International Journal of Physical Medicine & Rehabilitation

Sieman et al., Int J Phys Med Rehabil 2018, 6:5
DOI: 10.4172/2329-9096.1000485

Review Article Open Access

A to Z: Current Spinal Cord Injury Rehabilitation

Jony Sieman[1]*, Mohammad Yusof Ibrahim[2] and Constance Sat Lin Liew[3]

[1]*Department of Surgical Based Discipline, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Malaysia*

[2]*Department of Community and Family Medicine, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Malaysia*

[3]*Department of Medical Based Discipline, Universiti Malaysia Sabah, Malaysia*

***Corresponding author:** Jony Sieman, Department of Surgical Based Discipline, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Malaysia, Tel: 62109312678; Email: Johnsie1@ums.edu.my

Received date: September 13, 2018; **Accepted date:** September 19, 2018; **Published date:** September 20, 2018

Abstract

Over the past century, the remarkable advances in health care have changed the outlook on Spinal Cord Injury (SCI). The "*grim prognosis*" has become a story of the past, and today, the life expectancy of the SCI survivors has been comparable to that of general population, and the health care providers are working harder to improve quality of life of SCI patients, whilst various ongoing research are promising for a better healing potentials. At this moment, resources, management strategies and policies are important factors that must be properly managed to further improve the SCI outcomes.

As a newcomer, the telerehabilitation system promises to resolve issues on unmet medical needs, financial and manpower constraints, rehabilitation interventions and independence of activities of daily living.

Keywords: Rehabilitation; Spinal cord injury; Telerehabilitation; ASIA

Introduction

The spinal cord extends from the foramen magnum to the lower border of the first lumbar vertebra and the etiology of injury can generally be classified as: traumatic and non-traumatic [1]. In the era of ancient Egypt, the Spinal Cord Injury (SCI) was illustrated as "*an ailment not to be treated*", a fatal illness that requires laborious treatment. The victims were described as suffering catastrophic injury, losing control of motor, sensory, vasomotor as well as urination functions. Nevertheless, over the past decades, following remarkable advances in knowledge, acute medical and surgical care, the survival rate of SCI victims has increased, resulting in more demands on efforts to improve the Quality Of Life (QOL) of survivors. The multi-faceted issues which encompasses physical and psychosocial aspects, coupled with the life-long disabilities nature of SCI necessitates care of various disciplines. Nowadays, a "*well-organized and comprehensive care*" for SCI has replaced the "*old mindset*" and concepts of "*ailment not to be treated*". In 1995, Joel A. De Lisa and other leaders in the field of Rehabilitation Medicine successfully brought SCI Medicine as a subspecialty under the American Board of Physical Medicine and Rehabilitation [2]. The subspecialty of SCI medicine addresses the prevention, diagnosis, treatment and management of SCI [3].

Serious disability caused by SCI necessitates prolonged, costly and exhausting treatment and rehabilitation, giving rise to economic as well as psychosocial problems [4]. During acute and chronic phase, multiple organ function alterations require timely anticipatory actions so that general health can be maintained and maximum functional capability can be regained [5]. The provision of appropriate rehabilitation services is essential to minimize the deleterious effect of immobilization as well as to properly manage the consequences of spinal cord dysfunction. The ultimate goal of comprehensive SCI rehabilitation is the improvement of the quality of life to as reasonably as possible to a level close to that of persons in normal society. Proper application of knowledge and technology will substantiate patients' independence, facilitate their return to the communities to participate in increasing productivity.

Various spinal cord repair research since the past few decades have resulted in huge progress in insights about molecular and cellular events generated by SCI, and along with the research, various treatment modalities have been studied for their healing properties. So far there is still lack of evidence to definitively support the neuroprotective benefits of the modalities (pharmacologic and non-pharmacologic agents) that have been studied, therefore the treatment of SCI is largely considered as palliative [6].

Assessment of the neurological impairment is important in predicting the prognosis, updating the rehabilitation efforts, and setting up the functional goals [7]. The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) published by American Spinal Injury Association (ASIA) has been used as an international communication tool for researchers and clinicians to quantify the various degrees of neurological impairment resulting from spinal cord injury. The latest revision was available since February 2013 [8].

To achieve the rehabilitation goals, rehabilitation medicine practices interdisciplinary team approach. The "*team work*" model has been the distinguishing feature of rehabilitation medicine practices from other medical specialties. The team is led by a physiatrist (doctor, specialist in physical medicine and rehabilitation) and consists of the patient and family members, dieticians, occupational therapists, physiotherapists, prosthetists/orthotists (P&Os), psychologists, rehabilitation nurses, social workers, chaplains, speech therapists, respiratory therapists, and other consultant specialists as necessary.

In the past 2 decades, telerehabilitation services for SCI has been strongly encouraged by the immensely integrated Information Technology (IT) in the society, affordable IT, user friendly IT, and an abundance of internet information on SCI. In some rehabilitation centers, it seems that judicious adoption of applicable technology may be a necessity. This review intends to provide an overview of the current rehabilitation medicine practice on SCI.

