PHYSICAL AND REHABILITATION MEDICINE
for Medical Students

European Union of Medical Specialists (UEMS)
Board and Section of Physical and Rehabilitation Medicine

Editors
Maria Gabriella CERAVOLO
Nicolas CHRISTODOULOU

Project Managers
Franco FRANCHIGNONI
Nikolaos BAROTSIS

edi·ermes

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by Maria Gabriella Ceravolo - Nicolas Christodoulou (Editors)
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Forewords

European Academy of Rehabilitation Medicine

European Society of Physical & Rehabilitation Medicine

Physicians practice in a healthcare continuum that spans health, disease and disability.

Undergraduate medical education has the ultimate goal of training future physicians for appropriate competencies that meet reasonable patient expectations within a healthcare framework.

As any patient, after a disease or injury, may require rehabilitation treatment, all medical students need to gain a basic knowledge of Physical and Rehabilitation Medicine (PRM), an independent specialty, member of the Union of European Medical Specialists (UEMS) with a PRM Section and Board, recognizing that most will not practice as specialists in the field or carry out specific rehabilitation interventions.

Since 2008, a motion from the PRM Section and Board has been agreed and approved by the UEMS Council, that "undergraduate education in all the EU Medical Schools should include a teaching program on disability and rehabilitation issues".

Undergraduate training in PRM aims at basic knowledge in the social and medical model of disability, the ICF-model, as well as indications and contraindications of PRM-interventions and programs. These concepts already form part of obligatory training in PRM in most European countries.

The European Board of PRM has defined a core for an Undergraduate Training Curriculum with practical skills and definition of training period in a PRM department.

This e-book is a comprehensive guide that outlines what the Undergraduate PRM Curriculum needs to include, in order to support and enhance the development of undergraduate PRM education.

The book has been written by a group of well-known European PRM professors and clinicians, and in its 23 chapters, subdivided in five parts, it covers the development of skills, knowledge and abilities, that medical students must demonstrate by the time that they graduate. We have been particularly impressed by their excellent contributions!!

Special thanks to the book's editors (Maria Gabriella Ceravolo, President of the European Board of PRM, and Nicolas Christodoulou, President of the European Section of PRM) and book's project managers (Franco Franchignoni and Nikolaos Barotsis), for their hard work of compiling and organizing this document.

We are very happy and honored for the request to write the foreword for this multi-author e-book on "Physical and Rehabilitation Medicine for Medical Students", an educational initiative of the UEMS PRM Board, which in our opinion represents a remarkable achievement and an invaluable resource.

As Presidents of two PRM European bodies, we are delighted to endorse the initiative of this interesting e-book, which will enable medical teachers in PRM to develop excellent education in Undergraduate PRM training and inspire medical students.

Xanthi Michail
President of the European Academy
of Rehabilitation Medicine

Alain Delarque
President of the European Society
of Physical & Rehabilitation Medicine

International Society of Physical and Rehabilitation Medicine

The World Health Organization (WHO) defines Health as "*the complete physical, mental and social well-being and not merely the absence of disease or infirmity*" (Preamble to the Constitution of the World Health Organization, April 1948).

Significant advances in science and medicine have resulted in a profound change in health policy from a focus on acute, communicable (and lethal) diseases to the non-communicable, disabling and chronic diseases, and health conditions. An increase in life expectancy and ageing of the population also has led to the development of new health priorities that health systems must address.

Currently, in developed countries, outpatient care is responsible for the highest health expenditure (1); the prevalence of health conditions associated with severe disability has increased by nearly 183 million (compared to 2005); 74% of the Years Lived with Disability (YLDs) are linked to health conditions for which rehabilitation is beneficial (2, 3).

The World Report on Disability (4) states that disability prevalence is increasing affecting 15% of the global population in the World, 2-4% experiencing significant difficulties on functioning. Persons with disabilities represent an important part of the population of the World. Persons "experiencing disability" due to *sub-optimal health states interacting with the physical and social environment* (5) represent a much higher number, at least transitorily (almost) the entire population.

Medical Doctors must be aware of the above-mentioned reality, learn the philosophy and methodology of Physical and Rehabilitation Medicine (PRM), and understand the concepts of functionality and disability. The medical specialty of PRM must become a mandatory part of the undergraduate medical curriculum, training the medical students with the proper skills and knowledge needed to meet the healthcare needs of people with disabilities. Medical students must understand and learn, how to diagnose "disability" and the importance of the interaction between health conditions and the physical, social, cultural, and personal environment of an individual.

PRM is the "*...independent medical specialty concerned with the promotion of physical and cognitive functioning, activities (including behaviour), participation (including quality of life) and modifying personal and environmental factors...*"(6).

To include PRM in the medical student curriculum is **the** correct strategy to respond to the needs of people with disabilities in the 21st century. PRM can ensure healthy lives and promote well-being for all at all ages and can enable participation in education and gainful employment. PRM is essential in addressing the full scope of health needs of a population and achieving the United Nations Sustainable Development Goal n. 3: *Ensure healthy lives and promote well-being for all at all ages* (7).

ISPRM wishes to congratulate the European Union of Medical Specialists - Board and Section of Physical and Rehabilitation Medicine, the authors, editors and all that were responsible for this outstanding book on "Physical and Rehabilitation Medicine for Medical Students".

As President of ISPRM I am most honored for the invitation to write this foreword, wishing that this book become the standard for the undergraduate PRM education, not exclusively in Europe but also around the World.

Jorge Lains
President of the International Society
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Introduction

Rehabilitation medicine is a team-based aspect of medical practice that is patient centered, goal directed and aims to optimize patient function and quality of life, prevent complications and increase community participation.

This book has been written for medical students with the aim of providing the newly qualified doctors with the knowledge to apply basic rehabilitation principles to their clinical practice and appropriately assess and refer a person with a disability to rehabilitation services.

The incorporation of Physical and Rehabilitation Medicine (PRM) concepts into the medical student curriculum is expected to provide multiple benefits to medical students (and patients as well).

Beyond the fact that an increased awareness of PRM can give students a potential career option for specialty training, it must be underlined that medical students will be responsible for the care of patients with disabilities regardless of what field they choose to enter, as postgraduate trainees.

In the present times, patients treated by virtually all specialties express rehabilitation needs. In fact, epidemiologists teach that people currently survive what had formerly been a lethal disease but are now left to struggle on with impairment and disability, or to better say, with limitations in their activities and participation.

Medical students will learn from this book the concepts of the International Classification of Functioning Disability and Health (ICF), thus capturing the multifaceted components of health status definition and assessment.

Through an in depth knowledge of ICF, the students will be able to develop a framework in which to place the patient's medical needs in the context of the whole person, thus learning to incorporate patient's beliefs and values in the design of treatment plans in all aspects of medicine.

By reading this book, the students will come to know:

- how to include functional aspects into the history, physical examination, assessment, and management plan;
- which are the functional consequences and medical complications associated with certain diagnoses,
- which are the issues of preventive care for the physically impaired patient, and their potential for functional recovery through rehabilitation.

Finally, the main PRM concept of an interdisciplinary team approach to the patient' care needs will be described. The interdisciplinary premise is that the treatment team is an essential component in the delivery system of care, with application for all ages from pediatrics to geriatrics, and with a special emphasis on treating the individual through multiple stages and multiple settings, from the acute inpatient unit to the home-care environment.

Maria Gabriella Ceravolo
President UEMS PRM Board

Nicolas Christodoulou
President UEMS PRM Section

Part I

Fundamentals of Physical and Rehabilitation Medicine

The cultural background of rehabilitation

1

Mauro ZAMPOLINI, Christoph GUTENBRUNNER

THE ROOTS OF REHABILITATION

Rehabilitation therapy is a very important part of PRM activity. Before 1000 BC, Taoists priests in China employed Cong Fu, as movement therapy to relieve pain. The ancient Hindus used exercises consistent with body positioning to cure chronic rheumatism (arthritis). Around 500 BC in ancient Greece, Herodicus, the Greek physician, described gymnastic exercises for the prevention and treatment of disease. Hippocrates was the first physician to recommend therapeutic exercises. He understood the principle of muscle, ligament, and bone atrophy due to inactivity (1). Hippocrates was the first to use electrical stimulation, applying torpedo-fish electric shock for headaches and Aristotle recommended massage rubbing with oil and water as a treatment for tiredness. The Roman physician Galen described interventions to rehabilitate injuries in the second century, and believed that moderate exercises strengthened the body, increased body temperature, allowed the pores of the skin to open, and improved a person's spiritual well-being. During the Middle Ages, the philosopher-physician Maimonides emphasized Talmudic principles of healthy exercise habits, as well as diet, as preventive medicine in Medical Aphorisms, published between 1187-1190; and in 1569 the philologist-physician Mercurialis promoted gymnastics as both a preventive and a rehabilitative method in The Art of Gymnastics. In the eighteenth century, Niels Stenson explored the biomechanics of human motion and Joseph Clement Tissot's 1780 Medical and Surgical Gymnastics promoted the value of movement as an alternative to bed rest for patients recovering from surgery, facing neurological conditions, and recuperating after stroke. In the nineteenth century, the concept of neuromuscular re-education was proposed by Fulgence Raymond (1844-1910). The 20th Century was in fact the period in which biomedical technology has an exponential development and in which the diffusion of specific diseases, such as poliomyelitis, determines the elaboration of prostheses and devices useful for the global rehabilitation of people disabled because of disease. Another major source of disability is represented, in the 20th Century, by World Wars I and II. The great number of injured and mutilated soldiers induced the necessity to define the first Rehabilitation Unit within military hospitals or as charity product such as Stoke Mandeville Spinal Cord Unity in UK (2).

In Europe, the progress of medical rehabilitation went in the direction of further refinement of rehabilitative techniques and the proposition of new and original approaches. The physician Karel Bobath (1906-1991) and his wife Berta (1907-1991), physiotherapist, elaborated an innovative strategy for the rehabilitation of persons with disability due to disorders of the central nervous system. Several other methods has been developed during the 20th Century including the more recent task oriented therapy, robotics and new technologies (2).

Another historical root for rehabilitation in Europe and in particular for persons suffering from chronic diseases comes from balneology and climatology or health resort medicine, respectively. In the 19th and early 20th Century these treatments were used to cure chronic diseases like diabetes, cardio-vascular, lung or intestinal diseases as well as painful musculo-skeletal conditions. In some countries such as Germany this type of treatment (or rehabilitation) was included in the social security system, and some aspects of it later were integrated in modern rehabilitation concepts (3).

MOVING FROM DISEASE TO DISABILITY

At its founding in 1947, the WHO left behind the old notion of health as the absence of disease. The WHO felt that health was a state of human functioning that involves the whole person in his environment.

This vision was strengthened in 1986 by the Ottawa Charter for Health Promotion, which emphasized that although this was a feature of the person, the promotion and achievement of health necessarily involves the entire experience of the person and his environment (4).

Health promotion is the process of allowing people to increase control and improve their health. To achieve a state of complete physical, mental and social well-being, a person or group must be able to identify and realize aspirations, meet needs, change or face the environment. Health, therefore, is seen as a resource for everyday life, not a life goal. Health is a positive concept that emphasizes personal and social resources, as well as physical abilities. Therefore, health promotion is not only a responsibility of the health sector but goes beyond healthy lifestyles and wellbeing.

WHO' definition of health according to Alma Ata declaration (5) envisioned health not only as the absence of a disease but also the complete physical and social wellbeing. This enlarges the perspectives of interventions far beyond the cure of diseases and including other aspects of human life experiences such as daily activities and integration into society. With the UN-convention of the rights of people with disabilities (6) the concept of rehabilitation became part of the basic rights of persons experiencing disability. This it is consequent, that the WHO included this health strategy in its concept of Universal health coverage and works towards implementation of rehabilitation services wherever needed (7).

A step forward to move from the disease to the consequences has been done when, in the 1980 World Health Organization (WHO) Classification of Impairment Disabilities and Handicaps (ICIDH) distinguished between:

- *Impairment*, as loss of physical or mental functions, and represents the extension of a pathological state. If this dysfunction is congenital it is a matter of disability;
- *Disability*, or any limitation of the ability to act, natural consequence of a state of disability/impairment;
- *Handicap*, disadvantage experienced by a person as a result of disability or impairment/impairment.

This means that while disability is understood as the disadvantage that the person presents at a personal level, handicap represents the disadvantage of the person with disabilities.

The ICIDH provides the sequence: Impairment → Disability → Handicap, which, however, is not automatic, as the handicap may be direct as a result of a disability without the mediation of the disability status.

FROM ICIDH TO ICF

The ICDH has been a step forward moving from the disease concept to their consequences but revealed some limitation. On the one hand ICIDH makes it clear that handicaps are primarily caused by the social reaction to people with disabilities, the key element of the social model. On the other hand, ICIDH suggests a linear pattern in which the disease causes disabilities, causing disability and hence handicap, suggesting that all aspects of disability start from medical conditions, the fundamental element of the medical model.

Despite this confusion, ICIDH represents a significant advance in the disability debate. Conceptualization allows data collectors, political analysts, and researchers to identify what aspects are of relevance and to which are not. ICIDH also recognizes that disability is viewed in the light of the entire environment. ICIDH, however, was only published for field trial and derived from the consensus of a group of experts. It has not previously been approved by the WHO.

The medical (or biological) pattern of disability has long been predominant, as it is in some ways closer to our disability. We commonly think that a person has a disability when there is "something wrong" with their body or mind. The medical model is just a more sophisticated version of this common idea: disabilities are deficits or physiological or psychological abnormalities that emerge directly from some adverse health state such as a disease, a disorder or a lesion. Disability, so to speak, resides in the person, though it has an effect like the person living in his world, things he can do and the social roles he can cover.

Because disabilities are seen fundamentally a person's attribute, the only appropriate response is to target or change the body and mind of the person directly. Physical and therapeutic interventions seek to correct the deficits in the body, either by treating the health condition at the base, or by modifying the person's functioning so that it functions more normally.

Partly as a reaction to the medical model of disability, many researchers and advocates of the rights of the disabled since the Second World War have argued that what is the basis of disability is not an abnormality, but the way in which the society treats People with an abnormality. Those who propose the social model do not dispute that people with disabilities present physical and psychological differences and difficulties, but these are disadvantages, not disabilities.

The social model emerged for the first time after the First World War when returnee veterans on return insisted on changes in laws to allow them to return to a company and/or to community life despite their injuries. Veterans asked for guaranteed access to rehabilitation as a human right. This was the beginning of a close link between the social model of disability and legal claims for the fairness of opportunities and human rights, which is bringing elements to the agenda of the movements of the rights of the disabled these days.

The lesson to learn here has two parts. First of all, the fact that both the medical and the social model provide us with essential elements of discovery about the nature of disability and the appropriate methods of intervention that are required to solve the problems people with disabilities encounter in their lives. Secondly, we see that both the medical model and the social model fail to adequately address some problems (or create other social problems) and so are not sufficient prospects alone.

This suggests that a disability model that embodies and synthesizes both social and medical perspectives would have the strength of both without their weaknesses. This is the basic idea behind the adoption of the biopsychosocial model in the ICF (8).

INTERNATIONAL CLASSIFICATION OF FUNCTIONING AND DISABILITY (ICF)

In order to do a further step forward on the classification of the functioning of persons a WHO group began to work on an updated version of the ICIDH. The first published version was ICIDH-2. As the revision was progressing the commission found difficult to classify the disabled people. Difficult is at which level of altered function it is possible to use the label "disabled". Based on a series of considerations they decide to classify the health status of the people and not just the disability. Disability is the result of a loss of health status (functioning).

Finally they agreed that:

- classification must be a classification of all human functioning not only of problems of functioning or disability; It must be based on a universal approach where disability is a common characteristic of all humanity, not a minority group;
- the underlying model must be an integrated biopsychosocial model, not just medical or social;
- the model must show an integration between health and environment, not a linear causal model;
- the model should include environmental factors and not focus on the person alone;
- classification, in its entirety, must be transcultural and not merely reflect Western perspectives;
- classification should be applicable throughout the life span, and not limited to adulthood.

According to those concepts of specific instruments may be classified according to the framework established by the International Organization for the Functioning, Disability and Health (ICF) of the World Health Organization (Fig. 1.1). This altered health status classification scheme consists of separate components of body function and structure, activity, and participation.

