Important Clinical Rehabilitation Principles Unique to People with Non-traumatic Spinal Cord Dysfunction

Peter Wayne New, MBBS, M Clin Epi, PhD, FAFRM (RACP),^{1,2,3} Inge Eriks-Hoogland, MD, PhD,⁴
Giorgio Scivoletto, MD, PhD,^{5,6} Ronald K. Reeves, MD,⁷ Andrea Townson, MD, FRCPC,^{8,9}
Ruth Marshall, MBBS, DPRM, FACRM, FAFRM (RACP),^{10,11} and Farooq A. Rathore, FCPS, MSc^{12,13}

¹Spinal Rehabilitation Service, Department of Rehabilitation, Caulfield Hospital, Alfred Health, Caulfield, Victoria, Australia;

²Epworth-Monash Rehabilitation Medicine Unit, Southern Medical School, Monash University, Victoria, Australia;

³Department of Epidemiology and Preventive Medicine, Faculty of Medicine, Nursing & Health Sciences, Monash University, Victoria, Australia; ⁴Swiss Paraplegic Centre, Nottwil, Switzerland; ⁵Spinal Unit, IRCCS Fondazione S. Lucia, Rome, Italy;

⁶Spinal Rehabilitation (SpiRe) Lab, IRCCS Fondazione S. Lucia, Rome, Italy; ⁷Department of Physical Medicine & Rehabilitation, Mayo Clinic College of Medicine, Rochester, Minnesota; ⁸GF Strong Rehab Centre, British Columbia, Vancouver, Canada; ⁹University of British Columbia, Vancouver, Canada; ¹⁰South Australian Spinal Cord Injury Service, Hampstead Rehabilitation Centre, Northfield, South Australia, Australia; ¹¹Discipline of Orthopaedics and Trauma, School of Medicine, Faculty of Health Science, University of Adelaide, South Australia, Australia; ¹²Department of Rehabilitation Medicine, PNS Shifa Hospital, Karachi, Pakistan; ¹³Department of Rehabilitation Medicine, Bahria University Medical and Dental College, Bahria University, Karachi, Pakistan

Background: Non-traumatic spinal cord dysfunction (SCDys) is caused by a large range of heterogeneous etiologies. Although most aspects of rehabilitation for traumatic spinal cord injury and SCDys are the same, people with SCDys have some unique rehabilitation issues. **Purpose:** This article presents an overview of important clinical rehabilitation principles unique to SCDys.

Methods: Electronic literature search conducted (January 2017) using MEDLINE and Embase (1990-2016) databases for publications regarding SCDys. The focus of the literature search was on identifying publications that present suggestions regarding the clinical rehabilitation of SCDys. **Results:** The electronic search of MEDLINE and Embase identified no relevant publications, and the publications included were from the authors' libraries. A number of important clinical rehabilitation principles unique to people with SCDys were identified, including classification issues, general rehabilitation issues, etiology-specific issues, and a role for the rehabilitation physician as a diagnostic clinician. The classification issues were regarding the etiology of SCDys and the International Standards for Neurological Classification of Spinal Cord Injury. The general rehabilitation issues were predicting survival, improvement, and rehabilitation outcomes; admission to spinal rehabilitation units, including selection decision issues; participation in rehabilitation; and secondary health conditions. The etiology-specific issues were for SCDys due to spinal cord degeneration, tumors, and infections. **Conclusions:** Although there are special considerations regarding the rehabilitation of people with SCDys, such as the potential for progression of the underlying condition, functional improvement is typically significant with adequate planning of rehabilitation programs and special attention regarding the clinical condition of patients with SCDys. **Key words:** non-traumatic spinal cord injury, patient care management, rehabilitation, review, spinal cord damage, spinal cord diseases, spinal cord dysfunction, spinal cord injury

Non-traumatic spinal cord dysfunction (SCDys) refers to spinal cord damage that is not caused by trauma. The etiology of SCDys is extremely varied and heterogeneous,¹ with the most common causes being degenerative conditions of the spinal column, benign and malignant tumors, vascular problems resulting in infarction or hemorrhage, infections, or inflammation.^{2,3}

The incidence of SCDys is difficult to estimate due to its heterogeneous etiology and lack of reporting in most countries. However, the incidence of SCDys is estimated to be much higher than the incidence of traumatic spinal cord injury (SCI) in many developed countries.^{3,4} The incidence of SCDys in Canada is estimated to be 68 per million,⁵ and in the State of Victoria, Australia,

Corresponding author: Dr. Peter Wayne New, Spinal Rehabilitation Service, Department of Rehabilitation, Caulfield Hospital, Alfred Health, 260 Kooyong Road, Caulfield, Victoria, 3162 Australia; e-mail: p.new@alfred.org.au

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the incidence rate is estimated as 26 per million.⁶ Furthermore, the incidence of SCDys varies by both age and gender. The incidence of SCDys in females is much higher than in traumatic SCI, but is still less than in males, with a female to male ratio of 1:1.6.⁶ The typical age of people with SCDys is higher than in SCI, with the typical median age reported in the range of 60 to 65 years.²⁻⁹

One study estimated that half of the causes of SCDys are age-related conditions.¹⁰ With population aging, it is projected that in most regions of the world the proportion of the population aged over 65 years will double between 2000 and 2050.¹¹ As a result, it is anticipated that the incidence of SCDys will increase dramatically,⁶ and SCI rehabilitation centers will have to deal increasingly with the rehabilitation of persons with SCDys.