Opportunities and Challenges in SCI Rehabilitation

Rehabilitation is a complex process of the integrated application of many procedures to achieve the restoration of the individual to his or her optimal functional status at home and in the community that the appropriate utilization of all of that patient's residual assets allows [9]. The rehabilitation efforts to SCI are directed towards preventing secondary complications, promoting neuro-recovery and maximizing function, improvement of patient independence in Activities of Daily Living (ADL), helping patient in accepting a new lifestyle and facilitating community reintegration [10]. World Health Organization (WHO) has defined rehabilitation as a progressive, dynamic, goal-oriented and often time-limited process, which enables an individual with an impairment to identify and reach his/her optimal mental, physical, cognitive and social functional level [11]. Crucial issues such as: the extent of recovery to be anticipated, expected independent activities, equipment and assistance needed, level of productivity and community integration can be achieved, and quality of life can be achieved for SCI patients have been clarified by Clinical Practice Guidelines (CPG). However, there is no attempt to define the components, character, or quantity of rehabilitation treatments, interventions, or processes that result in successful outcomes after SCI [12]. On the other side, the current declining in resources requires the rehabilitation healthcare providers to be efficient in implementing the most cost effective protocols to achieve the patient's optimal function. For SCI patients, the primary functional outcome of interest is the ability to walk. Other concerns are personal care abilities, sexuality, occupational and recreational handicaps [7].

"*Appropriate*", "*seamless delivery*" and "*integration*" of rehabilitation services are among the reasonable "*answer keywords*" for optimization of SCI rehabilitation outcomes. Specialized SCI centers have been developed and are operating in many countries such as: US (14 Spinal Cord Injury Model Systems) [13], UK (12 Spinal Injury Units) [14], and Australia (6 Spinal Units) [15]. Such specialized SCI centers, compared to non-specialized environment (commonly orthopaedic or general rehabilitation centers) have provided significant superior outcomes in the area of health, functional and social [14]. Fewer medical complications, improved rehabilitation efficiency, reduced length of acute hospitalization and hospital charges, and higher percentages of discharging patients to private residences have been reported as the success of SCI centers that run their activities using a systems approach in which there is a coordination of works of e.g.: the emergency rescue, acute care, rehabilitation, follow up and vocational services [1]. In this model of services, the professional providers have better chance to develop expertise in SCI care, patients get better access to variety of helpful experts, vocational and educational services, active peer support as well as opportunity to undergo rehabilitation with other patients with similar impairments [16]. However, so far, there is no international consensus on what constitutes the essential elements of SCI rehabilitation, therefore the definition of specialized SCI rehabilitation remains to be established. Spinal Cord Injury Research Evidence (SCIRE) Project [17] has attempted to propose an operational definition of specialized SCI rehabilitation:

"*A specialized SCI rehabilitation program provides comprehensive and patient-focused rehabilitation services, for inpatient, transitional living, outpatient and follow-up care, to empower people with SCI and their families to achieve optimal quality of life continuing into the community (focusing on increasing self-reliance and gaining independence). Through organized regional referrals, care is delivered through a multidisciplinary team provided by board certified physician specialists and accredited allied health professionals (i.e. physical/occupational/speech/ recreational therapists, nurse specialists, psychologists, dieticians, engineers, social workers, etc.). As a rehabilitation program specialized in the care of people with SCI (experienced through trauma or disease), active participation in research is facilitated through university affiliated teaching institutions*".

"*Areas of further expertise may include specialized clinics (i.e. seating, audiology, pain, wound, sexuality/reproduction), respiratory/paediatric services, community/peer-support/fitness-wellness/health-maintenance/injury-prevention/day/combined (i.e. brain injuries, strokes, amputations, orthopedic conditions, neuromuscular diseases, burns and related disabilities) programs, support groups, vocational counseling, innovation/research updates, education, etc. Such specialized programs will be nationally (and possibly internationally) recognized and may be accredited through independent accreditation bodies (e.g., CARF/Commission on Accreditation of Rehabilitation Facilities; JCAHO/Joint Commission on Accreditation of Healthcare Organizations; AC/Accreditation Canada)*".

In particular, the SCIRE Project has further defined the distinctive feature of specialized SCI rehabilitation facility, that in contrast to the general rehabilitation facility, the specialized SCI rehabilitation is designed to provide acute medical services and diagnostics that are capable of handling complex medical conditions which involving multiple body systems in SCI (with or without impaired cognition).

CPG by The Consortium for Spinal Cord Medicine have emphasized the important role of SCI specialized center [17]. However, to improve outcome and reduce morbidity, a lot of effort needs to be done in promoting standardization of care, decreasing the heterogeneity of management strategies and encouraging clinicians to make evidence-informed decisions, as well as influencing policy changes to ensure adequate resource allocation [10].

The majority of Spinal Cord Injury (SCI) cases are caused by trauma, however since the last 3 decades, along with the increasing life expectancy, there is a trend of increasing proportion of SCI from Non-Traumatic category (NT SCI) [18]. Spinal stenosis and neoplasm growth are the most common causes of NT SCI presenting for inpatient rehabilitation in United States (US) [3]. Nitin et al. [19] in an analysis of survey data from the US Nationwide Inpatient Sample databases for 1993-2012 found that a high rate of increase of SCI observed in men aged 65 to 74 years. The spinal cord injury associated with falls in those aged 65 years or older increased significantly from 28% in 1997-2000 to 66% in 2010-2012. They also highlighted that between 1993 and 2012, the incidence rate of acute traumatic spinal cord injury remains unchanged at 53 to 54 cases per million population [19]. Falls on the same level from slipping, tripping, and stumbling are the most common cause of fall induced SCI (20%), followed by falls from building (16%), stairs and steps (16%), and ladder (9%). People who are 61 years of age and older had the highest