In each component, there is a list of chapters. Under them there are 362 categories and further specification until the 4th level.

The crucial point is that ICF is intended neither a measurement tool nor an evaluation tool. It is a classification.

The ICF is a classification of health and related states: it is a tool for making a portrait of the person's overall state of health as well as the characteristics associated with his or her life experience.

We can add that the ICF has a complete vocabulary of human functioning and disability. As a classification of work and disability, ICF

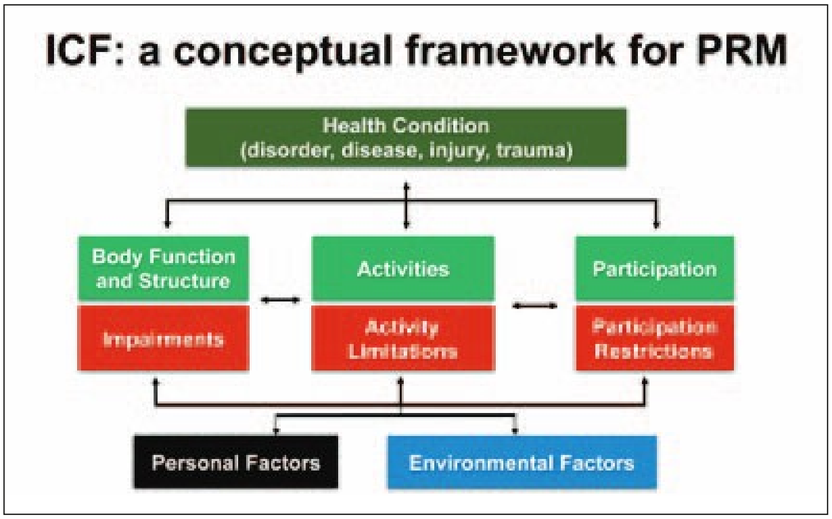

Figure 1.1 Biopsychosocial model is represented by ICF. The classification is about the health condition and the disability is the result of the loss of health status. The disability is considered an umbrella term including the consequence of the impairments, activity limitation and participation restriction. Note the bidirectional arrow meaning that the impairment leads to activity limitation and participation restriction but those aspects, if maintained, leads to a worsening of the impairment adding a further problem to the original disease as a consequence of a decrease of the activity in general.

makes the first essential step towards measurement and evaluation, thus carrying out the detailed scientific description of the operation and disability.

Each category has a qualifier that identifies the quantity of loss of normal functioning in the category. In the body structures, we can quantify the loss of anatomical parts, in body functioning we can identify the loss of functioning for each category.

The ICF does not only deal with body functions, but also activity and participation, that classifies the components that form the basis of daily and social life activities. In these components it identifies how the person can do activities and participation without any help (Capacity) and how the condition improves in the presence of environmental facilitators (help) or worsen in the presence of barriers (Performance) (Fig. 1.2).

Contextual factors are subdivided into the components of Environmental Factors (organized by the environment closest to the person to the general) and Personal Factors (not yet classified).

Identification of environmental factors allows to identify whether physical and relational components are barriers or facilitators. In the case of amputated prostheses represent a typical environmental factor that facilitates the recovery of au-

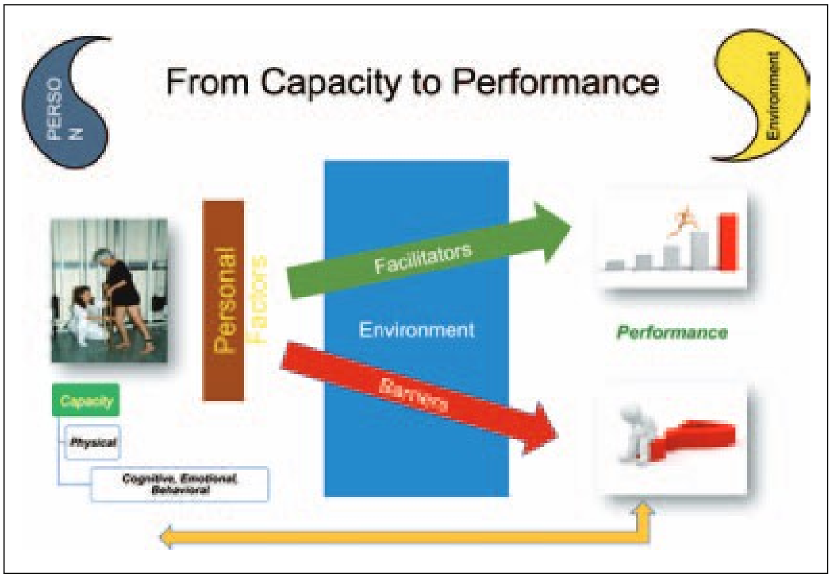

Figure 1.2 The capacity is only what the person can do in a neutral environment without any help. Performance is what happen in the real world with the environment that can be a facilitator improving the performance as compared to the capacity or a barrier decreasing the performance. The low performance can have a backward negative influence on the capacity.

tonomy and social reintegration by restoring the possibility of displacement.

An important achievement of this model is that it helps to understand disability as and interaction of a person with a health condition and the environment. This implies that disability is neither seen as a purely medical nor purely social problem but integrates both aspects. Furthermore it clarifies that disability cannot be seen as an attribute of a person.

ICF can thus become a universal language able to identify problems in a standardized manner, quantifying the severity both in terms of person's ability and performance in real mono. This quantification can be achieved using the scales already available and inserting them into the ICF framework.

In order to have a scale based on ICF the WHO developed the WHO-DAS II is the WHO-based inclusive assessment tool. Its reliability and validity are proven, and has been adopted by the WHO for its studies. WHO-DAS II is intended for adults only and relates directly to some ICF domains. It is prepared in either a short version of 12 questions - and in a longer version of 36 questions.

After a few years, a new version of ICF has been developed inserting some additional categories appropriate for young and children.

The ICF model and classification also was used to describe rehabilitation as a health strategy to decrease disability and to support functioning (9). The goal of rehabilitation has been defined as "to enable people with health conditions experiencing or likely to experience disability to achieve and maintain optimal functioning in interaction with the environment". In parallel the contribution of Physical and Rehabilitation Medicine has been defined using the same ICF-based concept (10).

The ICF classification is very extensive and the risk is to be complicated and time wasting to be applied in the practical activity. In order to overcome this problem, the German OMS Collaborator Center, ICF research branch, namely the Department of Physical Medicine and Rehabilitation at the University of Munich, Germany in collaboration with WHO, developed ICF Core Sets for different types of diseases, based on research projects and an international consensus process. Core Set must consider not only medical aspects of the health condition – impairments in body functions and structures – but also limitations on the activity and the associated restrictions on participation. In addition, the core set must include prototype environmental factors. Methodologically, the development of the Core Sets has been obtained with a consensus process based on Delphi round, a focus groups meeting.

In spite of the several years of implementation the diffusion of ICF in practical rehabilitation activities it is not yet widely diffused. One of the many challenging aspects is then to find a way to simplify selecting the most useful categories developing a minimal generic set of the domain of rehabilitation (11). The perspective is to use the validated scales and translate the score in the qualifiers quantification of health loss (12).

Another very important issue is related to the use of ICF in quality management in rehabilitation (13).

In order to strengthen the rehabilitation and abilitation approach to the disability World Health Assembly (WHA) in May 2014 adopted a global disability action plan 2014-2021:"better health for all people with disabilities" (14). The slogan is "to contribute to achieving optimal health, functioning, well-being and human rights of all persons with disabilities". This action plan is based on the concept that all persons with disabilities and their families should live in dignity, with equal rights and opportunities and able to achieve their full potential (15). The action plan has three objectives:

1. to remove barriers and improve access to health services and programmes;
2. to strengthen and extend rehabilitation, habilitation, assistive technology, assistance and support services, and community-based rehabilitation;
3. to strengthen collection of relevant and internationally comparable data on disability and support research on disability and related services (16).

The action plan has several implications for practice in rehabilitation.

The overall goals should contribute to achieving optimal health, functioning, well-being and human rights for all persons with disabilities. There is explicit mention that the dignity of persons with old age need special attention. Rehabilitation is needed in all phases of health care services including acute, post-acute, and long-term rehabilitation to guarantee the continuum of care.

The action plan emphasises the importance of the outcome research collecting data systematically using ICF. The data collection should taking in account the perspective of the persons with disability into the decision making process in data collection and research (15).

PERSONS WITH DISABILITY AND THEIR RIGHTS

Persons with disability have their right aimed to obtain and independent living throughout the best inclusion possible.

To define that, a real milestone has been the Convention for the Rights of Persons with Disabilities (CRPD) approved in July 2009 from 59 countries, 37 of them have ratified its Optional Protocol and 139 have signed the CRPD (6).

The Convention on the Rights of Persons with Disabilities clearly define that persons with disabilities have equal access and a right to full and effective enjoyment of all human rights – the removal of barriers explicitly termed as a condition for access and the enjoyment of equality.

The Disability Convention features eight general principles which underpin all the rights contained within the Disability Convention. They are:

- respect for inherent dignity, individual autonomy – including the freedom to make one's own choices – and independence of persons
- non-discrimination
- full and effective participation and inclusion in society
- respect for difference and acceptance of persons with disabilities as part of human diversity and humanity
- equality of opportunity
- accessibility
- equality between men and women
- respect for the evolving capacities of children with disabilities and respect for the right of children with disabilities to preserve their identities.

The implication for the practice in rehabilitation is the needs to involve the disabled person and their proxies to the rehabilitation programs sharing decision and tailoring the goals according with the needs and aspiration of the person.

In order to analyse the condition of disabled people The *World Report on Disability* is the first of its kind, providing global guidance on implementing the United Nations *Convention on the Rights of persons with Disabilities* (CRPD) and giving an extensive picture of the situation of people with disabilities (7).

THE ROLE OF CULTURAL AND PERSONAL ENVIRONMENT

The "social model of disability" was pioneered in the late 1960s and early 1970s, and continued to gain momentum and acceptance in the decades that followed. This model, introduced by people with disabilities, human rights activists and social theorists, specified that disability is not simply related to a person's impairment, but rather a complex phenomenon, created in part by features of the physical and social world. It is the environment that acts to facilitate integration or contribute to isolation, influencing a person's ability to participate in society.

The recognition of the environment's influence on the experience of disability and the implementation of Disability Discrimination Acts in various countries have led to the development and implementation of programs and initiatives for improving the environment experienced by a person with disabilities.

- *The concept of Universal Design*, where the underlying principle is the design of products, buildings and environments that are useable by all people. Issues such as accessibility, safety, individual ability and efficiency underpin the design of articles that make up the physical world, from buildings and forms of transportation to computer and Internet access, and products used in the home.
- *Integration of students with disabilities into mainstream or regular educational settings*. Enabling students with disabilities to participate in a regular education setting is thought to improve rather than hinder both academic and social learning (17).
- *Schemes for the provision of aids and equipment*, where individuals receive cost-free or low-cost equipment to help their performance of daily activities, such as self-care and mobility in and outside the house, and facilitate participation in sport, work, education and other activities.
- *Improvement of standards for accessible public transport*. Transport is a fundamental human right, including having ready access to safe and disability-friendly forms of public transport, but remains a common problem for people with disabilities.

A WAY FORWARD

The main change of the disability concept of the problem related to the person (ICIDH) to a result of interaction among a person and environment (ICF) has a number of practical implications. According to this vision the rehabilitation programs should be focused not only on the improvement of the capacity of the person obtained with the physical exercise but the global goals should be aimed to obtain a good performance in the real. The rehabilitation process should be focused on improving the capacity of the patient and in adapting the environmental factors (physical barriers, human relationships, social policies, and others). Starting from now, it is very important to implement this methodology within the rehabilitation process allowing fa quality improvement combining the patient's perspective with the appropriateness of rehabilitation intervention. These two aspects can be referred to two conceptual and practical elements of the ICF. The capacity of the person must be evaluated from an external, objective perspective, through validated measurement. The performance, on the other hand, that happens in the real life environment must be assessed taking in account the perspective of the patient. In this case, it is increasingly necessary to develop the research to find and validate measuring scales that can capture this perspective. One of these is the WHO-DAS 2 which, starting with simple questions, can capture the perspectives of the sick person always within the ICF reference system.

The ICF framework should be, at micro-level the basis for quality management in rehabilitation but also a reference point at meso-level to improve the quality of the organization of rehabilitation facilities and at the macro level to improve the planning of rehabilitation policies in favours of disabled people.

Key messages

- Since over 2000 years it is possible to find documents about the importance of exercises for the health. Only after the II World War there was a development of rehabilitation for the war injuries and for the consequences of infections such as poliomyelitis.
- Moving from the concept of health related to the absence of disease to the human functioning rehabilitation gained a further importance.
- The International Classification of Functioning (ICF) represents now the basic framework of rehabilitation introducing the concept of the disability as the result of interaction between person and environment.
- Several studies are carrying out aimed to use the ICF as assessment tools, to set the goals of the rehabilitation project and as a base of quality management in rehabilitation.

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The biological and clinical background of rehabilitation

2

Maria Gabriella CERAVOLO

INTRODUCTION

Rehabilitation is a problem-solving educational process, that is aimed at reducing activity limitations, optimizing social participation and patient well-being and limiting the stress of caregivers (1).

This definition highlights some important characteristics: 1) the attention of the rehabilitation is directed to treat the patient as a person and 2) the objectives refer to the social functioning, as well as to the health and the psycho-physical well-being, irrespective of disability kind (motor, sensory or cognitive), type of onset (acute or subacute), or severity.

Rehabilitation has a solid theoretical and conceptual basis derived from the International Classification of Functioning, Disability and Health (ICF) of the World Health Organization (2), describing the consequences of a health condition in terms of functioning and health experience. The description of functioning and disability takes into account three different perspectives: body, person, and person in a context. The body and the person are described in terms of body functions (physiological and psychological functions), body structures (anatomical parts of the body, organs, limbs and their components), activities (including the whole list of goal-oriented tasks any individual can perform) and participation (namely, the involvement of a person in a life situation). The ICF also provides a description of performance and capacity: the first indicates what the individual does in his/her own real environment, while the second quantifies the highest level of functioning achievable without the help/interference of any environmental factor. Contextual factors include both personal factors, such as age, gender or education, and environmental factors, which refer to the physical and social environment in which people live and to attitudes of family, peers and other relevant individuals. Among the personal factors, the patient's will, expectations and wishes can significantly influence the outcome of a therapeutic approach and adherence to treatment. Therefore, the information obtained from the ICF is useful not only for studying disability but also and above all for choosing the most appropriate methods and interventions (2).

Rehabilitation is usually described using three axes:

- *structure,* i.e. staff, equipment, facilities
- *process,* i.e. the whole set of actions aimed at defining the rehabilitation plan, including the diagnostic and prognostic evaluation, goal setting and intervention scheduling
- *outcome,* i.e. the level of functioning achieved by subjects after the rehabilitation intervention, not only in the short-term, but also in the medium- and long-term.

Rehabilitation as a problem-solving process, that is planned and implemented by a specialized team, has proven to be effective in reducing morbidity and mortality in most disabling disorders both in the acute phase and in the management of chronic conditions associated with reduced mobility.

Based on the evidence of the efficacy of either motor or cognitive training at re-shaping brain networks, due to the phenomenon of experience-driven brain plasticity, the interest into the theoretical background of rehabilitation efficacy has grown significantly, leading to the diffuse awareness that any approach able to reduce motor, cognitive, behavioral or emotional impairment, will always involve a neural reorganization.

BASIC CONCEPTS OF FUNCTIONAL PROGNOSIS AFTER ACUTE DISABILITY ONSET

The onset of a sensor, motor or cognitive impairment as a result of injury or disease can determine a variable limitation in the activities performed by the individual, based on the complex interplay between preserved capacity and the personal and contextual factors.

This adaptation process can be particularly difficult in the case of chronic-progressive diseases, in which subject's expectations must be continuously re-modulated as functional capacities shrink.

The goal of rehabilitation is therefore to guide the individual in the difficult path of achieving the highest level of functioning made possible by circumstances. The process necessary for this purpose requires that any care/rehabilitation decision be preceded by a correct clinical-functional assessment. This must use reliable, standardized tools in order to outline the individual functioning profile, based on body structures and body functions, activities and behaviors implemented by individuals (3).