Most aspects of rehabilitation for traumatic SCI and SCDys are the same, but because of age, gender, and etiological differences, people with SCDys have some unique rehabilitation issues that are important to consider. Despite the forecast increase in SCDys, there is relatively little practical information in the literature regarding the rehabilitation management of these patients. Given this situation, we considered it inappropriate to prepare a typical formal systematic review. The aim of this article is to present a narrative review and give an overview of important clinical rehabilitation principles unique to people with SCDys, with a focus on both general differences and aspects that are unique to certain etiologies.

Methods

Literature search

We conducted an electronic search of the literature (January 2017) using the MEDLINE and Embase databases (1990-2016) for publications regarding SCDys, including the most common reported causes of these conditions (degenerative, benign or malignant tumor, vascular problems resulting in infarction or hemorrhage, infections, or inflammation). The terms used in the literature search were exactly the same as those used in a previously published gold standard comprehensive search strategy for SCDys.¹²

To identify publications on important clinical rehabilitation principles unique to people with SCDys, the publications identified by the above search were combined with the search terms “Recommendation*” OR “Patient Care Management”. The focus of the literature search was on identifying publications that present suggestions regarding the clinical management during rehabilitation of SCDys, especially concerning differences when compared to patients with SCI. Only publications in English were included. The search was restricted to the years 1990 and onwards, because we believed that prior to this date there would be very few publications of relevance. We screened publications identified by the above process by reviewing the title and abstract, and we reviewed the full text of those potentially of relevance. The processes involved are summarized in **Figure 1**. We also screened the reference sections of included publications for potentially relevant additional publications.

Figure 1. Flow chart of the search methodology and overview of results regarding rehabilitation management issues unique for people with spinal cord dysfunction.

In addition to the electronic search of the literature, we explored our personal libraries for additional potentially relevant articles. Our diverse backgrounds, as rehabilitation medicine physicians (physiatrists) from 4 different continents and developing and developed countries, meant that this strategy would increase the number of useful publications identified.

Data extraction: Presentation of findings

The lead author noted key clinical management themes identified in the literature. Subsequently, the co-authors added important additional points based on their clinical experiences and personal libraries that were not previously covered in publications. All authors had input into the wording of the comments and recommendations made that were based on opinion. Our consensus opinions are clearly identified as such throughout. It is important to note that we have considerable experience in managing people with SCDys, with a median of 20 years (range, 11-31 years) experience working with these patients. As such, we represent a panel of experts, and we made comments and recommendations that we believe are important and where there is an absence of published evidence. The findings are discussed in a narrative review below.

Results

Literature search

The electronic search of MEDLINE and Embase identified 6 potentially relevant publications.¹³⁻¹⁸ After reviewing these articles in detail, we found that none met the inclusion criteria (**Figure 1**). As a result, the publications included in this review were all identified from our libraries.

Classification issues unique to people with SCDys

Classification of etiology

The International Spinal Cord Injury Data Sets for Non-traumatic Spinal Cord Injury was published in 2014 and includes a basic and extended data set option.¹ These include a classification system for the many heterogeneous

causes of SCDys based on a 2-axis approach. The first axis uses a 2-tier (congenital-genetic and acquired), 5-level hierarchy that provides for increasing detail regarding the etiology. The conditions in the second level of the acquired tier are vertebral column degenerative disorders, metabolic disorders, vascular disorders, inflammatory and autoimmune diseases, radiation related, toxic, neoplastic, infection, and other miscellaneous causes (**Table 1**). Increasing specificity regarding the etiology of SCDys is given with each additional level, for example, neoplastic (level 2), benign (level 3), intramedullary (level 4), and ependymoma (level 5). The basic level of the data set consists of the etiology classified using axis one to the second level, as listed above. The levels in the classification can be collapsed down where the patient population is very small, for example, congenital and genetic, and expanded to more levels for more frequent causes. For example, infection (level 2) has the following in level 3: viral, bacterial, spirochaetal, fungal, and parasitic.