frequency of falls on the same level [20]. Due to the higher frequency of cervical spinal stenosis, with relatively minor trauma, elderly people pose a greater risk of cervical SCI [3], and with high neurological level of injury, more costs for caring are needed [21]. Developing and implementing an effective fall prevention program may be a reasonable solution for SCI primary prevention in this group of population. Van den Berg et al. [18] in a systematic review study reported that annual crude incidence rates in traumatic SCI varied from 12.1 per million in the Netherlands to 57.8 per million in Portugal. Most of the traumatic SCI studies show a bimodal age distribution. The first peak is found in young adults between 15 and 29 years and a second peak in older adults (mostly 65 years) [18]. The arrangement of rehabilitation resources may need to cater to the local-actual epidemiologic facts, specific aging-related and geriatric needs [3].

The 2018 SCI data sheet from National Spinal Cord Injury Statistical Center (NSCISC) revealed that the annual incidence rate of SCI remains at 54 cases per one million people in the US (not including those who die at the scene of accident), the prevalence is estimated to be approximately 288,000 persons (ranging from 247,000 to 358,000), 78% of new SCI cases are male, vehicle crashes are the leading cause of injury [22]. In the state of Utah, the incidence of pre-hospital SCI death from the year of 1989 to 1991 is reported to be approximately 4 cases per million populations. There are variations in SCI incidence rate among states due to differences in population demographic characteristics, the definition of SCI, and the data collection methodology. The incidence rate tends to be highest for persons in their late teens and early twenties, consistently declining in later ages and lowest for the pediatric age group [23]. Across the US, SCI cases in children and adolescents under the age of 15 represents 5 percent of total SCI cases; with 38% to 64% are caused by motor vehicle accident, 23% are related to sporting injuries, and there is an increasing trend of violence as the cause [1]. However, in Australia, most SCI in children relates to non-traumatic causes, including tumors and transverse myelitis [15]. The most common age at injury is 19 years [23]. Lengths of stay in the hospital acute care unit have declined from 24 days in the 1970s to 11 days currently. Rehabilitation lengths of stay have also declined from 98 days in the 1970s to 34 days currently [22]. The pressures of managed care, as much as improvements in medical and rehabilitative expertise, are believed to be important factors that have driven the rehabilitation LOS declines [24]. Incomplete tetraplegia (47.2%) is the most frequent neurological category. The frequency of incomplete and complete paraplegia is virtually the same (around 20%). Less than 1% of SCI survivors experienced complete neurological recovery by the time of hospital discharge [22]. More than half (63.4%) of SCI patients are employed or in school at the time of their injury, and 53.7% are unmarried (1). The average age at injury has increased from 29 years in 1970s to 43 years in 2018 [22]. The Australian Spinal Cord Injury Register (ASCIR) revealed similar trend of increased average age at injury (38 years in 1995-96 to 42 years in 2007-08), and transport-related injuries (46%) and falls (28%) are the main contributors to traumatic SCI [15]. At one year after injury, about 12% of persons with SCI are employed, and at 20 years post injury, about one third is employed. The employability rate remains constant at 30 and 40 years post injury [22]. Persons who return to work within the first year of injury usually return to the same job and employer, while those who return to work after 1 year usually acquire a different job, different employer and often after retraining [3]. About 30% of persons with SCI are rehospitalized one or more times during any given year following injury. Among those rehospitalized the length of hospital stay averages about 22 days. Diseases of the genitourinary system are the leading cause of rehospitalisation, followed by disease of the skin. Respiratory, digestive, circulatory, and musculoskeletal diseases are also common causes. During the 40 years of patients' follow up, the causes of death that appear to have the greatest impact on reduced life expectancy for SCI population are pneumonia and septicemia [22]. Septicemia is usually associated with Pressure Ulcers (PUs), urinary or respiratory infections [3].

Unlike in the US, UK and Australia, in most Asian countries, data on SCI is very limited, and except in Taiwan and Japan, there are no traumatic SCI registries [25]. Nonetheless, by reflecting on the available data, it is expected that SCI's prevalence in Asia will also continue to grow up as in the US and other countries. The successful pre-hospital handlings (consist of evaluation, resuscitation, immobilization, extrication, and transportation) [26], advance medical and surgical care results in an increased rate of incomplete SCI injury (while the complete injury rate is decreasing) and SCI survivors as well, but however, inadequate rehabilitation in this growing population will lead to a high level of dependency, which in turn causes huge financial burden on the social welfare and public health care systems. Furthermore, there is a growing body of evidence [27] that intensive physical training in the outpatient rehabilitation settings enhances the functional achievement of incomplete SCI survivors.

