Neurorehabilitation in Spinal Cord Injury - A guide for Therapists and Patients

Authors :

Dr. V.C. Jacob (PT)

Dr. Amruta Paranjape (PT)

Dr. Alok Sharma

Associate Authors :

Dr. Joji Joseph (PT),Dr. Hema Biju (OT),

Dr. Jayanti Yadav (OT), Dr. Sanket Inamdar (OT),

Dr. Hemangi Sane,Dr. Nandini Gokulchandran

A NeuroGen Publication

Neurorehabilitation of Spinal Cord Injury

A Guidebook for Therapists and Patients

Neurorehabilitation of Spinal Cord Injury A Guidebook for Therapists and Patients

Author :

Dr. V. C. Jacob, B.Sc., DPT, M.I.A.P.
Deputy Director and Head of Neurorehabilitation,
NeuroGen Brain & Spine Institute, Navi Mumbai, India

Dr. Amruta A. Paranjape, BPT, M.Sc. (UK)
Physiotherapist and Research Associate
NeuroGen Brain & Spine Institute, Navi Mumbai, India

Dr. Alok Sharma, M.S., M.Ch.
Professor of Neurosurgery & Head of Department.
LTMG Hospital & LTM Medical College, Sion, Mumbai, India
Director, NeuroGen Brain & Spine Institute, Navi Mumbai, India
Consultant Neurosurgeon, Fortis Hospital, Mulund, Mumbai, India

Associate Authors :

Dr. Hema Biju, M.O.Th.
Consultant Occupational Therapist
NeuroGen Brain & Spine Institute, Navi Mumbai, India

Dr. Joji Joseph, B.P.T., F.C.R.
Consultant Physiotherapist, NeuroGen Brain & Spine Institute, Navi Mumbai, India

Dr. Hemangi Sane, MD (Internal Medicine, USA)
Deputy Director & Head of the Research and Development
Consultant Physician, NeuroGen Brain & Spine Institute, Navi Mumbai, India

Dr. Nandini Gokulchandran, MD
Deputy Director & Head- Medical Services
Consultant Regenerative Medicine
NeuroGen Brain & Spine Institute, Navi Mumbai, India

Dr. Jayanti B. Yadav, M.O. Th (Musculoskeletal Sciences)
Occupational Therapist, NeuroGen Brain & Spine Institute, Navi Mumbai, India

Dr. Sanket Inamdar, M.O.Th.,
Occupational Therapist, NeuroGen Brain & Spine Institute, Navi Mumbai, India

Scientific and Research Coordinator :

Ms. Pooja Kulkarni, M.Sc. (Biotechnology)
Sr. Research Associate

Neurorehabilitation of Spinal Cord Injury
A Guidebook for Therapists and Patients

Coverpage by

Shrijit

Printed by

Surekha Press,
A-20, Shalimar Industrial Estate,
MatungaLabour Camp, Mumbai 400 019.
Tel.: 2409 3877, 2404 3877

Special Contributors

Dr. Vijay Kulkarni, Consultant Andrologist
LTMG Hospital and LTM Medical College,
Bhatia Hospital, Raheja Hospital,
The National Institute for Research in Reproductive Heallth

Ms. Vaishali Ganwir, M.A. (Clinical Psychology)
Clinical Psychologist

Mr. Rishabh Sharan, MPT
Research Associate

Special Thanks

Ms. Bijoli Shah

Mr. Hutaib Adib

Ms. Nehal Thakkar

Ms. Virali Modi

Mr. Adil Ansari

Mr. Darshan Patil

Mr. Roheed Saad

Acknowledgement

Dr. Prerna Badhe, MD
Deputy Director & Consultant Neuropathologist

Dr. Khushboo Bhagawanani, B.P.Th., MIAP, CBE (USA)
Physiotherapist

Dr. Sarita Kalburgi, M.P.Th (Neuroscience)
Physiotherapist

Dr. Dhara Mehta, M.P.Th (Neuro)
Physiotherapist,

Ms. Jasbinder Kaur
Physiotherapist and Research Associate

Dr. Shruti Shirke, M.P.Th (Adult Neurology)
Physiotherapist

Dr. Shruti Kamat, B.O.Th.,
Occupational Therapist

Dr. Lalita Shinde, M.Sc (Advanced Occupational Therapy)
Occupational Therapist

Ms. Ridhima Sharma, (Psychology),
Counselling Psychologist

Ms. Maitree Maheshwari, (Psychology)
Clincal Psychologist

Ms. Sonali Nalawade, D.Ed.,
Special Educator & Art Based Therapist

Mrs. Nilam Pacharne,
Consultant Nutrutionist

Mrs. Vibhuti Bhatt
Yoga Consultant

Dr. Monali Dhanrale, M.H.A.
Hospital Administrator & H.R. Head

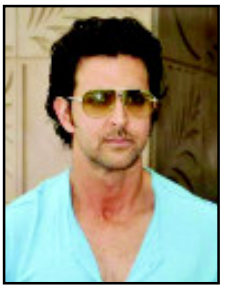
Dr. Hema Sriram, D.A., M.D., D.N.B.
Consultant Anaesthesiologist

Dr. Richa Bansod, M.B.B.S, MS

Grateful Acknowledgements

Mr. John Julius, Ms. Nupur Jha, Ms. Kruti Pitroda, Ms. Monica Chugh, Ms. Hridika Rajesh, Larissa Monteiro, Ms. Monica Vachhani, Mrs. Geeta Arora, Dr. Vinita More, Dr. Snehal Sontate, Dr. Sushil Kaserkar, Dr. Reena Jain, Dr. Kirti Lad, Mrs. Kanchan Patil, Mrs. Manjula Shete, Mrs. Daisy Devassy, Mr. Sumedh Kedare, Mrs.Yasmeen Shaikh, Mr. Abhishek Patil, Mrs. Mani Iyer

Foreword



To the therapists looking after patients of spinal cord injury and the patients themselves :

Writing a preface for this book takes me back in time when I was preparing for my role in Guzaarish. In the movie, I portrayed a man with quadriplegia and his fight to earn his own death. Euthanasia, the subject of the movie was grave and it portrayed one of the grim fates of people who suffer from quadriplegia. It took me a while to understand, comprehend and most importantly accept the way of living of a quadriplegic.

I met a lot of quadriplegic people in the process and I felt that death is not the solution. One of them was John- a wheelchair bound quadriplegic, who had a road accident. The hopelessness that I had portrayed in the movie was whisked away by real life experiences with John. John in the coming time underwent stem cell transplantation and rigorous rehabilitation at NeuroGen Brain and Spine Institute and looking at the way he improved I felt that there is hope for patients with spinal cord injury. I also understood the importance of rehabilitation in the lives of quadriplegics and paraplegics. Rehabilitation is a tool that can help them maximize their potential and far beyond that.

This book is unique and special in its pictorial depiction of step wise rehabilitation for the patients with spinal cord injury. It will help numerous patients who have lost all hopes of living an independent life. There was much need for a guidebook for patients suffering from spinal cord injury and I am happy that such initiative has been taken.

Unlike the hopelessness and helplessness that I felt while I was portraying 'Ethan Mascarenhas' in reality the quadriplegics live with a great dignity and unyielding spirit. If this book had been available before I played the role of 'Ethan' it would have been a great help to me.

I thank the authors for putting together this much needed book as well as for asking me to write this introduction. My best wishes are with all the therapists and patients who read this book. I want all the therapists to know that your hard work helps makes a big difference to the lives of Spinal cord injury patients and I wish to tell all the patients who read this book to not give up on themselves since as long as there is life there is always hope.

Hrithik Roshan

Preface

For those of us working in the field of spinal cord injury, our work has always been challenging and demanding and yet often not yielding the results that the patients expected. All these years despite the wonderful research done by thousands of researchers we still seemed far away from a cure for spinal cord. But all that is changing now. New research in the fields of Neurorehabilitation and Regenerative medicine are finally showing us the silver lining that we have waited for all these years and giving us hope that a satisfactory cure can be achieved in the near future.

Until then what do we do? We have to continue all our efforts at rehabilitation. But Spinal cord injury rehabilitation is very difficult and time consuming. WHO has declared Spinal cord injury as the most devastating disability. It is a challenge for all the persons in the Rehab team, viz. Surgeons, Physiotherapists, Occupational Therapists, Medical Social Workers, Orthotists, Psychological Counselors and Vocational Counselors. Unless all these team members come together, satisfactory results cannot be achieved.

The purpose of writing this book is to highlight the various problems of SCI and showing the ways and means of solving them. The therapy techniques are shown with pictures. This book is intended to be a handy guide for therapists when they are treating paraplegics and quadriplegics. It is also intended to help the patients themselves through their process of rehabilitation. All efforts have been made to make this book useful to Physiotherapy and Occupational Therapy students as well as persons who are undergoing treatment.

New developments in the field of Regenerative medicine, the significant increase in the conducting of clinical trials in spinal cord injury and the availability of stem cell therapy have resulted physiotherapists and occupational therapists having to play playing a greater role in the overall management in many aspects including pretreatment evaluations, planning of the treatments, and post treatment therapies and monitoring the improvements. It is important therefore for all rehabilitation therapists to keep themselves updated with the newer developments in these fields.

This is a collective venture of our colleagues, P.T, O.T, Psychologists .We are thankful to each one of them. To all those reading this book what we have to say to you is that your hard work can lift a wheelchair patient back into his feet. The work may be challenging but it makes a big difference to the lives of these patients.

Dr. V. C. Jacob (PT)

Dr. Amruta Paranjpe (PT)

Dr. Alok Sharma

Contents

SECTION A

Introduction to Spinal Cord Injury

Chapter 1
About Spinal Cord Injury

Spinal cord is the continuation of the brain and means of communication between the body and the brain. The nervous tracks extend from the brain into the spinal cord and then spread through the network of nerves throughout the body. Through the network of sensory fibers spread in the body spinal cord sends the sensory information to the brain, these fibers enter the spinal cord at different levels. There are nervous fibers that run up and down in the spinal cord. The levels from where motor fibers spread out and sensory fibers enter the spinal cord are called spinal cord roots and are very important to understand the implications of spinal cord injury.

Structure of the spine

Human spine or spinal column consists of 33 bones, vertebrae. These are divided in 4 sections, Cervical (7), Thoracic (12), Lumbar (5), Sacral (5) bones are fused together to form Sacrum and Coccygeal (4) are fused to form coccyx or tailbone (Figure 1.1). The main function of the vertebrae is to protect the spinal cord and to support the head.

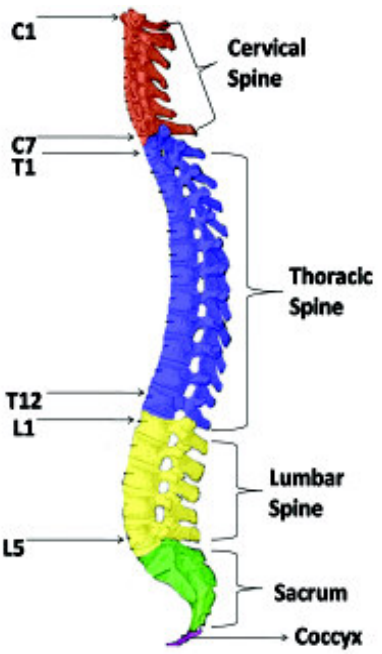


Figure 1.1 Structure of the Spine

Structure of the spinal cord

Spinal cord is the extension of the brain running down the back and is protected by the bony spinal column. It is covered by a fluid buffer continuous with the brain, cerebro spinal fluid and then multilayered outer coverings. Spinal cord consists of all the nerve tracts and nerve roots that come out of the spinal columns at different levels. Nerve roots give rise to the network of nerves running through the entire body. The nerve fiber tracts in

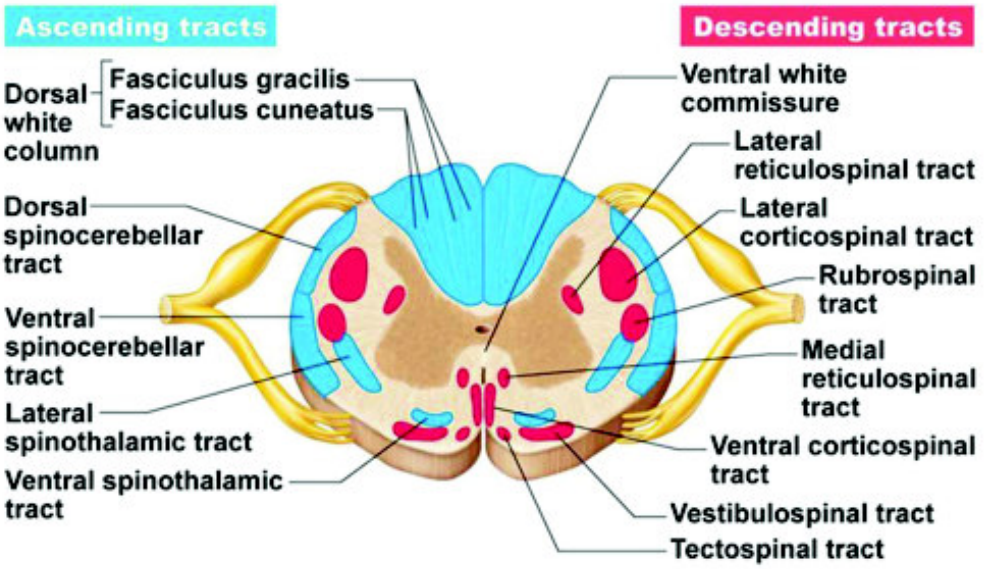


Figure 1.2 Structure of the Spinal cord
Picture courtesy: Marieb, E.N. & S. Mitchell, 2011. Human Anatomy and Physiology Laboratory Manual. 11th Ed (Cat Version). Pearson Benjamin Cummings, San Francisco, CA. (ISBN: 10-0-321-61612x)

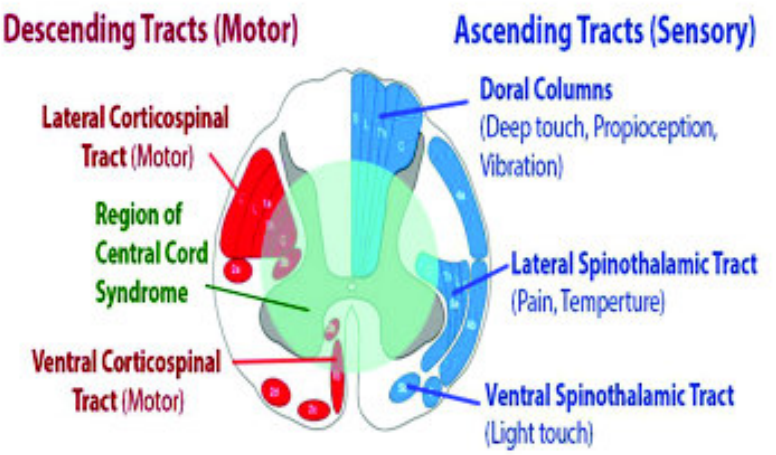


Figure 1.3 Functions of Spinal cord tracts
Picture courtesy: http://i.imgur.com/xtQmbXZ.jpg

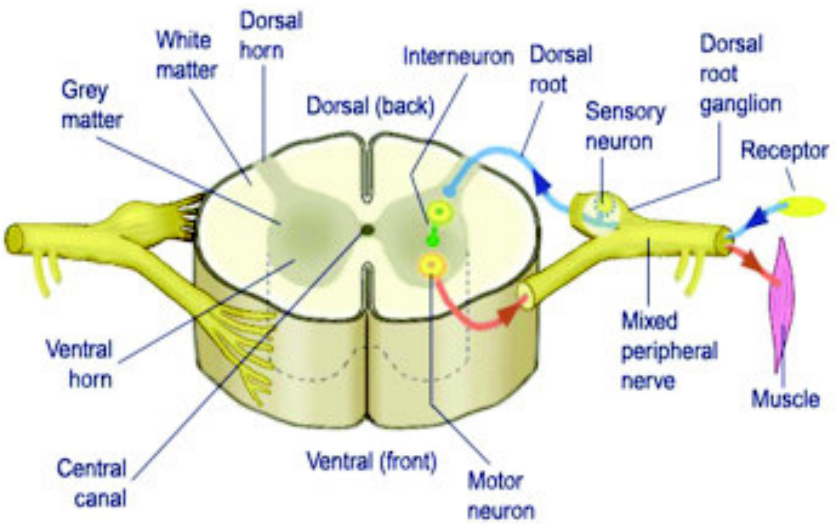


Figure 1.4 Structure of Spinal nerve root
Picture courtesy: https://anjungsainssmkss.wordpress.com/category/sains-ting-4-form-4/chapter-2-body-coordination/

the cord are of two types motor and sensory. Motor tracts are usually aligned centrally at the posterior part of the cord and are more to the periphery at the anterior part of the cord. This placement is of particular relevance incase of partial injuries and infection where the direction of the injury may selectively damage the motor tracts and preserve the sensory tracts.