Table 1. Brief outline of classification on spinal cord dysfunction

Tier	Level 1	Level 2
Congenital - genetic	Congenital	Spinal dysraphism
		Arnold-Chiari malformation
		Skeletal malformations
		Other congenital
	Genetic disorders	Hereditary spastic paraplegia
		Spino-cerebellar
		Adreno-myeloneuropathy
		Other leukodystrophies
		Spinal muscular atrophies
Acquired	Acquired abnormalities	Genetic – other
		Vertebral column degenerative disorders
		Metabolic disorders
		Vascular disorders
		Inflammatory and autoimmune diseases
		Radiation related
		Toxic
		Neoplastic
		Infection
		Miscellaneous

Axis 2 uses the International Statistical Classification of Diseases to code the initiating diseases or process that caused the SCDys. Additional items in the dataset include the timeframe of the onset of SCDys symptoms (acute [≤ 1 day], subacute [≤ 1 week], prolonged [>1 week to month], and lengthy [>1 month]) and the presence of any iatrogenic component in the etiology. The non-traumatic datasets facilitate an improvement in comparative research involving people with SCDys, especially epidemiological and prevention studies.

We recommend that the International Spinal Cord Injury Data Sets for Non-traumatic Spinal Cord Injury¹ be used when classifying the etiology of SCDys in clinical practice and research.

Neurological classification

The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) were originally developed for traumatic SCI.¹⁹ Numerous authors have used them in people with SCDys,²⁰⁻²⁴ even though they have not been formally validated in these patients. It is believed, however, that for now, there is no reason why the ISNCSCI should not be used for describing the neurological impairment in people with SCDys.

General rehabilitation issues unique to people with SCDys

Predicting neurological improvement, rehabilitation outcomes, and survival

Predicting neurological improvement, rehabilitation outcomes, and survival following SCDys is extremely challenging, and the literature on these topics is scarce.^{3,4} People with SCDys tend to be older than those with traumatic SCI.^{2,3,5,6} As a result, even though there are no published studies to support our assertion, we believe that they have an increased occurrence of comorbid health conditions, such as obesity, diabetes, cardiovascular and respiratory diseases, or arthritis and other musculoskeletal conditions, and that the presence of these comorbid conditions can have an adverse influence on neurological improvement and rehabilitation outcomes. Level and grade of spinal cord damage influence neurological improvement

and rehabilitation outcomes. SCDys typically results in an incomplete grade of spinal cord damage.^{9,22} It is very difficult, especially in the early period, to know which patients with SCDys will change in their level or completeness of lesion. Another important issue that limits interpretation of research to date is that many studies include SCDys patients with different etiologies and different prognoses.²⁵ In particular, some conditions that cause SCDys are progressive, such as inoperable benign tumors, genetic conditions (eg, hereditary spastic paraplegia), inflammatory diseases (eg, multiple sclerosis and neuromyelitis optica), and infections (eg, human immunodeficiency virus).¹ It is much more difficult to predict the neurological and rehabilitation outcomes in these patients with progressive or potentially progressive SCDys than in patients with non-progressive causes of SCDys. Issues unique to people with SCDys due to tumor are discussed in detail in a section below, and many of these also apply to other progressive causes of SCDys. As a result of the above factors, we believe that predicting the neurological and functional recovery in people with SCDys is more difficult than in SCI.

In addition to the limitations previously outlined that influence predicting the neurological and functional outcomes, the comparison of samples of rehabilitation patients with SCI and SCDys is made additionally challenging because of referral and selection bias and the fact that many studies come from single centers, typically with small sample sizes. The findings across studies have shown a high degree of variability.

It has been reported that people with SCDys have major neurological improvement in the American Spinal Cord Injury Association Impairment Scale (AIS) grade.^{2,26} The authors, however, did not correct for the confounding effects of age, sex, impairment at admission, and the level of the lesion. In a study comparing SCI with SCDys, the same degree of neurological improvement was seen, with approximately 25% of AIS grade A, B, and C patients achieving an improvement of at least 1 AIS grade between admission and discharge.²⁷ A study of people with SCDys due to spinal cord abscess compared to a sample with SCI reported a greater AIS improvement in the abscess group.²⁸

A number of studies have compared rehabilitation outcomes in different SCDys etiologies^{9,27,29-36}

with samples of SCI. In some studies, SCI patients achieved greater functional improvement than SCDys patients, with the exception of patients with vascular-related SCI.^{32,33} One study found similar degree of improvements in SCDys compared with SCI, but the SCDys cohort had higher admission and discharge functioning than SCI⁹; other studies report comparable outcomes at discharge for the traumatic and non-traumatic populations.^{27,31,34,35}

In some studies, it seems that traumatic and non-traumatic patients have the same functional status at admission to rehabilitation.^{8,37} However, others authors report lower functional status for traumatic patients.^{9,27,36,38} It has been suggested that the low functional status of patients with traumatic SCI could be due to non-neurological trauma-related factors, such as major surgery sequelae, orthotics, and associated lesions that may affect the level of independence.²⁷ In some studies, patients with SCDys achieve lower functional gains during a shorter length of stay compared to traumatic patients.⁸ However, other authors report that traumatic SCI and SCDys patients at discharge have comparable levels of daily life independence, walking ability, and bladder control.²⁷