A study from Tan Tock Seng Hospital, Singapore [28] revealed that the most common causes of SCI are industrial injuries (34.5%) and road traffic accidents (33.1%). Forty-four percent had cervical injuries, 29.6% had thoracolumbar injuries, and 20.8% had lumbar injuries. Tulaar [29], reported that, in 2017 the epidemiological data of SCI in Indonesia is starting to be collected. The data from the 292 newly diagnosed SCI during 2006-2009 in the Department of Rehabilitation Medicine, Hospital Kuala Lumpur [30], revealed that 77% of the victims are males, the mean age is 39 years with a range between 2 years and 82 years. Forty-six percent of the victims are of the lower income group earning less than USD 180 per month. More than half of the injuries (57%) are traumatic in origin, involving mainly young males of age between 16 to 30 years. Among the traumatic SCI, Motor Vehicle Accidents (MVA) are the main cause (66%), followed by falls (28%). Sixty-three percent are diagnosed as paraplegic and 37% are tetraplegic. About half (51%) are classified as severe SCI (ASIA Impairment Scale of A and B). A recent study in Taiwan [31] found that higher degree of education (college degree or higher), less functional limitations, perceiving greater social support are associated with higher likelihood of employment.

In the context of reduced lengths of stay in the hospital, the discharge planning has to include the anticipative measures on possible later complications as well as some later common health related SCI problems. The expected arising problems encompass physical as well as psychological issues. Mental health status and possible risk of psychosocial problems need to be evaluated as early as when in acute care [17]. Depression and denial may make it difficult for patient to adequately participate in the rehabilitation program. It is the duty of the physician to facilitate the patient's psychological adjustment by carefully and timely explaining the realities of the injury to the patient and family [32].

The life-long disability nature of SCI, combined with the increased risk of complications associated with SCI and aging process, requires the effective implementation of the concept of continuum of care for SCI population. Dr. Rusk [33], the founding father of rehabilitation medicine had stated: "*Rehabilitation of the chronically ill and the chronically disabled is not just a series of restorative techniques; it is a*

philosophy of medical responsibility. Failure to assume this responsibility means to guarantee the continued deterioration of many less-severely disabled persons until they too, reach the severely disabled and totally dependent category." Accomplishing the rehabilitation missions across the care continuum is done through several models of rehabilitation service delivery [27], and according to World Health Organization (WHO) rehabilitation guidelines [34], models of rehabilitation service delivery include: in-patient, out-patient (includes day rehabilitation), outreach (includes in-reach, mobile and telerehabilitation), and home-based. Within rehabilitation environment, the client centered care is expected to optimize physical recovery, function and psychosocial wellbeing, maximizes independence, vocation & lifestyle opportunities [27]. The services offered may include nursing, physical therapy, occupational therapy, respiratory management, medical management, recreation and leisure, psychology, bowel and bladder management, mobility training, self-care training, homemaking activities, vocational counseling, driver assessment and training, nutritional services, speech pathology, social worker, sexual health counseling, assistive device prescription and pharmaceutical services (Table 1).

Reference	Key statement
Ien et al. [7]	The current declining in resources requires the rehabilitation healthcare providers to be efficient in implementing the most cost effective protocols to achieve the patient's optimal function.
Smith et al. [14]	Specialized SCI centers, compared to non-specialized environment have provided significant superior outcomes in the area of health, functional and social.
Frederick [1]	Fewer medical complications, improved rehabilitation efficiency, reduced length of acute hospitalization and hospital charges, and higher percentages of discharging patients to private residences have been reported as the success of SCI centers that run their activities using a systems approach.
Early Acute Management in Adults with Spinal Cord Injury: A CPG for Health-Care Professionals [17].	The Consortium for Spinal Cord Medicine have emphasized the important role of SCI specialized center. However, the definition of specialized SCI rehabilitation remains to be established.
Fehlings et al. [10]	To improve outcome and reduce morbidity, a SCI center need to do a lot of effort in promoting standardization of care, decreasing the heterogeneity of management strategies and encouraging clinicians to make evidence-informed decisions, as well as influencing policy changes to ensure adequate resource allocation
Berg et al. [18]	There is a trend of increasing proportion of SCI from Non-Traumatic category (NT SCI)
Jain et al. [19]	There is high rate of increase of SCI observed in men aged 65 to 74 years. The spinal cord injuries associated with fall in those aged 65 years or older have increased significantly.
NSCISC [22].	The annual incidence rate of SCI remains at 54 cases per one million people in the US. The average age at injury has increased from 29 years in 1970s to 43 years in 2018. The frequency of incomplete and complete paraplegia is virtually the same (around 20%).
	At one year after injury, about 12% of persons with SCI are employed, and at 20 years post injury, about one third is employed. The employability rate remains constant at 30 and 40 years post injury.
	Diseases of the genitourinary system are the leading cause of rehospitalisation, followed by disease of the skin. Respiratory, digestive, circulatory, and musculoskeletal diseases are also common causes.
	Septicaemia is the leading cause of death and is usually associated with Pressure Ulcers (PUs), urinary or respiratory infections.
https://www.aci.health.nsw.gov.au/__data/assets/pdf_file/0005/357251/Spinal-Cord-Injury-Model-of-Care-Diagnostic-Report.pdf [15].	The Australian Spinal Cord Injury Register (ASCIR) revealed similar trend of increased average age at injury (38 years in 1995-96 to 42 years in 2007-08), and transport-related injuries (46%) and falls (28%) are the main contributors to traumatic SCI.
DeVivo et al. [23]	The SCI incidence rate tends to be highest for persons in their late teens and early twenties, consistently declining in later ages and lowest for the pediatric age group.
Whiteneck et al. [24]	The pressures of managed care, as much as improvements in medical and rehabilitative expertise, are believed to be important factors that have driven the rehabilitation Lengths Of Stay declines.

