, and the peak of this severe process of bone loss achieves a plateau 6-9 months after the SCI [14]. Faster bone loss occurs in the hip and lower extremities. Bone loss is associated with an increased risk of fractures, the number of which increases with time from the SCI. The mean time from the SCI to the first fracture is 9 years on average, and the fracture frequency in people with chronic SCI is 25-46%. The most common locations of fractures are the supracondylar area of the femur and the proximal part of the tibia, the distal part of the tibia, the femoral shaft, the femoral neck and the humerus [53].

Education, lifestyle modification and regular exercise are recommended in the prevention and treatment of osteoporosis. The use of FES more than 3 times a week over 3 months has been shown to significantly improve bone mineral density. The effectiveness of bisphosphonates has not been fully proven [54]. The degenerative changes occurring with age have serious consequences for the functioning of patients after SCI. Scoliosis, kypho-

sis, or Charcot joint may develop within the structures of the spine, causing it to become unstable. Degeneration of the limb joints typically involves the shoulder, knee and hip [20].

It has been observed that muscle atrophy (especially of the denervated muscles) progresses in patients after SCI [55]. This can lead to joint pain, limitation of the range of motion, or injury (fracture), limiting a patient's functioning. These changes occur more frequently in the area of the upper limbs due to overuse of the muscles of the upper limbs while moving in a wheelchair and daily functioning [20].

Upper limb pain is a common musculoskeletal problem associated with the aging process after SCI (affecting over 70% of people with chronic SCI) [56]. It results from compression of the nerves, or overload syndromes. The incidence of peripheral nerve compression syndromes increases with age from the SCI [57]. 67% of people after SCI have diagnosed compression neuropathy of the upper limb [58]. The most commonly affected joint in the upper limb is the shoulder joint (71%) [59], and the most common complication within the wrist and hand is carpal tunnel syndrome (49-73%) [60]. The most common overload syndromes causing pain in the upper limb include osteoarthritis, damage/inflammation of the rotator cuff, and inflammation of the subacromial bursa, or joint capsule [61]. Ergonomics, maintaining optimal body weight, selecting the suitable wheelchair and medications are crucial in prevention and treatment. Rehabilitation should be based on balanced training to strengthen the muscles of the upper limbs without overloading them [62].

#### The impact of aging on the endocrine system

In people after SCI, an increased glycemic profile, insulin resistance, and lipid disorders occur earlier, and the incidence of diabetes is 4 times higher than in the general population. These disorders are promoted by lack of exercise (resulting from paresis and immobilization), and hormonal disorders (growth hormone deficiency, testosterone deficiency) [14]. Low levels of these hormones can result in a diminished ability to repair cells and to maintain lean muscle mass and strength [63]. A deficiency of insulin-like growth factor 1 in the serum in patients after SCI, compared to the general population, may indicate premature aging [64]. A normal result of glucose load test after SCI occurs in approximately 38% of patients with tetraplegia and 50% of patients with paraplegia; 22% of such patients have diabetes, and 34% have impaired glucose tolerance [63].

Several studies have also shown evidence of thyroid dysfunction after SCI compared to the general population [65, 66].

A decrease in testosterone levels after SCI is greater than in the control population of men without injury. Men after SCI showed an age-related annual decrease in total serum testosterone by 0.6%, compared with 0.4% in the general male population [67]. Low testosterone levels are due to dysfunction of the hypothalamic-pituitary-spinal axis, which in the general male population may lead to decreased libido, impotence, insomnia, fatigue, hot flushes, poor memory, anxiety, depression and irritability [68].

#### The effects of aging on the digestive system

The intestinal problems that develop in old age include decreased intestinal mobility, which along with an increase in water resorption in the colon leads to the formation of hard stool, an increased risk of constipation, anal fissures, hemorrhoids, or diverticular diseases [69]. Disturbances in the autonomic control of the gastrointestinal tract function impair the feeling of the need to defecate, a prolonged time of stool passage in the intestines (in the colon), impaired sensation and motor control around the anus [70].

The incidence of gastrointestinal complications and problems is highest in people 60 years of age or older and in patients over 30 years one from their SCI, but a noticeably higher incidence of bowel dysfunction is noted in people as early as the fifth year after SCI [71]. However, it should be remembered that the severity of the injury plays a major role in the increase of intestinal dysfunction [72]. The neurogenic colon may exacerbate the consequences of aging in people after SCI. SCI patients often have a higher rate of gut-related complications compared to the general population [44, 73]. The incidence of colorectal cancer is higher [74], and it is detected at a higher stage than in patients without paralysis [75]. Constipation, flatulence, abdominal pain, rectal bleeding, hemorrhoids, intestinal accidents and autonomic hyperreflexia occur in 27–72% of patients after SCI [14]. People affected by SCI may experience a worsening of symptoms associated with constipation as well as a reduction in fecal incontinence over time [76]. This is associated with reduced colonic movements, inability to use abdominal muscles, inadequate intake of fiber and water, and the use of anticholinergic drugs to treat neurogenic bladder [77]. These patients can often report symptoms of lack of appetite and nausea, and the administration of anti-nausea drugs may have an anticholinergic effect, promoting constipation. It has been found that approximately 60% of tetraplegic patients, and approximately 16% of paraplegic patients, require assistance with bowel movements [78]. Lifestyle modification, a balanced diet, oral medications, suppositories, and transrectal flushing of the intestine are also used to facilitate peristalsis [79, 80]. Surgical treatment

includes neoappendicostomy, implantation of sacral anterior root stimulation (SARS) or a stoma [79–81].