There are very limited data on survival after SCDys,^{9,39} and the generalizability is limited by the samples coming from a single center. A recent study found that SCDys from any etiology is independently associated with an increased mortality risk.⁹ The impact on life expectancy, however, varies according to the cause for SCDys. As would be expected, individuals with SCDys from metastatic cancer had the most limited survival after SCDys (1.6 ± 0.7 years), however other types of tumors did well. The survival of individuals with intramedullary tumors such as ependymomas did not differ from traumatic SCI. Following metastatic cancer, vascular SCDys due to ischemia had the second largest reduction in survival (mean survival, 5.5 ± 1.6 years). Age, male gender, SCDys etiology, and discharge functional status all influence survival after discharge from rehabilitation. Discharge FIM scores under 100 were associated with 10-year survival rates under 50%. Neither injury severity nor injury level is independently associated with survival after SCDys.⁹

Overall, persons with SCDys benefit from inpatient rehabilitation. As noted previously, discharge functional status is an important predictor of survival.⁹ Therefore, inpatient rehabilitation is as important for SCDys as it is for SCI. Similar to the wide range of outcomes following SCI, there is a wide range of outcomes following SCDys. Etiology, however, appears to be a critical factor in predicting outcomes following SCDys. Length of stay, outcomes, and survival all vary by SCDys etiology. Additional research is needed to identify optimal treatment pathways and to more thoroughly understand prognosis.

Admission to spinal rehabilitation units

There is evidence from numerous studies that people with SCDys have improved outcomes when admitted to a specialist spinal rehabilitation unit (SRU)⁴⁰⁻⁴² compared with those admitted to a general rehabilitation unit because of the improved access to critical services and spinal cord medicine rehabilitation expertise.^{40,43} Despite this, many spinal SRUs preferentially admit people with SCI over those with SCDys.^{40,44,45} This bias appears to be directed against those people with underlying malignancy as the cause of SCDys.⁴⁶⁻⁴⁸

Therefore, if the needs of people with SCDys are the same as people with SCI, a personalized rehabilitation program is similarly essential. Two particularly important aspects of SCDys rehabilitation are (1) the uncertain, variable, and, at times, gradually deteriorating, neurological prognosis and (2) the uncertain, variable, and, at times, relatively short, life expectancy. These uncertainties pose particular challenges in relation to resource allocation decisions. For example, is an expensive power wheelchair indicated if life expectancy is 6 months? 12 months? A comprehensive examination of issues surrounding ethics and resource allocation is beyond the scope of this article, but these considerations are important in SCDys rehabilitation.

As with SCI, comorbid secondary health problems such as age- and frailty-related considerations; environmental factors, particularly the home access and internal layout; and personal factors, especially the availability of a caregiver and financial resources, all impact the rehabilitation

plan. SCDys patients with limited life expectancy are managed with shorter rehabilitation hospital admissions that focus on basic rehabilitation goals and adaptation of temporary devices. Where possible, it is recommended that, before admission to a rehabilitation service, there is discussion between the patients, their families, and a senior rehabilitation physician (physiatrist) from the team regarding anticipated rehabilitation goals, estimated length of hospital stay, likely costs of equipment, possible home modifications, and an estimate of ongoing care. Further discussion on this issue for people with malignancy is provided below in the section, "Specific aspects relating to tumour as a cause of non-traumatic spinal cord dysfunction."

We strongly believe that there is no justification for any selection bias of SRUs against people with SCDys. Although evidence shows that persons with SCDys have better outcomes from inpatient rehabilitation in a specialized SRU,⁴² not all patients with a potential for functional improvement receive adequate rehabilitation.⁴⁵ This might be caused by a lack of information on rehabilitation potential by, for example, physicians and health insurance companies, as well a lack of available specialist rehabilitation programs for persons with SCDys. If there are challenges in meeting the demand for services to provide access to specialist SRU, then these should be addressed by a combination of lobbying of health bureaucrats and reconfiguring health systems models of care. For example, specialist in-reach teams provided in acute hospitals⁴⁹ and a hub-and-spoke model of service provision, with support from specialist SRUs to non-specialist rehabilitation units, are 2 models of health service delivery that have potential for providing increased access to specialist spinal rehabilitation services.

Participation in rehabilitation

Some people with SCDys require ongoing treatments during rehabilitation for health conditions associated with the cause of their SCDys. For example, patients may require plasma exchange, intravenous immunoglobulin, or immunosuppressant medications (eg, rituximab for inflammatory conditions, such as neuromyelitis optica). With optimal planning for these treatments,

it is possible to deliver them and rehabilitation services; these should not be a reason to defer transfer of a patient from acute wards to an SRU. Individuals with tumors may need radiation therapy or chemotherapy, and the scheduling of these treatments so as to minimize the impact on rehabilitation care is essential. For example, therapy might be better scheduled in the earlier part of the day and medical treatments delivered later in the day.