William [26]	Advance medical and surgical care results in an increased rate of incomplete SCI injury (while the complete injury rate is decreasing) and SCI survivors as well, but however, inadequate rehabilitation in this growing population will lead to a high level of dependency, which in turn causes huge financial burden on the social welfare and public health care systems.
Ning et al. [25]	In most Asian countries, data on SCI is very limited, and except in Taiwan and Japan, there are no traumatic SCI registries.

Table 1: The key points about the opportunities and challenges in SCI rehabilitation.

Asia Impairment Scale

The need for a standardized model of care for the growing population of SCI was one of the important reasons for the development of the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI), and the continuous refinement of the "*standards"* is the reflection of efforts to improve the many aspects of the standards, including but not limited to its reliability, validity, documentation, practicality, objectivity, and prognostication [35]. The ISNCSCI is published by the American Spinal Injury Association (ASIA), and it has been widely used as an international communication tool for researchers and clinicians to quantify the neurological impairment resulting from spinal cord injury [8]. However, to ensure accuracy or to properly assess the impairment resulted from SCI, proper training is mandatory [36].

The neurological examination described in the ISNCSCI does not represent a comprehensive neurological examination for a patient with SCI, and compared to standard neurological examination, some differences exist. Based on experts consensus, considering the current knowledge and the many specific aspects to SCI, the manual for the ISNCSCI recommends all testing for motor function be conducted in supine position(except for the rectal examination that can be performed side-lying) regardless of the level of muscle strength, and the specific function of the muscle as well. A muscle may be graded as normal (muscle strength on manual muscle testing/MMT=5) if it is felt to be fully innervated even with the presence of pain or spasticity which causes some inhibition to muscle performance. The required sensory modalities to be tested are sharp/dull (pinprick) discrimination and light touch. Testing for the appreciation of deep pressure in the anal area is required for confirmation purpose when the anal sensation to pinprick or light touch is not conclusive. Other sensory tests such as joint movement appreciation, deep pressure appreciation; are believed to have clinical values, but are considered optional. Testing of each sensory modality has to be performed using a standard method in specified key sensory points. Alternative spots in the particular dermatome may be used in certain conditions such us in case of casting, laceration, and amputation; but a notation should be made. A standard safety pin and a tapered wisp of cotton is the standard tool used for testing pinprick and light touch respectively. Minimal data set, high validity, high precision and reliability which are obtained in accordance with ISNCSCI will be very helpful in multicentre research. With ISNCSCI, several measures of neurological impairment are generated; consist of: 4 separate neurological levels (left sensory level, left motor level, right sensory level, and right motor level), sensory scores (pinprick and light touch), motor scores (upper and lower limb), and Zone of Partial Preservation (ZPP). The sensory level is the most caudal, normally innervated dermatome for both pin prick (sharp/dull discrimination) and light touch sensation. The motor level is the lowest key muscle function that has a grade of at least 3 (on MMT), providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5 on MMT). The NLI refers to the most caudal segment of the spinal cord with normal sensory and antigravity motor function on both sides of the body, provided that there is normal (intact) sensory and motor function rostrally. The sensory scores refer to a numerical summary score of sensory function. There is a maximum total of 56 points each for light touch and pin prick (sharp/dull discrimination) modalities, for a total of 112 points per side of the body. The motor scores refer to a numerical summary score of motor function. There is a maximum score of 25 for each extremity, totalling 50 for the upper limbs and 50 for the lower limbs. The ZPP refers to those dermatomes and myotomes caudal to the sensory and motor levels that remain partially innervated [37].

Tetraplegia (preferred to "*quadriplegia*") is the term used in ISNCSCI to impairment or loss of motor and/or sensory function in the cervical segments of the spinal cord due to damage of neural elements within the spinal canal. Persons with tetraplegia have impairment of function in the arms as well as typically in the trunk, legs and pelvic organs, i.e., including the four extremities. It does not include brachial plexus lesions or injury to peripheral nerves outside the neural canal. Paraplegia is the term refers to impairment or loss of motor and/or sensory function in the thoracic, lumbar or sacral (but not cervical) segments of the spinal cord, secondary to damage of neural elements within the spinal canal. Persons with paraplegia have spared arm functioning but, depending on the level of injury, the trunk, legs, and pelvic organs may be involved. The term is used in referring to cauda equina and conus medullaris injuries, but not to lumbosacral plexus lesions or injury to peripheral nerves outside the neural canal. The terms: tetraparesis and paraparesis are not recommended to be used [37].

With the standardized and accurate measurement, an impairment scale which classifies the severity of injury can be generated. Single NLI is required when applying the classification for AIS C and D. In 2010, the ASIA developed the International Standard Training e-Learning Program (InSTeP), a web-based training program. The training courses are now available online, and further have been developed for the performance of the International Standards examination in the pediatric population (WeeSTeP) and the Autonomic Standards e-Program. The 2011 ISNCSCI has some substantial changes compared to the 2003 ISNCSCI reference manual, and with the 2011 ISNCSCI, the 2003 reference manual is no longer recommended to be distributed [38] (Table 2).