The first aim of the evaluation is to determine the gap between the present level of functioning (in terms of independence in basic and instrumental activities of daily living) and that expressed immediately before the onset of illness; in case of congenital disorders this assessment is not possible, so the reference is represented by the functional abilities of individuals of the same age.

The second objective is to establish the individual potential for recovering the observed gap, or otherwise the risk for further functional decline.

The third objective is to select the rehabilitation strategy that best suits the circumstances, with respect to the residual abilities of the subject, his/her expectations, the natural history of the disease and the environmental opportunities/constraints (4).

Given these premises, rehabilitation must be regarded as a process targeting non-stereotyped (unknown *a priori*) aims, making each rehabilitation project a unique experience. Notwithstanding, even with a large degree of flexibility, there are rules to be abided and precise steps to be followed when planning a rehabilitation intervention. In the subsequent section, a few basic concepts driving the formulation of the functional prognosis will be explained.

The functional prognosis: when and why

Central nervous system (CNS) disorders, such as stroke, head or spinal injury, infective or inflammatory diseases, usually show incidence rates differing by age or gender, and are often associated to different patterns of clinical, functional, medical and social consequences. An important prognostic role is played by the site and size of damaged structures, the severity of emerging motor, sensory or cognitive impairment and the combination of injured systems: in particular, the addition of a cognitive dysfunction to any emerging motor disability adversely affects the recovery, by either hindering or slowing the motor re-learning process.

The severity of an emerging disability, as quantified using generic measures, like the Barthel ADL Index or the Functional Independence Measure (FIM), is one of the most powerful predictors of recovering the pre-morbid independence level and returning home after discharge from the acute ward (5). For instance, the FIM total score at rehabilitation start is the main predictive factor of the FIM score achieved at the end of treatment, in any individual experiencing an acute disability onset; moreover, the trunk control measured in the acute stroke phase, using a simple quantitative instrument such as the Trunk Control test, allows to predict not only the probability of recovering the standing and walking ability, but also of achieving a high level of independence and being discharged home after the event (6).

On the other hand, severe disability, pre-existing CNS damage, or severe cognitive impairment reduce, if not exclude, the effectiveness (and usefulness) of the rehabilitative approach.

The use of a simple classification, like the modified Rankin scale, which ranks the severity of functional impairment in six levels (from 0 = no symptoms at all, to 5 = severe disability; bedridden, incontinent and requiring constant nursing care and attention) proves extremely useful if applied retrospectively to outline the pre-morbid independence profile. Such information will strongly influence the functional prognosis, helping to determine the gap induced by the illness in the individual functioning, set the maximum level of expected recovery and help to define the risk for complications (*the higher the Rankin score, the greater the risk*).

Finally, the absence of any family/social network member, willing to play the caregiver role, would substantially increase the risk of subjects' institutionalization, even in case of a mild residual disability at the end of the rehabilitation process, and could nullify the several benefits obtained with an intensive training: in such cases, it would seem more appropriate, in the sake of cost-effectiveness, to involve the patient in an extensive rehabilitation program, rather than refer him to an intensive rehabilitation facility (7).

Whatever the setting defined in the acute phase for ensuring a continuum of care, the rehabilitation project recognizes a standard series of critical steps, whose ultimate goal is "to assist patients in achieving optimal physical, emotional, social, psychological and vocational functioning, within the limits imposed by the clinical picture and the available therapeutic options".

In conclusion, the prognostic evaluation is mainly oriented to establish whether or not: a) the emerging disability is either severe or complex enough to make an intensive rehabilitation appropriate; b) the individual expresses any recovery potential and a sufficient level of compliance to an intensive rehabilitation program, based on his/her tolerance to physical effort, learning ability and motivation; c) the environmental context will be able to cope with the subject's health needs, either in the short or medium term, in order to allow him/her to return home.

The integration of this information will shape the delivery of a continuum of care across different rehabilitation setting in the post-acute phase.

NEUROPHYSIOLOGICAL BASIS OF RECOVERY AFTER ACUTE LESION OF THE NERVOUS SYSTEM

THE CONCEPT OF NEUROPLASTICITY

The nervous system consists of complex neuronal networks specialized in the control of different vital functions, such as the sensory representation of the external world, the production of behaviors or the regulation of vegetative activities.

Neural plasticity is the ability of the CNS to change and adapt in response to environmental signals, experience, behavior and, eventually, acute or chronic progressive diseases (8).

Several observations indicate that the conditions necessary for the plastic processes to take place are present only during a precise time window, at the end of which such processes are actively suppressed. In other words, the genetic program determines the start and the end of a critical period for the development of functionally specialized neural networks. However, there is also an alternative interpretation. If the plasticity phenomena can be traced back to a series of competitive processes, then they could end when the neural circuits reach an attitude that prevents any further competitive interaction. The end of the critical period could therefore be due not only to the loss of the inherent plastic capacities of the nervous system, but also to the fact that the neural circuits have reached a configuration of stable connections which effectively prevent any further interaction between the nervous elements. This hypothesis would explain, for instance, why the critical period is prolonged when experience is delayed or missing.

Irrespective of what interpretation will be accredited by future studies, it is shown that plasticity phenomena are maximally active in the developmental phase of the CNS, during intrauterine life and in postnatal age, while they shrink significantly after the CNS has achieved complete maturation. Even in this phase, however, the CNS ability to undergo changes is not extinguished: in fact, not only children, though also adults, can change their behaviors, learn new information, memorize new events. The plastic modifications of the CNS which are the basis for learning and memory consist in continuous modifications of the effectiveness of signal transmission between neurons. Experiments conducted in the last 20-30 years have revealed that the efficacy of many synapses can be modified for very short time durations (namely, milliseconds up to minutes, in the so-called *short-term synaptic plasticity*) or for up to several months/years (in the *long-term synaptic plasticity*). At present, it is assumed that the learning process is associated to long-term modifications of synapses: these variations can be regarded as the biological correlate of a mnemonic trace and the neural substrate of learning new motor skills (i.e. dancing, playing sports or music), in the healthy state, or re-learning motor skills, that have been compromised by an injury or illness.

POST-LESIONAL NEUROPLASTICITY AND THE PRINCIPLES OF MOTOR LEARNING

The concept of neuroplasticity is certainly innovative. A few years ago, researchers in neuroscience hypothesized that rehabilitation efficacy could be attributable to the exercise-dependent change in brain function and structure. Thanks to some pioneers (9, 10), it was possible to demonstrate that repetitive motor training is able to induce persistent structural changes in the cortical representations of the trained movements, and that these changes are directly related to the improvement in motor performances after the CNS damage.

Numerous experiments carried out in animal models have documented how, following an acute focal CNS lesion, a plastic reorganization takes place, both due to the activation of functionally quiescent anatomical connections, starting when the dominant connections are damaged, and to the sprouting of cortical axons, i.e. the growth of nerve fibers that reach new cellular targets, in response to sensory inputs, thus generating new synaptic contacts (*synaptogenesis*).

The remodeling of neural maps following injury does not however take place in a stereotypical mode, but is strictly experience-driven. The exposure to external sensory stimuli (and to the internal feedbacks generated by the individual motor behavior) can modulate both the entity and specificity of neuroplasticity processes, provided that specific requirements are met, as those highlighted below (11):

1. *Specificity*. The congruence of the trained activity with the skill to be learned or re-learned plays a crucial role in brain reorganization. In practical terms, to learn to ride a bike you have to pedal, to relearn walking after suffering a lower limb paresis, you have to walk, and so on.
2. *Repetition*. Each single component of the task to be learned must be repeatedly trained, in order to facilitate the consolidation of the synaptic connection.
3. *Intensity*. The duration and frequency of training sessions must be sufficiently high to obtain maximum benefits in the shortest possible time.
4. *Timeliness*. In those who have suffered a CNS injury, more than in other disease scenarios, the earlier the training is started the greater the opportunities for functional recovery through neuroplasticity mechanisms. The optimal time window for obtaining the maximum result from motor training, for the purposes of functional recovery after stroke, is estimated to be around 12 weeks.
5. *Salience*. The active participation of the subject in training is as important as doing a massive practice. For example, training movements usually performed in daily living (e.g. drinking from a cup, fastening or unfastening a button, picking a key and using it to unlock a door) induces a greater emotional arousal than performing intransitive gestures. Goal-oriented activities are especially useful due to their ability to drive subject's attention towards the task and improve learning capacity.
6. *Contextual interference*. Learning new tasks may be slowed down or prevented by the competition with previously acquired and consolidated skills or concomitant sensory experiences. In order to avoid such effect, it is recommended that different tasks are simultaneously trained in a random sequence rather than let patients master any ability at the maximum level before asking them to train a new one. For example, to develop a strong manual grip it is useful to ask the patient to pick a glass, then a spoon, then a mobile phone, according to a random, unpredictable sequence. A similar approach stimulates the idea that each exercise represents a problem to be solved, rather than a temporal sequence of repetitive movements in a stereotypical mode.
7. *Use it or lose it*. If an intense sensory experience, related to a repetitive practice, promotes learning and its consolidation over time, the lack of experience, or sensory deprivation, inevitably leads to function decline and to the loss of previously learned skills. Hence, the lack of practice induces a phenomenon of "learned non-use", following the missing activation of the neural substrates of that specific skill: the depotentiation of synaptic connections is the basis for the so-called "maladaptive plasticity".

TRADITIONAL AND INNOVATIVE REHABILITATION TECHNIQUES AND THEIR RATIONALE OF USE

Neurophysiological techniques

Neurophysiological techniques refer to neurophysiological mechanisms of motor impairment; they do not require the cooperation of the patient, who plays a passive role. The most important and used are:

- Bobath Method (or Bobath Concept): it was developed as a technique for neuromotor reconditioning in children with cerebral palsy and has been adapted and used also in adults. Currently, it is probably the most widely diffuse method in Europe. It is based on a passive limb mobilization, associated with tactile and proprioceptive stimuli, and the maintenance of postures, mainly oriented to reduce spasticity in order to allow a more effective activation of muscles used in functional movements.

- Brunnstrom method: this technique is aimed at promoting motricity recovery, using both reflex activity and proprioceptive and exteroceptive stimuli to evoke desired motion or muscle tone changes.
- Vojta method: developed to treat newborns with congenital brain damage, it is based on the stimulation of specific nerve endings to promote the development of physiological movement patterns. It has been also applied to adults with focal brain injury.
- Rood method: it refers to a hierarchical organization of the CNS and emphasizes the use of sensory inputs to produce and modify motor responses; the developmental stage and abilities of the patient are used to develop purposeful responses.
- Johnstone method: it mainly aims at controlling the pathological reflex systems causing spasticity and the consequent alteration in voluntary movements and posture. It uses positioning and limb immobilization in order to inhibit pathological patterns, avoid muscle hypertonia and allow the restoration of central control.

Motor learning techniques

While neurophysiological techniques are relatively independent of the patient's collaboration, motor learning techniques (11) need the active participation of the subject in the exercise as a mandatory requirement.

- Perfetti method: widely used in Italy, it has been initially devised to manage spasticity, but has been subsequently applied in several disorders even not related to CNS damage. Also called "Cognitive Therapeutic Exercise", it aims at stimulating the cortical mechanisms of learning such as perception, memory, conception and motivation, looking to the interconnection between functional movements and the patient's interaction with the environment.
- Task-Oriented Training: the therapeutic intervention focuses on specific tasks and offers contextualized exercises that reproduce activities of daily life. It refers to the theory of a central control of movement, considering that the execution of goal-oriented movements (i.e. of movements performed in a specific context for the solution of a specific problem), is binding in order to allow the optimal recovery of impaired motor skills.

Constraint-Induced Movement Therapy

The Constraint-Induced Movement Therapy (CIMT) was developed by Edward Taub based on the observation of the "learned non-use" phenomenon in hemiparetic stroke subjects. The treatment proposed by Taub combines an intensive use of the paretic limb with the movement restriction and sensory deprivation of the healthy limb, by the application of a bandage or splint. It has been shown that, following the use of CIMT, a cortical reorganization takes place, mostly favored by the positive component (intensive use of the paretic limb) rather than the negative one (sensory deprivation of the healthy limb) (12).

Action observation, motor imagery and mirror therapy

Recent research suggests that both imagination and observation of movements may represent an additional source of information useful for the recovery of motor function in patients suffering a CNS injury. Using functional Magnetic Resonance Imaging, it has been shown how brain areas normally involved in the planning and execution of a movement (the prefrontal cortex, the premotor cortex and some extra motor area (like the cingulate cortex, the parietal cortex and the cerebellum) are active even when the same movement is imagined, but not executed. Other studies have documented that even the observation of a gesture performed by others is sufficient to activate the same cortical areas competent for the execution of that gesture. The neural substrate that presides these phenomena is the *system of mirror neurons*. The mirror neuron function is relevant both for learning by imitation and for understanding others' intentions. Rizzolatti et al. discovered that a group of neurons in the parietal cortex of monkeys were active not only when the animals took a peanut, but also when they observed the experimenter perform the same action. Afterwards, the same group of researchers provided the first evidence that mirror neurons also existed in humans, demonstrating that the simple observation of a movement is effective at facilitating its subsequent execution (13). Rehabilitation protocols based on action observation, as a means to foster motor re-learning, have successfully enhanced paretic upper limb recovery in stroke survivors (14), walking improvement in subjects with Parkinson's disease and verbs production in subjects with non-fluent aphasia (15).

Motor imagery can be defined as the cognitive process of imagining to move the body (limb) without actually moving it. Over the last decade, studies on motor control have shown that there are close analogies between real and imagined movements, like in the phenomenon known as "mental isocronia", where the time taken to complete an imagined movement is similar to that needed to actually execute it. Moreover, in line with the theories and scientific evidence regarding mirror neurons, it has been found that the brain areas activated during the imagination of certain actions are the same as those activated during their actual execution.

The application of motor imagery protocols in rehabilitation is still considered experimental, even if preliminary experiences regarding the recovery of the upper limb function after stroke have given encouraging results.

Mirror Therapy. Ramachandran was the first to use the visual illusion created by a mirror to treat phantom limb pain (16). Patients who looked at the image of the healthy limb in a mirror had the illusion that the observed movement was performed by the contralateral (amputated) limb: in this way, they developed the perception of being still able to move and relax the amputated arm and perceived relief from pain. Following this first evidence, mirror therapy has been used to treat complex regional pain syndrome (CRPS), and manage severe dysesthesia after hand trauma; moreover, it has been successfully applied to enhance upper limb motor recovery in stroke survivors, by creating the illusion of the paretic limb movement.

The mechanisms explaining the effectiveness of mirror therapy are likely different.

Some believe that the proprioceptive inputs from the affected limb, triggered by the illusion provided by the mirrored healthy limb movement, enhances the neuron excitability in the premotor cortex. Others hypothesize that the mirrored movements just stimulate motor imagery, thus activating the networks responsible for the execution of the same movements.

Non-invasive cortical stimulation techniques

The application of cortical stimulation, with the intent of increasing/decreasing the excitability threshold of the motor cortex, was introduced in the 1980s, using the *repetitive Transcranial Magnetic Stimulation* (rTMS). This technique exploits the electrical impulse, flowing in a coil applied on the head, to induce a magnetic field of very short duration; the transition of a magnetic field, across the skull, to the underlying nervous tissue, generates an electric field that is able to modify the neuron membrane potential.

The mechanisms by which rTMS determines persistent cortical reorganization include, hypothetically: a) the enhancement or suppression of synaptic circuits, b) the modulation of gabaergic and glutamatergic systems, through an action on the NMDA receptors, and c) the modulation of gene expression, through the increase of BDNF mRNA, a neurotrophic factor implicated in the mechanism of neuroplasticity. rTMS protocols exert variable neurophysiological effects, depending on the stimulus frequency, the length of the interstimulus interval (ISIs) and the duration of the stimulation sessions. For example, while frequencies >5 Hz increase cortical excitability, those ≤1 Hz cause intra-cortical inhibition of the stimulated hemisphere. Short ISIs (2-5 ms duration), and long ISIs (100-200 ms) are followed by intracortical inhibition phenomena, whereas intermediate ISIs (7 to 20 ms duration) obtain the facilitation of cortical activity and increase the excitability of glutamatergic circuits.