Because some rehabilitation units will not have experience with all specialist medical treatments, staff training may be necessary to ensure patient safety; not every treatment will be possible in every SRU. In our experience, however, the patient's rehabilitation needs and many types of medical management can be accommodated within the SRU.

Secondary health conditions in non-traumatic SCDys

Secondary health conditions after SCDys, such as pressure injuries, neuropathic pain, and spasticity, are prevalent, but they appear to be less common than in SCI during inpatient rehabilitation.^{10,50,51} In a community sample of people with SCI and SCDys, it was reported that there was no major difference in the occurrence or severity of most secondary health conditions in the 2 groups.⁵² However, another study from Canada reported that there was a lower prevalence of secondary health conditions in the SCDys cohort,⁵³ but this may be partially accounted for by those with SCDys having more incomplete spinal cord damage. Based on our clinical experience and expertise, we believe that the treatment of these conditions in principle does not differ between those with SCDys or SCI, after adjusting for age.

Sexuality issues

Although it has been proposed that people with SCDys have inferior sexual adjustment compared to those with traumatic SCI because they may have more medical complications that can potentially interfere with sexual rehabilitation programs,⁵⁴ this assertion is not supported by evidence from a recent study. This study, using the self-report version of the International SCI Data Sets for sexual function for males and females, found that, compared to those with traumatic SCI, those with SCDys were more likely to have sexual issues prior to

their SCDys, retain the ability to have orgasms, and be less likely to be able to ejaculate or menstruate.⁵⁵ Otherwise, there was no difference between those with traumatic SCI and non-traumatic SCDys regarding sexual problems or issues, the ability to have psychogenic erections or genital arousal, and the ability to have reflex erections or genital arousal. These differences could possibly be explained by the older age and higher frequency of incomplete spinal cord damage in people with SCDys. Another difference regarding sexuality in people with SCDys is that they have reported to be less likely to receive education regarding the consequences of SCDys for sexuality during SRU admission compared to those with traumatic SCI.⁵⁶ Overall, respondents with either etiology reported a low rate of having received sexuality education and a very poor satisfaction with the education provided. There was a belief among those with SCDys that there was a bias of staff against offering sexuality education to females, those who did not have a partner, and those who were older.

Specific aspects relating to degenerative causes of non-traumatic SCDys

Degenerative conditions of the spine are recognized as the most common cause of SCDys globally.^{3,22} When patients have a spinal fusion as part of the surgical management of their degenerative spinal condition, it is important for clinicians to remember that there can be late complications, including symptomatic adjacent spinal segment degeneration. This occurs in 5% to 18% of patients during a follow-up of 4 to 14 years.⁵⁷ As with all patients with SCDys or SCI, life-long follow-up in a specialist spinal rehabilitation review clinic is recommended as best practice.⁵⁸ In these reviews, it is important to question patients with previous spinal fusion about any symptoms regarding loss of function or pain that could indicate the hallmark of adjacent spinal segment degeneration.

Specific aspects relating to tumor as a cause of non-traumatic SCDys

Benign and malignant tumors are among the most common causes of SCDys, responsible for

between 15% and 30% of patients in SRUs that admit patients with any etiology of spinal cord damage.^{1,9,22} Having the dual diagnosis of a tumor causing SCDys presents enormous challenges for the patient, their family, and the rehabilitation team. Practical recommendations for rehabilitation teams concerning the management of people who have SCDys due to tumor have been reported previously.^{48,59-61} We highlight key aspects of these recommendations.

A framework has been previously proposed for guiding the rehabilitation of people with SCDys due to tumors, which forms an acronym, NOMPRS^{48,59}; this was based on earlier work in this area.⁶¹ The acronym stands for neurological, oncologic, medical, pain, rehabilitation, and support status of the patient. A detailed expansion of the NOMPRS framework and practical considerations for rehabilitation teams managing people with SCDys due to tumor are given in **Table 2**, which is adapted from previously published versions.^{48,59} The cornerstones of NOMPRS are as follows:

- N:** Neurological status. The more complete spinal cord damage, the worse the probability of improvement.²² Because SCDys lesions can be progressive, it is important to anticipate functional status changes.
- O:** Oncologic status determines the survival prognosis, which varies for different tumor types. Within the same tumor groups, there is also a wide variation in prognosis.
- M:** Medical comorbidities may have an additional influence on the ability of patients to participate in rehabilitation and require optimal management.
- P:** Pain is common and multifactorial. Comprehensive assessment is necessary to diagnose the cause(s) and formulate management strategies.
- R:** Rehabilitation-specific team and organization issues include a target length of stay for inpatient rehabilitation, based on previous studies and opinion of experts, of 4 to 6 weeks for those with a poor prognosis (eg, <6 months).^{46,48,62-64}
- S:** Social supports have a critical influence on discharge planning, particularly the person's ability to return to the community and remain at home as long as possible, if that is