#### Urological changes related to aging after spinal cord injury

Health problems of the genitourinary system of the elderly include, among other things, urinary incontinence (resulting from the reduced capacity and compliance of the bladder and the increase in its involuntary contractions), progressive kidney breakdown, prostate enlargement in men, urinary tract infections (more common in women), or neoplastic diseases [1]. In patients after SCI, the coordination of bladder filling and emptying is disturbed [82]. These problems are mainly the lack of sensation in bladder filling, urinary incontinence, and the lack of coordination between the bladder sphincter and its detrusor during voiding. These impairments are associated with an increased risk of urological complications, such as urinary tract infections, bladder stone formation, and increased urinary tract pressure causing secondary kidney damage [83, 84]. The risk of nephrolithiasis also increases to up to 90% in older tetraplegics [85], and repeated episodes of vesicoureteral reflux can cause kidney damage as early as four years after SCI [86].

The accurate assessment of bladder functioning and the introduction of an appropriate method of emptying it are of key importance in preventing these complications. Intermittent catheterization (CIC) is the method of choice for people with impaired bladder function [87], as it shows the lowest rate of complications [87] but is often very difficult to perform for patients with tetraplegia due to manual difficulties and lack of third-party help. An indwelling catheter is not recommended because it is associated with an increased risk of infections, urethral strictures, kidney stones, or even bladder cancer, often with cystostomy [14, 84, 88–90]. Suprapubic catheterization is typically easier to manage in terms of hygiene and causes less frequent occurrence, epididymitis, vesicoureteral reflux, and deterioration in renal function. Crede treatment and triggered voiding reflex is not recommended at present [84, 91]. The anticholinergic drugs used are conducive to arrhythmia, visual blurring, xerostomia, and constipation. Botulinum toxin injections improve bladder emptying, disappearance of autonomic dysreflexia, reduction in urinary incontinence and improvements in urodynamic parameters and the patient's quality of life [92]. Cystoplasts are considered only after less invasive treatment options. An artificial urinary sphincter can be used to treat patients with stress urinary incontinence. Less common surgical treatment options are neuromodulation / electrical stimulation, nerve or muscle grafts, and urethral stents [92].

Testosterone reduction in the aged able-bodied is associated with prostate gland enlargement, while the size

of the prostate gland and the PSA levels are lower in SCI patients (much smaller in severely paralyzed people). It is unclear when this atrophy occurs - early in the course of paralysis or progressively over the years. The etiology of prostate atrophy in severe SCI is possibly related to neurohormonal effects of the spinal cord lesion, prostate resection, alcohol abuse, or dyssynergia [93].

#### Sexual disturbances and aging in spinal cord injury

Generally, the frequency of sexual activity and intercourse decreases after SCI [94]. This fact may result from the biological consequences of SCI, or may reflect the psychological aspect related to the loss of a partner, emotional disorders or the lack of interpersonal contacts. The need for sexual expression and intimacy often lingers. In this regard, the level of neurological damage is also important, as is the time since the SCI. If the injury is below the 12 thoracic cord segment, men and women can experience psychogenic arousal in response to auditory, visual, imaginative or tactile stimuli. Sexual activity increases with time after the injury, but its expression often changes [95]. Individuals become more open-minded and can engage in sexual fantasies. The frequency of hugging, kissing, manual stimulation, and the use of oral and genital stimulation did not differ statistically in relation to couples without SCI. However, the biggest problem pertains to ejaculation, with as many as 95% of men after SCI having problems [96]. Up to 2 years after the SCI, up to 80% of patients regain some erectile function [97], but problems with arousal may remain [98]. Sexual dysfunction may also affect the symptom of autonomic dysreflexia (with damage greater than Th6), which is often very troublesome for the patient [99].

The treatment of sexual disorders includes phosphodiesterase inhibitors, vacuum erection devices, implantation of cavernous body prostheses and SARS. In penile injections, papaverine, phentolamine and prostaglandin PGE1 can be used [100, 101].

#### Depression and cognitive disorders after spinal cord injury

Post-SCI depression is relatively common, even reaching an incidence of over 70%, and is higher than in the general population [102, 103]. It influences the mood, ambitions, views, problem-solving abilities and energy level, and contributes to decreased well-being of the sick person, a worse assessment of their health, and poorer quality of life. Aging with SCI is more difficult for women. Mc Coll found that age, gender, and disability exacerbate depression in older women after SCI [104]. Krause *et al.* showed that starting from the age of 30–39 at the time of SCI, patients were more prone to developing depression [105]. Factors conducive to the development of depression are aging, gender, ethnic origin, and

indicators of socio-economic status (education and income, being dependent on another family member) [105, 106]. Untreated or poorly treated depression also reduces the quality of life [107].