The clinical evidence of efficacy of rTMS application in rehabilitation mainly concerns subjects with stroke (17). An improvement in the paretic upper limb function was observed when the cortical stimulation session was combined with the motor training, and, more exactly, when it preceded exercise by a few minutes. This finding has led to the hypothesis that an rTMS protocol aimed at reducing the excitability threshold in the primary motor cortex exerts a priming effect, facilitating the activation of the sensorimotor areas where movement is represented and the creation of new synaptic circuits.

Transcranial Direct Current Stimulation (tDCS) consists in the release of a continuous electric current, of low intensity (1-2 mA), that flows between two poles, an active electrode, applied on the head over the target cortical area, and a reference one, placed either on the supraorbital region or on the shoulder (18). The neuroplastic effects induced by tDCS are explained both by the action on the ionic channels, that leads to the redistribution of the Na^+ and Ca^+ ions at the intra- and extracellular level, and by the action on the NMDA receptors, that modulates the neurotransmitter systems: the net result is a change in the resting membrane potential, either for a hyperpolarizing inhibitory effect of a cathodal stimulation, or a depolarizing excitatory effect of an anodal stimulation. In stroke patients, the inhibition of the unaffected hemisphere, contralateral to the damaged brain area, is pursued in order to reduce the interhemispheric inhibition. The physiologic competition between the two hemispheres is often disrupted following a stroke, as the lesioned hemisphere shows a reduced activity and a decreased inhibitory capacity, whereas the healthy hemisphere manifests a hyperexcitability and exerts an enhanced inhibition of the contralateral damaged one, thus likely reducing its recovery potential.

Several pilot studies, and a few randomized controlled trials have produced conflicting results concerning the real efficacy of integrating tDCS protocols with rehabilitation treatment in subjects with subacute or chronic stroke outcomes (19).

Functional electrical stimulation techniques

Electrostimulation is essentially based on functional electrical stimulation techniques (FES), which induce muscle contraction in order to promote recovery, reduce spasticity or favor alignment of articular heads. Transcutaneous electrical nerve stimulation (TENS), or electro-analgesia, provides low intensity high frequency stimulation of the nociceptive afferent fibers, without producing muscle contraction. The evidence supporting the use of either modality is based upon a few controlled studies and sparse meta-analyses, but is still undergoing revision.

An updated version of FES combined with cycling (so-called FES-cycling) has been used to promote gait recovery in stroke patients. The electrical stimulation ensures an effective muscle activation in the paretic lower limb, synchronized with the movement of the contralateral limb: the aim is to produce a symmetrical pedaling and thus train the cyclic gait pattern. A few studies suggest that FES-cycling is effective at strengthening the paretic muscles and the cycling performance, while it is still argued whether it also improves walking significantly, especially in patients who have not yet recovered independent gait.

Virtual reality rehabilitation

Virtual reality is a computerized technology providing digital sensory information and allowing people to interact with/within three-dimensional environments. In recent years, such technique has been frequently implemented in rehabilitation protocols of motor and cognitive training. The fundamental novelty of virtual reality-based rehabilitation protocols is their ability to induce the perception, in the subjects, to be part of a simulated environment.

Simulation can be achieved in an either immersive or non-immersive modality.

Immersive augmented reality is typically obtained using a head-mounted display (HMD), worn on the head, provided with a small display in front of one or both eyes. Virtual reality devices applied in rehabilitation usually display only computer-generated imagery: this mode provides a three-dimensional view and correlates the movements of the head with the virtual environment, with the result that the perceived environment changes with the movements of the user giving the feeling of being within the environment itself.

The non-immersive mode provides the vision of the virtual environment on a computer monitor or projected on a screen, giving the subject the perception of looking through a window (20).

To enhance feedbacks generated by the subject's movements, special sensory gloves or joysticks can be used. The gloves allow subjects to see their hand movements projected onto the screen and feel feedbacks in the form of tactile sensation. The joysticks allow subjects to interact with the virtual environment, giving them different feedbacks depending on the speed and precision of movements, or on the power of muscle contraction.

In summary, virtual reality training:

- allows to shape training intensity and difficulty, based on the patient's progresses in motor performances;

- provides a quantitative assessment of the motor performances;
- allows people with motor or cognitive impairments to engage, safely, in activities that would be risky for them to practice in the real environment (e.g. driving cars or playing sports)
- provides a motivating goal-oriented experience, able to stimulate patient's willingness to keep on training, for longer periods and with greater compliance than that observed with standard rehabilitation; this advantage can be increased, thanks to the diffusion of commercial systems (like Wii-Balance for Nintendo®, or EyeSports for PlayStation®), that allow patients to train in their home environment, extending the exercise duration with great advantages in terms of rehabilitation cost-effectiveness (20).

CONCLUSIONS

The rehabilitation project is a quality element of the management of people with acute or chronic disability of any kind. The main factor of any rehabilitation protocol efficacy consists in its capacity to induce neuroplastic changes in the brain networks responsible for both motor and cognitive functions and for behavioral adaptation.

In order to ensure an optimal result, the collaboration and active participation of the patient in the recovery/adaptation process are essential. In this frame, the rehabilitation team has the responsibility of: a) allocating the most appropriate treatment to the individual according to his/her learning profile; b) interacting with other health professionals to share the ultimate goals of rehabilitation care; c) ensuring a continuum of care through the different phases of disease/disability progression; d) adapting the goals and strategies of rehabilitation to the health needs of disabled subjects, as far as they grow up, get older and sicker; e) producing effective and sustainable organizational solutions, able to meet the needs of individuals with acute, chronic or chronic-progressive disability.

Key messages

- Rehabilitation is a problem-solving educational process, aimed at assisting patients in achieving optimal physical, emotional, social, psychological and vocational functioning, within the limits imposed by the clinical picture and the available therapeutic options.
- Any rehabilitation intervention must be preceded by a correct clinical-functional assessment. This must use reliable, standardized tools in order to outline the subject's functioning profile, based on the interaction between body structures and body functions, environmental factors and individual expectations.
- Neural plasticity is the ability of the CNS to change and adapt in response to environmental signals, to experience, to a certain behavior and, eventually, to acute or chronic progressive diseases.
- Cortical reorganization after brain damage does never take place in a stereotypical mode, but is strictly experience-driven. Hence, the kind, complexity, intensity and duration of subject's exposure to external sensory stimuli (and to the internal feedbacks generated by the individual motor behavior) can modulate both the entity and specificity of neuroplasticity processes.
- The main factor of any rehabilitation protocol efficacy consists in its capacity to induce neuroplastic changes in the brain networks responsible for both motor and cognitive functions and for behavioral adaptation.

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Part II

The disabling consequences of neurological disorders

Overview of the main acute traumatic and non-traumatic neurological disorders

Sara LAXE

This overview refers to those neurological conditions that comprise a diverse set of medical diseases or injuries to the nervous system that can abruptly happen in an individual and they can threaten life and lead to a lack of functioning such as Traumatic Brain Injury, Stroke or Spinal Cord Injury (1). The impact of the loss of functioning in the individual, the family but the whole society in addition to its high prevalence makes it very important for government and institutions to have a plan for prevention and treatment.

The World Health Organization (WHO) in its report of the Global Burden of Disease Study alerts that disability death and disability due to neurological conditions, which also include conditions such as Alzheimer or Multiple Sclerosis, are increasing globally meaning a 7.1% of the global burden of diseases (2).

The overall costs of these conditions include direct costs and derived from the health service provision and institutionalization but also there are indirect costs associated with the inability to the return to work and caregiver care. Quality of life of individuals but also of the caregivers and family members are also reduced and can lead to secondary conditions (3).

Research has shown how governmental policies and legislation play a role in the prevention of these medical conditions. The introduction of policies on speed control, the use of restraint systems such as seat belts or child restraints have reduced the incidence of injuries such as head injury or spinal cord injury. This has resulted in a change in the epidemiological pattern, at least in developed countries. In contrast, in developing countries where road conditions and traffic safety legislation are not so strict, the first cause of SCI and TBI is still traffic accidents.

On the other hand, in developed countries, the increase in unhealthy living lifestyle such an increase of sedentarism in combination with diet rich in carbohydrates and fats as well as increased longevity have increased the incidence of cerebrovascular diseases (4).

These three conditions have in common a sudden insult to a part of the central nervous system that derivates in an acute loss of functioning (5).

The sudden loss of certain body functions and impairment in central nervous system structure has a direct repercussion on the individual's ability to carry out the basic daily life activities as well as guaranteeing the correct reintegration into his social and work life. In terms of the International Classification of Functioning, Disability and Health, functioning (understood as the relation of body functions, body structures, activities & participation) is affected.

After the insult and the initial treatment, some of the impaired body functions and structures can be recovered, but the extension of the recovery varies in each patient and many will remain with sequelae. Rehabilitation plays an important role during the recovery process in order to help with the restoration of the loss function, the adaptation of the sequelae and the personal adjustment to disability.

CHARACTERIZATION OF EMERGING DISABILITY AFTER BRAIN/SPINAL CORD DAMAGE AND IMPACT ON ACTIVITY AND PARTICIPATION IN THE SHORT AND LONG TERM

The repercussion of these diseases should be analysed in a holistic way in a patient-centered approach (6). This means that there is a need from a shift of focusing in the medical condition but to focus on the functioning status of the patient.

A practical way of considering the holistic evaluation of the patients is the use of the ICF core sets. There are core sets to be used in an acute setting as well as in a post acute, there are ICF core sets in Neurological Conditions, TBI, Stroke and SCI (7-11).

It is important to make an assessment of the body functions and structures that are impaired in order to try to restore the loss through medical strategies such as pharmacotherapy interventions, surgical procedures, physiotherapy, neuropsychological treatment etc. But, PRM doctors should also be aware of the repercussions of the impairments in the ability of performing the daily life routines and participation in society.

Rehabilitation strategies should start as soon as possible and carried out throughout time until the patient is reinserted in the society, independently from his or her level of recovery. There are patients whose recovery will go faster and may have the possibility of living an independent life, whereas others will have a level of dependency on a third person (1, 12, 13).

Rehabilitation needs to be understood as a continuum of care that should start even as a preventive medicine, including the factors mentioned above regarding preventive policies, and should continue until the patient goes back to the community. This implicates different phases. In these phases, the aims and set of objectives to establish the rehabilitation plan may vary according to the diseases, their severity, but also the patient´s characteristics. Nevertheless, at the beginning, when prognostic outcome may be difficult to predict and the repair of the neurological process is still active, the main interest of the rehabilitation team is the recovery of lost function, paying particular attention to problems in body structures and functions, and applying restorative strategies. As time goes on (and underlying deficits cannot be effectively remediated), rehabilitation approach targets use of compensatory strategies, focusing on activites and participation. Environmental factors, though they should be present through the whole process, tend to have a higher impact once the patient is at home, and normally after one year after the onset of the disease. Once the patient has realized that the recovery of functioning is stabilized, the circumstances and environmental factors around him and his family have been related to impact more the quality of life (13).

Key messages

- Disability due to neurological conditions is increasing and it is expected to be one of the most causes of disability worldwide.
- The burden of the consequences of neurological diseases not only is reflected at an individual but also at a societal level.
- Rehabilitation plays an important role in the regain of functioning or adjusting to disability.

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Traumatic brain injury

3

Sara LAXE

INTRODUCTION

Traumatic brain injury (TBI) is a sudden an unexpected condition that results from an insult to the brain due to an external mechanical force that is evidenced by a loss of consciousness, a posttraumatic amnesia period or by the neurological findings that can be reasonably attributed to the trauma. TBI is known as the “silence epidemy” since many of its symptoms occur long after its happening, many of the TBI patients are not aware of their deficits and there is an underestimation, especially in mild and moderate TBI in the diagnosis.

Due to this, the World Health Organization (WHO) considers TBI as a chronic condition (1) that requires from different medical services during the acute phase, such as emergency and intensive care, neurosurgery, neurology and rehabilitation but also throughout time with an initial treatment in intensive inpatient rehabilitation, outpatient treatment, ambulatory rehabilitation, housing programmes or vocational rehabilitation. A good coordination among medical services but also with social services and environment of the patient is important to provide the patient to have an opportunity to regain functioning (2).

EPIDEMIOLOGY

TBI is an important health problem, literature reports an incidence of 200/100,000 severe injuries with a mortality initial rate of 15/100,000. The etiology has traditionally been due to traffic accidents, though the latest epidemiological studies in Europe have shown a change in the patterns (3) and falls seem to be the first cause of TBI in Europe.

The severity of the TBI is typically classified according to the initial Glasgow Coma Scale (GCS) into mild (GCS 13-15), moderate (GCS 9-12) and severe (<8) with a long term prognosis outcome. Additionally, the duration of the loss of consciousness (LOC) and the length of posttraumatic amnesia have shown to be of use in the classification of severity. A LOC <30 min. would be mild TBI, between 30 minutes and 6 hours moderate, and more than 6 hours severe TBI.

TBI in terms of pathophysiology can be categorized in closed injury or open injury, being the latest one with a worse prognosis. In the closed injury the acceleration of deceleration of the brain within the skull can produce a shear in the white matter and stretching the axons cause what is call the diffuse axonal injury. Imaging techniques show that MRI findings in mild TBI are located in the cortex, and they go deeper reaching the corpus callosum of brain stream in more severe cases. Local injuries such as contusions are most frequently situated in the frontal and temporal lobes.

After the primary injury, secondary mechanism of TBI damage can arise such as intracranial haemorrhage due to subdural, epidural or intracerebral hematomas, brain swelling, increase intracranial pressure, and due to the liberation of excitotoxic neurotransmitters, seizures and more neuronal death can add severity to the initial damage.

CONSEQUENCES AND FUNCTIONING IN TBI

The consequences of TBI are complex leading to problems in body functions, body structures, that can lead to activity limitations and participation restriction. The heterogeneity of symptoms as well as the personal factors and environmental factors makes it difficult to conduct studies and therefore finding which is the best treatment and intervention tailored to different patients is complicated as well as expensive. Considering the level of disability due to TBI, the repercussions of the TBI consequences are extended to the family, relatives and overall society constituting a major health problem (1).

BODY FUNCTIONS AND STRUCTURES IMPAIRMENTS AFTER TBI

Disorders of consciousness (DOC)

The main three syndromes of DOC are coma, unresponsive wakefulness syndrome and minimally conscious state (4).

- *Coma*: Severe TBI produces a loss of consciousness that starts with a come, which is a state in which the patient shows no evidence of cognition, does not open the eyes and does not react to any painful stimulation.
- *Unresponsive wakefulness syndrome* (UWS) is the proposed name by the European Task Force on Disorders of Consciousness for the former "vegetative state". In this phase the patients show wakefulness signs with their eyes open giving the impression of an existence of sleep wake cycles but they seem to be unaware of themselves and environment because they cannot show sustained, reproducible, purposeful or voluntary behavioural responses to sensory stimuli.
- *Minimally consciousness state* (MCS), in which patients show inconsistent signs of consciousness such as following commands, verbalizations, visual pursuit or purposeful movements such as taking away a sheet from the bed.

Posttraumatic amnesia (PTA)

This is a state of confusion that can occur directly after the brain injury or after being in a period of disorder of consciousness. PTA itself is a prognostic factor. Those patients with a PTA period longer than one week are likely to have a worse functional outcome. The most widely measurement to assess the PTA as well as to track its recovery is the Galveston Orientation Amnesia Test (GOAT). A score more than 75 is defined as normal. During this period patients are likely to have neurobehavioral problems such as agitation.

Behavioural problems

Specially during the PTA phase, but also later during the recovery process, people with TBI are very likely to show behavioural problems such us emotional lability, motor overactivity, irritability, depression and aggression. Some of the behavioural problems can appear or be triggered once the patient returns home.

Cognitive problems

Often the most salient features after a TBI are cognitive changes and they typically contribute more to persisting activity limitations. The extent of these include memory impairments, executive dysfunction, attention problems, reduced processing speed.

Sensory deficits

Patients can suffer from sensorial deficits such as cranial nerves neuropathies. Olfactory, facial, audio-vestibular and ocular motor nerves are the most frequently involved. They can also have anaesthesia, hypoesthesia of different areas of the body but also positive phenomenon like paresthesias or neuropathic pain (5).