Table 2. NOMPRS framework and practical considerations for managing people with spinal cord dysfunction due to tumors^a

Framework	Practical considerations
Neurological	<ul style="list-style-type: none"> • The AIS grade of severity on initial assessment is the basis for neurological prognosis.²² This is supplemented by the patient/clinician reporting or assessment of improvement since the onset of SCDys, together with the oncologic prognosis. • When the clinician provides the neurological and functional prognosis to the patient and family, this needs to balance hope against realism and be honest but empathic, particularly if the patient is within 4-6 weeks of onset.
Oncologic	
Prognosis	<ul style="list-style-type: none"> • A determination of oncologic prognosis is essential prior to accepting the patient for inpatient rehabilitation as it is vital for guiding rehabilitation goal setting and determining the anticipated length of stay. • Oncologic prognosis should be requested from the oncologist. Physiatrist experience and literature review should supplement understanding of the patient's life expectancy and functional prognosis. Oncologists reluctant to give a prognosis may be prompted to provide an estimate of the prognosis in terms of timeframes (for example <3 months, 3-6 months, 6-12 months, 1-2 years, >2 years). • If the prognosis is more than 3 months, then it is generally appropriate to consider inpatient rehabilitation admission. If it is less than 3 months, then consider admission to a palliative care unit. For patients cognizant of their limited life expectancy and who wish to return home, a very short rehabilitation admission for family/patient training and equipment prescription with discharge home utilizing hospice services may be appropriate. • The oncologist should provide management options and guidance if the tumor recurs or progresses quicker than anticipated.
Long bone metastases	<ul style="list-style-type: none"> • It is important to identify bone metastases at risk for pathologic fracture. Request appropriate specialty advice concerning fracture risk and whether there are weight-bearing limitations. If a high fracture risk is identified or restriction on weight-bearing is necessary, then prophylactic surgery and/or radiotherapy should be considered prior to inpatient rehabilitation admission.
Cancer treatments	<ul style="list-style-type: none"> • Oncologic treatments, including chemotherapy and radiotherapy, are not an absolute barrier to SRU admission. • Consideration of the nature of oncology treatment and the setting where this is to be given (whether within SRU/same site or off-site) and frequency of treatment is important. If weekly/twice weekly treatments are given off-site, then this should be able to be factored into the rehabilitation program. • If insurance limitations permit combined oncologic and rehabilitation treatment, then reasonable accommodations to allow SRU admission can often be achieved. • Scheduling cancer treatment in the afternoon may allow adequate time and energy for a self-care routine and therapy session(s) in the morning, especially if the person has incontinence issues or major mobility disabilities requiring a hoist for transferring.
Medical	<ul style="list-style-type: none"> • Physiatrists are best placed to manage spinal cord-related problems and comorbidities during inpatient rehabilitation. • Physiatrists have an important role in liaising with other specialists and the primary care physician.
Pain	<ul style="list-style-type: none"> • Pain does not have to be completely controlled prior to a patient's acceptance for inpatient rehabilitation. • If a patient can tolerate being transferred by hoist and can sit out of bed comfortably for 30 to 60 minutes, then he or she is considered appropriate for transfer to inpatient rehabilitation if it is believed that further improvement in the patient's pain is possible during admission. • Rehabilitation physicians in the SRU, along with relevant allied health staff, should have appropriate expertise to adequately manage patients with pain. • Pain management, if necessary, should be supplemented by palliative care, anesthetics, and/or pain program expertise.
Rehabilitation issues	
Reframe the mindset of the rehabilitation team	<ul style="list-style-type: none"> • The rehabilitation team should be educated to re-conceptualize that the goals and objectives for patients with SCDys from oncologic causes are different from those typically set for people with SCDys from other etiologies. This applies especially to compromises between ideal independent functioning and the actual goals. In patients with a poor prognosis, this is best served by a very short inpatient admission. • Set the discharge destination, goals of inpatient rehabilitation admission, and the estimated length of stay according to prognosis. • Recognize that death or transfer from rehabilitation to a hospice or palliative care is not a failure of rehabilitation. • Provide emotional support for staff to mitigate burn out and emotional distress. Strategies include debriefing to experienced colleagues, formal external psychological support services, and repeated education sessions focusing on how these patients differ from patients with other causes of spinal cord damage.

Table 2. NOMPRS framework and practical considerations for managing people with spinal cord dysfunction due to tumors^a (CONT.)