Cognitive impairment after SCI affects 40–50% of patients [108]. It is often associated with concomitant brain damage, a premorbid state (poor intellectual or occupational functioning), pre-existing brain trauma, alcohol abuse, drug abuse, low blood pressure, or psychiatric disorders [14]. However, secondary changes in the organization or activity of the brain resulting from the injury itself may also be the causes of cognitive impairment [109]. Studies have shown changes in the excitability of the spine [110], and plasticity [111] during learning process, directly linking the deterioration of certain cognitive functions to SCI. Additionally, reactive depression may deteriorate these functions [112], and negatively affect the patient's cognitive abilities [113].

Treatment of depression should be tailored to the individual preferences of a patient. In addition to antidepressants, individual counseling and exercise may be promising methods of treatment. These are the patients' preferred treatment options as part of medical and rehabilitation care, but not in mental health clinics [114]. Myelopathy, secondary to degenerative disease in the elderly, may well represent the model of aging of patients after SCI. Kowalczyk *et al.* showed that changes in motor activity in cervical myelopathy result not only from the compression of the spine itself, but also from distal effects related to the reorganization of the cortex, and the reduction of N-acetyl aspartate/creatine in the motor cortex [115]. This proves that changes in the functioning of the brain after SCI are not only related to the aging effect, but that SCI itself can determine changes in the reorganization of the cerebral cortex.

#### Changes in the skin and subcutaneous tissues associated with aging after spinal cord injury

Deterioration of the skin structure in the elderly is caused by losses and/or disturbances of collagen (responsible mainly for the tensile strength of the skin), and elastin fibers [116]. This increases the susceptibility of older people to pressure ulcers and an impaired healing process. It is estimated that as a result of prolonged pressure related to sitting and reduced skin integrity (collagen degradation), approximately 85% of people after SCI will develop pressure during their lifetime [117]. Older patients have an increased risk of developing pressure ulcers, the risk being 30% higher in patients with SCI over 50 years of age compared to patients with SCI up to 30 years of age [118]. Pressure ulcers after SCI usually occur in the sacrum, trochanteric region, on the heels, in the occipital region (in a lying patient), and in the area

of sciatic tumors (in a sitting patient). They are more common in patients with complete SCI [119].

In terms of general management, it is recommended to relieve the wound sites, eliminate risk factors, take care of general health and diet, and avoid lying/sitting on the wound. Treatment depends on the severity of the wound and includes cleaning it and keeping the skin around it dry, exudation control, the use of occlusive dressings such as hydrogels, hydrocolloids, foams, silicones, and surgical treatment via the removal of necrotic tissues or surgical preparation of the wound. Supportive therapies are electrical stimulation (best effect) and hyperbaric oxygen therapy, laser, and ultrasound [100, 120].

## QUALITY OF LIFE AND AGING IN SPINAL CORD INJURY

Elderly people suffering from SCI seem to show the greatest decline in activity and functioning in personal and social life, as well as deterioration in life satisfaction [14]. The functional independence of patients after SCI decreases with the passage of time following the SCI [121]. However, studies by Amsters *et al.* showed that initially, during the first 10 years after the SCI, patients experience a relative functional improvement, and only beyond that time is a functional decline observed, along with a greater dependence on agents that facilitate the movement of patients [122].

It has been proven that aging has a greater impact on the self-assessment of health by people with SCI compared to those without the injury [123]. The worst assessed aspects of the quality of life were sexual life and loss of health, employment, and finances [124-126]. The quality of life of older patients with SCI is influenced by changes in complications and comorbidities and environmental factors over time (economy, technology) [125-127], as

well as reduced social integration and participation in social life [124, 127]. It has been proven that life satisfaction is lower in patients after SCI compared to the general population [128, 129]; there is a relationship between age and the assessment of life satisfaction in patients after SCI [129]. It has been demonstrated that early observations about the patient's life satisfaction can be used as predictors of their assessment of it at a later stage [130].

## CONCLUSIONS

A number of studies have supported the finding that individuals with SCI age faster than the able-bodied population. Our knowledge of this area is growing through research, clinical experience, and the self-reported outcomes of people living with SCI. The more we know about the complications caused by SCI and their treatment, the faster we can identify them and minimize their effects. The consequences of SCI overlap with problems related to aging, hence patient care requires knowledge, early identification of the problem and the quick implementation of the treatment. Therefore, adequate care for these patients, education for health care providers, patients and their families, access to treatment methods, development of new technologies and the continuation of research on this issue are critical. Due to the continuous development of medical technologies for the treatment and prevention of SCI, nowadays, in addition to classic methods including physical therapy and pharmacotherapy, new therapies such as functional stimulation, drug injection, implantation of stimulating systems, robotics are also applied. The choice of treatment method always requires an individual approach as the implementation of appropriate treatment does help people with SCI with the aging process more effectively while it also minimizes the effects of the disease and improves the quality of their lives.

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Absent.

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