Nutrition and dysphagia

An increased metabolism and catabolism is seen in the first phases after TBI in addition to the need of finding an alternative mean of feeding the patient, as a nasogastric tube or a gastric tube. But after the acute phase and in addition to endocrine impairments, changes in body mass index are seen and can have a negative impact in the patients functioning.

Another symptom that is very prevalent in TBI patients at the time of the transfer to rehabilitation is dysphagia. A clinical assessment and a videofluoroscopy assessment should be done. Patients can have a delay or absence of swallowing responses, reduced tongue control, reduce pharyngeal transit, reduced laryngeal closure, or spasm. Patients with dysphagia without the correct treatment can have aspiration, pneumonia, weight loss and immune complications.

Motor problems

Different degrees of loss of strength can happen due to the cortical lesion but also due to the lack of movement. But also movement related disorders like ataxia or tremor are frequent and can arise after the first onset of the symptoms and often once the patient has already been discharged (6, 7).

Spasticity

Spasticity can occur after TBI and can deal to secondary problems such as deformities, pain, impairment of the gait and grasping. Patients should be assessed not only with the neurological examination but also considering how spasticity has produced an impairment in gait or daily life activities.

Neurological medical complications

Patients can complain about headaches, dizziness, problems in sleep. Seizures can occur after a TBI. Typically, seizures can happen in the first week due to the trauma, the bleeding and the liberation of neurotransmittors and prophylactic treatment is necessary. After the first week, the titration of medication can be done. If epilepsy occurs after the first week it is likely that the mechanism is due to a structural change after TBI and treatment may be used for a long period of time. There are different medications for the treatment of TBI-related secondary epilepsy that can have a positive effect on behavioural problems and that do not produce more cognitive negative changes. For instance, valproic acid should be used instead of phenytoin since it can control the mood changes typically observed after TBI and may not interfere in cognitive problems.

Hydrocephalus is another complication that may arise in the first weeks and the patient may need a craniectomy, but also can have a delayed diagnosis and indeed posttraumatic hydrocephalus is the most common neurosurgical complication of persons with TBI. Any loss of acquired milestones should be carefully assessed by the clinician and if needed have a imaging study to be detected.

Other medical complications

Patients with TBI may also experience other medical changes such as endocrine dysfunctions that are commonly misdiagnosed and dysautonomic signs.

The formation of mature bone in soft tissue, known as heterotopic ossification, may lead to a decrease in mobility, can be a source of pain and eventually diminish functionality.

Patients with severe injuries may have a tracheostomy and during the rehabilitation process it has to be determined whether it is necessary its continuation or can be taken away.

ACTIVITY LIMITATION AND PARTICIPATION RESTRICTION

The ability of doing daily live activities, returning to work, driving, maintaining a social life are affected due to the aforementioned consequences of TBI, and are responsible for loss of quality of life in families and individuals with TBI.

Prognostic factors in TBI

The prediction of functional outcome after sustaining a traumatic brain injury is very uncertain due to the multitude of determinants that contribute to the prognosis. Most of the literature available is written from an isolated neurological, neurosurgical or from rehabilitation perspective alone (8) and therefore some authors suggest the need for a multidisciplinary research in this area to integrate the outcome prediction. The prediction of long term clinical outcome for patients is of an utmost importance to provide rehabilitation services but reliable guidelines for prediction the long term outcome are lacking (9).

Among the numerous barriers in determining the prognosis factors of outcome after TBI lead the heterogeneity of the injury and the personal factors involved.

Most of the studies regarding prognosis of TBI are centred on the severe and moderate lesions and as expected, moderate TBI patients have milder motor and cognitive impairments than those with a more severe lesion.

At an acute stage, an older age, a lower Glasgow Coma Scale, and absent pupil reactivity and the presence of a major extracranial injury have shown to predict a poor prognosis.

A worse handicap and social integration has been related to violence injuries, a severe or moderate injury, females older than 65, member of minorities and not working at injury time (10). In addition, pre-injury unemployment, pre-injury substance abuse and more disability at rehabilitation discharge are more important predictors of long term disability and predictors of being non-productive after TBI.

Patient´s that developed epilepsy after TBI had a lower functional independence score compared to those no epileptics and also showed to have a higher disability score (11).

Studies report an incidence between 40-50% of depression after TBI and recently Bombardier et al have showed that depression was an outcome predictor of a poorer quality of life after TBI and was associated also with comorbid anxiety (12).

Post-traumatic amnesia (PTA) has shown in some studies (13) to be an indicator of prognosis during the early stage of recovery. Patients in a shorter period of PTA have shown to have better results than those that remained in that state for a longer period of time.

Some cognitive measures can contribute to the prediction of functional outcome that is not accounted by the injury severity, demographics or trauma variables. A shorter duration of PTA, less fatigue, absence of intracranial findings and a higher education can contribute to a better outcome (14). Some neuropsychological assessments for test orientation, verbal memory and processing speed have been found to be consistent predictors of outcome.

A highest functional score in the FIM scale was a positive predictor of functional level of discharge (15). Various other scales have been proposed to determine disability after TBI such as the Glasgow Outcome Scale (GOS), Disability Rating Scale (DRS), the Community Integration Questionnaire, and the Functional Status Examination (16).

AIMS OF REHABILITATION

Rehabilitation as a multidisciplinary and holistic approach has shown to be beneficial for decreasing hospitalization time, reducing health care costs and improving not only patient´s quality of life but the life of those around him like the family. Altogether this makes rehabilitation interventions not only successful at an individual level but at a societal level (17).

The aims of rehabilitation in Traumatic Brain injury should be directed towards:

- Make a clinical assessment of the disorder of consciousness and determine the level of cognitive functioning of the patient.
- Stabilize the medical issues related to brain injury, for example reduce psychotropic medication such as phenytoin or benzodiazepines that can interfere with regaining consciousness or cognitive problems.
- Prevent secondary complication such as spasticity, contractures, pressure sores, aspiration due to dysphagia.
- Restore the loss of functional abilities that limit activities and restrict participation.
- Provide adaptive devices to enhance functional independence.
- Provide educational sources for the patient and family.
- Provide psychosocial care for TBI patients and their families.

The PRM specialist should lead the multidisciplinary team and deliver treatments to a TBI patient according to the Rehabilitation Cycle defined by Rauch (18), including the following parts:

- Patient should be assessed medically but also regarding functioning. The ICF TBI Core Sets can provide a guideline for the assessment (19).
- Use the common outcome measures to characterize the level of functioning and track changes across time (16). The Disability Rating Scale, the Glasgow Outcome scale, the Coma Recovery Scale and a neuropsychological battery should be administered.
- According to the prognostic factors such as age, previous studies, medical complications, length of stay in intensive care, tracheostomy... the doctor should be able to make a prediction of the future level of disability and establish goals and objectives of rehabilitation (2).
- Provide interventions such as:
    - Pharmacotherapy to improve disorders of consciousness, cognitive and behavioural problems.
    - Pain management.
    - Spasticity management.
    - Assessment of nutrition and dysphagia. Videofluoroscopy diagnosis and counselling.
    - Training of daily live activities with occupational therapy, family intervention and education, use of virtual reality.
    - Neuropsychological assessment and treatment.
    - Gait training and use of new technologies.

Key messages

- The consequences of TBI are complex leading to problems in body functions, body structures, that can lead to activity limitations and participation restriction.
- A highest functional score in the FIM scale was a positive predictor of functional level discharge.
- A PRM specialist working in a multidisciplinary team and with an holistic approach is the key for rehabilitation of TBI patients.

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Stroke

4

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AIMS AND STRATEGIES OF REHABILITATION MANAGEMENT FROM THE VERY ACUTE PHASE TO THE SUBACUTE AND CHRONIC PHASE

Main body function impairment

According to the site of the lesion, many different impairments can be variously associated leading to a lot of possible clinical presentations. Language disorders (aphasia), dysexecutive disorders, other cognitive impairments as apraxia or agnosia, visuo-spatial neglect and neglect syndrome, visual field amputation (hemianopsia, quadrantanopsia), swallowing disorders, paresis, spasticity, anesthesia or hypoesthesia, abnormal motor control. Each of them can be isolated or associated with others to different extent. They have to be carefully identified by a complete examination. Consequences on activities and participation depend on their severity and association. For example, the walk may be impaired by paresis of course, but also by sensitive impairment and cognitive disorders as visuo-spatial neglect and anosognosia.

Some syndromes are typical, just mentioned here: middle cerebral artery with contralateral hemiparesis, hemi-anesthesia, hemianopsia and aphasia for left hemispheric lesion and neglect for right hemispheric lesion (in right handed subjects); superficial middle cerebral artery with upper limb and face dominance of the deficit, anterior cerebral artery with lower limb deficit and dysexecutive disorders; posterior cerebral artery with hemianopsia and contralateral hemianesthesia; cerebellar syndrome; Wallenberg syndrome, etc.

Rehabilitation goals

The ***first goal*** of rehabilitation after stroke is to stimulate neuronal plasticity aiming at the best possible recovery of the different impaired functions (language, motor control, sensitivity, etc.). The recovery of a function can be due to a true recovery as after small infarcts, needing that some tissue that is crucial for function is spared (1), but most of the recovery proceedings are due to *plasticity*. Plasticity is mainly made of remapping of the cortex and neurons sprouting with regulation of synaptic activity and formation of new synapses. Motor, sensory and language cortices are loosely organized into somatotopic functional maps that exhibit high levels of use-dependent plasticity: the maps can be modified by experience. After stroke, cortical remapping is both activity dependent and based on competition for available cortical map territory.

Recovery is likely to involve peri-infarct tissue that has a similar function. According to the size of the cortical lesion and to the persistence of intact corticofugal fibers to send the signal out of the ipsilesional cortex. The integrity of the corticospinal track is crucial (2). Neuronal plasticity depends on the integrity of the spared parenchyma then the pre-stroke brain status, is a critical factor.

To trigger and stimulate neuronal plasticity needs specific intensive training directed on impairments. A critical period of heightened neuroplasticity might exist after stroke (3-5). Such physical or cognitive rehabilitation has been proven to be effective on neuronal plasticity then on recovery when provided at the sub-acute stage after stroke. Most of the studies took place within the first 3 months, beginning after the 10-15th days in rehabilitation departments after the stroke unit discharge. The role of early intensive training is still unknown. Now, the early period could be crucial for neural plasticity stimulation as observed in animals (6, 7) and in humans (4, 8), but at the very early period it does not seem to be useful, even harmful, to provide the patient with intensive physical rehabilitation (9, 10).

The ***second goal*** is to prevent some frequent complications. Some of them must be prevented as soon as the first hours as they could impact survival and functional prognosis.

Immobility related events including bed sores, deep venous thrombosis, pulmonary embolism and chest infections have been a major concern, not so far away responsible for 51% of the deaths after stroke (11). The organisation of care in multidisciplinary stroke units has reduced the risk of death and dependence after stroke (12-14). Among the explanations for such positive result, early mobilization and rehabilitation take an important part. The Very Early Mobilization (VEM) is defined as a first mobilization within the first 24 hours, each day until discharge of the stroke unit, 6 days a week, provided by physical therapists (PT) or nurses, helping the patient to be out-of-bed, sitting or standing, at least twice a day more than usual practice (9) VEM is different from intensive training. VEM is beneficial when provided 2 to 3 per day and there is no need to increase this number (9). But there are still many uncertainties relating to how early should rehabilitation begin and how intensive should rehabilitation be.

Shoulder pain, neuro-algodystrophia – A painful shoulder-hand syndrome can occur after stroke. This kind of neuro-algodystrophia usually occurs during the first weeks after stroke, mostly when the impairments are severe. The main cause is traumatic management of the upper limb during washing, dressing or helping the patient to move in his/her bed. The treatment must be preventive, based on the education of all professionals and care givers to the good way to help a hemiplegic patient. Once triggered, this painful syndrome is very difficult to treat: oral drug for pain, local corticosteroid and physiotherapy are the main treatments. Other causes of shoulder pain may be: spasticity with muscle contraction and tendinopathies, sometimes gleno-humeral sub-luxation or real neuropathic pain.

Muscle contractures and joint deformities – Muscle contractures are secondary to muscle changes related to immobility and to the spasticity usually associated. Spasticity is a term that is often used beyond its definition (increased stretch myotatic reflex), to refer to various types of muscle overactivity observed after Central Nervous System lesion, like spasticity, spastic dystonia and synkinesia; however, the term "muscle overactivity" is more appropriate and should be preferred.

Spasticity can be disabled because of the limitation of active or passive range of motion, with negative consequences on motricity, limb position, function. The mainly involved muscles are, in the upper limb, all the flexors muscles from the shoulder to the fingers and, in the lower limb, triceps surae and tibialis posterior for foot plantar flexion, knee extensors and hip adductors.

Postures and stretching of the paretic muscles have to be done daily by the physical therapist, as soon as the first day, depending on the rapidity of the apparition of the spastic hypertonia.

Not all spastic patients necessarily require treatment, which is considered only when muscle overactivity is disabling or problematic. A list of personal objectives must be proposed for each patient, which will drive assessment and treatment. Physical therapies represent the mainstay of treatment. Self-rehabilitation with stretching and active exercises, intramuscular injections of botulinum toxin, alcohol or phenol injections, oral drugs, intrathecal baclofen, and surgery make up the armamentarium available to the clinician.

Pressure sores – The risk for pressure sores is directly linked to the severity of the motor and sensory deficiencies and consciousness disorders. Usual preventing measures by the nursing staff have to be developed.

Pneumonia – Initial pneumonia is usually related to swallowing disorders. Swallowing disorders are mainly secondary to brain stem lesion or to bilateral hemispheric lesions. It can also occur after a unique hemispheric stroke either massive or located in swallowing motor cortex. Early detection of swallowing disorders by the medical staff is mandatory as to adapt the nutrition. Rehabilitation by speech or physical therapist is then needed.

Urinary disorders – At the early stage the main risk is the retention, needing catheterization to be replaced as soon as possible by intermittent catheterization if needed.

The ***third goal*** is to help the patient recovering the best autonomy despite the residual impairments. Consequences of impairments on activities and participation must be addressed and must be a main goal for rehabilitation, to reduce activity limitations and restriction of participation. The role of rehabilitation professionals and social workers is crucial. Many topics have to be addressed: home adaptation, return to the job, drive a car, and so on.

REHABILITATION

Professionals

Rehabilitation usually involves different professionals. Physical therapists, occupational therapists, speech therapists are the more often needed, sometimes also neuropsychologists, and orthotic and prosthetic technicians. Medical care, coordination and supervision by a PRM specialist, from the early to the chronic stage are highly recommended.

Where rehabilitation should be done?

At the very early stage, i.e. within the first 2 weeks, rehabilitation has to be provided in the acute unit, at the best being a stroke-unit with specialized medical and paramedical teams.

As soon as possible, patient should be discharged and beneficiate from rehabilitation either at home or in a PRM specialised facility. A favourable environment can be provided by the mean of the concept of "early supported discharge", rehabilitation being prepared and organized as soon as the first days in hospital, to be provided at home (15). When the deficiencies are severe or multiple, rehabilitation should be provided in an inpatient PRM department for weeks or months, the patient being then discharged with ambulatory rehabilitation at home or in daily hospitalization.

How long rehabilitation should be provided?

Looking at body function impairment, most of the recovery is achieved within the first 6 months, even 3 months. This is undoubted for motor control altered by paresis. But this is not the case for language disorders, visual and sensitive neglect needing much more time, sometimes years before achieving their maximum recovery. This is also not the case for the consequences of the deficiencies on activities and participation which can be improved long time after the stroke. Maintaining rehabilitation must be questioned when the patient's gain between two evaluations is not obvious. Roughly, if there are no complications, this is about between 3 to 6 months for walking, between 6 to 12 months for hand function and between 12 to 24 months, for cognitive impairments. Then, the chronic stage depends on the function. The main reason to maintain physical rehabilitation is the persistence of disabling spasticity, physical therapy being the best treatment. Education is recommended as self-administered training must be learned: stretching, activities, fighting functional decline, along with the secondary prevention of cardiovascular diseases (cf. infra).

General bases for rehabilitation

All the exercises devoted to recovery follow the same principles. They have to give an intensive stimulation to the patient, i.e. to be slightly more difficult and of longer duration than the patient could spontaneously tolerate, repetitive, motivating. They must respect the fatigue but have to be repeated along the day and the weeks. An amount of 2 to 4 hours a day is needed according to the tolerance.