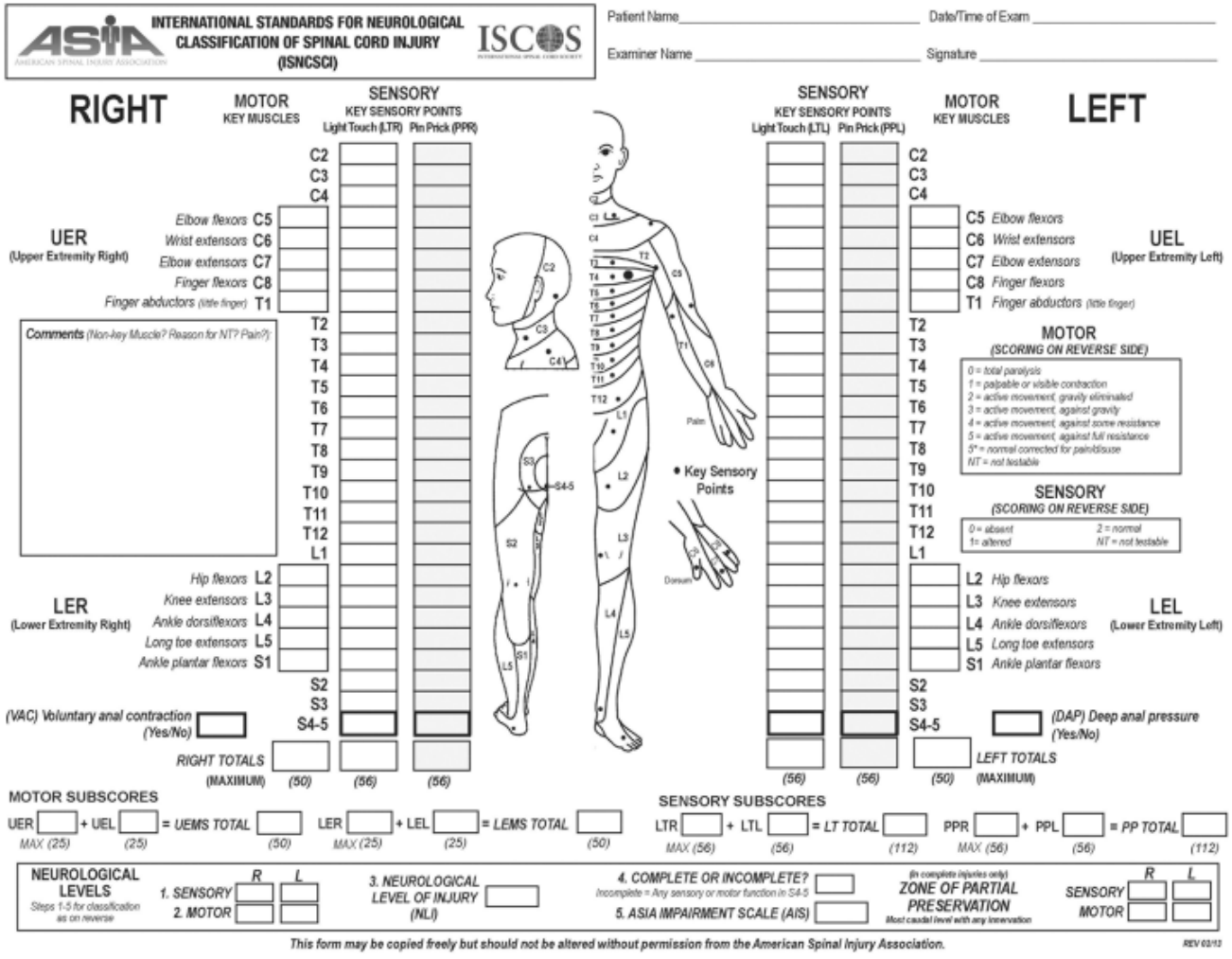
Causes of spinal cord injury

Causes of spinal cord injury can be divided in two categories for simplicity traumatic which involves a physical trauma to the cord or surrounding structures and non-traumatic which involves infection or compression of the cord due a disease process and space occupying lesion (tumors).

Traumatic spinal cord injury may occur due to road traffic accidents, falls, assaults, gunshot wounds, sports activities, household, outdoor and industrial accidents. Most often other structures are injured in the process. Commonest injury associated with traumatic spinal cord injury is vertebral fractures and rib fractures. Associated fractures in other parts of the body are also common.

Sometimes a fall or a minor injury can also lead to spinal cord injury if the vertebral frame is weak as in the case of old age, osteoporosis, rheumatoid arthritis, tuberculosis infection of the spine, spinal cord tumors and spinal surgeries.

Traumatic spinal cord injury can occur due to direct trauma to the cord or as a secondary complication following the trauma. There could be a compression of the


INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY (ISNCSCI)
ASIA
ISCOS
Patient Name
Date/Time of Exam
Examiner Name
Signature
RIGHT
MOTOR KEY MUSCLES
SENSORY KEY SENSORY POINTS
Light Touch (LTR)
Pin Prick (PPR)
UER (Upper Extremity Right)
Elbow flexors C5
Wrist extensors C6
Elbow extensors C7
Finger flexors C8
Finger abductors (little finger) T1
Comments (Non-key Muscle? Reason for NT? Pain?)
LER (Lower Extremity Right)
Hip flexors L2
Knee extensors L3
Ankle dorsiflexors L4
Long toe extensors L5
Ankle plantar flexors S1
(VAC) Voluntary anal contraction (Yes/No)
RIGHT TOTALS
(MAXIMUM)
(50)
(56)
(56)
C2 C3 C4 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 L1 S2 S3 S4-5
• Key Sensory Points
Palm
Dorsum
SENSORY KEY SENSORY POINTS
Light Touch (LTL)
Pin Prick (PPL)
MOTOR KEY MUSCLES
LEFT
C5 Elbow flexors
C6 Wrist extensors
C7 Elbow extensors
C8 Finger flexors
T1 Finger abductors (little finger)
UEL (Upper Extremity Left)
MOTOR (SCORING ON REVERSE SIDE)
0 = total paralysis
1 = palpable or visible contraction
2 = active movement, gravity eliminated
3 = active movement, against gravity
4 = active movement, against some resistance
5 = active movement, against full resistance
5* = normal corrected for pain/disuse
NT = not testable
SENSORY (SCORING ON REVERSE SIDE)
0 = absent
1= altered
2 = normal
NT = not testable
L2 Hip flexors
L3 Knee extensors
L4 Ankle dorsiflexors
L5 Long toe extensors
S1 Ankle plantar flexors
LEL (Lower Extremity Left)
(DAP) Deep anal pressure (Yes/No)
LEFT TOTALS
(MAXIMUM)
(56)
(56)
(50)
MOTOR SUBSCORES
UER + UEL = UEMS TOTAL
MAX (25) (25) (50)
LER + LEL = LEMS TOTAL
MAX (25) (25) (50)
SENSORY SUBSCORES
LTR + LTL = LT TOTAL
MAX (56) (56) (112)
PPR + PPL = PP TOTAL
MAX (56) (56) (112)
NEUROLOGICAL LEVELS
Steps 1-5 for classification as on reverse
1. SENSORY
2. MOTOR
R L
3. NEUROLOGICAL LEVEL OF INJURY (NLI)
4. COMPLETE OR INCOMPLETE?
Incomplete = Any sensory or motor function in S4-5
5. ASIA IMPAIRMENT SCALE (AIS)
(In complete injuries only)
ZONE OF PARTIAL PRESERVATION
Most caudal level with any innervation
SENSORY
MOTOR
This form may be copied freely but should not be altered without permission from the American Spinal Injury Association.
REV 02/13

Muscle Function Grading

0 = total paralysis

1 = palpable or visible contraction

2 = active movement, full range of motion (ROM) with gravity eliminated

3 = active movement, full ROM against gravity

4 = active movement, full ROM against gravity and moderate resistance in a muscle specific position

5 = (normal) active movement, full ROM against gravity and full resistance in a functional muscle position expected from an otherwise unimpaired person

5* = (normal) active movement, full ROM against gravity and sufficient resistance to be considered normal if identified inhibiting factors (i.e. pain, disuse) were not present

NT = not testable (i.e. due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or contracture of > 50% of the normal range of motion)

Sensory Grading

0 = Absent

1 = Altered, either decreased/impaired sensation or hypersensitivity

2 = Normal

NT = Not testable

Non Key Muscle Functions (optional)

May be used to assign a motor level to differentiate AIS B vs. C

Movement	Root level
Shoulder: Flexion, extension, abduction, adduction, internal and external rotation **Elbow:** Supination	C5
Elbow: Pronation **Wrist:** Flexion	C6
Finger: Flexion at proximal joint, extension. **Thumb:** Flexion, extension and abduction in plane of thumb	C7
Finger: Flexion at MCP joint **Thumb:** Opposition, adduction and abduction perpendicular to palm	C8
Finger: Abduction of the index finger	T1
Hip: Adduction	L2
Hip External rotation	L3
Hip: Extension, abduction, internal rotation **Knee:** Flexion **Ankle:** Inversion and eversion **Toe:** MP and IP extension	L4
Hallux and Toe: DIP and PIP flexion and abduction	L5
Hallux: Adduction	S1

ASIA Impairment Scale (AIS)

A = Complete. No sensory or motor function is preserved in the sacral segments S4-5.

B = Sensory Incomplete. Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-5 (light touch or pin prick at S4-5 or deep anal pressure) AND no motor function is preserved more than three levels below the motor level on either side of the body.

C = Motor Incomplete. Motor function is preserved below the neurological level**, and more than half of key muscle functions below the neurological level of injury (NLI) have a muscle grade less than 3 (Grades 0-2).

D = Motor Incomplete. Motor function is preserved below the neurological level**, and at least half (half or more) of key muscle functions below the NLI have a muscle grade ≥ 3.

E = Normal. If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without an initial SCI does not receive an AIS grade.

** For an individual to receive a grade of C or D, i.e. motor incomplete status, they must have either (1) voluntary anal sphincter contraction or (2) sacral sensory sparing with sparing of motor function more than three levels below the motor level for that side of the body. The International Standards at this time allows even non-key muscle function more than 3 levels below the motor level to be used in determining motor incomplete status (AIS B versus C).

NOTE: When assessing the extent of motor sparing below the level for distinguishing between AIS B and C, the ***motor level*** on each side is used; whereas to differentiate between AIS C and D (based on proportion of key muscle functions with strength grade 3 or greater) the ***neurological level of injury*** is used.

ASIA
AMERICAN SPINAL INJURY ASSOCIATION

INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

ISCOS
INTERNATIONAL SPINAL CORD SOCIETY

Steps in Classification

The following order is recommended for determining the classification of individuals with SCI.

1. Determine sensory levels for right and left sides.
The sensory level is the most caudal, intact dermatome for both pin prick and light touch sensation.

2. Determine motor levels for right and left sides.
Defined by the lowest key muscle function that has a grade of at least 3 (on supine testing), providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5).
Note: In regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level, if testable motor function above that level is also normal.

3. Determine the neurological level of injury (NLI)
This refers to the most caudal segment of the cord with intact sensation and antigravity (3 or more) muscle function strength, provided that there is normal (intact) sensory and motor function rostrally respectively.
The NLI is the most cephalad of the sensory and motor levels determined in steps 1 and 2.

4. Determine whether the injury is Complete or Incomplete.
(i.e. absence or presence of sacral sparing)
*If voluntary anal contraction = **No** AND all S4-5 sensory scores = **0** AND deep anal pressure = **No**, then injury is **Complete**.*
*Otherwise, injury is **Incomplete**.*

5. Determine ASIA Impairment Scale (AIS) Grade:

Is injury Complete? If YES, AIS=A and can record ZPP (lowest dermatome or myotome on each side with some preservation)

NO ↓

Is injury Motor Complete? If YES, AIS=B

NO ↓ (No=voluntary anal contraction OR motor function more than three levels below the motor level on a given side, if the patient has sensory incomplete classification)

Are at least half (half or more) of the key muscles below the neurological level of injury graded 3 or better?

NO ↓ AIS=C

YES ↓ AIS=D

If sensation and motor function is normal in all segments, AIS=E
Note: AIS E is used in follow-up testing when an individual with a documented SCI has recovered normal function. If at initial testing no deficits are found, the individual is neurologically intact; the ASIA Impairment Scale does not apply.

cord due to accumulation of fluid and blood leading to cord compression or damage to the cord tissue. In addition selective injury to the blood vessels may also cause spinal cord damage.

Non-traumatic spinal cord injury can be the result of infection to the spinal cord or infection to the spinal bones that compress the spinal cord and may damage it permanently. It could also be due to cysts and tumors of the spinal cord or spinal bones and other connective tissue surrounding the cord.

Types of Spinal cord injury

Spinal cord injury can be classified based on causes of injury, extent of injury, presentation after injury and level of injury. It is classified into traumatic and non-traumatic depending on the cause of injury. Based on the extent of injury it is classified as complete or incomplete injury. It is also classified on the basis of vertebral levels. Most commonly used classification is based on the ability to use one or more limbs, differentiated as paraplegia and tetraplegia. Tetraplegia is more commonly known as quadriplegia. Paraplegia refers to loss of motor power in lower limbs but the upper limbs are unaffected and tetraplegia refers to loss of motor power in lower limbs and complete or partial loss of motor power in upper limbs.

The most standard method of classifying a spinal cord injury is American Spinal Injury Association's (ASIA) standard neurological classification of spinal cord injury (Figure 1.2). It is also known as ASIA scale for spinal cord injury classification.

According to this scale injury is classified into

A: **Complete** - No motor or sensory function preserved in the sacral segments S4-S5.

B: **Incomplete** - Sensory but not motor function preserved below the neurological level including the sacral segments S4-S5.

C: **Incomplete** - Motor function preserved below the neurological level and more than half of the key muscles below the neurological level have a muscle grade less than 3.

D: **Incomplete** - Motor function preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more.

E: **Normal** - Motor and sensory functions are normal.

This classification includes thorough testing of the patients using dermatomes and myotomes.

What are dermatomes?

These are specific areas on the skin that are selectively innervated by only one nerve root.

What are myotomes?

These are specific group of muscles innervated by a single nerve root. Specific movements are suggestive of these myotomes.

Symptoms at different levels of injury in complete spinal cord injury

Symptoms are different at different levels of the injury. Essentially there is muscle weakness or loss of muscle power and sensory abnormalities observed in the areas of body below the level of spinal cord injury. Some of the symptoms salient to these are mentioned below.

1. Cervical level injuries

Sensory and motor loss with injuries at higher cervical levels can cause weakness of diaphragm and all the body muscles including arms, trunk and legs causing inability to breath and complete loss of movement in the body. As the levels shift lower the breathing ability is preserved and some of the arm muscles may also be preserved allowing partial movement of the upper limbs.

Loss of normal bowel and bladder control is seen in all of the cervical injury patients with complete cord injury, in an incomplete injury partial sensations, partial motor power and bladder and bowel function may be preserved.

Spasticity is a common feature in injuries at these levels. Spasticity is increased tone or tightness of the muscles. Muscles may remain in continuous state of contraction and lead to inability to perform movements and sudden jerks bending or straightening the limbs. These jerks can be painful at times.

In addition, autonomic dysreflexia, i.e. abnormal body responses to sudden change in body position and postural hypotension, i.e. sudden drop in the blood pressure while assuming the erect posture either in sitting or standing, may be noted.

2. Thoracic level injuries

Injuries to the high thoracic spinal cord lead to sensory and motor impairment in trunk and lower limbs whereas upper limbs are unaffected. Bowel and bladder control is also impaired. In higher thoracic injuries symptoms like autonomic dysreflexia, postural hypotension and spasticity will be seen more often that lower level thoracic injuries.