A	Complete	No motor or sensory function is preserved in the sacral segments S4-5. Sensory sacral sparing includes sensation preservation (intact or impaired) at the anal mucocutaneous junction (S4-5 dermatome) on one or both sides for light touch or pin prick, or Deep Anal Pressure (DAP). Motor sacral sparing includes the presence of voluntary contraction of the external anal sphincter upon digital rectal examination.
B	Incomplete	Sensory but not motor function is preserved in the sacral segments S4-5.
C	Incomplete	Motor function is preserved below the neurological level; more than half of key muscles below the neurological level have a muscle grade less than 3.
D	Incomplete	Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade greater than or equal to 3.
E	Normal	Sensory and motor function is normal.

Table 2: American Spinal Injury Association Impairment Scale.

Interdisciplinary Team Work in Rehabilitation

Rehabilitation medicine practices Inter-Disciplinary Team (IDT) approach. The "*team work*" model is considered appropriate for comprehensive rehabilitation practice and has been the distinguishing feature of rehabilitation medicine practice from other medical specialties. The team is led by a physiatrist (doctor, specialist in physical medicine and rehabilitation) and consists of the patient and family members, dietician, occupational therapist, physiotherapist, P&Os, psychologists, rehabilitation nurses, social workers, chaplains, speech therapists, respiratory therapist, and other consultant specialists as necessary [1]. Payers, case managers, biomedical engineers, audiologists, lawyers and employers can also be involved and collaborate in the process of achieving a sustainable outcome [37]. This team work model is expected to facilitate better group decision-making and group responsibility for optimal care planning. The concept of "*client-centered therapy*" is applied, in which the patient is considered part of this planning group and has a central role in the considerations [39]. Better compliance and satisfaction, reduced costs, lower mortality, reduced length of stay, and increased team member job satisfaction are among the benefits of the IDT approach [40]. Common values and objectives are the backbone for a rehabilitation team work to meet the patient's needs, restoration of patient's function to its fullest, and to reintegrating patient into all aspects of life [39].

Despite the potential for excellence, and advocated by some accrediting agencies (e.g., The Commission on Accreditation of Rehabilitation Facilities/CARF, The Joint Commission/TJC), however there are some drawbacks or challenges to the interdisciplinary team approach. The successful implementation of this team work model requires effective team dynamics and communication, but unfortunately, it was not sufficiently trained during each of the professionals training time, and as a solution, expensive team training may be needed. The health care system may refuse to pay for health services based on the patient desires, and the patients' autonomy in decision making may very much depend on their level of education. The physician may be uncomfortable with the team decision-making process as well as with the decision itself because the physician is the one who must usually assume the greatest medico legal responsibility for the team actions and plans [39].

Effective IDT requires team leaders to possess good interpersonal skills, including communication and negotiation skills, a willingness to compromise, and ability to value and accept individual differences. Each team member should appreciate and aware of one's own talents, biases, and limitations. According to Secrest (2007), a number of components are required for an effective IDT: trust, mutual respect, and communication, coordination of care, knowledge, shared responsibility and commitment. In rehabilitation one thing is certain: no one discipline and no single approach can provide the comprehensive services needed to facilitate recovery from complex injuries and mitigation of multiple deficits (Table 3) [40].

1	Providing safe care	Consider ergonomics and space requirements to address the needs of patients and staff using manual and powered wheelchairs and specialised equipment.
		Allow clinical staff appropriate visual connection with patients.
		Minimising the need to move patients around the facility to access services.
		Provide spaces that promote interdisciplinary team based care, handover and information sharing.
		Use of technology.
2	Providing a healing environment.	Access to natural light and fresh air, temperature control (allowing local/patient control where possible), noise reduction.
		Therapeutic green spaces; visual art and music.
		Physical environment that enables patient independence and participation in rehab and daily living activities, socialisation with family and friends, interaction with peers.
3	Treating the whole patient	Recognition that the patient centered model incorporates family and friends; spaces should facilitate family/carers interactions (both social and for involvement in care).

		Principles of self-care: Patients have control over their own health care
		Support Privacy and dignity while allowing for the visibility needed for safe care.
4	The patient journey	Ensure care is provided in the most appropriate environment.
		Co-locating services/similar activity to utilize opportunities to share facilities, equipment, for flexible use and efficiencies.

Table 3: The four key aspects of a patient center care model (Adapted from the South Australia Spinal Cord Injury Services document (27)).

Telerehabilitation for SCI Services

Telerehabilitation refers to the delivery of rehabilitation and habilitation services via information and communication technologies [35]. By telerehabilitation, services that are possible to be carried out include assessment, monitoring, prevention, intervention, supervision, education, consultation, and counseling. Furthermore, telerehabilitation allows the expansion of service points, which may include health care settings, clinics, homes, schools, or community-based worksites [41].