Rehabilitation of the balance and walking function includes rehabilitation of motor control and sensitivity. If the deficiencies are severe, the use of robotic system can be recommended to train automatisms as the main way to achieve the walk is to walk. An orthosis fixing lower limb joints is sometimes needed especially in case of proprioceptive disorder. An ankle-foot orthosis is often needed to avoid or to limit equino-varus foot during walking. The treatment of the main spastic muscles, triceps, tibialis posterior and quadriceps, is sometimes mandatory. Except in case of bilateral strokes or severe cerebellar lesion, usually the walk has to be achieved, at least for the in-house displacements.

Rehabilitation of the hand function is mostly based on directed goal exercises. It includes also rehabilitation of motor control and sensitivity. The use of robotic system could help recovery of severe deficiencies. Video and serious games, electrostimulation are in an increasing development but their real benefit has to be confirmed. Rehabilitation of hand function is strongly linked to rehabilitation of cognitive disorders.

Rehabilitation of the language must be provided by a speech therapist. In case of non-fluent aphasia, it is recommended to begin as soon as possible to try to avoid the patient developing stereotypes. One hour a day is recommended. Initially the rehabilitation aims at restoring lexicon and grammar for a fluent normal language. When this appears to be impossible, the development of non-verbal communication is trained.

Rehabilitation of the visual neglect requires all the rehabilitation staff, speech therapists, occupational and physical therapist as well as nurses. Two main approaches are developed, a top-down one based on the awareness of the disorder, and a bottom-up one using stimulation aiming at modifying the visual and corporeal referential. These stimulations are for example visual prisms deviating the visual field, electric stimulations with TENS applied in the neck or transcranial magnetic stimulation. Interesting results in research studies have to be confirmed for a daily use. Visual neglect has a high impact on autonomy and risk of falls, it may require long rehabilitation beyond one year.

Rehabilitation of the swallowing disorders: they have firstly to be detected by a cautious early clinical examination. Then measures to prevent pneumonia are mandatory. Persistent disorders in case of cerebellar disorder or multiple strokes need speech or physical therapists.

Rehabilitation of the urinary and bowel function: the main risk is the retention at the early stage (cf. supra) but usually it does not last. The possible persistent disorder is a urinary incontinence usually manageable. There is no place for rehabilitation except in case of cognitive disorders needing behavior rehabilitation.

MAIN PROGNOSTIC FACTORS OF FUNCTIONAL RECOVERY AFTER STROKE

Key period for plasticity: cf. supra.

Previous quality of the central nervous system: as plasticity depends on the quality of the spared parenchyma, previous stroke, small vessels disease, chronic high blood pressure are negative factors.

Side and site of the lesion: there is no major hemisphere when talking about autonomy. Aphasia may limit participation of the patient but dysexecutive and visuo-spatial disorders have a high negative impact on autonomy which can last along the life. The site of the lesion plays of course an important role: for example, integrity of the cortico-spinal tract has been proven to be crucial for motor control and sensitivity recovery.

Age: there is always controversy about the role of the age. The main role of the age is related to the increasing frequency of associated diseases or disorders and previous neurological impairment playing a negative role on the functional prognosis. Plasticity is still efficient after 80 years.

Prevention of complications: cf. supra.

Cognitive impairments have a higher impact on autonomy than motor impairment.

Familial and social environment plays a crucial role on quality of life.

RISKS FOR COMPLICATIONS/ FUNCTIONAL DECLINE IN THE LONG TERM

After a stroke related to atherosclerosis, diabetes or high blood pressure, there is a high risk of cardiovascular diseases, heart failure, new stroke. The priority is the secondary prevention by treating the cardio-vascular risks: treatment of high blood pressure, diabetes, dyslipidemia.

Functional decline of the physical condition must and can be prevented by daily stretching and regular cardiovascular training. Exercises have to be adapted to the deficiencies. They can include walking, bicycle, swimming two or three times a week.

Long term physical therapy is sometimes needed when there is a disabling spasticity, mainly associated to severe impairments, to limit the risk of muscle contractures or maintain the ability to walk in house.

Key messages

- The first goal of rehabilitation after stroke is to stimulate neuronal plasticity aiming at the best possible recovery of the different impaired functions.
- The second goal is to prevent some frequent complications among which immobility related events, consequences of spasticity, shoulder pain and neuro-algodystrophia.
- The third goal is to help the patient recovering the best autonomy despite the residual impairments.
- The main prognostic factors of functional recovery after stroke are the site and size of the lesion, previous quality of the central nervous system and potential co-morbidities affecting function.
- Rehabilitation usually involves different professionals as physical, occupational and speech therapists. Medical care, coordination and supervision by a PRM specialist, from the early to the chronic stage are highly recommended.

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Spinal cord injury

5

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INTRODUCTION

Spinal Cord Injury (SCI) disrupts neurological communication between the brain and the body; consequently the motor signals from brain to the body and the peripheral sensory influx to brain centres are corrupted or completely fail to bypass the level of injury of the spinal cord. The outcome is often a complex and catastrophic injury which is immensely challenging to manage. SCI can lead to devastating medical, social, emotional, psychological, and financial burdens. Such burdens inevitably affect not only the patients, but also their families, friends, employers and ultimately the community as a whole. Additionally, SCI has a derogatory impact on school enrolment, education and economic participation. This could lead to substantially high financial negative influences on the individual and the society (1).

Regarding the incidence of SCI, there is no reliable data for global prevalence; however the estimated annual global incidence is around 40 to 80 cases per million population. Males are the highest risk group. The age distribution lies at the two age extremities of young adults (20-29 years) and elderly (70+). The peak age of incidence of SCI in females is at adolescence (15-19) as well as beyond 60 years of age. Studies reported that adult male-to-female ratio is around 2:1, yet this ratio often fluctuates and is sometimes considerably higher. People with SCI are two to five times more likely to die prematurely, with worse survival rates in low and middle-income countries.

As far as the causes of SCI are concerned, mechanical SCI is due to a variety of mechanisms such as road traffic collisions, falls, diving, violence, work and sports related injuries. On the other hand, non-traumatic causes of SCI result from narrowing of the spinal canal, infections, vascular insufficiency, inter-vertebral disc disease leading to nerve compression, primary or secondary tumours of the cord, and others.

The severity and extent of disability after SCI is largely related to the level of injury to the cord itself. For instance, injuries at the thoracic, lumbar or sacral segments would commonly result in motor and sensory loss in part of the trunk and legs (paraplegia), whereas, cervical SCI often leads to tetraplegia, where all the four limbs and the trunk are paralyzed. There are several factors which could potentially contribute to the severity and the nature of the resulted disability after SCI. Some of these factors are the severity of damage to the cord, mechanism of injury, and patients' pre-morbid conditions such as obesity, old age, poly-pharmacy, advanced diabetes, cardio-vascular disease, mechanical or inflammatory multi-joint diseases, pre-existing neurological conditions, mental health problems and patients' pre-injury lifestyle.

In cases of complete SCI, there would be a complete absence of transmission of motor as well as sensory signals across the point of damage. In incomplete cord injury, however, there could sometimes be a degree of conduction preserved of these signals of variable velocities and potentials. These motor and sensory dysfunctions often result in peripheral motor weaknesses and impairment of different sensory modalities of skin. Moreover, SCI could produce a wide range of disruptions to the involuntary body activities below the level of injury, namely cardio-respiratory, gastrointestinal, urogenital and endocrinological. It can also impair immunological responses, thermoregulatory and homeostatic mechanisms.

Immediately following SCI starts the phase of spinal shock. Soon after the shock phase starts to elapse, patients with suprasacral injuries will often gradually retain reflex activities below the injury level, whereas patients with more caudal injuries are less likely to do so (2).

At the scene of SCI, suspected SCI victims should be strictly immobilized until appropriate handling and transfer by well trained staff become available. Patients should then be carefully transported to dedicated casualty centres where an urgent initial medical assessment would be carried out. Once the patient has been resuscitated and haemodynamically stabilised, the next step is to consider further management of the SCI itself. This would entail either surgical or conservative approach depending on the individual case.

As far as rehabilitation is concerned, it is pivotal that this is commenced as early as possible during the journey of SCI victim's medical care. Rehabilitation intervention essentially includes a multiprofessional input from a wide range of health care providers including Physical and Rehabilitation Medicine (PRM) physicians, nurses, physical therapists, occupational therapists, psychologists, social workers/community liaisons, and others on demand e.g. speech and language therapists, respiratory therapists, kinesiologists, etc. It also involves working along other medical disciplines already involved or that can be beneficially involved in patients' care such as neurosurgeons, vertebral surgeons, internal medical specialists, urologists, etc.

The backbone of a successful and effective teamwork implies a clear communication amongst the team members plus a reasonable understanding of the patient's impairment and the dynamic patho-physiology of it. It also involves establishing a familiarity with the symptoms and signs related to the SCI of each patient. Rehabilitation is a dynamic process which should always emphasize on understanding the rationales behind holistic multidisciplinary care, plus respectfully establishing the real needs, priorities and predicaments of each individual patient at different stages of their post-injury care.

Rehabilitation team sets out realistic short-term and long-term goals for each SCI patient. These goals are framed around medical, rehabilitative and psycho-social needs. They also address any future vocational perspectives including reintroducing the post-injury individual back to the community.

Rehabilitating SCI patients is usually done in a staged manner. The immediate focus of the programme is on the medical treatment of the fractured spines as well as focusing on the consequential multi-system dysfunction. This phase also takes into account the non-medical impact of such life-changing experience on the patients and their families. Following this, comes the stage which mainly deals with restrictions and limitations of activities and participations during the course of rehabilitation, which may last anytime from 3-6 months or more, depending of the level and the extent of the SCI, as well as any associated co-morbidities and complications. Adequate management of affected body systems can potentially result in a reasonable or sometimes near-normal overall functionality. This would subsequently minimise the rate of morbidity, mortality, the length of hospital stay and the overall costs of stay, while maximising patient's health, quality of life and productivity of the individuals to be able to live a fulfilling life.

THE INJURY, ASSESSMENT AND DIAGNOSIS

The mechanism of spinal injury may vary according to the direction and the velocity of the trauma to the cord. It can take one or combination of the following forms:

- Hyperflexion;
- Hyperextension;
- Rotation:
- Luxation;
- Direct immediate damage to the cord.

The latter is commonly seen in traffic collisions or gunshot injuries. Primary impacts to the nervous tissue are commonly followed by secondary damages due to vasogenic oedema and anoxia. The degree of motor and/or sensory impairment is determined by the level and severity of the cord damage.

The most vitally crucial assessment of SCI injury patients is best to be carried out in the causality unit in a systematic and succinct way. This allows clinicians to determine the patency of the patient's airway, also to assess for respiratory or cardiovascular compromise and manage them accordingly. It is additionally useful in fishing for any occults intra-abdominal, pelvic or limb active bleeding or injuries. After ensuring that SCI victims are clinically and haemodynamically stable, they are then cautiously transferred to a SCI-specialized centre.

Assessment of neurological deficit after traumatic SCI should always be combined with screening for any potential spinal instability including bone fractures, disc injuries and ligament tears. It is pivotal to holistically examine patients with traumatic SCI and actively look for other non-spinal cord related impacts on other areas of the body such as head, ribs, visceral, genital, pelvic, limbs, and vascular injuries.

SCI can potentially lead to a profound autonomic system instability which almost always manifests itself as bradycardia and hypotension. These changes may determine the practicalities and the nature of both acute and rehabilitative managements of SCI patients. Moreover, because the autonomic system is malfunctioning after SCI, the body could potentially fail to effectively handle any excessive fluid input or early verticalization which may both further destabilize the already vulnerable area of SCI.

Different radiological modalities can be of help in assessing the extent of the cord injury. They are also useful in diagnosing possible associated ligament tears, local haematomas and vertebral fractures. These imaging modalities are chosen according to local facilities, clinical indications and, of course, justifiable contraindications. Examples of some of the widely used radiological investigations are: X-rays, computerised tomography (CT) scans and magnetic resonance imaging (MRI) scans.

The extent of the depth and the level of the actual SCI are measured according to the American Spinal Injuries Association (ASIA) impairment scale (AIS) and the Standard Neurological Classification of Spinal Cord Injury (3). The level of SCI and the functional residual ability can be better determined by physical examination of 10 key muscles on each side of the body. As a rule of thumb, the level of injury is determined by its corresponding key muscles. These muscles will have a power grade of at least 3/5 i.e. movement against gravity or against some resistance. This is confirmed by the fact that the proximally adjacent group of muscles should be fully intact with a power grade of 5/5 i.e. full strength is preserved. For instance, if the level of SCI is at C6, clinical examination would indicate 3/5 muscle power of wrist extensors and a normal 5/5 power of elbow flexors of the same limb. Detailed neurological examination between 72 hours and 1 week following injury may provide a rough predictive guide to the neurological and functional recovery.

Decision about the final treatment of SCI itself, whether surgical or conservative, depends on several factors. Some of these factors are related to the degree of spine instability, progression of neurological impairment and patients' clinical profile and age. This decision tends not to be a final one stop-shop. It is usually subject to regular assessments within the multi-professional team and effective communication and liaising with the spinal surgeons.

PROGNOSIS, NATURAL HISTORY AND RELATIONSHIP TO IMPAIRMENT

Physiological and biomechanical stability determines the outlook of post-SCI motor functionality. Most patients with motor or at least sacral sparing, i.e. incomplete AIS B-E, 72 hours following the injury will regain motor power sufficient to enable them to walk again. Patients with complete injury (AIS A) have the worst prognosis with only 10% chance of some recovery. Amongst those who progress from complete to incomplete injuries, around 3-6% will restore functional strength in the lower extremities.

Further recovery after SCI is possible within the zone of partial preservation, or when the bony fracture is below the neurological level of injury. It also happens in cases of non-functioning myotomes with existent pin-prick sensation. Both complete and incomplete SCI patients need a focused rehabilitation management which would enable them to learn new skills to compensate for lost functionalities, it would also help them minimise limitations imposed by the impairment.

The functional capacity of the patient is largely dependent on the metameric level of the tetra/paraplegia as follows:

C1-C4 (High complete tetraplegia) – Patients have little or no movements of their arms, while movements of head and neck and shoulder shrugging are possible. While C4 tetraplegic patients may not require long-term mechanical ventilatory support, patients with C1-C3 injuries are likely to be dependent on it. This is because of the disruption of the innervation to the diaphragm as part of the SCI. The physiological status of nearly all C1-C4 tetraplegic patients is insecure and may require advanced and permanent assistance.

C5 and C6 tetraplegia – Patients generally have an active elbow flexion; additionally C6 patients may preserve a possible wrist extension with tenodesis action. These movements would enable them to use assistive devices for feeding, grooming, and sometimes dressing. They can also use manual wheelchairs with grip enhancements, as well as power wheelchair for long distances and on uneven surfaces. In terms of other tasks such as full dressing, transfer mobility, bowel and bladder care, these patients often require assistance; however some C6 injury patients may function independently, even including ability to drive adapted vehicles.

C7 tetraplegia – In this category, active elbow extension remains intact. With the help of assistive technology patients may successfully achieve independence in feeding, dressing, bathing, grooming, bed mobility, transfers and community manual wheelchair propulsion, although not on very uneven surfaces and curbs. Male patients may master bladder management usually via intermittent catheterisation. Oppositely females commonly require external help with intermittent catheterisation. C7 injured patients may potentially be able to use computers and phones, which can open some vocational perspectives for them.

C8 tetraplegia – These patients tend to have good hand grasp and release movements. This enables them to comfortably achieve self-care and independent driving of adapted vehicles.

Paraplegia – Individuals with thoracic or lumbar injuries can regain a reasonable level of self-reliance with activities of daily-living, including advanced transfer from floor to wheelchair for instance. They can also reach a satisfactory stage of community skills and participations.

Patients with lower thoracic and lumbar injuries may be able to stand through using bilateral hip-knee-ankle-foot orthoses (HKAFO) or knee-ankle-foot (KAFO) orthoses and crutches. The skills to use these aids can help them become independently ambulant in community. From T11 level downwards there would be a noticeable advancement in patient's ambulatory skills. The lower the level the steadier the ambulation would be. For a safe and confident community ambulation functional hip flexion and knee extension should be preserved. This is usually the scenario in L2 and L3 SCI.