3. Lumbo-Sacral level injuries

At the lumbo-sacral level below the level of second lumbar vertebra or L2 the symptoms are different from that of higher level injuries. Although there is loss of motor power and sensations, spasticity rarely is seen in these injuries. Instead of spasticity there is flaccidity of the muscles which means loss of tone and flabby muscles in the lower limbs.

Symptoms of incomplete spinal cord injury

Symptoms of incomplete spinal cord injury cannot be predicted. There is generally some sensation or motor power present below the level of the injury. Bowel and bladder, sensation and control may also be present. There are some patterns of the sensory, motor, bowel and bladder preservation in incomplete spinal cord injury as mentioned below.

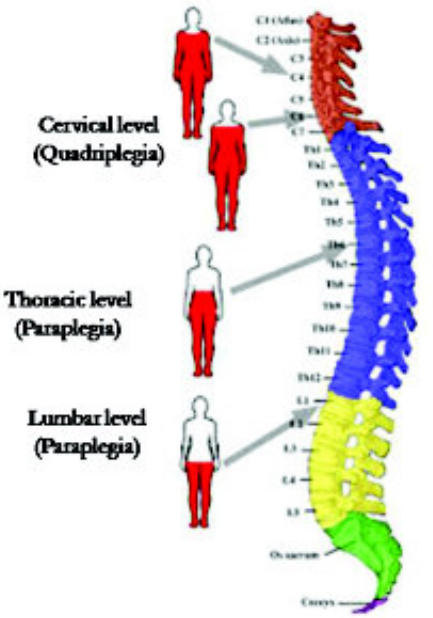


Figure 1.6 Levels of Spinal cord injury

Central Cord Syndrome (CCS):

Commonest of the incomplete injuries, it is characterized by weakness in upper more than lower limbs with sacral sparing and some sensory loss below the level of the injury. It occurs due to damage to the central part of the cord damaging the cervical fibers and sparing the dorsal, lumbar and sacral fibers. The prognosis of this injury is good with recovery pattern of lower limbs followed by bowel and bladder followed by proximal upper limb, distal upper limb and then intrinsic muscles of upper limb.

Brown -Sequard Syndrome (BSS)/ Hemicord Syndrome::

It occurs rarely in case of traumatic injuries with selective injuries to the spine with loss of sensation with flaccid paralysis in the ipsilateral side of the injury. All the superficial and deep sensations except for pain and touch are impaired on the ipsilateral side. Pain and touch are impaired on the contralateral side. The difference is due to crossing of spinothalamic fibers carrying pain and temperature. A variant of BSS, Brown Sequard plus syndrome (BSPS) exhibits motor weakness or paralysis on the ipsilateral side and reduced pain perception of the contralateral side.

Anterior Cord Syndrome (ACS):

It is caused due to the damage to the anterior part of the spinal cord. It can occur in traumatic injury or in injuries and disease that selectively affect the arteries supplying this part of the cord. Clinically the motor power is impaired below the level of lesion and superficial sensations like pin prick may be impaired but deep sensations like proprioception and deep pressure may be preserved. The prognosis of motor recovery is very poor in this case.

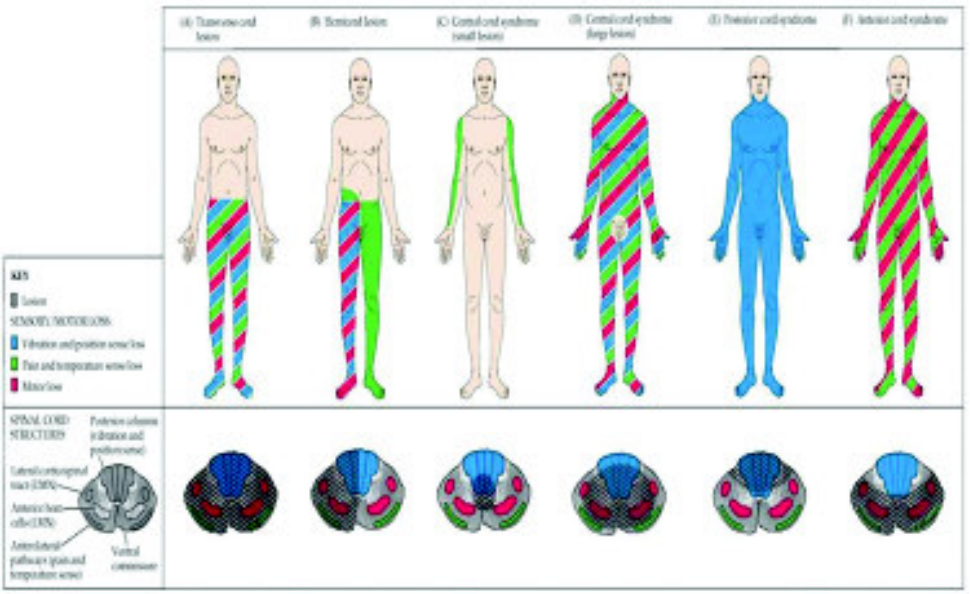


Figure 1.7 Spinal cord injury syndromes
Picture courtesy: https://www.studyblue.com/notes/note/n/anatomy/deck/9642969

Cauda Equina and Conus Medullaris Syndrome:

These syndromes are caused due to the injury to the lower end of the spine below is at the level of first lumber vertebra (L1). Table 1 describes the differences in the characteristics of these injuries.

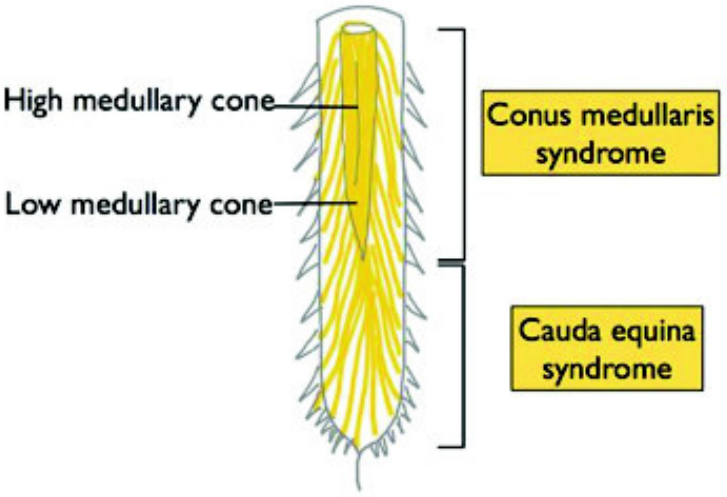


Figure 1.8 Cauda equina syndrome and Conus Medullaris syndrome

Table 1. Characteristics of Cauda equina and Conus Medullaris syndrome

Clinical criteria	Cauda equina syndrome	Conus medullaris syndrome
Anatomical location	Below the level of L1	At the level of L1
Sensations	Localized numbness to saddle area, asymmetrical & unilateral (saddle anaesthesia)	Localized numbness to perianal area, symmetrical & bilateral
Sphincter control	LMN impairment	LMN impairment
Sphincter sensation	Preserved	Preserved
Lower limb motor control	Preserved	Impaired (Atrophy and muscle weakness)
Lower limb sensations	Preserved	Preserved
Reflexes	affected knee and ankle jerk	affected ankle jerk
Muscle tone	Reduced (Flaccidity)	Reduced (Flaccidity)
Prognosis	Good	Good
Occurrence	Rare	Rare
Impotence	Infrequent	Frequent

Chapter 2
Radiological investigations in Spinal Cord injury

In addition to the physical examination special investigations should be used to identify associated injuries and to rule out complications that may hinder the rehabilitation of the patients.

Radiological investigations

X-Ray

An X-ray is required to identify the problems with the bony structure of the body. In case of chronic spinal cord injury a physiotherapist should take a detailed history about weight bearing activities performed by the patient and as a precautionary measure may ask for X-rays of the following regions

1. ***X - ray Spine anteroposterior and lateral view*** - To identify the surgical fixation and any associated problems with the same.
2. ***X - ray Pelvis and both hips anteroposterior view*** - To identify myositis ossificans and bladder stones.

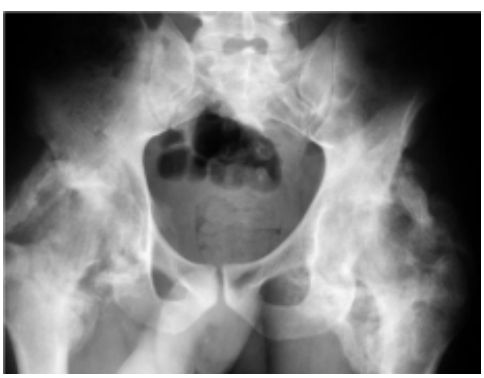


Figure 2.1 X-ray showing myositis ossificans of hip joints,, seen has white foggy appearance in the muscles around pelvis region

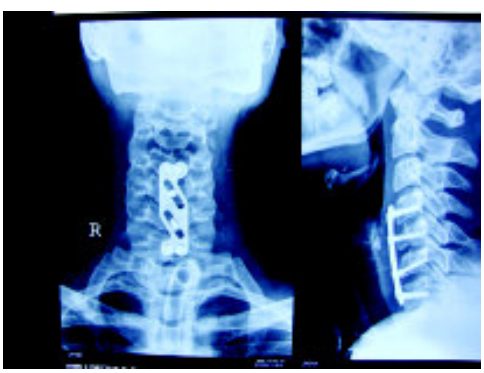


Figure 2.2 X-ray showing the surgical fixation

In addition if the patients present any history of fall since injury screen for the fractures of the relevant bones. Associated fractures at the time of spinal cord injury should also be screened by X -ray before starting rigorous rehabilitation and weight bearing exercises. Any restriction of the movement with a bony endfeel in the regions of elbow, knee and hip should be screened for presence of myositis ossificans using the X-ray.

MRI

MRI of the spine and spinal cord should be viewed to identify the extent of injury whether the transaction is complete or not and to identify any other associated soft tissue injuries of the spine.

Figure 2.3 Spinal cord injury with posterior dislocation of the vertebra

Figure 2.4 Spinal cord injury with posterior vertebral dislocation and superior displacement

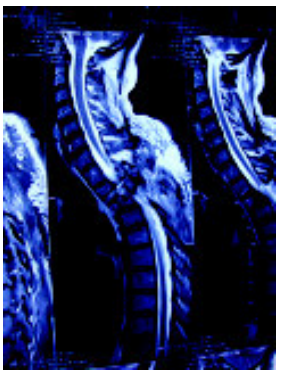


Figure 2.5 Thoracic spinal cord injury

Ultrasound

Ultrasound of the abdomen and bladder gives information about any associated visceral injuries, bladder stones and other bladder pathologies.

Urodynamic investigations

Whether or not urodynamic evaluation is required will be decided by the urologist. Preliminary investigations before consulting a urologist are

- Bowel and bladder history
- Routine urine test
- Urine culture test (in case any signs of infection are evident like fever and uncontrolled spasticity or spasms)
- Ultrasound of the bladder and urethra

If the urologist advices so, the urodynamic evaluation should be done. Urodynamic studies are usually advised in presence of symptoms of lower urinary tract dysfunction. Some of these symptoms are

- Frequent leakages
- Frequent or painful urination
- Uncontrolled urge to pass urine
- Difficulty in micturition
- Inability to void the bladder completely

Urodynamic evaluation is to thoroughly investigate the bladder, urethra and sphincter function. Different evaluations done and the information they provide during the urodynamic testing are as follows:

- Uroflowmetry, is conducted to measure the speed and flow of urine to find out any blockages or weakness of detrussar muscles
- Postvoid residual measurement is performed to evaluate bladder incontinence
- Cystometric test, conducted to identify involuntary bladder contractions. A cystometric test measures how much urine the bladder can hold, how much pressure builds up inside the bladder as it stores urine, and how full it is when the urge to urinate begins.
- Leak point pressure measurement conducted to identify at what pressure the bladder leaks and is performed to find out the type of bladder problem
- Pressure flow study evaluates what is the rate of urine flow when a certain pressure is applied by the bladder and what pressure is required to produce by the bladder to start emptying the urine. This tests helps to locate any urine outlet blockages.
- Electromyography of bladder is performed to understand muscles' response to nerve stimulation, if the nerve impulses are reaching the muscles or not and if the muscles are responding to these impulses or not.

Functional MRI:

Functional magnetic resonance imaging (fMRI) is a noninvasive method for measuring activity in the brain and spinal cord. fMRI uses MRI technology to measure brain

activity at rest as well as while performing a particular task by detecting changes in the blood flow in the area of activation.

Oxygen in the blood is carried by hemoglobin. Oxygenated hemoglobin is diamagnetic (resistant to magnetism) than deoxygenated haemoglobin which is paramagnetic (attracted to magnetism). When a particular area of brain or spinal cord is active, blood flow to that area increases bringing in more oxygenated hemoglobin. This rise in oxygenated hemoglobin in the activated area is picked up by MRI scanner as an MR signal which is mapped and represented graphically by color coding according to the strength of activation. This way images of active brain areas can be collected at rest and while specific activities (such as visualizing/looking at an object/light, listening to sound/music, moving limbs, etc) are being performed.

Procedure

In SCI, fMRI is used to track changes in the function of brain and spinal cord following injury and to monitor effects of any treatment over time. During the fMRI procedure, the patient is asked to perform a specific task or is stimulated to trigger sensory response for a period of 30 seconds followed by rest for 30 seconds. This pattern of task followed by rest is repeated several times and MRI images are obtained which are computed and analyzed by a radiologist. For studying the areas involved in motor (movement) function, tasks like tapping the fingers, toes, moving feet up and down are commanded to perform, whereas for studying the areas involved in sensory function, sensory stimuli like stroking with a brush along a particular part of the patient's body are performed.

fMRI is used clinically and for research purpose in a variety of brain and spinal cord disorders. In SCI, it is used to:

- Help assess the effects of SCI on brain and spinal cord function.
- Map neuronal activity at different levels of the spinal cord in response to various sensory stimuli and motor tasks.
- Study how the brain or spinal cord recovers following an injury.
- Detect a neuronal response in the spinal cord below the site of injury to check areas of impaired and preserved activity.
- Identify the cause and mechanism of chronic neuropathic pain in SCI patients.
- Compare the effects of a treatment intervention with respect to function using a pre intervention and a post intervention fMRI.

Contraindications of f-MRI:

- Patients with metal and electronic implants
- Pregnant females, especially in the first trimester

Chapter 3
Assessment of Spinal cord injury

Spinal cord injury assessment is a complex and thorough examination of the patient. It starts with developing a good rapport with the patient and a keen conversation to know the details about the past events.

Evaluation is a process of obtaining and interpreting data necessary for intervention. This includes steps like gathering the information, identification of problem areas, formulating hypothesis and decision making process for treatment intervention. This can be carried out in formal or informal screening, review of medical records, interviews, observation and by using standardized tests.