In the past 2 decades, several rehabilitation centers have developed SCI tele-rehabilitation services. This long distance services are made possible by various conditions, such as the integration of Information Technology (IT) in the society, affordable IT, user friendly IT, and a large amount of internet information on SCI. Nowadays, videoconferencing, email, texting, are no longer a luxury and rare thing. Robotic technologies, drones are now available for telerehabilitation. Non rehabilitative technologies or telemonitoring which may be needed such as remote monitoring for cardiogram, blood pressure and oxygen saturation are also available. Overall, telerehabilitation are cost effective [42]. According to Brennan et al. [43] "*telerehabilitation services are delivered to adults and children by a broad range of professionals that may include but not limited to physical therapists, speech-language pathologists, occupational therapists, audiologists, rehabilitation physicians and nurses, rehabilitation engineers, assistive technologists, psychologists, teachers, and dieticians. Paraprofessionals, family members, and caregivers may assist during telerehabilitation sessions*". In the context of telerehabilitation services, some terminology have developed; such us teleOT, telespeech which refer to specific rehabilitation services in Occupational Therapy (OT) and speech-language pathology respectively. It is important to note that safe and effective telerehabilitation requires specific training, skills and techniques. On top of that, specific issues relating to administrative, clinical, technical and ethical principles must be considered and properly addressed when telerehabilitation is about to be implemented [43]. Jongbae et al. [44] reported a great interest in telerehabilitation services among individuals with spinal cord injury, specifically on services aimed to resolve issues on unmet medical needs, rehabilitation interventions and independence of ADL. Services by telerehabilitation most required by patients are those to solve issues related to UTIs, PUs, neurogenic pain, OH, depression, obesity management, paralytic ileus, osteoporosis, and respiratory problems; while preferred communication methods are to use internet connected service, videophone or videoconference service, Internet Protocol Television Video (IPTV), video system with telemedicine service, and mobile or Personal Digital Assistant (PDA) [44]. The judicious adoption of the applicable technology (communication systems, microcomputers, and wireless sensors) may be needed to develop an effective telerehabilitation system that suits local needs [42].

Conclusions

Tremendous advances in knowledge, acute medical-surgical-rehabilitation care and technology in the last century provide greater hope for SCI survivors to get a better quality of life. However, currently, healthcare is facing resource constraints, and there is no single standard of services across the available SCI facilities. The specialized SCI centers as advocated by the Consortium for Spinal Cord Medicine are currently limited in number and only available in certain developed countries. The complexity of the problem in SCI patients requires highly skilled professionals, a supportive working environment, accurate data management, and an effective team work to provide all types of care: promotive; preventive; curative; rehabilitative; and supportive/palliative throughout the client's lifetime.

The current state of IT development has strongly supported the telerehabilitation system which promises to provide effective and efficient long-distance services to resolve issues on unmet medical needs, financial and manpower constraints, rehabilitation interventions and independence of ADL. However there are still many issues that must be addressed before its implementation.

Conflict of Interest

This review article does not involve any new studies of human or animal subjects performed by any of the authors, and no conflicts of interest to declare.

Acknowledgments

All named authors, take responsibility for the integrity of the work as a whole, and have given final approval to the version to be published. No funding or sponsorship was received for this study or publication of this article.

References

1. Frederick FS (2004) Spinal Cord Injury Medicine. Braddom RL (ed), Handbook of Physical Medicine and Rehabilitation. Saunders, Philadelphia, USA, pp. 814-858.
2. Ibrahim EM (2003) History of Spinal Cord Medicine. Lin VW (ed), Spinal Cord Medicine Principles and Practice: Demos Medical. New York, USA, pp: 3-14.
3. Steven K, Monifa B (2010) Rehabilitation of Spinal Cord Injury. Frontera WR (ed), DeLisa's Physical Medicine & Rehabilitation Principles and Practice. Wolters Kluwer Lippincott, Williams & Wilkins, Philadelphia, USA.
4. Nas K, Yazmalar L, Şah V, Aydın A, Öneş K (2015) Rehabilitation of spinal cord injuries. World J Orthop 6: 8-16.
5. Indira L, Willian H (1995) Spinal Cord Injury. Susan JG (ed), Physical Medicine and Rehabilitation Basics. Philadelphia: J.B. Lippincott Company.