Incomplete SCI patients may benefit from body-weight supported treadmill training, while functional electrical stimulation may be useful in both complete and incomplete SCI to achieve tasks in ventilation, self-care and ambulation. Tendon transfer surgery may be used as an option to promote limb functional movements and advance these movements to more distal SCI levels.

Spasticity is very common after SCI and is one of the most challenging complications to effectively manage, however spasticity is not always a disadvantageous issue. Contrarily, spasticity can be of tremendous benefit to some patients. This is because preserving a degree of limb spasticity in some patients can help them perform some of their daily activities via using the spastic part of the limb e.g. turning, standing, operating assistive devices, etc. It is very crucial to bear in mind that spasticity can be aggravated by several factors such as pain, urinary retention, constipation, certain medications, mental status of the patient and exhaustion. All these aggravators need careful screening and appropriate management to improve the outcome of spasticity management following SCI. Generally speaking, for the majority of patients increased spasticity results in a wide range of complications including restricted movements, pain, poor hygiene, skin abrasions, pressure sores, infections, bone and joints dislocation and fractures. Tackling spasticity in these cases is a must.

Pressure sores are another difficult sequel of SCI. Impairment of sensory neuronal pathways post-SCI can cause a profound skin paraesthesia or anaesthesia which can endanger skin integrity and texture leading to pressure and shearing skin sores, more obviously over bony prominences and pressure areas of the body. It usually results from inadequate skin support and care by staff or patients themselves at a later stage. Pressure sores can lead to significant health implications if not identified and managed appropriately whether conservatively, surgically or combination of both.

Neurogenic bladder can often follow SCI when innervation to bladder walls and sphincters is affected. Inappropriate bladder care without well-structured voiding regime can pose a serious threat to the upper urinary tract and lead to significant morbidity and mortality due to risk of infections, stones formations and structural damage to the renal tract. Bladder management programme should be designed around the nature and the severity of bladder dysfunction. It can take the form of spontaneous scheduled voiding, intermittent catheterisation, or rarely supra-pubic cystostomy. Sound and robust management of neurogenic bladder is essential for a better quality of life and to reduce the morbidity and mortality rates after SCI. Similarly, nerve supply to the bowels can be involved in SCI which leads to neurogenic bowels. The presentation of neurogenic bowels can take the shape on the scale from diarrhoea to constipation. Bowel management with the use of various techniques and/or through regular administration of one or combination of laxatives is vital.

SCI-induced osteoporosis is a multi-factorial sequel where prevention, effective screening, early diagnosis and management are necessary to avoid pains and pathological fractures.

Haemodynamic instability with the potential to develop autonomic dysreflexia has been mainly observed in tetraplegic and high paraplegic patients, and they must be monitored in all phases from early-acute to the long-term.

THE MULTIPROFESSIONAL TEAM APPROACH TO SCI

The main objective of acute care after SCI is to ensure a priority is given to maintain biomechanical and physiological stability. This may help preserve the unaffected fibres at the site of injury. Moreover, careful attention should be paid to detect and manage complications as early as possible (4). Certain pharmacological agents can be used in the immediate phase following traumatic SCI. The most popular is Methylprednisolone which is administered early after the onset of the injury (5).

Multiprofessional approach is the backbone of effective rehabilitation which should be proactively commenced as early as possible, ideally on the first day of admission. PRM specialists should holistically assess the patient through history taking and a thorough clinical examination. This initial assessment helps identify and address any clinical, neurological, or functional issues. They should also set out realistic rehabilitation short and long-term goals and map out future management of the patient accordingly.

Effective leadership skills is one of the most essential attributes PRM specialists have to adopt in order to successfully lead the team and to coordinate the team dynamics, undertake and delegate tasks appropriately, prescribe medications, liaise and refer to other specialities, also write discharge letters, and provide rehabilitation and orthotic aids. They should also have the skills and competencies to perform certain procedures e.g. comprehensive tracheostomy care or surgical removal of necrotic tissue from pressure sores. Such skills are driven by available resources, up-to-date staff training and clinical demands of the particular SCI unit.

Physical therapists are an essential element of productive rehabilitation. They continuously provide and monitor progress and effectiveness of kinesio-therapy and hydrotherapy. Moreover, they provide patients with regular sessions to help them develop skills and muscle power for balance, sitting, standing, transfers, mobility, verticalization, ambulation and maintaining range of motions. Other forms of therapy such as biofeedback, electrotherapy, thermal therapy, ultrasound, magnetotherapy and balneotherapy may be used as well, however, robust evidence behind their effectiveness is still lacking. On the other hand, some studies succeeded to provide evidence for the use of functional electrical stimulation as an option to improve function of upper extremities (6).

One of the main pillars of rehabilitation team is occupational therapists. Their main focus is to improve patients' posture, transfer, and undertaking activities of daily-living such as feeding, grooming, cooking, shopping and personal-care. Their role extends even further to involve evaluation of equipment e.g. wheelchairs, hand splints and orthotics, as well as housing adaptations and driving assessments. With the help of ever evolving technology, novel robotic and virtual reality technologies may facilitate these skills in the future.

Nurses have the biggest and most effective share of SCI patients care. They play a golden role on a daily bases in assessing and treating bladder and bowel dysfunctions. They also provide round the clock skin care and ensure adequate dietary intake by patients particularly at the early catabolic stage of SCI. Intermittent catheterisation is the gold standard and most effective practice for neurogenic bladder. Sufficient education on self-catheterisation can be provided by the ward nurses to patients who would benefit from it and are keen to accept and perform it themselves. Likewise, education of families and caregivers can be secured as it is proven to be a necessary part of rehabilitation and continuation of patients care.

SCI is a catastrophic and life-changing event, which may understandably leave a tremendous negative psychological impact on patients and their relatives. Here comes the duty of the Psychologist who should provide continuous support to patients as well as their families and provide feedback to other team members. Premorbid mental health illnesses should, always, be taken into account as it would help determining the level and urgency of the psychological intervention. Referral to specialist psychiatrists is sometimes required in refractory cases or in suicidal patients.

Social workers/community liaisons provide early support during inpatient rehabilitation time and reaching to the community service that would enable the use of available resources and prepare for soft-landing of the patient to his community, schooling, professional and leisure activities.

Some SCI patients may develop swallowing and speech problems such as dysphagia, odynophagia, aphasia, dysphasia or dysarthria respectively. Swallowing and speech problems are particularly common in cases of concomitant brain or high cervical injuries, post-intubation or post-tracheostomy. Speech and language therapists regularly screen for and address swallowing and speech problems related to SCI. Special tests can sometimes be used to assess swallowing such as the blue dye swallow testing and the fiberoptic endoscopic evaluation of swallowing (FEES), this largely depend on local availability and staff training.

Dieticians usually deal with each individual patient's needs according to their medical background, dietary requirements, body weight, as well as the stage after spinal cord injury whether at the early (catabolic) phase or late on to monitor and prevent obesity.

Finally, given the complexity of SCI, it is not uncommon to have a wide range of other specialists and health care providers contributing to the care for SCI patients such as neurosurgeons, anaesthetists, ICU staff, traumatologists, orthopaedic surgeons, general medical specialists, etc. Therefore, maintaining a high quality communication and continuous liaison with other specialities is paramount in SCI patient's care.

GOALS OF THE REHABILITATION PLAN

The aim of rehabilitation management is to address any issues that can negatively alter the body function and structure; it also aims to minimise limitations and restrictions to participating in daily and social activities.

Due to impaired body mobility of SCI patients, they are often in need for an external help for turning in bed, sitting, transfer, personal care, walking, eating and grooming depending on the severity and the onset of the SCI. The vast majority of SCI cases are young who suddenly transform from independently functioning at the peak levels of productivity and energy into totally disabled and reliant on others for the simplest of human needs to survive and minimize harm. The initial focus on rehabilitation programme should be around the loss of control of primary body functions before moving onto more complex issues such as social activities and participation.

Focusing on enhancing patients' potential to participate in social and general life activities is one of the long-term goals of successful rehabilitation. This is usually the case where limited participation in life activities would likely be detrimental to professional and personal lives. Rehabilitation team has to think broadly to help such victims overcome these obstacles by the careful choice of methods and equipment used in the community to secure them decent and fulfilling living standards.

Spinal cord injury profoundly affects almost every single aspect of patient's life. The more the complete and proximal the levels of injury, the more disturbed these functions are. Difficulties leading to restrictions in participation are seen in all ages and both sexes. The nature of these difficulties though varies depending on the age and commitments each patient has to inevitably adhere to. For instance, younger individuals have difficulties in completing education not only because of physical barriers, but also because the choice and the nature of their education have to be adjusted or even completely altered to realistically match their post-SCI status. Such adaptations are not necessarily appealing to patients and their relatives who would adopt a refractory denial state to the severity of injury and paralysis and the actual impacts on the youngster's capabilities.

Participation restrictions in professional life become more obvious in less educated patients with slimmer chances for potential new qualifications or skills after SCI injuries. These skills could enable them to undertake non-physical desk jobs. This group of blue collar labourer become very disadvantaged after the disability as they tend to lose their jobs or take an early retirement then consequently lose the supportive role for themselves and their families. Besides these vocational restrictions, social involvement and hobbies become a cumbersome. This not only because of physical limitations, but a hefty of patients' time would be spent on their medical needs. Therefore, attempts to restoring these activities should concentrate on patients' transfers, movements and sphincter control. It also includes establishing a wide social network, return to own property, involvement in vocational and leisure activities.

In summary, the main goals of rehabilitation intervention are to return the patient to a reasonably productive life, diminish the sequel of neurological injuries and to improve the overall functional abilities, so that patients remain physically and mentally as healthy as possible, and complications are minimised.

OUTCOME, DISCHARGE PLANNING AND LONG-TERM FOLLOW-UP

Effective rehabilitation program should comprehensively evaluate every single aspect concerning patients' needs including a review of medical records, extensive history taking, systematic physical examination, blood investigations, radiological imaging, bowel and bladder assessment involving urological studies, skin care, medications review, physical and occupational therapy evaluations for motor and sensory changes, assessment of daily-living activities such as posture, transfers, personal care, grooming, cooking, shopping, eating and drinking. Moreover, it also looks into assessing the need for psychosocial input, walking aids and equipment, all in the short and long terms.

Generally speaking, discharge for inpatients commences approximately 3 months after admission for paraplegic, and 6 months for tetraplegic patients. Planning entails continuous communication and liaising with patients' relatives and the relevant authorities at the patients' locality to address specific needs of each patient individually after the discharge. A detailed written discharge care plan and recommendation is then sent out to the caring General Practitioner (GP). This care plan should clearly specify each patient's expected needs and follow-up in the community including medications reviews and specific follow-up investigations, physical therapy and necessary nursing care. Some patients may need a referral by their own GPs to the local PRM departments for further assessment; some of them are offered assessment at their own properties through organised home-visits.

Following the initial inpatient rehabilitation phase illustrated above, patients will be re-admitted to the SCI centre for a follow-up assessment 12 months post-discharge. The idea of this is to ensure that initial plans have been implemented, and to also offer another round of inpatient physical and occupational rehabilitation if indicated. The length of stay in the SCI unit this time varies depending on the individual's need, yet it tends to be considerably shorter than the initial admission episode following the SCI. Following this follow-up readmission, patients undergo annual readmissions to the SCI unit for the first 3-5 years, or until they establish consistent healthy routines and participations in the community, whichever comes first.

Once patients have consistently demonstrated their ability to well manage their complex and chronic conditions, a reduction in frequency of readmissions is possible to every other year, or sometimes even less often. This largely depends on the patients' readiness, the level of support available at home, and the local provider's facilities and expertise. The frequency of reassessing and readmitting SCI patients to the SCI unit is not rigidly fixed. We should always bear in our minds that SCI patients' coping mechanism and physiology tend to cease as the time goes by, therefore their medical and functional conditions can immensely deteriorate. In this case they may require a more frequent reassessment which is usually kept at annual bases to early recognise and address new health issues and prevent major costly disasters.

Further information about SCI management can be found on website of The International Spinal Cord Society (ISCoS), which promotes the highest standard of care in the practice of SCI, through its medical and multidisciplinary team of professionals, to foster education, research and clinical excellence (7).

Key messages

- Spinal Cord Injury is a catastrophic event which leads to paralysis of essential parts of the body and multi-system dysfunctions. It is, therefore, vital to holistically rehabilitate SCI victims to restore and maintain a reasonable quality of life and to minimise the burden on their families and communities.
- Successful rehabilitation means a focused multiprofessional team effort in dedicated rehabilitation units with availability of equipment and expertise to deal with all potential presentations; this should be guided by a PRM specialist.
- Intelligent and timely approach to the acute medical and rehabilitative issues, followed by a robust long-term care planning, may well lead to near-normal eventualities, which will in turns enhance patients' chances in living a fulfilling life after the injury.

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Multiple sclerosis

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INTRODUCTION

Multiple Sclerosis (MS) is due to a multifocal and progressive autoimmune demyelination resulting in characteristic plaques of different ages scattered throughout the Central Nervous System (CNS) (1). Not all of these lesions induce clinically evident impairments and symptoms. Some of them remain "silent" depending on their localisation, but all together contribute to a progressive deterioration of the transmission and the neuronal treatment of information within the brain and the spinal cord. The CNS might be able to compensate such impairments for some time so as they might become clinically manifest and disabling only at a later stage of the disease. However, the CNS networks being forced to deal with an increasing number of impaired connections, the functioning of the CNS becomes more and more complicated resulting in physical and intellectual fatigue already at early stages of the disease.

At the onset of the disease, about two thirds of the MS patients present a relapsing-remitting form of the disease. The brisk onset of neurological symptoms and impairments is followed by a clinical remission lasting until the next exacerbation of the disease. Over the years most of them will convert to a progressive form. Only about 10% of the patients retain a relapsing-remitting course for their whole life. About 20% of the MS patients start with a primary chronically progressive form. The remaining patients start with a form which associates a progressive course with superimposed acute episodes.

VARIABLES INFLUENCING DISABILITY OCCURRENCE AND PROGRESSION

The disease-related impairments of MS are quite complex. Different parts of the CNS can be affected sometimes simultaneously sometimes sequentially at different moments of the evolution of the disease, leaving or not permanent clinical sequelae (2). Each MS patient has his own pattern of acute and chronic symptoms and impairments which also vary over time as the disease progresses. Therefore, disease-related disability is very complex and differs from patient to patient, and from time to time in the same patient. Additional impairments secondary to those directly related to the disease further complicate the situation by extending and aggravating the primary impairments.

The diversity, multiplicity and complexity of the functional profiles of MS patients and their evolution in time make rehabilitation planning and implementation a challenging enterprise. Only an individual holistic approach by a medically coordinated multi-professional team can bring about optimal results.

The type of MS, either relapsing-remitting, primary chronic progressive or progressive with superimposed acute episodes, also influences the planning and content of the rehabilitation interventions.

In the case of the relapsing-remitting form, rehabilitation interventions focus on the prevention of secondary impairments during the acute phase of the relapse and the recovery of the lost functions. Special attention is given to the correction of any loss of endurance during the acute relapse.

For the chronic progressive MS type, the rehabilitation program aims at promoting functioning at the highest possible level. This includes uplifting weak functions to a state of training which allows compensating for their weakness by regular exercise and practice, substitute activities or change the way they are performed (adaptation), provide orthosis or appropriate external aids to promote activity and participation as well as adapting the patient's environment for maximal participation. The prevention of secondary impairments that enhance the burden of MS-related disability is also a compulsory component of any rehabilitation plan for these MS patients.

For the progressive MS type with superimposed acute episodes the two strategies must be combined.

GENERAL PRINCIPLES OF REHABILITATION MANAGEMENT

MS is a chronic disease and MS patients need a lifelong rehabilitation program which must be regularly adapted to the progressive aggravation of the functional profile taking also into account the patient's individual life habits, needs and context factors which might also change over time (2).