Observation before examination:

1. Bony prominences and vulnerable area of skin.
2. Scar tissue.
3. Pressure sores.
4. Secondary bad postures because of pressure sores.
5. Any external appliances like urinary catheters

Sensory examination:

Sensory examination is undertaken from superficial and deep sensory assessment and to determine the level of spinal cord injury. For ASIA classification only the superficial touch and pin prick tests are used on the dermatomal map of the body (figure 3.1)

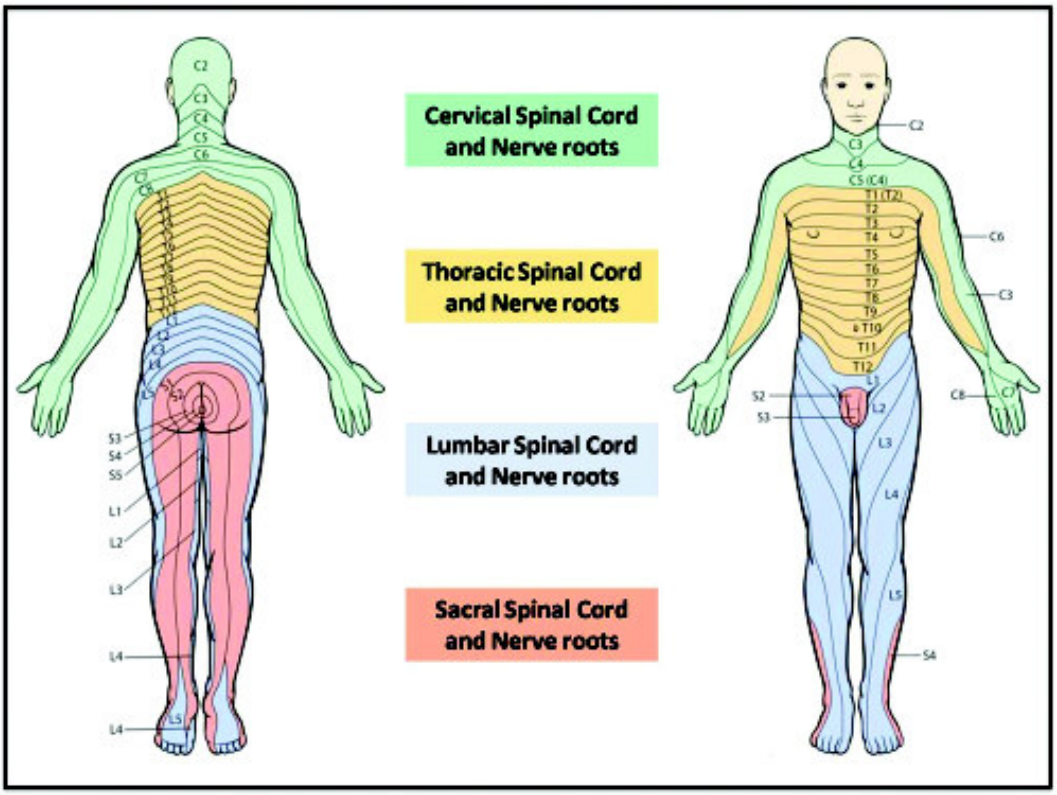


Figure 3.1 Dermatomal map of the body

It is important to check for the anal sensation as it is usually the first sign of recovery and presence of it will change the ASIA neurological classification.

Motor examination:

1. Tone assessment

In the last decade Decq subdivided the pathophysiology of increased muscle tone in 3 components as follows

(1) Intrinsic tonic spasticity (Tone): manifested as increased resistance to passive stretch or passive movement

(2) Intrinsic phasic spasticity (Deep tendon reflexes): manifested as exagerraged or brisk reflexes and clonus

(3) Extrinsic spasticity (Spasms): manifested sudden violent and uncontrolled, flexion and extension movements

Intrinsic tonic spasticity evaluation

Technique: Move the joints through 1 or 2 quick movements through the whole range of motion.

Most commonly used scale of measuring spasticity is Modified Ashworth scale (Table 2.1). However it only takes into consideration one aspect of spasticity which is resistance to passive movement for a complete evaluation of spasticity several other scales are available and are given in detail in the later part of this chapter.

Table 2.1 Modified Ashworth Scale

Grade	Description
0	No increase in muscle tone
1	Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part(s) is moved in flexion or extension
1+	Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the ROM
2	More marked increase in muscle tone through most of the ROM, but affected part(s) easily moved
3	Considerable increase in muscle tone, passive movement difficult
4	Affected part(s) rigid in flexion or extension

Intrinsic phasic spasticity assessment

Technique: With a knee hammer gently tap on the tendon and observe the joint movement.

Interpretation:

Absent: No response

Diminished: A slight but definitely present movement

Normal: Movement through partial range of motion

Brisk: Movement through the same range as that of normal reflex but with higher speed

Exaggerated: Increased speed and range of movement with a sudden explosive movement after the tap

Extrinsic spasticity assessment:

There may not be any spasticity on passive movement however patient may exhibit presence of spasm in the body which is a form of increased tone and spasticity. Detailed history of spasms and the movements or triggering factors for spasm should be taken so that these movements can be minimized during therapy.

Spasms evaluation is essential and various scales are available for recording the spasms as mentioned below. The description of these scales is given in detail in the later section of this chapter.

Common muscle spasticity patterns

Commonly the spasticity is observed in the antigravity muscles that is flexors of upper extremity and extensors of lower extremity and back extensors. But it is not restricted to only these groups.

2. Strength assessment:

Technique: The muscle strength is assessed using manual muscle testing observing the range of the movement and if it is performed in gravity assisted or eliminated plane.

The grading of the muscles ranges from 0 to 5 with modified medical research council grading as follows:

Table 2.2: Modified Medical Research Council grading for manual muscle testing

mMRC - MMT grade	Description
0	No Movement
1	A flicker of movement is seen or felt in the muscle
2	Muscle moves the joint when gravity is eliminated
3	Muscle moves the joint against gravity, but not through full mechanical range of motion
3	Muscle cannot hold the joint against resistance but moved the joint fully against gravity
3+	Muscle moves the joint fully against gravity and is capable of transient resistance, but collapses abruptly
4-	Same as grade 4, but muscle holds the joint only against minimal resistance
4	Muscle holds the joint against a combination of gravity and moderate resistance
4+	Same as grade 4 but muscle holds the joints against moderate to maximal resistance
5-	Barely detectable weakness
5	Normal strength

Although the manual muscle testing is used for the muscles the muscles are tested in the myotomal pattern to identify the muscle weakness

Myotomes:

Upper Extremity

C1-C2 neck flexion

C3 neck extension

C4 shoulder shrugs/elevation

C5 shoulder abduction

C6 elbow flexion

C7 wrist flexion

C8 thumb extension

T1 fingers abduction & adduction

Lower Extremity

L1-L2 hip flexion

L3 knee extension

L4 foot dorsi flexion

L5 toe extension

S1/S2 plantar flexion

Common muscle compensations seen in spinal cord injured patients

1. Neck flexors may be instead of upper abdominals
2. Shoulder internal rotators can compensate for elbow flexion
3. Shoulder external rotators can compensate for elbow extension
4. Shoulder abdutors can compensate shoulder flexion in scaption movement
5. Trapezius can for be used shoulder flexion and abduction through shouler and scapular elevation
6. Wrist extension can be used for finger flexion through tenodesis
7. Pronation can be used for wrist flexion in gravity assisted plane
8. Supination can be used for wrist extension gravity assisted plane
9. Latissimus dorsi can be used instead of quadratus lumborum for hiking of pelvis
10. Extenrnal and internal obliques can be used for pelvic hiking as well as to generator hip flexion movement in gravity eliminated plane
11. Trunk side flexors can mimic the movement of hip abduction in gravity eliminate plane

These muscle compensations should be identified and encouraged for functional benefits. If the patients are not able to perform the movements using these compensations these should be taught to the patient.

3. Range of motion assessment:

Restricted ROM hinders the functional tasks performed by patients and therefore a thorough investigation about the restriction of ROM must be carried out and patients should be treated for the same.

Therapists must carry out range of motion (ROM) assessment for all the joints. The joint range of motion should be checked through active movements initiated by patients as well as passive movements performed by therapists.

In case of Restricted AROM test for PROM, if PROM is complete the loss of range is because of the agonist muscle weakness or antagonist muscle spasticity, therefore check for antagonists muscle spasticity when checking for PROM.

In case of restricted AROM and restricted PROM pay attention to the endfeel. Springy endfeel is suggestive muscle tightness or contractures, Bone endfeel could be suggestive surgical fixation or myositis. In the presence of Bone endfeel advice an X-ray to identify the cause.

4. Balance assessment

Balance is impaired in all of the SCI patients. It is important to check multiple components that may impair balance.

Start with assessment of postural alignment and identify the factors that may affect the balance. Scoliosis, restricted back extension due to surgical fixation, restriction of trunk rotation due to surgical fixation and restricted hip ROM due to tight hamstrings can significantly impair sitting balance. Associated injuries and fractures may restrict the ROM of shoulder and rib joints which will also affect sitting balance. Identification of these factors is crucial to training balance.

Once the postural alignment has been assessed ask the patient to maintain a posture for 30 seconds in sitting and standing, for assessing static balance.

Then perform various movements of trunk and arm to assess the dynamic balance. During dynamic balance testing try to identify limiting factors. Limiting factors are poor strength, poor ROM and poor proprioception.

Respiratory assessment

Assessment components:

Chest expansion

Maximum inspiratory volume

Forced exhalation

Coughing ability

Range of motion of rib joints

Range of motion of shoulder joints

Respiratory Muscle Strength Evaluation:

1. Diaphragm.
2. Abdominals.
3. Accessory muscles like intercostals, scalenes, serratus anterior, pectorals, erector spinae and sternocleidomastoid.

Respiratory history and associated medical history may indicate that he may require preventive measures for chest complications. Evaluation of upper and lower chest expansions may give a clue as to which lobes require to be attended. Lack of chest expansion and mobility may lead to decreased vital capacity. Lack of ROM at shoulder level may lead to poor chest expansion. It is essential to have normal flexibility of trunk and hips as it is easier for him to cough effectively. Normal posture of trunk is essential for rib mobility as excessive tightness of ribs would lead to poor Vital capacity. If abdominal muscles are weak, it may effect in poor coughing because of inability to build up intrathoracic pressure to expel air and therefore bronchial hygiene may be affected very badly.

Occupational Therapy Assessment

Apart from the sensorimotor and neuromusculoskeletal assessment, occupational therapy assessments include the following

1) Assessment of ADL with or without adaptive devices and orthosis by using standardized ADL scales. The various assessment tools used are

   - FIM assesses the level of patients disability and indicates the burden of caring for them and the items are scored on the basis on how much assistance is required for the individual to carry out the daily living
   - Modified Barthel Index is used to measure the level of functional independence. The areas focused are personal hygiene, bathing, feeding, toilet use, stairs, dressing, bowel, bladder mobility, transfers,
   - Spinal Cord Injury Independence Measure (SCIM): this tool is used to assess traumatic, nontraumatic, acute, chronic SCI patients.
   - Canadian Occupational Performance Measure (COPM): this tool assesses an individual's perceived occupational performance and identification of problem areas in self-care, productivity and leisure activities.
   - Quality of Life (QOL) : The QOL tool is to used to assess the quality of life (QOL) within the context of an individual's culture, values, systems, personal

goals, standards and concerns. It addresses the 4 QOL domains like physical health, psychological health, social relationships, and environment.

2) Environmental Assessment for evaluation of home work and work place

   - Home: it is important for safety factors, accessibility, architectural barriers and restrictions that affect the participation of an SCI individual.

3) Work Site evaluation: it is done to assess and determine a person's ability to go back to his/her original job. It involves assessment of work, worksite and worker.

   - Assessment of work includes assessment of job demands, for a particular job. Work evaluation is done to have a comprehensive assessment of person's potential for performing any kind/type of work. It can be both general and specific work evaluation.
   - Assessment of work station includes assessment of ergonomic considerations like accessibility to workplace, parking area, seating arrangements and environmental factors like lighting, sound, temperature and noise at the work place in which the individual works
   - Assessment of worker includes the physical, psychological difficulties face by an individual at the workplace. It includes physical, mental and psychological difficulties performed by the individual.

4) Hand Function Evaluation includes measurement of motion, sensation and function of the hand functions using standardized assessment tools

   - Motion assessment includes both passive and active ranges of the small joints of the hand using Goniometer and individual muscle strength testing of the small muscles of the hand. E.g. Graded and Redefined Assessment of Strength, Sensibility and Prehension (GRASSP) used to assess upper limb strength.
   - Sensory assessment includes detailed sensory evaluation of superficial, deep and mixed sensations in the hand. E.g. AIS sensory assessment for assessing the Pin-prick and light-touch sensation of each dermatome, AsTex® Sensory Test assesses the texture discrimination capabilities of the thumb and fingertips.
   - Functional Assessment includes grip strength assessment using dynamometer, pinch strength assessment using electronic pinchometer. Standardized assessment scales are used to assess the gross co-ordination and dexterity skills of an individual. Also different grasps and prehension patterns, thumb functions and in hand manipulation skills are assessed. Eg: Various assessment tools that can be used are Modified Action Research Arm Test (ARAT): standardized measure of unilateral hand and upper limb function for assessing grasp, grip, pinch and gross movement and AuSpinal

Hand Assessment is a unilateral measure of hand function using a key, nut/bolt, coin, credit card, sweet, telephone receiver and soft drink can

5) Wheelchair Evaluation, measurement and wheelchair selection and seating systems are carried out by a team of Occupational Therapists, physiotherapist, nurses, and rehabilitation technology supplier. It includes selection of appropriate wheelchair type, wheelchair measurement, wheelchair modifications to accommodate the needs of the individual with SCI. Also available wheelchair skills are assessed to plan a rehabilitation program.

6) Assessing and the need for appropriate Splints and Assistive devices is important.

7) Conduct driving evaluations to assess whether the illness has caused any problems that could affect an individual's ability to drive safety. On road and off road assessments are done to check for their driving skills and also to evaluate the need for any modifications

8) Vocational Evaluation to assess the individuals, work habits, work behaviors, physical and cognitive abilities, psychological skills, work skills in relation to individuals interests, motivation, age, and educational level.

Different outcome measures used for assessment of patients with Spinal cord injury

Some of the common assessment areas and the outcome measures used for the assessment of SCI patients are as follows

Neurological Impairment and Autonomic Dysfunction

American Spinal Injury Association Impairment Scale (AIS): International Standards for Neurological Classification of Spinal Cord Injury

Spasticity

Ashworth and Modified Ashworth Scale (MAS)

Penn Spasm Frequency Scale (PSFS)

Pain

Classification System for Chronic Pain in SCI

Brief Pain Inventory (BPI)

Lower Limb & Walking

6-Minute Walk Test (6MWT)

10 Meter Walking Test (10 MWT)

Berg Balance Scale (BBS)

Timed Up and Go Test (TUG)

Walking Index for Spinal Cord Injury (WISCI) and WISCI II

Upper Limb

Hand-Held Myometer

Jebsen Hand Function Test (JHFT)

Self Care & Daily Living

Lawton Instrumental Activities of Daily Living scale (IADL)

Spinal Cord Independence Measure (SCIM)

Quadriplegia Index of Function Modified (QIF-Modified)

Quality of Life and Health Status

Short Form 36 (SF-36)

Skin Health

Spinal Cord Injury Pressure Ulcer Scale (SCIPUS) Measure

Wheeled Mobility

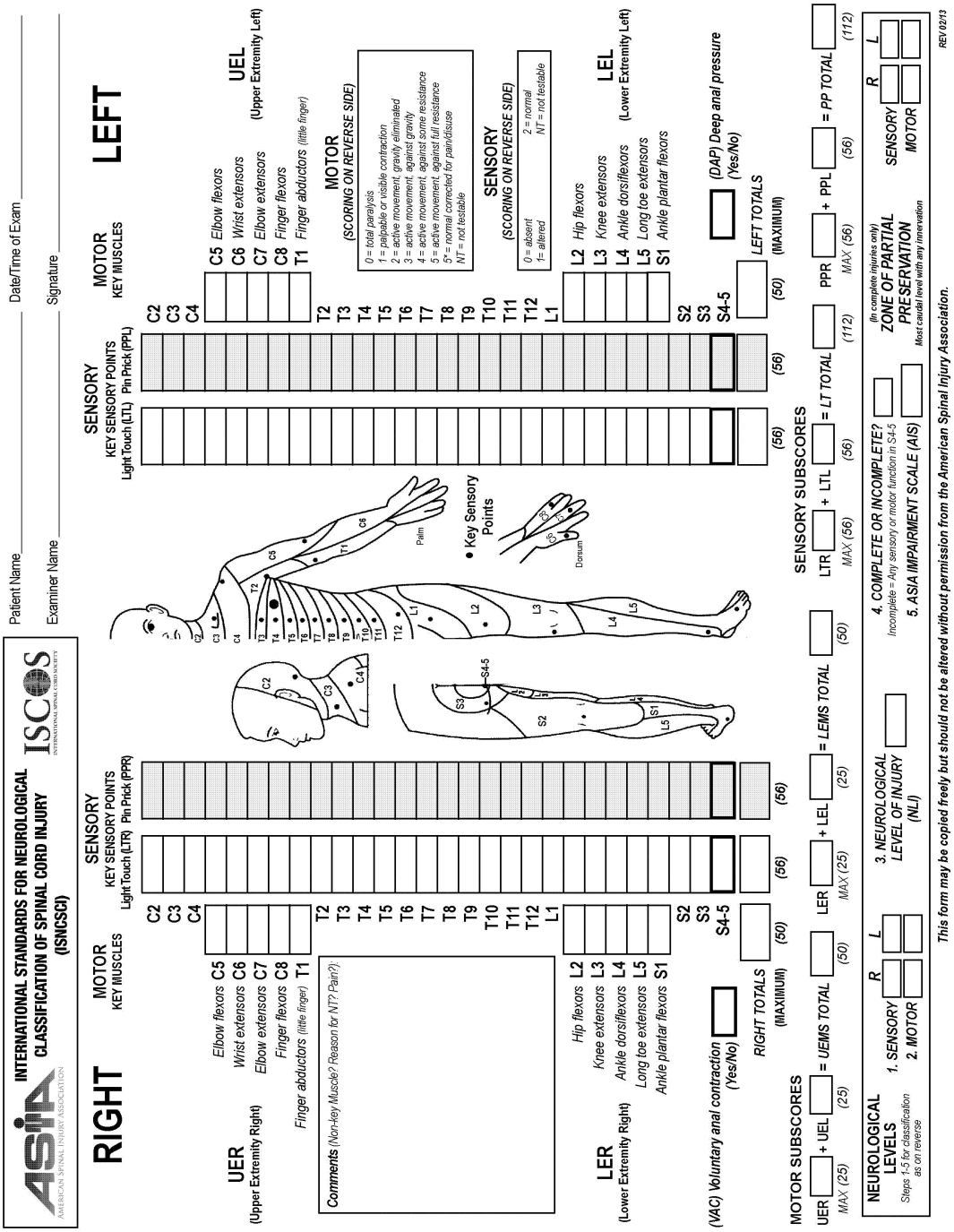
Wheelchair Skills Test (WST)