Framework	Practical considerations
	<ul style="list-style-type: none"> • The multidisciplinary team is expanded to include, where relevant, radiotherapy, oncology, palliative care, and surgery. Good communication between all involved is essential. • Recommend palliative and/or hospice care while the patient is still in rehabilitation if the prognosis indicates that these services may be required in the near future. In this situation, it is best to establish a relationship with the palliative care team early.
Length of stay	<ul style="list-style-type: none"> • The inpatient rehabilitation length of stay in people with malignant tumor causing SCDys should be as short as possible, taking into consideration the oncologic prognosis, in order to optimize their time in community and out of hospital. A “short, sharp, shiny” admission is the aim. Patients and their family should be asked what they hope to achieve during inpatient rehabilitation and what is needed to achieve an optimal discharge. It is important to determine what the family can do or provide. • Based on previous studies and the opinion of experts, a target length of stay for inpatient rehabilitation of 4 to 6 weeks is suggested for those with a poor prognosis (eg, <6 months).^{46,48,62-64} In the United States, a much shorter length of stay is the norm, typically 1 to 2 weeks. • If the patient or family expresses a wish to extend the length of stay beyond that recommended by the SRU team in order to achieve goals that the team do not consider absolutely necessary for discharge with consideration of the oncologic prognosis, a suggested strategy is to explain that the extra goals can be addressed through ongoing community-based or home-based rehabilitation after discharge. • People who had a malignant cancer and received presumptive curative treatment and those with a benign tumor do not need their hospital admission reduced unnecessarily. • Rehabilitation is often appropriate after discharge from inpatient rehabilitation into the community. This is particularly true for people with prolonged life expectancy. Ongoing formal therapy may address persisting disability, equipment prescription and revision, education of the patient or carers, and assistance with managing spinal cord damage-related issues, such as spasticity, pain, and continence.
Goal setting	<ul style="list-style-type: none"> • Important to focus inpatient goals on the practical aspects of managing at home. • Bladder: Recommend an indwelling catheter if the person has a malignant tumor, poor prognosis, and complete (or almost complete) spinal cord damage. • Fecal continence: Management depends on the assistance available after discharge and the discharge destination. If the prognosis is poor, then it is not inappropriate to discharge a patient still fecally incontinent as long as they have resources to manage at home or if they are going to nursing home. Otherwise, controlled continence should be a major priority for inpatient rehabilitation. • Equipment: Explore available options to loan or hire equipment instead of purchasing it if the prognosis is poor. • Home modifications: Focus on only those modifications that are essential for discharge. Consider temporary or portable ramps. It is often acceptable to discharge people home who do not have independent access in/out of home or access to all areas of their home. • Carer training is paramount.
Support status	
Pre-admission	<ul style="list-style-type: none"> • Social supports, including the immediate and extended family, the physical home environment, and financial resources, are crucial factors influencing whether timely discharge back into the community is viable. They will affect discharge planning and the length of stay in rehabilitation. It is important to determine the potential of supports to be adequate for facilitating discharge into the community as part of the acute hospital assessment prior to a decision regarding admission to SRU. • It is vital to gauge the expectations of persons with SCDys due to tumor and those of their family, educate both regarding realistic outcomes, and discuss the objectives of admission in the SRU and the likely timeframes.
Post-admission	<ul style="list-style-type: none"> • A family meeting should occur within 1 week of admission to rehabilitation in order to reconfirm overall rehabilitation goals, the discharge plan, and estimated length of stay. • There should be periodic meetings with the patient and family involving the rehabilitation physician and other team members if the patient/family need to clarify discharge plans and length of stay according to the oncological and functional prognosis. • It is important to provide support from clinical psychology staff and the rest of the rehabilitation team to help optimize the challenging adjustment faced by people with SCDys due to tumor.⁷⁹
Post-discharge	<ul style="list-style-type: none"> • Review of the social supports is needed to help sustain the discharge plans after leaving the SRU. If the patient has a malignant or progressive benign tumor, he or she should be maintained in the community for as long as possible.

Note: AIS = American Spinal Injury Association (ASIA) Impairment Scale; NOMPRS = Neurological, Oncologic, Medical, Pain, Rehabilitation and Support status of the patient; SCDys = (non-traumatic) spinal cord dysfunction; SRU = spinal rehabilitation unit.

^aAdapted from previously published versions of the framework.^{48,59}

what he or she desires. Supports can be either provided by the family or paid for by the patient or family.