The first objective of rehabilitation interventions in MS patients is maintaining the best possible levels of performance in all domains of functioning. Appropriate regular strength and endurance exercise programs allow to prevent weakness and muscle atrophy secondary to prolonged inactivity and generalized deconditioning. Exercise is safe and effective as long as it is used with moderation and adapted to the patient's individual tolerance. Exercise programs should preferentially involve muscles that are needed for activities which are meaningful to the patient and which are adapted to his context and needs. A good level of force, endurance and cardio-vascular fitness increases tolerance to activity and exercise, delays the occurrence of fatigue and maintains functioning as long as possible. Sometimes muscle strengthening must be temporarily focused on muscle groups needed to compensate impaired or lost function or to use assistive devices (e.g., training of shoulder girdle and arm muscles for the use of crutches, for the performance of push-ups for wheelchair users and for transfers to and from the wheelchair).

After acute relapses of the disease, special attention should be paid to disuse weakness and deconditioning. Whereas the CNS function recuperates, there is only limited spontaneous recovery from the loss of muscle strength, local and cardio-vascular endurance or motor skills unless an appropriate exercise program is initiated. Otherwise MS patients go on functioning at a lower level than what the recovered function of the CNS would allow.

As the disease progresses rehabilitation intervention will focus more and more on compensation for lost functions, boosting residual function, introducing mobility aids like crutches, splints, orthoses, wheelchairs, scooters, robotic devices, etc. Each technical aid must be wisely chosen and adapted to the patient special needs and context. It is important to teach the patient practically how to use the device through appropriate training and exercise sessions. The patient's environment must be progressively adapted to the increasing disability which sometimes means to change accommodation as well. As MS is a progressive disease, any function eventually changes, so a diagnostic follow-up is needed in order to regularly update the management program.

In MS patients with severe disability, rehabilitation is centred on the preservation of adequate joint mobility and muscle length to allow optimal positioning in bed and on the wheelchair and facilitate care. Optimal positioning reduces fatigue and pain and ensures the best possible level of quality of life.

REHABILITATION APPROACHES TO SPECIFIC FUNCTION IMPAIRMENTS

Gait and balance impairment

Nearly all MS patients have difficulties with posture, balance and mobility (3). The CNS systems involved in the control of posture, balance and gait are progressively damage by the disease bringing on an increasing motor disability:

- Damage to the pyramidal system induces a dysfunction of the modulation of the activity of the lower motor neurons. The regulation of muscle tone and the voluntary activation of the skeletal muscles are impaired producing weakness and spasticity. The coordination between agonists and the reciprocal inhibition between agonists and antagonists are disturbed. Generally, the muscle strength is more affected at the lower than the upper limbs.
- The cerebellar dysfunction induces ataxia of the trunk and the limbs, interferes with postural control and causes postural and intentional tremor. Together with the impairment of central vestibular pathways the cerebellar dysfunction decreases balance and delays postural adjustments to correct instability.

- Sensory loss is another important component of motor dysfunction in MS with a pronounced impact on balance and gait.

Adequate levels of functioning can be preserved by compensating the decrease of performance of the neural motor and postural control by regular training of the defective systems. Exercise for balance sitting and standing at rest and during activity are typical representatives of such rehabilitation interventions. Exercises should be performed in a low stimulus environment to increase the patient's capacity to concentrate and enhance the learning effects.

To preserve mobility and balance at the highest possible level it is vital to maintain adequate joint mobility (range of motion) and muscle length (flexibility). Appropriate mobilisation and stretching programs must be included into all rehabilitation interventions in MS patients especially in the presence of spasticity (see below).

Exercises in a pool are an interesting approach also in MS patients. However due to the heat sensitivity of the impairments of MS patients, care should be taken to exercise only in moderate warm or cold water. The microgravity environment decreases the pressure in the joints thus reducing muscle tone and relieving pain and spasticity. It helps to keep and train up-right balance and can be used to assist weak muscles. Exercise against water resistance allows to train strength and endurance; the resistance water opposes to movements increases with speed. Falling in the water is much slower than on ground and patient have much more time to correct a loss of balance. Therapists have also more time to react. This makes water an interesting place to practice static and dynamic postural control and balance.

Unfortunately, the evidence concerning the efficacy of any physical therapy approach to gait/balance impairment in MS patient is sparse and hampered by several limitations.

According to a recent systematic review, 8 weeks of weekly home/outpatient physical therapy is probably effective for improving balance, disability, and gait in MS subjects able to walk ≥5 meters (3).

Other exercise protocols have been found possibly effective for improving gait and/or balance in MS subjects suffering from mild to moderate disability.

Upper limb dexterity impairment

The rehabilitation of upper limb function follows the same principles as the rehabilitation for posture, balance and mobility as the problems are the same: pyramidal weakness, spasticity, lack of intermuscular coordination, ataxia and sensory loss. In earlier phases of the disease, the upper limb dysfunction is manly linked to the loss of the precision of the neuro-motor command. At this stage, the activities which are important for the patient's autonomy, profession or leisure might be improved by specific therapeutic exercise. Effective upper limb movements are very dependent on an accurate control of posture and balance. It is therefore important to integrate upper limb exercise into global training situations which are as close as possible to real life situations.

At later stages it might be necessary to compensate the progressive loss of function by simplification of tasks, introducing technical aids and equipment to compensate the lack of precision (e.g., instruments to assist buttoning) or lost function (e.g., electric toothbrush or computerized environment control).

At some stages, special strengthening of the shoulder girdle and the upper limbs might be necessary to enable patients to use walking aids like canes and crutches or to perform transfers to and from the wheelchair safely and do the regular push-ups to protect the skin of the bottom when sitting in a wheel chair.

Fatigue or impaired tolerance to effort

MS related fatigue is different from the fatigue experienced by healthy persons after a physical or intellectual effort or a sleepless night. The fatigue is physical as well as cognitive and the one of the most common symptoms observed in MS.

MS related fatigue occurs even during and after minimal activity and is perceived as a feeling of continuous exhaustion. MS fatigue is day time dependant and occurs preferentially during the afternoon and in the evening. It is thought to be related to an increase of energy required for nerves to transmit signals through zones with impaired or absent myelin sheets, which complicates the way the CNS works (4).

There is also an increased fatigue of function. Weak functions must operate at unusual high levels of activity to respond to the functional performance imposed by everyday life. This leads to an accelerated fatigue of the involved CNS structures. The occurrence of a foot drop after prolonged walking is an example of fatigue of function. The continuous fight of weak muscles against their spastic antagonists is another source of fatigue of function.

Fatigue can be very disabling even in patients with otherwise mild symptoms, in whom it can limit the ability to participate to intensive rehabilitation programs and cause a reduced ability to work.

Moderate exercise might be the most appropriate approach, since even activities leading to an increased fatigue are not harmful by themselves, though the impact of the fatigue they induce must be considered and activities of daily life must be modulated accordingly (5).

An increase of body temperature can markedly enhance physical and cognitive impairments as the conduction of axons with impaired myelin sheets is much more affected by high temperature than in normally myelinated axons. Hence, care should be taken to avoid marked increases of the body temperature. It is recommended to exercise in low temperature environments. Body cooling by using ice-jackets can improve function and decrease fatigue induced by repetitive activities. Pools, baths and showers should not exceed about 29 °C which is a lower temperature than that considered as neutrally comfortable.

Planning the rehabilitation intervention, it is better to proceed with several short exercise or training periods per day rather than one long session and allow plenty of rest between workouts.

For the daily living activities should be organised so as to take advantage of the physically and cognitively favourable periods of the day and minimise fatigue through periods of rest. Activities should be reviewed according to the principle of Energy Conservation (6). Unrewarding activities should be abandoned or delegated, rewarding activities made more ergonomic, simplified or provided with assistance. Very rewarding activities must be prioritized.

Spasticity or muscle tone impairment

Spasticity is the most common symptom in MS but mild forms are not always swiftly recognized. Yet even mild spasticity can affect the reciprocal inhibition significantly. As a result, the motor impairment increases. The increased resistance to movement during motor tasks contributes to the increased fatigue seen in MS patients. Spasticity preferentially affects upper limb flexors and lower limb extensors and is generally most pronounced in lower limbs.

It is important to remember that spasticity can be increased by noxious sensory inputs from any body structure, but especially from internal organs, joints, soft tissue and skin (like skin ulcers, infections of the skin and the underlying tissues, nail lesions and infections, unstable joints, neuropathic pain, bladder or bowel distension, faecal impaction, appendicitis, uro-lithiasis, pyelo-nephritis). In case of a sudden increase of spasticity it is mandatory to search actively for these conditions and eliminate all identified causes promptly. Orthoses and wheelchair seating have to be checked and adapted periodically in order to avoid that they become a source of nociception.

Untreated spasticity leads to muscle shortening and muscle contractures, worsening of posture and function, which in turn increase the risk of further disability, pain, pressure sores and loss of quality of life.

The management is the same as for spasticity in other CNS diseases (7). Ideally the spastic muscles are stretched systematically every few hours, but this intervention is often difficult to put into practice especially for stages beyond mild motor impairment. The stretching techniques used should make sure that muscles running over two joints are effectively stretched as well.

Oral antispastic drugs, are often helpful but one has to bear in mind that in many MS patients posture and motor activities rely to some extent on spasticity. The weakness induced by oral antispastic medication affect both spastic muscles as well as weak flaccid muscles and can disturb posture, locomotion and other motor activities significantly, if their indication is not carefully thought over and their dosage is not cautiously adapted. Frequently, an inappropriately low tonus of the trunk muscles increases limb spasticity. As a consequence, limb spasticity can paradoxically increase if the trunk is weakened by a vigorous oral antispastic treatment. The somnolence and additional fatigue induced by such medications amplify the impairments due to the ongoing disease and may increase existing disability.

Whenever possible, local and regional treatments should be preferred. Oral baclofen is the most recommended medication. In case of severe spasticity of the trunk or the lower limbs baclofen can also be administered locally to the spinal cord through an implantable pump. This technique allows reducing general side effects of baclofen but not muscle weakness. The benefits of a more flaccid trunk and limbs for moving and care has to be carefully pondered against the loss of function induced.

Tizanidine and dantrolene sodium are not considered as first choice medications, the former because of the marked somnolence it induces, the latter because of its hepatotoxicity which might increase the hepatotoxicity of drugs used for the basic treatment of the disease or pain medication. Cannabis preparations and derivatives might also reduce spasticity (and pain) in MS patients but are still under investigation.

Focal and regional treatments for spasticity such as botulinum toxin, motor point blocks by phenol or alcohol, nerve blocks by phenol and various surgical procedures are used in the same way as for treating spasticity in other CNS diseases. Focal and regional treatments should always be strongly considered before introducing oral medication as these interventions avoid general side effects. They can be targeted on precise muscle groups or chains where needed to improve specific motor functions.

Bladder, bowel and sexual function impairment

Nearly all MS patients experience bladder problems at some time point of the course of the disease (8). There is a strong correlation between physical disability and bladder problems. Bladder problems are a significant cause of morbidity and contribute more to the overall disability of MS patients than any other impairment. Bladder problems have a major impact on self-esteem and a carry a high risk for social exclusion.

An overactive bladder or a weak sphincter make it difficult to store urine with symptoms of frequency, urgency, incontinence and nocturia. An underactive bladder or a hyperactive sphincter hinder voiding with symptoms of hesitancy, urinary retention, recurrent or chronic urinary infection and spill-over incontinency. Urinary retention due to detrusor-sphincter dyssynergia (detrusor contractions increase the tone of the bladder sphincter leading and blocks the urinary flow during voiding) leads to high pressures in the urinary system with reflux towards the kidneys and risk of chronic pyelo-nephritis and impaired renal function.

At any stage of the MS bladder problems must be promptly detected by systematically questioning the patients specifically about bladder symptoms, toileting habits, self-imposed fluid restriction to control bladder symptoms, recurrent urinary infection etc. As symptoms are not reliable to determine the underlying pathophysiology, the urinary system should be investigated with urodynamic tests.

Bladder related impairments and disabilities are cared for by appropriate management and rehabilitation programs similar to those used for patients with spinal cord injury. It is however important to adapt these techniques to the individual sensori-motor and cognitive disabilities of the patient. Context factors such as the level of care the family is able to provide, the availability of community nursing care, the built environment and others must also be taken into account in order to achieve an appropriate bladder management.

Bowel and anal sphincter dysfunction is common in MS patients: about 50% of MS patients indicate at least one episode of faecal incontinence over the preceding 3 months and 25% of them state having one or more episodes of faecal incontinence per week. Combined with motor disabilities faecal incontinence can lead to disastrous situations and impede Quality of Life considerably.

Constipation is a frequent problem and due to reduced gastro-intestinal motility, inactivity, side effect of anticholinergic drugs used for the bladder management, weakness of abdominal muscles, diet low in fibre, voluntary fluid restriction related to bladder problems and postponement of defecation related to impaired mobility and self-sufficiency on toilets. Constipation is also a known cause of increased spasticity.

A bowel management program similar to that used for paraplegic persons and adapted to the patient's special needs should be introduced. The patients should be carefully instructed how to put the program into practice and get the necessary support from specialised nursing practitioners.

About 75% of male and 50% of female MS patients complain about difficulties regarding their sexual activity. However, these issues are rarely discussed spontaneously and openly. The problems they experience are generally due to a combination of specific impairments which affect sexual functions directly and the interference of disabilities related to other body systems and functions.

Patients complain about loss of libido, impaired erection and ejaculation, reduced vaginal lubrication, decreased genital sensations and altered experience of orgasm. These difficulties are amplified by fatigue, the impaired osteo-articular and motor function (muscle weakness, spasticity, ataxia, muscle and joint contractures, etc.) as well as bladder and bowel dysfunction. The altered self-image, the lowered self-esteem and depression are also contributors to the restriction of participation in the domain of sexuality.

Any rehabilitation plan of a MS patient should systematically address the domain of sexual activity. The performance in this domain of participation must be optimised through an appropriate management of the patient's medication and rehabilitation interventions to reduce interfering disabilities as much as possible.

Visual impairment

Following optic neuritis, MS patients often present visual impairments which are not always readily detected such as decreased contrast sensitivity, visual acuity and colour vision. MS affects also the coordination of the eye movements leading to an inability to focus on objects or track moving scenes. These impairments can be quite distressing in everyday life even in cases where they are considered as mild because they add to the impairments of other systems. It is characteristic of MS patients that the addition of many "mild" or "little" impairments bring about a bothersome global handicap as the possibilities for the CNS to create compensations within and between the different neural systems are reduced. When planning rehabilitation interventions the impact of visual disturbances on the overall functioning of the patient has to be studied carefully and integrated into the therapeutic approach.

Cognitive and affective impairment

Depending on the number and distribution of plaques a large number of combinations of cognitive impairments can be seen in MS patients. The communication within the CNS is progressively damaged which decreases its capacity to process information and slows down cognitive brain function. MS patients often have difficulties to learn and recall information and impaired executive functions. The latter is often referred to as frontal impairment even if other brain lesions can bring about the same type of symptoms. Visuo-spatial problem solving and conceptual reasoning are often impaired. Dysexecutive problems like difficulties to plan, initiate, adapt, stop or evaluate activities are often misinterpreted by health carers as laziness, voluntary lack of collaboration, opposition, lack of motivation, etc. and can lead to open conflicts. It is therefore important for all health professionals are aware of these dysfunctions which may not be immediately obvious without a specialized evaluation by a neuropsychologist.

Depending on the situation the rehabilitation of cognitive dysfunctions takes place either globally integrated into the rehabilitation of mobility, balance and activities of daily living or specifically by neuropsychological training methods as used for other neurological conditions.

Depression is quite common in MS patients and about 5 times more frequent than in a general population (9). The suicide rate in MS patients is also increased by a factor of about 7. Depression adds a further negative impact on physical and cognitive functioning and rehabilitation. It is therefore important to recognize depression swiftly and introduce medication or psychotherapy, where appropriate.

It is well established that exercise and optimal functioning have a positive impact on mood which makes rehabilitation a precious mean for preventing and improving mood disorders.

Euphoria and the emotional dysregulation syndrome are frequently seen in MS patients. They tend to interfere with the capacity to adapt to the real world and hamper social interactions and must be addressed in the frame of a rehabilitation program.

CONCLUSION

Rehabilitation interventions in MS aim at keeping the patient functionally independent as long as possible and keep him/her integrated into his social and physical environment. The family has to cope and adjust to the progressive disability.