Table 1. Summarizes the psychometric properties of the scales

Scale	Inter-rater reliability	Intra-rater Reliability	Validity
Moified Ashworth Scale	NA	adequate	Excellent
Penn Spasm frequency scale	NA	Adequate	Adequate
Brief Pain Inventory (BPI)	NA	Excellent	Excellent
6-Minute Walk Test (6MWT)	Excellent	Excellent	Excellent
10 Meter Walking Test (10 MWT)	Excellent	Excellent	Excellent
Berg Balance Scale (BBS)	Good	NA	Excellent
Timed Up and Go Test (TUG)	Excellent	Excellent	Excellent
Walking Index for Spinal Cord Injury - WISCI	Excellent	NA	Excellent
WISCI II	Excellent	NA	Excellent
Hand-Held Myometer	Adequate	Excellent	Adequate
Jebsen Hand Function Test (JHFT)	NA	Adequate	Adequate
Lawton Instrumental Activities of Daily Living scale (IADL)	NA	NA	Adequate
Spinal Cord Independence Measure (SCIM)	Excellent	Excellent	Excellent
Quadriplegia Index of Function Modified (QIF-Modified)	Adequate	NA	Excellent
Short Form 36 (SF-36)	Adequate	Adequate	Excellent
Spinal Cord Injury Pressure Ulcer Scale (SCIPUS) Measure	NA	NA	Adequate
Wheelchair Skills Test (WST)	Excellent	Excellent	Excellent

Neurological Impairment and Autonomic Dysfunction

1. American Spinal Injury Association Impairment Scale (AISA): International Standards for Neurological Classification of Spinal Cord Injury



Muscle Function Grading

0 = total paralysis

1 = palpable or visible contraction

2 = active movement, full range of motion (ROM) with gravity eliminated

3 = active movement, full ROM against gravity

4 = active movement, full ROM against gravity and moderate resistance in a muscle specific position

5 = (normal) active movement, full ROM against gravity and full resistance in a functional muscle position expected from an otherwise unimpaired person

5* = (normal) active movement, full ROM against gravity and sufficient resistance to be considered normal if identified inhibiting factors (i.e. pain, disuse) were not present

NT = not testable (i.e. due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or contracture of > 50% of the normal range of motion)

Sensory Grading

0 = Absent

1 = Altered, either decreased/impaired sensation or hypersensitivity

2 = Normal

NT = Not testable

Non Key Muscle Functions (optional)

May be used to assign a motor level to differentiate AIS B vs. C

Movement	Root level
Shoulder: Flexion, extension, abduction, adduction, internal and external rotation **Elbow:** Supination	**C5**
Elbow: Pronation **Wrist:** Flexion	**C6**
Finger: Flexion at proximal joint, extension. **Thumb:** Flexion, extension and abduction in plane of thumb	**C7**
Finger: Flexion at MCP joint **Thumb:** Opposition, adduction and abduction perpendicular to palm	**C8**
Finger: Abduction of the index finger	**T1**
Hip: Adduction	**L2**
Hip: External rotation	**L3**
Hip: Extension, abduction, internal rotation **Knee:** Flexion **Ankle:** Inversion and eversion **Toe:** MP and IP extension	**L4**
Hallux and Toe: DIP and PIP flexion and abduction	**L5**
Hallux: Adduction	**S1**

ASIA Impairment Scale (AIS)

A = Complete. No sensory or motor function is preserved in the sacral segments S4-5.

B = Sensory Incomplete. Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-5 (light touch or pin prick at S4-5 or deep anal pressure) AND no motor function is preserved more than three levels below the motor level on either side of the body.

C = Motor Incomplete. Motor function is preserved below the neurological level**, and more than half of key muscle functions below the neurological level of injury (NLI) have a muscle grade less than 3 (Grades 0-2).

D = Motor Incomplete. Motor function is preserved below the neurological level**, and at least half (half or more) of key muscle functions below the NLI have a muscle grade ≥ 3.

E = Normal. If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without an initial SCI does not receive an AIS grade.

** For an individual to receive a grade of C or D, i.e. motor incomplete status, they must have either (1) voluntary anal sphincter contraction or (2) sacral sensory sparing with sparing of motor function more than three levels below the motor level for that side of the body. The International Standards at this time allows even non-key muscle function more than 3 levels below the motor level to be used in determining motor incomplete status (AIS B versus C).

NOTE: When assessing the extent of motor sparing below the level for distinguishing between AIS B and C, the ***motor level*** on each side is used; whereas to differentiate between AIS C and D (based on proportion of key muscle functions with strength grade 3 or greater) the ***neurological level of injury*** is used.

AMERICAN SPINAL INJURY ASSOCIATION

INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

INTERNATIONAL SPINAL CORD SOCIETY

Steps in Classification

The following order is recommended for determining the classification of individuals with SCI.

1. Determine sensory levels for right and left sides.
The sensory level is the most caudal, intact dermatome for both pin prick and light touch sensation.

2. Determine motor levels for right and left sides.
Defined by the lowest key muscle function that has a grade of at least 3 (on supine testing), providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5).
Note: in regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level, if testable motor function above that level is also normal.

3. Determine the neurological level of injury (NLI)
This refers to the most caudal segment of the cord with intact sensation and antigravity (3 or more) muscle function strength, provided that there is normal (intact) sensory and motor function rostrally respectively.
The NLI is the most cephalad of the sensory and motor levels determined in steps 1 and 2.

4. Determine whether the injury is Complete or Incomplete.
(i.e. absence or presence of sacral sparing)
*If voluntary anal contraction = **No** AND all S4-5 sensory scores = **0** AND deep anal pressure = **No,** then injury is **Complete.***
*Otherwise, injury is **Incomplete.***

5. Determine ASIA Impairment Scale (AIS) Grade:

Is injury Complete? **If YES, AIS=A** and can record ZPP (lowest dermatome or myotome on each side with some preservation)

NO ↓

Is injury Motor Complete? **If YES, AIS=B**

NO ↓ (No=voluntary anal contraction OR motor function more than three levels below the motor level on a given side, if the patient has sensory incomplete classification)

Are at least half (half or more) of the key muscles below the neurological level of injury graded 3 or better?

NO ↓ **AIS=C** **YES** ↓ **AIS=D**

If sensation and motor function is normal in all segments, AIS=E
Note: AIS E is used in follow-up testing when an individual with a documented SCI has recovered normal function. If at initial testing no deficits are found, the individual is neurologically intact; the ASIA Impairment Scale does not apply.

Spasticity

1. Ashworth and Modified Ashworth Scale (MAS)

2. Penn Spasm Frequency Scale (PSFS)

Penn spasm frequency scale is a self-reported outcome measure to be marked by patients themselves.

Spasm Frequency:

0 = No spasm

1 = Mild spasms induced by stimulation

2 = Infrequent full spasms occurring less than once per hour

3 = Spasms occurring more than once per hour

4 = Spasms occurring more than 10 times per hour

Spasm Severity:

1 = Mild

2 = Moderate

3 = Severe

Pain

1. Brief Pain Inventory (BPI)

It is a clinician reported outcome measure that looks at the detailed assessment of pain.

1903

Date: ☐☐ / ☐☐ / ☐☐
(month) (day) (year)

Subject's Initials : _____

Study Subject #: ☐☐☐☐

PLEASE USE BLACK INK PEN

Study Name: _____

Protocol #: _____

PI: _____

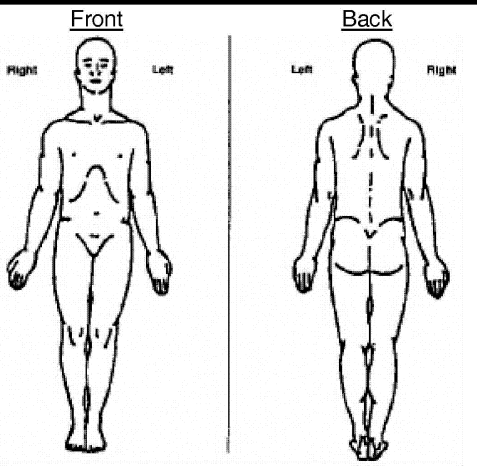
Revision: 07/01/05

Brief Pain Inventory (Short Form)

1. Throughout our lives, most of us have had pain from time to time (such as minor headaches, sprains, and toothaches). Have you had pain other than these everyday kinds of pain today?

☐ Yes ☐ No

2. On the diagram, shade in the areas where you feel pain. Put an X on the area that hurts the most.



3. Please rate your pain by marking the box beside the number that best describes your pain at its worst in the last 24 hours.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

4. Please rate your pain by marking the box beside the number that best describes your pain at its least in the last 24 hours.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

5. Please rate your pain by marking the box beside the number that best describes your pain on the average.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

6. Please rate your pain by marking the box beside the number that tells how much pain you have right now.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

No Pain — Pain As Bad As You Can Imagine

1903

Date: ☐☐ / ☐☐ / ☐☐
(month) (day) (year)

Subject's Initials : _____

Study Subject #: ☐☐☐☐

PLEASE USE BLACK INK PEN

Study Name: _____

Protocol #: _____

PI: _____

Revision: 07/01/05

7. What treatments or medications are you receiving for your pain?

8. In the last 24 hours, how much relief have pain treatments or medications provided? Please mark the box below the percentage that most shows how much relief you have received.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
☐ No Relief	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐ Complete Relief

9. Mark the box beside the number that describes how, during the past 24 hours, pain has interfered with your:

A. General Activity

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

B. Mood

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

C. Walking ability

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

D. Normal Work (includes both work outside the home and housework)

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

E. Relations with other people

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

F. Sleep

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

G. Enjoyment of life

☐ 0 Does Not Interfere ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Completely Interferes

2. Classification System for Chronic Pain in SCI

Pain categorization is performed by first comparing the pain location and distribution with the subject's level of injury. This information is combined with a classification of chronic SCI pain that uses a matrix that compares the type of pain with location and with the effects of activity, position, and light touch on pain (see table below). If the pain does not seem to fit a specific category on the basis of the information, the subject's self-reported source of pain (musculoskeletal or nervous system) and pain exacerbators are used to help make the final categorization.

Categorization is outlined in the table below (fill out with +, - or +):

Pain Category (major)	Pain Category (Specific)	Location	Related to activity	Affected by position	Worse with light touch
Neuropathic	SCI Pain	Below injury in area without normal sensation			
	Transition zone pain	At level of injury, bilateral			
	Radicular Pain	At any dermatome level, usually unilateral, usually radiates			
	Visceral	In abdomen			
Musculoskeletal	Mechanical spine pain	In back or neck, often bilateral			
	Overuse pain	Often above injury in areas of normal sensation in an incomplete, can be below			

+ yes, - no, + maybe

Lower limb and walking

1. WISCI I

Physical limitation for walking secondary to impairment is defined at the person level and indicates the ability of a person to walk after spinal cord injury. The development of this assessment index requires a rank ordering along a dimension

of impairment, from the level of most severe impairment (1) to least severe impairment (19) based on the use of devices, braces and physical assistance of one or more persons. The order of the levels suggests each successive level is a less impaired level than the former. The ranking of severity is based on the severity of the impairment and not on functional independence in the environment. The following definitions standardize the terms used in each item:

Physical assistance:

'Physical assistance of two persons' is moderate to maximum assistance

'Physical assistance of one person' is minimal assistance.

Braces:

'Braces' means one or two braces, either short or long leg.

'No braces' means no braces on either leg.

Walker:

'Walker' is a conventional rigid walker without wheels.

Crutches:

'Crutches' can be Lofstrand (canadian) or axillary

Cane:

'Cane' is a conventional straight cane.

Level Description

1 = Ambulates in parallel bars, with braces and physical assistance of two persons, less than 10 meters.

2 = Ambulates in parallel bars, with braces and physical assistance of two persons, 10 meters.

3 = Ambulates in parallel bars, with braces and physical assistance of one person, 10 meters.

4 = Ambulates in parallel bars, no braces and physical assistance of one person, 10 meters.

5 = Ambulates in parallel bars, with braces and no physical assistance, 10 meters.

6 = Ambulates with walker, with braces and physical assistance of one person, 10 meters.

7 = Ambulates with two crutches, with braces and physical assistance of one person, 10 meters.

8 = Ambulates with walker, no braces and physical assistance of one person, 10 meters.

9 = Ambulates with walker, with braces and no physical assistance, 10 meters.

10 = Ambulates with one cane/crutch, with braces and physical assistance of one person, 10 meters.

11 = Ambulates with two crutches, no braces and physical assistance of one person, 10 meters.

12 = Ambulates with two crutches, with braces and no physical assistance, 10 meters.

13 = Ambulates with walker, no braces and no physical assistance, 10 meters.

14 = Ambulates with one cane/crutch, no braces and physical assistance of one person, 10 meters.

15 = Ambulates with one cane/crutch, with braces and no physical assistance, 10 meters.

16 = Ambulates with two crutches, no braces and no physical assistance, 10 meters.

17 = Ambulates with no devices, no braces and physical assistance of one person, 10 meters.

18 = Ambulates with one cane/crutch, no braces and no physical assistance, 10 meters.

19 = Ambulates with no devices, no braces and no physical assistance, 10 meters

WISCI Levels:

Level	Devices	Braces	Assistance	Distance
1	Parallel bars	Braces	2 persons	Less than 10 meters
2	Parallel bars	Braces	2 persons	10 meters
3	Parallel bars	Braces	1 person	10 meters
4	Parallel bars	No braces	1 person	10 meters
5	Parallel bars	Braces	No assistance	10 meters
6	Walker	Braces	1 person	10 meters
7	Two crutches	Braces	1 person	10 meters
8	Walker	No braces	1 person	10 meters
9	Walker	Braces	No assistance	10 meters
10	One cane/crutch	Braces	1 person	10 meters
11	Two crutches	No braces	1 person	10 meters
12	Two crutches	Braces	No assistance	10 meters

13	Walker	No braces	No assistance	10 meters
14	One cane/ crutch	No braces	1 person	10 meters
15	One cane/ crutch	Braces	No assistance	10 meters
16	Two crutches	No braces	No assistance	10 meters
17	No devices	No braces	1 person	10 meters
18	One cane/ crutch	No braces	No assistance	10 meters
19	No devices	No braces	No assistance	10 meters

2. WISCI II

Physical limitation for walking secondary to impairment is defined at the person level and indicates the ability of a person to walk after spinal cord injury. The development of this assessment index required a rank ordering along a dimension of impairment, from the level of most severe impairment (0) to least severe impairment (20) based on the use of devices, braces and physical assistance of one or more persons. The order of the levels suggests each successive level is a less impaired level than the former. The ranking of severity is based on the severity of the impairment and not on functional independence in the environment. The following definitions standardize the terms used in each item:

Physical assistance:

'Physical assistance of two persons' is moderate to maximum assistance

'Physical assistance of one person' is minimal assistance.

Braces:

'Braces' means one or two braces, either short or long leg. (Splinting of lower extremities for standing is considered long leg bracing)

'No braces' means no braces on either leg.