Specific aspects relating to infections as cause of non-traumatic SCDys

Patients with infections resulting in SCDys are reported to account for between 2.5% and 13% of patients admitted into SRUs in developed countries^{2,36} and 25% to 44% in developing countries.^{51,65,66} The most common pathogens that cause infections resulting in SCDys are bacteria (especially *Staphylococci* and *Streptococcus* species in developed countries). *Mycobacterium tuberculosis* (especially in developing countries) and viruses are also well documented, while fungal and parasitic aetiologies are rare.^{36,67-70}

There are challenges to the early recognition of symptoms relating to the onset of SCDys in patients with an infectious cause, especially those due to bacteria and *M. tuberculosis*.^{71,72} Pain and weakness are the most common presenting symptoms, even more common than fever.³⁶ The insidious onset of clinical symptoms and the non-specificity of examination findings early in the onset of infections resulting in SCDys means that there is often a delay in diagnosis and management of these infections that increases their severity.^{71,72}

It is possible that cases of infections causing SCDys, including bacteria such as *M. tuberculosis*,⁷³ could be prevented by appropriate education programs targeting health care providers and focusing on strategies to raise awareness of key clinical features that suggest the possibility of an infectious cause for a SCDys.⁷⁴ National and global programs are needed to provide the education and resources necessary to reduce the incidence of infections causing SCDys. *M. tuberculosis* control programs in developing countries do not specifically address SCDys, resulting in increased morbidity and long-term disability.

Reported outcomes following SCDys due to infections are variable. Some authors have reported favorable neurological and function recovery to a better degree than with other causes of SCDys.^{22,74} It has been reported that people with an infectious cause of SCDys have significant improvement in their AIS grade,^{22,28,74} bladder and bowel continence,

and mobility.^{74,75} One study found that continence and especially mobility can continue to improve up to a year after rehabilitation discharge.⁷⁴ In contrast, a different study reported that infection-related SCDys patients had complete injuries more commonly, had lower functional status, and longer length of stay than patients with other causes of SCDys and with overall rehabilitation outcomes very similar to SCI patients.³⁶

Rehabilitation physician as a diagnostic clinician

Sometimes there are patients with SCDys who come under the care of a rehabilitation physician (physiatrist), either admitted into an SRU or seen in a clinic, with an unresolved diagnosis of their SCDys or with an incorrect diagnosis. A rehabilitation physician can sometimes identify a differential diagnoses not previously considered and commence investigations while starting functional rehabilitation. In some instances, the rehabilitation physician can make the correct diagnosis and start the appropriate condition-specific management plan or identify a medical reason for lack of improvement or deterioration in neurology or functioning. A number of examples of these situations have been discussed previously,⁷⁶ and others include spinal cord damage being mistakenly diagnosed as due to inflammation instead of spondylosis⁷⁷; and multilevel bacterial infections of the spine that are not recognized, especially tuberculosis, with only one level being identified in acute hospital work-up⁷⁸ until lack of improvement/deterioration in rehabilitation or medical instability triggers a search for the reason.

Based on these situations, and our clinical experiences, we feel that it is important to note that rehabilitation physicians working with people who have SCDys have a vital role as diagnostic clinicians to identify the correct diagnosis where there is a possibility of a missed or incorrect diagnosis.

Discussion

A number of important clinical rehabilitation issues unique to people with SCDys have been highlighted in this article. Classification issues were identified regarding the use of the International Spinal Cord Injury Data Sets for Non-traumatic

Spinal Cord Injury to classify the etiology of SCDys and the lack of formal validity testing of the ISNCSCI in people with SCDys. General rehabilitation issues involve the prediction of survival, improvement, and rehabilitation outcomes; decisions about admission into spinal rehabilitation units; participation in rehabilitation; and secondary health conditions. There were numerous important rehabilitation principles unique to persons with SCDys due to degenerative conditions, tumors, and infections that were identified. Finally, we identified a role for the rehabilitation physician as a diagnostic clinician.

As far as we are aware, this is the first article to synthesize the literature regarding issues unique to the rehabilitation management of people with SCDys and combine these with recommendations from experts. We have provided a framework for guiding clinicians who have less experience working with people who have SCDys that we hope will be useful for optimizing the rehabilitation outcomes. We decided against preparing this article as a formal systematic review, because we did not believe that there would be a sufficient number of publications of adequate scientific rigor to make such an approach of practical value to clinicians.

There are a number of limitations that need to be acknowledged. The inability of the

electronic literature search to find any relevant articles is possibly a reflection of the likelihood that the recommendations made in journal articles only appear in the discussion section and are not likely to be included in the abstract or considered in the listing of key terms for indexing in electronic databases. It may also be indicative of the different terms used to describe SCDys in the literature.¹² As a result, the literature search may have missed some important publications. To address this, we also searched our personal libraries for relevant publications. The inclusion of publications from our libraries does restrict the ability of researchers to replicate our method. However, given the results of the formal literature search, we believe that this approach was necessary and appropriate.

In conclusion, there are numerous special considerations regarding the rehabilitation of people with SCDy that are different from the rehabilitation of people with traumatic SCI. However, with adequate planning of the rehabilitation program and special attention to the clinical conditions of patients with SCDys, functional improvement is typically significant. People with SCDys should have the same access to specialist spinal rehabilitation as that available to people with traumatic SCI.

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