6. Silva NA, Sousa N, Reis RL, Salgado AJ (2014) From basics to clinical: A comprehensive review on spinal cord injury. Prog Neurobiol 114: 25-57.
7. Ien S, Robert LW (2003) Outcomes Following Spinal Cord Injury. Vernon WL (ed), Spinal Cord Medicine. Principles and Practice. Demos Medical Publishing, New York, USA, pp. 87-103.
8. Schuld C, Franz S, Brüggemann K, Heutehaus L, Weidner N, et al. (2016) International standards for neurological classification of spinal cord injury: impact of the revised worksheet (revision 02/13) on classification performance. J Spinal Cord Med 39: 504-512.
9. Frederic K, Justus FL (1990) Preface to the Krusen's Handbook of Physical Medicine and Rehabilitation (4th ed). WB Saunders Company, Philadelphia, USA.
10. Fehlings MG, Tetreault LA, Aarabi B, Anderson P, Arnold PM, et al. (2017) A Clinical Practice Guideline for the Management of Patients With Acute Spinal Cord Injury: Recommendations on the Type and Timing of Rehabilitation. Global Spine J 7: 231S-238S.
11. https://scireproject.com/about-scire/rehab-from-bedside-to-community/rehabilitation/
12. http://www.pva.org/media/pdf/CPG_outcomes%20following%20traumatic%20SCI.pdf
13. https://msktc.org/about-model-systems/sci
14. Smith M (2002) Eficacy of specialist versus non- specialist management of spinal cord injury within the UK. Spinal Cord 40: 10-16.
15. https://www.aci.health.nsw.gov.au/__data/assets/pdf_file/0005/357251/Spinal-Cord-Injury-Model-of-Care-Diagnostic-Report.pdf
16. Ploumis A, Kolli S, Patrick M, Owens M, Beris A, et al. (2011) Length of stay and medical stability for spinal cord-injured patients on admission to an inpatient rehabilitation hospital: a comparison between a model SCI trauma center and non-SCI trauma center. Spinal Cord 49: 411-415.
17. Consortium for Spinal Cord Medicine (2008) Early Acute Management in Adults with Spinal Cord Injury: A Clinical Practice Guidelinefor Health-Care Professionals. J Spinal Cord Med 31: 403-479.
18. van den Berg ME, Castellote JM, Mahillo-Fernandez I, de Pedro-Cuesta J (2010) Incidence of spinal cord injury worldwide: A systematic review. Neuroepidemiol 34: 184-192.
19. Jain NB, Ayers GD, Peterson EN, Harris MB, Morse L (2015) Traumatic spinal cord injury in the United States, 1993-2012. JAMA 313: 2236-2243.
20. Chen Y, Tang Y, Allen V, DeVivo MJ (2015) Fall-induced spinal cord injury: External causes and implications for prevention. J Spinal Cord Med 39: 24-31.
21. Ho CH, Wuermser LA, Priebe MM, Chiodo AE, Scelza WM, et al. (2007) Spinal cord injury medicine. 1. epidemiology and classification. Arch Phys Med Rehabil 88: :S49-S54.
22. https://www.nscisc.uab.edu/Public/Facts%20and%20Figures%20-%202018.pdf
23. DeVivo, Michael J (2003) Epidemiology of Spinal Cord Injury. Vernon WL (ed), Spinal Cord Medicine Principles and Practice. Demos Medical Publishing, New York, USA.
24. Whiteneck G, Gassaway J, Dijkers M, Backus D, Charlifue S, et al. (2011) Inpatient treatment time across disciplines in spinal cord injury rehabilitation. J Spinal Cord Med 34: 133-148.
25. Ning GZ, Wu Q, Li YL, Feng SQ (2012) Epidemiology of traumatic spinal cord injury in Asia: A systematic review. J Spinal Cord Med 35: 229-239.
26. William W (2003) Prehospital Management of Spinal Cord Injured Patients. Vernon W.L (ed), Spinal Cord Medicine Principles and Practice. Demos Medical Publishing, New York, USA.
27. www.cpsu.asn.au/upload/2016-Info-Updates/UPDATED-SA-Spinal-Cord-Injury-Service-SubAcute-Model-of-Care-30-Nov-2016.pdf
28. Lim PA, Tow AM (2007) Recovery and regeneration after spinal cord injury: A review and summary of recent literature. Ann Acad Med Singapore 36: 49-57.
29. Tulaar AB, Karyana M, Karunia WL, Paulus AF, Tinduh D (2017) People with Spinal Cord Injury in Indonesia. Am J Phys Med Rehabil 96: S74-S77.
30. Ibrahim A, Lee KY, Kanoo LL, Tan CH, Hamid MA, et al. (2013) Epidemiology of spinal cord injury in hospital Kuala Lumpur. Spine 1: 419-424.
31. Huang IC (2017) Employment outcomes following spinal cord injury in Taiwan. Int J Rehabil Res 40: 84-90.
32. Murray FM (1990) Traumatic and congenital lesions of the spinal cord. Kottke FJ, Lehmann FJ (ed), Krusen's Handbook of Physical Medicine and Rehabilitation. W.B. Saunders, Philadelphia, USA.
33. Kottke FJ, Lehmann JF, Stillwell GK, Krusen FH (1982) Krusen's Handbook of Physical Medicine and Rehabilitation. WB Saunders, Philadelphia, USA.
34. www.who.int/disabilities/care/matrix.docx
35. Roberts TT, Leonard GR, Cepela DJ (2017) Classification in brief: American spinal injury association (ASIA) Impairment Scale. Clin Orthop Relat Res 475: 1499-1504.
36. https://scireproject.com/outcome-measures/outcome-measure-tool/american-spinal-injury-association-impairment-scale-ais-international-standards-for-neurological-classification-of-spinal-cord-injury/#1467983894080-2c29ca8d-88af
37. Kirshblum SC, Burns SP, Sorensen FB, Donovan W, Graves DE, et al. (2012) International standards for neurological classification of spinal cord injury, Revised 2011. J Spinal Cord Med 34: 535-546.
38. Kirshblum SC, Waring W, Biering-Sorensen F, Burns SP, Johansen M, et al. (2011) Reference for the 2011 revision of the international standards for neurological classification of spinal cord injury. J Spinal Cord Med 34: 547-454.
39. http://www.worldcat.org/title/delisas-physical-medicine-rehabilitation-principles-and-practice/oclc/703374597
40. http://samples.jbpub.com/9781449634476/80593_ch05_5806.pdf
41. https://www.matrc.org/telerehabilitation-telepractice
42. Peretti A, Amenta F, Tayebati SK, Nittari G, Mahdi SS (2017)Telerehabilitation: Review of the state-of-the-art and areas of application. JMIR Rehabil Assist Technol 4: e7.
43. Brennan D, Tindall L, Theodoros D, Brown J, Campbell M, et al. (2010) Alan lee a blue print for telerehabilitation guidelines. Int J Telerehab 2: 2
44. Jongbae K, Shinyoung L, Jayeon Y, Da-Hye K (2012) Telerehabilitation needs: A bidirectional survey of health professionals and Individuals with spinal cord injury in South Korea. Kim. Telemed J E Health 18: 713-717.