Walker:

'Walker' is a conventional rigid walker without wheels.

Crutches:

'Crutches' can be Lofstrand (canadian) or axillary

Cane:

'Cane' is a conventional straight cane.

Level Description

0 = Client is unable to stand and/or participate in assisted walking.

1 = Ambulates in parallel bars, with braces and physical assistance of two persons, less than 10 meters.

2 = Ambulates in parallel bars, with braces and physical assistance of two persons, 10 meters.

3 = Ambulates in parallel bars, with braces and physical assistance of one person, 10 meters.

4 = Ambulates in parallel bars, no braces and physical assistance of one person, 10 meters.

5 = Ambulates in parallel bars, with braces and no physical assistance, 10 meters.

6 = Ambulates with walker, with braces and physical assistance of one person, 10 meters.

7 = Ambulates with two crutches, with braces and physical assistance of one person, 10 meters.

8 = Ambulates with walker, no braces and physical assistance of one person, 10 meters.

9 = Ambulates with walker, with braces and no physical assistance, 10 meters.

10 = Ambulates with one cane/crutch, with braces and physical assistance of one person, 10 meters.

11 = Ambulates with two crutches, no braces and physical assistance of one person, 10 meters.

12 = Ambulates with two crutches, with braces and no physical assistance, 10 meters.

13 = Ambulates with walker, no braces and no physical assistance, 10 meters.

14 = Ambulates with one cane/crutch, no braces and physical assistance of one person, 10 meters.

15 = Ambulates with one cane/crutch, with braces and no physical assistance, 10 meters.

16 = Ambulates with two crutches, no braces and no physical assistance, 10 meters.

17 = Ambulates with no devices, no braces and physical assistance of one person, 10 meters.

18 = Ambulates with no devices, with braces and no physical assistance, 10 meters.

19 = Ambulates with one cane/crutch, no braces and no physical assistance, 10 meters.

20 = Ambulates with no devices, no braces and no physical assistance, 10m.

WISCI L

Level	Devices	Braces	Assistance	Distance
1	Parallel bars	Braces	2 persons	Less than 10 meters
2	Parallel bars	Braces	2 persons	10 meters
3	Parallel bars	Braces	1 person	10 meters
4	Parallel bars	No braces	1 person	10 meters
5	Parallel bars	Braces	No assistance	10 meters
6	Walker	Braces	1 person	10 meters
7	Two crutches	Braces	1 person	10 meters
8	Walker	No braces	1 person	10 meters
9	Walker	Braces	No assistance	10 meters
10	One cane/crutch	Braces	1 person	10 meters
11	Two crutches	No braces	1 person	10 meters
12	Two crutches	Braces	No assistance	10 meters
13	Walker	No braces	No assistance	10 meters
14	One cane/crutch	No braces	1 person	10 meters
15	One cane/crutch	Braces	No assistance	10 meters
16	Two crutches	No braces	No assistance	10 meters
17	No devices	No braces	1 person	10 meters
18	No devices	Braces	No assistance	10 meters
19	One cane/crutch	No braces	No assistance	10 meters
20	No devices	No braces	No assistance	10 meters

3. Timed up an go

- The individual is instructed to stand up from an arm chair, walk 3 meters, return to the chair and sit down at their preferred walking speed.
- Instructions to the patient: "When I say 'go' I want you to stand up and walk to the line, turn and then walk back to the chair and sit down again. Walk at your normal pace."

- Scoring:

  Time for 'Up and Go' test: _____sec.

  Unstable on turning? Y/N

  Walking aid used? Y/N Type of aid: _____

4. 10 Meter Walk Test

The testing area should be set up in an area that is at least 14 meters long. The floor should be labeled with lines of tape at 0, 2, 12 and 14 meters. Place a chair at each end.

1. Ensure the participant is seated and measure the participant's resting heart rate and blood pressure. If the participant's blood pressure is >180/100 mm Hg or their heart rate is >100 bpm or 80% of predicted maximum heart rate (estimated as 220 - age), do not start the test.
2. Instruct the patient: "You are going to walk a distance of about 40 feet. We will repeat this distance 2 times. Both times will be completed at your comfortable pace. Do you have any questions?"
3. Position the participant at the start line (0 m). Before the first trial, tell the participant, "You are going to walk at a comfortable pace to the chair. (Use appropriate descriptor of chair/location as needed but do not refer to the tape on the floor.) Continue walking until I say 'STOP.' The start command will be 'Ready and Go.'"
5. Ensure the patient is ready, then say, "Ready and Go.'" If the participant starts too early, have him or her start again.
6. Start the stopwatch when the participant's first foot crosses the plane of the 2-m line, and stop the stopwatch when the participant's first foot crosses the plane of the 12-m line. The participant should continue walking until he or she reaches the chair after the 14-m line.
7. Record the time taken for the participant to walk the 10-m distance between the 2-m line and the 12-m line on the worksheet.
8. Allow the participant to rest in the chair at the 14-m line.
9. Repeat the test with the participant, starting from the 14-m line and walking towards to the 0-m line. Start the stopwatch at the 12-m line, and stop the stopwatch at the 2-m line.
10. Record the time for the second trial. The participant can rest, if needed, in the chair at the 0-m line.
11. Instruct the participant to sit in the chair after he or she crosses the 0 m line. Take the participant's pulse and blood pressure.

12. Record the participant's assistive device or type of ankle-foot orthosis, if applicable.

10. Meter Walk Test Form:

    Patient name: _____ Date: _____

    Assistive or mobility device used: _____

    Self-selected or maximal velocity? (Circle one)

    Trial 1: _____ seconds

    Trial 2: _____ seconds

    Trial 3: _____ seconds

    Average time taken: _____ seconds

    Average velocity = 10 / average time taken = _____ m/s

Self Care and Daily living

Spinal cord injury independence measure is a scale to assess daily function of the patients. It can marked by both patients as well as clinicians.

שירותי בריאות כללית

LOEWENSTEIN HOSPITAL REHABILITATION CENTER
Affiliated with the Sackler Faculty of Medicine, Tel-Aviv University
Department IV, Medical Director: Dr. Amiram Catz Tel: 972-9-7709090 Fax: 972-9-7709986 e-mail: amiramc@clalit.org.il

Patient Name: _____ **ID:**_____ **Examiner Name:** _____

(Enter the score for each function in the adjacent square, below the date. The form may be used for up to 6 examinations.)

SCIM-SPINAL CORD INDEPENDENCE MEASURE

Version III, Sept 14, 2002

EXam 1 2 3 4 5 6

Self-Care

DATE \ \ \ \ \ \

1. Feeding (cutting, opening containers, pouring, bringing food to mouth, holding cup with fluid)

0. Needs parenteral, gastrostomy, or fully assisted oral feeding
1. Needs partial assistance for eating and/or drinking, or for wearing adaptive devices
2. Eats independently; needs adaptive devices or assistance only for cutting food and/or pouring and/or opening containers
3. Eats and drinks independently; does not require assistance or adaptive devices

2. Bathing (soaping, washing, drying body and head, manipulating water tap). **A-upper body; B-lower body**

A. 0. Requires total assistance
1. Requires partial assistance
2. Washes independently with adaptive devices or in a specific setting (e.g., bars, chair)
3. Washes independently; does not require **a**daptive **d**evices or **s**pecific **s**etting (not customary for healthy people) (adss)

B. 0. Requires total assistance
1. Requires partial assistance
2. Washes independently with **a**daptive **d**evices or in a **s**pecific **s**etting (adss)
3. Washes independently; does not require **a**daptive **d**evices (adss) or **s**pecific **s**etting

3. Dressing (clothes, shoes, permanent orthoses: dressing, wearing, undressing). **A-upper body; B-lower body**

A. 0. Requires total assistance
1. Requires partial assistance with **c**lothes **w**ith**o**ut **b**uttons, **z**ippers or **l**aces (cwobzl)
2. Independent with cwobzl; requires **a**daptive **d**evices and/or **s**pecific **s**ettings (adss)
3. Independent with cwobzl; does not require adss; needs assistance or adss only for bzl
4. Dresses (any cloth) independently; does not require adaptive devices or specific setting

B. 0. Requires total assistance
1. Requires partial assistancewith **c**lothes **w**ith**o**ut **b**uttons, **z**ipps or **l**aces (cwobzl)
2. Independent with cwobzl; requires adaptive devices and/or specific settings (adss)
3. Independent with cwobzl without adss; needs assistance or adss only for bzl
4. Dresses (any cloth) independently; does not require adaptive devices or specific setting

4. Grooming (washing hands and face, brushing teeth, combing hair, shaving, applying makeup)

0. Requires total assistance
1. Requires partial assistance
2. Grooms independently with adaptive devices
3. Grooms independently without adaptive devices

SUBTOTAL **(0-20)**

Respiration and Sphincter Management

5. Respiration

0. Requires tracheal tube (TT) and permanent or intermittent assisted ventilation (IAV)
2. Breathes independently with TT; requires oxygen, much assistance in coughing or TT management
4. Breathes independently with TT; requires little assistance in coughing or TT management
6. Breathes independently without TT; requires oxygen, much assistance in coughing, a mask (e.g., peep) or IAV (bipap)
8. Breathes independently without TT; requires little assistance or stimulation for coughing
10. Breathes independently without assistance or device

6. Sphincter Management - Bladder

0. Indwelling catheter
3. Residual urine volume (RUV) > 100cc; no regular catheterization or assisted intermittent catheterization
6. RUV < 100cc or intermittent self-catheterization; needs assistance for applying drainage instrument
9. Intermittent self-catheterization; uses external drainage instrument; does not need assistance for applying
11. Intermittent self-catheterization; continent between catheterizations; does not use external drainage instrument
13. RUV <100cc; needs only external urine drainage; no assistance is required for drainage
15. RUV <100cc; continent; does not use external drainage instrument

7. Sphincter Management - Bowel

0. Irregular timing or very low frequency (less than once in 3 days) of bowel movements
5. Regular timing, but requires assistance (e.g., for applying suppository); rare accidents (less than twice a month)
8. Regular bowel movements, without assistance; rare accidents (less than twice a month)
10. Regular bowel movements, without assistance; no accidents

8. Use of Toilet (perineal hygiene, adjustment of clothes before/after, use of napkins or diapers).

0. Requires total assistance
1. Requires partial assistance; does not clean self
2. Requires partial assistance; cleans self independently
4. Uses toilet independently in all tasks but needs adaptive devices or special setting (e.g., bars)
5. Uses toilet independently; does not require adaptive devices or special setting)

SUBTOTAL **(0-40)**

Mobility (room and toilet) DATE \ \ \ \ \ \ \

9. Mobility in Bed and Action to Prevent Pressure Sores ☐☐☐☐☐☐

0. Needs assistance in all activities: turning upper body in bed, turning lower body in bed, sitting up in bed, doing push-ups in wheelchair, with or without adaptive devices, but not with electric aids
2. Performs one of the activities without assistance
4. Performs two or three of the activities without assistance
6. Performs all the bed mobility and pressure release activities independently

10. Transfers: bed-wheelchair (locking wheelchair, lifting footrests, removing and adjusting arm rests, transferring, lifting feet). ☐☐☐☐☐☐

0. Requires total assistance
1. Needs partial assistance and/or supervision, and/or adaptive devices (e.g., sliding board)
2. Independent (or does not require wheelchair)

11. Transfers: wheelchair-toilet-tub (if uses toilet wheelchair: transfers to and from; if uses regular wheelchair: locking wheelchair, lifting footrests, removing and adjusting armrests, transferring, lifting feet) ☐☐☐☐☐☐

0. Requires total assistance
1. Needs partial assistance and/or supervision, and/or adaptive devices (e.g., grab-bars)
2. Independent (or does not require wheelchair)

Mobility (indoors and outdoors, on even surface)

12. Mobility Indoors ☐☐☐☐☐☐

0. Requires total assistance
1. Needs electric wheelchair or partial assistance to operate manual wheelchair
2. Moves independently in manual wheelchair
3. Requires supervision while walking (with or without devices)
4. Walks with a walking frame or crutches (swing)
5. Walks with crutches or two canes (reciprocal walking)
6. Walks with one cane
7. Needs leg orthosis only
8. Walks without walking aids

13. Mobility for Moderate Distances (10-100 meters) ☐☐☐☐☐☐

0. Requires total assistance
1. Needs electric wheelchair or partial assistance to operate manual wheelchair
2. Moves independently in manual wheelchair
3. Requires supervision while walking (with or without devices)
4. Walks with a walking frame or crutches (swing)
5. Walks with crutches or two canes (reciprocal walking)
6. Walks with one cane
7. Needs leg orthosis only
8. Walks without walking aids

14. Mobility Outdoors (more than 100 meters) ☐☐☐☐☐☐

0. Requires total assistance
1. Needs electric wheelchair or partial assistance to operate manual wheelchair
2. Moves independently in manual wheelchair
3. Requires supervision while walking (with or without devices)
4. Walks with a walking frame or crutches (swing)
5. Walks with crutches or two canes (reciprocal waking)
6. Walks with one cane
7. Needs leg orthosis only
8. Walks without walking aids

15. Stair Management ☐☐☐☐☐☐

0. Unable to ascend or descend stairs
1. Ascends and descends at least 3 steps with support or supervision of another person
2. Ascends and descends at least 3 steps with support of handrail and/or crutch or cane
3. Ascends and descends at least 3 steps without any support or supervision

16. Transfers: wheelchair-car (approaching car, locking wheelchair, removing arm- and footrests, transferring to and from car, bringing wheelchair into and out of car) ☐☐☐☐☐☐

0. Requires total assistance
1. Needs partial assistance and/or supervision and/or adaptive devices
2. Transfers independent; does not require adaptive devices (or does not require wheelchair)

17. Transfers: ground-wheelchair ☐☐☐☐☐☐

0. Requires assistance
1. Transfers independent with or without adaptive devices (or does not require wheelchair)

SUBTOTAL **(0-40)** ☐☐☐☐☐☐

TOTAL SCIM SCORE (0-100) ☐☐☐☐☐☐

Quality of life

SF36 is by far the most widely used and widely researched tool for quality for life measurement.

SF-36 QUESTIONNAIRE

Name:_____ **Ref. Dr:**_____ **Date:** _____

ID#: _____ **Age:** _____ **Gender: M / F**

Please answer the 36 questions of the **Health Survey** completely, honestly, and without interruptions.

GENERAL HEALTH:
In general, would you say your health is:
◯ Excellent ◯ Very Good ◯ Good ◯ Fair ◯ Poor

Compared to one year ago, how would you rate your health in general now?
◯ Much better now than one year ago
◯ Somewhat better now than one year ago
◯ About the same
◯ Somewhat worse now than one year ago
◯ Much worse than one year ago

LIMITATIONS OF ACTIVITIES:
The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports.
◯ Yes, Limited a lot ◯ Yes, Limited a Little ◯ No, Not Limited at all

Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf
◯ Yes, Limited a Lot ◯ Yes, Limited a Little ◯ No, Not Limited at all

Lifting or carrying groceries
◯ Yes, Limited a Lot ◯ Yes, Limited a Little ◯ No, Not Limited at all

Climbing several flights of stairs
◯ Yes, Limited a Lot ◯ Yes, Limited a Little ◯ No, Not Limited at all

Climbing one flight of stairs
◯ Yes, Limited a Lot ◯ Yes, Limited a Little ◯ No, Not Limited at all

Bending, kneeling, or stooping
◯ Yes, Limited a Lot ◯ Yes, Limited a Little ◯ No, Not Limited at all

Walking more than a mile
◯ Yes, Limited a Lot ◯ Yes, Limited a Little ◯ No, Not Limited at all

Walking several blocks
◯ Yes, Limited a Lot ◯ Yes, Limited a Little ◯ No, Not Limited at all

Walking one block
◯ Yes, Limited a Lot ◯ Yes, Limited a Little ◯ No, Not Limited at all

Bathing or dressing yourself
◯ Yes, Limited a Lot ◯ Yes, Limited a Little ◯ No, Not Limited at all

PHYSICAL HEALTH PROBLEMS:
During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities a result of your physical health?

Cut down the amount of time you spent on work or other activities
◯ Yes ◯ No

Accomplished less than you would like
Yes No

Were limited in the kind of work or other activities
Yes No

Had difficulty performing the work or other activities (for example, it took extra effort)
Yes No

EMOTIONAL HEALTH PROBLEMS:
During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

Cut down the amount of time you spent on work or other activities
Yes No

Accomplished less than you would like
Yes No

Didn't do work or other activities as carefully as usual
Yes No

SOCIAL ACTIVITIES:
Emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

Not at all Slightly Moderately Severe Very Severe

PAIN:
How much bodily pain have you had during the past 4 weeks?

None Very Mild Mild Moderate Severe Very Severe

During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

Not at all A little bit Moderately Quite a bit Extremely

ENERGY AND EMOTIONS:
These questions are about how you feel and how things have been with you during the last 4 weeks. For each question, please give the answer that comes closest to the way you have been feeling.

Did you feel full of pep?
All of the time
Most of the time
A good Bit of the Time
Some of the time
A little bit of the time
None of the Time

Have you been a very nervous person?
All of the time
Most of the time
A good Bit of the Time
Some of the time
A little bit of the time
None of the Time

Have you felt so down in the dumps that nothing could cheer you up?

- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you felt calm and peaceful?

- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Did you have a lot of energy?

- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you felt downhearted and blue?

- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Did you feel worn out?

- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you been a happy person?

- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you felt so down in the dumps that nothing could cheer you up?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you felt calm and peaceful?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Did you have a lot of energy?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you felt downhearted and blue?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Did you feel worn out?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you been a happy person?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Did you feel tired?

- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

SOCIAL ACTIVITIES:

During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

- All of the time
- Most of the time
- Some of the time
- A little bit of the time
- None of the Time

GENERAL HEALTH:

How true or false is each of the following statements for you?

I seem to get sick a little easier than other people

Definitely true | Mostly true | Don't know | Mostly false | Definitely false

I am as healthy as anybody I know

Definitely true | Mostly true | Don't know | Mostly false | Definitely false

I expect my health to get worse

Definitely true | Mostly true | Don't know | Mostly false | Definitely false

My health is excellent

Definitely true | Mostly true | Don't know | Mostly false | Definitely false

Balance

Berg balance test is the most widely used test for evaluating balance of the patient

Berg Balance Scale

The Berg Balance Scale (BBS) was developed to measure balance among older people with impairment in balance function by assessing the performance of functional tasks. It is a valid instrument used for evaluation of the effectiveness of interventions and for quantitative descriptions of function in clinical practice and research. The BBS has been evaluated in several reliability studies. *A recent study of the BBS, which was completed in Finland, indicates that a change of eight (8) BBS points is required to reveal a genuine change in function between two assessments among older people who are dependent in ADL and living in residential care facilities.*

Description:
14-item scale designed to measure balance of the older adult in a clinical setting.

Equipment needed: Ruler, two standard chairs (one with arm rests, one without), footstool or step, stopwatch or wristwatch, 15 ft walkway

Completion:

Time: 15-20 minutes

Scoring: A five-point scale, ranging from 0-4. "0" indicates the lowest level of function and "4" the highest level of function. Total Score = 56

Interpretation:
41-56 = low fall risk
21-40 = medium fall risk
0 –20 = high fall risk

A change of 8 points is required to reveal a genuine change in function between 2 assessments.

Berg Balance Scale

Name: _____ Date: _____

Location: _____ Rater: _____

ITEM DESCRIPTION	SCORE (0-4)
Sitting to standing	_____
Standing unsupported	_____
Sitting unsupported	_____
Standing to sitting	_____
Transfers	_____
Standing with eyes closed	_____
Standing with feet together	_____
Reaching forward with outstretched arm	_____
Retrieving object from floor	_____
Turning to look behind	_____
Turning 360 degrees	_____
Placing alternate foot on stool	_____
Standing with one foot in front	_____
Standing on one foot	_____

Total _____

GENERAL INSTRUCTIONS

Please document each task and/or give instructions as written. When scoring, please record the lowest response category that applies for each item.

In most items, the subject is asked to maintain a given position for a specific time. Progressively more points are deducted if:

- the time or distance requirements are not met
- the subject's performance warrants supervision
- the subject touches an external support or receives assistance from the examiner

Subject should understand that they must maintain their balance while attempting the tasks. The choices of which leg to stand on or how far to reach are left to the subject. Poor judgment will adversely influence the performance and the scoring.

Equipment required for testing is a stopwatch or watch with a second hand, and a ruler or other indicator of 2, 5, and 10 inches. Chairs used during testing should be a reasonable height. Either a step or a stool of average step height may be used for item # 12.

Berg Balance Scale

ITTING TO STANDING
NSTRUCTIONS: Please stand up. Try not to use your hand for support.
) 4 able to stand without using hands and stabilize independently
) 3 able to stand independently using hands
) 2 able to stand using hands after several tries
) 1 needs minimal aid to stand or stabilize
) 0 needs moderate or maximal assist to stand

TANDING UNSUPPORTED
NSTRUCTIONS: Please stand for two minutes without holding on.
) 4 able to stand safely for 2 minutes
) 3 able to stand 2 minutes with supervision
) 2 able to stand 30 seconds unsupported
) 1 needs several tries to stand 30 seconds unsupported
) 0 unable to stand 30 seconds unsupported

' a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

ITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL
NSTRUCTIONS: Please sit with arms folded for 2 minutes.
) 4 able to sit safely and securely for 2 minutes
) 3 able to sit 2 minutes under supervision
) 2 able to able to sit 30 seconds
) 1 able to sit 10 seconds
) 0 unable to sit without support 10 seconds

TANDING TO SITTING
NSTRUCTIONS: Please sit down.
) 4 sits safely with minimal use of hands
) 3 controls descent by using hands
) 2 uses back of legs against chair to control descent
) 1 sits independently but has uncontrolled descent
) 0 needs assist to sit

'RANSFERS
NSTRUCTIONS: Arrange chair(s) for pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way oward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.
) 4 able to transfer safely with minor use of hands
) 3 able to transfer safely definite need of hands
) 2 able to transfer with verbal cuing and/or supervision
) 1 needs one person to assist
) 0 needs two people to assist or supervise to be safe

TANDING UNSUPPORTED WITH EYES CLOSED
NSTRUCTIONS: Please close your eyes and stand still for 10 seconds.
) 4 able to stand 10 seconds safely
) 3 able to stand 10 seconds with supervision
) 2 able to stand 3 seconds
) 1 unable to keep eyes closed 3 seconds but stays safely
) 0 needs help to keep from falling

TANDING UNSUPPORTED WITH FEET TOGETHER
NSTRUCTIONS: Place your feet together and stand without holding on.
) 4 able to place feet together independently and stand 1 minute safely
) 3 able to place feet together independently and stand 1 minute with supervision
) 2 able to place feet together independently but unable to hold for 30 seconds
) 1 needs help to attain position but able to stand 15 seconds feet together
) 0 needs help to attain position and unable to hold for 15 seconds

Berg Balance Scale continued...

REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING
INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at the end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure the distance forward that the fingers reach while the subject is in the most forward lean position. When possible, ask subject to us both arms when reaching to avoid rotation of the trunk.)
( ) 4 can reach forward confidently 25 cm (10 inches)
( ) 3 can reach forward 12 cm (5 inches)
( ) 2 can reach forward 5 cm (2 inches)
( ) 1 reaches forward but needs supervision
( ) 0 loses balance while trying/requires external support

PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION
INSTRUCTIONS: Pick up the shoe/slipper, which is in front of your feet.
( ) 4 able to pick up slipper safely and easily
( ) 3 able to pick up slipper but needs supervision
( ) 2 unable to pick up but reaches 2-5 cm(1-2 inches) from slipper and keeps balance independently
( ) 1 unable to pick up and needs supervision while trying
( ) 0 unable to try/needs assist to keep from losing balance or falling

TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING
INSTRUCTIONS: Turn to look directly behind you over toward the left shoulder. Repeat to the right. (Examiner may pick an obje to look at directly behind the subject to encourage a better twist turn.)
( ) 4 looks behind from both sides and weight shifts well
( ) 3 looks behind one side only other side shows less weight shift
( ) 2 turns sideways only but maintains balance
( ) 1 needs supervision when turning
( ) 0 needs assist to keep from losing balance or falling

TURN 360 DEGREES
INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.
( ) 4 able to turn 360 degrees safely in 4 seconds or less
( ) 3 able to turn 360 degrees safely one side only 4 seconds or less
( ) 2 able to turn 360 degrees safely but slowly
( ) 1 needs close supervision or verbal cuing
( ) 0 needs assistance while turning

PLACE ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED
INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool four times.
( ) 4 able to stand independently and safely and complete 8 steps in 20 seconds
( ) 3 able to stand independently and complete 8 steps in > 20 seconds
( ) 2 able to complete 4 steps without aid with supervision
( ) 1 able to complete > 2 steps needs minimal assist
( ) 0 needs assistance to keep from falling/unable to try

STANDING UNSUPPORTED ONE FOOT IN FRONT
INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate t subject's normal stride width.)
( ) 4 able to place foot tandem independently and hold 30 seconds
( ) 3 able to place foot ahead independently and hold 30 seconds
( ) 2 able to take small step independently and hold 30 seconds
( ) 1 needs help to step but can hold 15 seconds
( ) 0 loses balance while stepping or standing

STANDING ON ONE LEG
INSTRUCTIONS: Stand on one leg as long as you can without holding on.
( ) 4 able to lift leg independently and hold > 10 seconds
( ) 3 able to lift leg independently and hold 5-10 seconds
( ) 2 able to lift leg independently and hold ≥ 3 seconds
( ) 1 tries to lift leg unable to hold 3 seconds but remains standing independently.
( ) 0 unable to try of needs assist to prevent fall

( ) TOTAL SCORE (Maximum = 56)

SECTION B

Multidisciplinary Management of Spinal Cord Injury

Chapter 4
Management of acute spinal cord injury

Medical management:

After the spinal cord injury emergency care is the most important predictor for the further recovery. A spinal cord trauma is a medical emergency requiring immediate treatment to reduce the long- term effects. To prevent further neurological injury and enhance neural recovery short-term medical treatment includes anatomical realignment and stabilization interventions of the spine and pharmacological management.

Prehospital management:

At the sight of the accident it is difficult to know about the spinal cord injury and its extent. Mechanism of injury, pain in the vertebral column,or neurologic symptoms can help the emergency medical personnel regarding assumed spinal injury. Complex and severe trauma those resulting from falling from heights should be suspected for spinal cord damage involving the head and pelvis.

Immediate stabilization and immobilization of the spine at the sight of injury and transporting the patient to the emergency department is very much important. Most often damage to the spinal cord is due to the poor handling and transport.

Emergency departmentmanagement:

A. ABC resuscitation: airway, breathing and circulation should be assessed at sight of the accident and if needed it should be started then and there. Resuscitation is focussed at airway maintenance, adequate oxygen saturation of peripheral blood, restoring blood pressure to acceptable limits, preventing bradycardia. Performed simultaneously to prevent any further ischemic damage to the previously injured spine.

   Oral secretions are cleared to maintain airway patency and to prevent aspiration. When indicated intubation should be carefully performed to avoid spine movement and further injury to the spinal cord.

Before diagnosing for neurogenic shock patients with acute spinal cord injury should be over ruled for hemorrhagic and/or neurogenic shock.

I. **Excluding haemorrhagic shock:** the most common sources of occult hemorrhage like chest, abdominal, retroperitoneal injuries and fractures of the pelvis or long-bones may be revealed in computed tomography (ct) scan or x- ray.

II. **Neurogenicshock:** history of spinal cord injury with exclusion of haemorrhage suggests spinal shock anagement of neurogenic shock

   i. **Fluid resuscitation:** fluid resuscitation with isotonic crystalloid solution is the initial treatment of choice for neurogenic shock. These patients are at risk for the acute respiratory distress syndrome (ARDS) and hence volume overload should be avoided with judicious fluid resuscitation.

   ii. **Maintaining blood pressure:** maintain systolic blood pressure above 90 mmhg and avoid hypotension.

   iii. **Maintaining oxygenation:** mechanical ventilation and/or supplemental oxygenation is required to maintain adequate oxygenation and perfusion of the injured spinal cord.

   iv. **Monitoring heart rate:** heart rate should be 60-100 beats per minute (bpm) in normal sinus rhythm. Atropine can be given for treatment of hemodynamically significant bradycardia.

   v. **Maintaining urine output:** insert foley cathetere to decompress the bladder.Urine output should be monitored and maintained more than 30ml/h.

   vi. **Inotropic support:** a low dose of dopamine in the 2-to 5-mcg/kg/min range is usually sufficient for patients who have decreased urinary output despite adequate fluid resuscitation.

B. Assessment and management of associated injuries:spinal cord injuryis most commonly associated with head injury. A detailed evaluation for intracranial injury should be done in the presence of amnesia, external signs of head injury or basilar skull fracture, focal neurologic deficits, associated alcohol intoxication or drug abuse, and a history of loss of consciousness.

Corticosteroid therapy:

Methyl prednisolone is beneficial in causing favorable neurological outcome if administered early enough (within 8 hours) of the primary insult. It helps by reducing damage to nerve cells and by decreasing inflammation near the site of injury.

Monosialotetrahexosylganglioside (gm-1): gm-1 administered following acute spinal cord injury as an adjunct after the administration of methylprednisolone may be of benefit.

Methylprednisolone enhances the flow of blood to the injured spinal cord, preventing the typical decline in white matter, extracellular calcium levels, and evoked potentials, thus preventing progressive post traumatic ischemia.

The therapist must be aware of side effects that may occur with such high doses of steroids, including gastric ulcers, decreased wound-healing time, hypertension, cardiac arrhythmias, and alteration in mental status.

Deep vein thrombosis prophylaxis: low molecular weight heparin can be used to prevent dvt.

Spinal traction: spinal traction is a more conservative and less invasive approach to allow the bones to heal naturally without surgery. Traction prevents movement of the spine.The skull may be held in place with tongs (metal braces placed in the skull and attached to traction weights or to a harness on the body).The spine braces may need to be worn for a long time.

The other type is halo traction device which has three parts: the ring, the uprights, and the jacket. The ring fits around the skull, just above the ears andis held in place by four pins that are inserted into the skull. The uprights are attached to the ring and jacket by bolts. The jacket is usually made of polypropylene and lined with sheepskin. It is left in place for 6 to 12 weeks until bony healing is satisfactory.The advantage of using the halo device is the ability to mobilize the client as soon as the device has been applied without compromising spinal alignment. This allows the rehabilitation program to commence more rapidly. It also allows for delayed decision making regarding the need for surgery.

Surgical management:

The treatment of spinal cord injury patients may require surgery.There are three major goals of surgery-

A. Spinaldecompression:involves removal offluid tissue, bone fragments,disk fragments, or foreign objects that compresses the spinal cord.

B. Prevention of tethering: surgery may prevent tethering of the spinal cord. Neurological disorders related to pulling of the spinal cord at the base of the spinal canal can cause stretching and damage which can be prevented.

C. Stabilization of the spine:the fractured vertebrae may not be capable of supporting the normal weight from the body and protect the spinal cord and can further lead to severe injuries. Spinal instrumentation and fusion can be used to provide permanent stability to the spinal column. The procedure helps to correct, join, and solidify the level where a spinal element has been damaged. Metal screws, rods, plates or cage or combination of all may be necessary to hold the vertebrae together and stabilize them until the bones heal.

Type of surgery:

The type of surgery performed (anterior vs. Posterior), distraction forces during surgery, preoperative grade all influence the outcome. The surgeriesare-

Spinal decompression:

The major types of surgery for spinal decompression are-

A. Microdiscectomy/corpectomyb. Laminectomy

Stabilization of the spine: can be achieved by spinal fusion with or without instrumentation.

1. In the craniovertebral junction,stabilization may be achieved by
   A. C1-c2 fixation using pedicle screws/transarticularscrew/sublaminar wires
   B. Occipitocervical fixation
2. In the cervical spine stabilization may be achieved by
   A. Anterior approach using vertebral body plates and screw
   B. Posterior approach using lateral mass screws
3. In the dorsal spine stabilization may be achieved by
   A. Anterior transthoracic approach for interbody cage placement
   B. Posterior approach using transpedicular screw and rod system
4. In the lumbarspine,types of stabilization procedures are-
   A. Anterior lumbar interbody fusion(alif)
   B. Posterior lumbar interbody fusion(plif)
   C. Transforaminal lumbar interbody fusion
   D. Transforaminal interbody fusion(tlif)

Postoperative physiotherapy

Post operative physiotherapy starts immediately after the surgery and is continued during the convalescent period. Respiratory management plays a very important role to prevent post operative complications.Restorative physiotherapy starts immediately after the patient is stabilized.

Acute neurorehabilitation for spinal cord injury

Therapeutic rehabilitation should be effectively delivered at the beginning in an acute-care setting at the time of injury.

Inpatient rehabilitation begins during the critical and acute care stages after an sci. The primary emphasis of early rehabilitation is to lessen the adverse effects of neuro trauma and immobilization. This focus may last from a few days to several weeks, depending on the severity and level of injury and other associated injuries.

During the acute phase patients may begin participating in early therapy that should include,

a. Respiratory care,
b. Prevention of indirect impairments and complications
c. Range-of-motion (rom) exercises and initiating active exercises in available musculature
d. Normalization of tone
e. Early strength training
f. Gaining upright tolerance,
g. Out-of-bed activities
h. Sensory reeducation,
i. Skin-management education

Goals during this phase should focus on prevention of secondary complications and preparing the client for full rehabilitation participation. The treatment team must begin discharge planning and family training in this phase.

Respiratory care should include deep breathing exercises, glossopharyngeal breathing, strengthening respiratory muscles, assisted coughing, abdominal support and stretching of the thorax.

Full range of motion exercises should be completed daily by the patient if not possible should be performed by the therapist except in those areas that are contraindicated.With paraplegia, motion of the trunk and some motions of the hip are contraindicated.Straight leg raising more than 60 degree and hip flexion beyond 90 degrees (during combined hip and knee flexion) should be avoided. To normalize the muscle tone facilitatory or inhibitory techniques should be used as per the need.

Every 2 hourly patient should be positioned and splinted in the neutral position. The use of an abdominal binder, compression garments and elastic stockings will retard venous pooling and prevent dvt. Upright activities should be initiated by gradually elevating the head of the bed and progressing to tilt table or reclining wheelchairs. Vital sign should be observed and recorded during these movements. This will also help to decrease postural hypotension after the continuous bed rest. Gradual strengthening program should be followed for the weak muscle which will help in the later phase of rehabilitation. The bed mobility should be initiated with proper precautions.

Activity based training should be initiated to reinforce the movements from the paralysed muscle. Mental imagery, mirror therapy and contemporary task oriented approach of training for the paralyzed limb can be focused to get better results in active phase of rehabilitation. Careful monitoring of autonomic dysreflexia, postural hypotension and hypothermia is important and should be reported to other medical care professionals.

Intervention for sensory issues

Sensory training is a vital part of neurorehabilatation in the individuals with sci as the sensory impairment becomes the major issue and makes these individual prone to many other risk factors. The sensory rehabilitation emphasise to normalize the sensation and can help to get better motor response. The techniques used are

Compensatory techniques: used when there is loss or impairment of protective sensation. The primary goal of compensatory techniques is to prevent injury

- Safety first
- Increase awareness of deficit
- Minimize risk of tissue damage (like continuous low pressure, concentrated high pressure, excessive heat or cold, repetitive mechanical stress, pressure on infected tissue)

Compensatory methods and techniques include:

- Use of other senses like vision (observe for signs of inflammation from repetitive pressure, excessive force, and if these signs occur rest the hand) and hearing to rubbing sounds while propelling wheelchair)
- Should not handle sharp objects, or directly check temperature of hot water or it may cause cuts or burns respectively in hand
- Using adaptive devices like hand cuff to prevent callous formation due to prolonged use of manual wheelchairs, built up handles to distribute the pressure as well as to enhance the grasp
- Skin care: use of protective glove mitts to prevent blister formation while handling hot utensils, regular moisturizing of skin to prevent dryness of hand
- Avoid gripping for long duration instead use modified handles and grip aids

Sensory reeducation techniques: it can be started when the individual can appreciate deep, moving touch. The modalities are first used with eyes closed, then eyes open and then again eyes closed. This technique can be used to develop good touch localization after the individual has developed a faint perception of light moving touch.

Modalities for sensory reeducation include the following:

- Blunt end of pencil for training for graphesthesia
- Dowels of different textures
- Different fabrics
- Objects of different rough/ smooth edges
- Games
- Performing adlswith vision occluded

Desensitization techniques: few patient experience hypersensitivity at or above the level of injury, or neurogenic pain above the level of injury

Goal of this technique is to increase the pain threshold of an individual and reduce the discomfort due to pain.

The technique progresses from desensitizing the affected area using a soft texture, followed by coarse and finally rough texture and one can gradually increase the force, duration and frequency of application.

Following modalities are used for desensitization:

- Therapeutic massage
- Percussion/ tapping/ stroking with different textures
- Vibration
- Pressure/ compression
- Tens
- Fluid therapy

Chapter 5
Complications of Spinal Cord Injury

A serious condition like Spinal cord injury results in functional, psychological and socioeconomic implications. Several complications follow the occurrence of Spinal cord injury (SCI). These could be immediate or long term secondary to the injury. Hence continued care is required for these patients to prevent the complications and to treat the complications of time. Complications may require re-hospitalization and are most often the cause of morbidity and death. They significantly hamper the quality of life and functional abilities and independence of the patients. Prevention, early identification and immediate treatment of these complications is important for improving quality of life and lifespan of the spinal cord injury patients.

We have discussed some of the significant complications of spinal cord injury which are as follows

1) Autonomic Dysreflexia
2) Pulmonary Embolism
3) Deep Vein Thrombosis
4) Postural Hypotension
5) Edema
6) Pain
7) Abnormalities of temperature regulation
8) Heterotopic (Ectopic) Ossification
9) Contractures
10) Osteoporosis

Autonomic Dysreflexia:

Autonomic Dysreflexiais due anover-activity of the Autonomic Nervous system. It is seen in patients at T5 and above level of injuries. Autonomic dysreflexia can develop suddenly, and is a possible emergency situation. If not treated promptly and correctly, it may lead to seizures, stroke, and even death.

Mechanism: It can occur when an irritating stimulus is introduced to the body below the level of spinal cord injury, such as an overfull bladder. The stimulus sends nerve impulses to the spinal cord, where they travel upward until they are blocked by the lesion at the level of injury. Since the impulses cannot reach the brain, a reflex is activated that increases activity of the sympathetic portion of autonomic nervous system. This results in spasms and a narrowing of the blood vessels, which causes a rise in the blood pressure. Nerve receptors in the heart and blood vessels detect this rise in blood pressure and send a message to the brain. The brain sends a message to the heart, causing the heartbeat to slow down and the blood vessels above the level of injury to dilate. However, the brain cannot send messages below the level of injury, due to the spinal cord lesion, and therefore the blood pressure cannot be regulated. This can be a MEDICALEMERGENCY because extremely high blood pressure can result in stroke, seizures, or death.

Causes:

There can be many stimuli that cause Autonomic Dysreflexia. Anything that would have been painful, uncomfortable or physically irritating before the injury may cause AD after the injury. Things to consider include

1) Bladder associated triggers (most common)- from overstretch or irritation of bladder wall.

   This includes

   - Urinary tract infections
   - Urinary Retention
   - Blocked Catheter
   - Overfilled collection bag
   - Non compliance with intermittent catheterization program etc

2) Bowel related triggers - over distention or irritation
   - Constipation / impaction
   - Distention during bowel program(digital stimulation)
   - Hemorrhoids or anal fissures
   - Infection or irritation (e.g., appendicitis)

3) Skin related triggers
   - Any direct irritant below the level of injury(e.g., prolonged pressure by object in shoe or chair, cut, bruise, abrasion)
   - Pressure Sores (Decubitus ulcers)
   - Ingrown toe nails
   - Burns(e.g., sun burn, burns from using hot water)

- Tight or restrictive clothing or pressure to skin form sitting on wrinkled clothing

4) Sexual Activity related triggers:
   - Overstimulation during sexual activity (stimuli to the pelvic area which ordinarily be painful if sensation were present)
   - Menstrual cramps
   - Labor and delivery
5) Others:
   - Heterotopic Ossification
   - Acute Abdominal condition (gastric ulcers, colitis, peritonitis)
   - Skeletal fractures

What are the Signs of AD?

A patient with AD may have one or more of the following findings on physical examination

1) Pounding headache (caused by high blood pressure)
2) Goose bumps/ cool, clammy skin
3) Sweating above the level of injury
4) Nasal Congestion
5) Nausea
6) Slow Pulse/ Heart Rate (< 60 beats per minute)
7) Blotching of the Skin
8) Restlessness

The sudden rise in the blood pressure in AD is usually because of slow heart rate. Normal systolic pressure for SCI above T6 is 90-110mm Hg. Blood pressure 20-40mmHg above the reference range may be a sign of AD for individuals with SCI. However patients with AD may display no symptoms, despite elevated blood pressure.

Prevention of AD:

Following are the list of precautions that one should take to prevent episodes of AD:

- Frequent pressure relief or change of position in bed/ chair
- Avoidance of sun burn/scalds (avoid overexposure, use of #15 or greater sunscreen, watch water temperatures)
- Maintain a regular bowel program.
- Well balanced diet and adequate fluid intake
- Compliance with medications

- Persons at risk and those close to them should be educated in the causes, signs and symptoms, first aid, and prevention of autonomic dysreflexia.
- If you have an indwelling catheter:

Keep the tubing free of kinks

- Keep the drainage bags empty
- Check daily for grits (deposits) inside of the catheter.
- If you are on an intermittent catheterization program, catheterize yourself as often as necessary to prevent overfilling.
- If you have spontaneous voiding, make sure you have an adequate output.
- Carry an intermittent catheter kit when you are away from home.
- Perform routine skin assessments.

What to do if these signs are coming on?

Initial Steps:

- SIT UP or raise the head of the bed immediately
- Look for the cause or alert your nurse, therapist or caregiver so they can look too
- Bladder: Do you need to catheterize? Is the Foley kinked, plugged or full?
- Bowel: Do you get constipated often? Has it been 3 or more days since your last bowel movement?
- Skin: Do you have pressure sores, burns cuts, bruises? Is your clothing/ undergarments twisted? Do you have an ingrown toenail?
- FIX IT! Catheterize, do your bowel program, adjust clothing or remove whatever offending stimulus is bothering your body! Once the stimulus is removed, you should notice relief from the above symptoms. If not, get to the EMERGENCY ROOM and be ready to explain dysrreflexia because not all health care providers encounter SCI or dysreflexia on a regular basis.
- Consider medical management. If systolic BP remains above 150mm.

Further Treatment:

If symptoms persist or BP still remains elevated following the above efforts or a cause cannot be readily identified, pharmacological treatment with a short acting antihypertensive medication should be started simultaneously with the search for and treatment of the noxious stimulus.

NOTE: teaching the patient and care giver about this complication is essential.

Reminder

Obtain emergency medical treatment, if you are unable to find the stimulus causing autonomic dysreflexia.

Pulmonary Embolism:

What is pulmonary Embolism?

Pulmonary Embolism is a potential cardiovascular emergency that occurs when a part of thrombus , usually dislodged from a DVT (called an embolus), passes in the pulmonary circulation and blocks the pulmonary arteries that supply the lungs with blood. Blood clots in the lungs prevent enough oxygen from getting into our body and oxygen is what fuels our brain, muscles, everything. PE is a potentially life-threatening condition which can be preventable.

Incidence of Pulmonary Embolism:

Studies show a correlation between the Incidence of deep vein thrombosis (DVT), pulmonary embolism (PE), and death during the initial acute hospitalization after traumatic spinal cord injury (SCI). Studies show that incidence of Pulmonary Embolism is 4.6% and DVT is 14.5% with higher incidence of mortality seen in quadriplegics as compared to paraplegics.

Diagnosis of PE:

PE is a potentially life-threatening condition and in severe cases the occurrence of circulatory collapse and cardiac arrest may result in sudden death, hence rapid diagnosis is crucial. Early fatality occurs in up to 15% of patientsand thus rapid diagnosis is crucial. However, the diagnosis of PE may be missed because of its non-specific clinical symptom.

Common signs and symptoms of PE are:

- Dyspnoea, Shortness of breath (worse than the breathing problems your SCI may cause)
- Chest pain, also pain in jaw or shoulder (like the signs of a heart attack)
- Heavy feeling in chest
- Cough
- Fever
- Haemoptysis (Red streaks in coughed-up secretions)
- Syncope
- Unilateral leg pain

- Signs of DVT (unilateral extremity swelling)
- Irritable or anxious feeling
- Fast heartbeat (pulse)
- Pale complexion, bluish tint to lips

These symptoms are not specifically diagnostic of PE. Hence careful judgment of the clinician is required regarding the need for imaging tests designed to detect PE. A clinician should maintain a high index of suspicion for this condition, because prompt treatment of PE can dramatically reduce the levels of morbidity and mortality associated with PE.

How it is diagnosed?

When you visit your doctor for your symptoms, they'll ask about your overall health and any pre-existing conditions you may have. Your doctor will typically perform one or more of the following tests to discover the cause of your symptoms:

- Chest X-ray: This standard, noninvasive test allows doctors to see your heart and lungs in detail, as well as any problems with the bones around your lungs.
- Electrocardiography (ECG): This test measures your heart's electrical activity.
- Magnetic resonance imaging (MRI): This scan uses radio waves and magnetic field to produce detailed images.
- Computerized tomography (CT) scan: This scan gives your doctor the ability to see cross-sectional images of your lungs.
- Pulmonary angiography: This test involves making a small incision so your doctor can guide specialized tools through your veins. Your doctor will inject a special dye so that the blood vessels of the lung can be seen.
- Duplex venous ultrasound: This test uses radio waves to visualize the flow of blood and to check for blood clots in your legs.
- Venography: This is a specialized X-ray of the veins of your legs.

What to Do if there are signs for PE?

THIS IS AN EMERGENCY! CALL the doctor.

- Avoid massaging legs and avoid pressure behind legs
- ecrease activity level (your lungs aren't getting enough fuel…don't use more!)
- Sit up/lean forward or get into a position that makes breathing easier
- Remove tight clothing that may restrict breathing
- Use supplemental oxygen if available.

How it is treated?

The treatment for a pulmonary embolism depends on the size and location of the blood clot. If the problem is minor and caught early, you may be advised to take medications to break the clots. Commonly used drugs:

- anticoagulants: Also called as blood thinners, e.g., heparin and warfarin, these drugs prevent formation of new clots in your blood.
- Thrombolytics(clot dissolvers): These drugs are used to break the clot. They're used in emergency situations because of its side effects which include dangerous bleeding problems.

Surgery may be necessary to remove problematic clots, especially those that restrict the blood flow to the lungs or heart. Some surgical procedures your doctor may use in the case of a pulmonary embolism

- **Vein filter:** A small incision will be made to install a small filter in your inferior vena cava (the main vein that leads from your legs to the right side of your heart). The filter prevents blood clots from traveling from your legs to your lungs.
- **Clot removal:** A thin tube called a catheter will suction large clots out of your artery. It isn't an entirely effective method because of the difficulty involved, so it's not always a preferred method of treatment.
- **Open surgery:** Doctors use open surgery only in emergency situations when a person is in shock or medications aren't working to break up the clot.

  Follow-Up Care: includes care after you are properly treated for the pulmonary embolism at hospital
- Treatment of the underlying cause. This is typically deep vein thrombosis.
- Blood thinner medications, such as heparin and warfarin, to prevent blood clots from returning.
- Regular use of compression stockings to prevent clots from forming in your legs.
- Regularly passive ROM exercises to prevent future blood clot

Deep Vein Thrombosis:

Deep Vein Thrombosis is one of the common complications seen in patients with Spinal Cord Injury. DVT and subsequent Pulmonary embolism remain significant causes of morbidity, mortality and substantial healthcare costs in patients with SCI. Venous thromboembolism remains the third leading cause of death after SCI. Morbidities include thromboembolism, prolonged edema and pressure ulcers. It is a condition in which a blood clot is formed in one or more of the veins in the body, most often in the lower legs or thigh. DVT can result in life threatening danger if the

clot breaks loose from the leg vein and finds its way to the lungs causing pulmonary embolism. The risk of DVT is high in the acute phase of SCI.

Incidence:

Incidence of DVT varies significantly among the various racial groups and it also varies from population to population and from country to country. Asian patients have been reported to have a significantly lower incidence of idiopathic and secondary venous thromboembolism as compared to the western patients. The clinical symptoms are seen in only 15% of patients with acute SCI and pulmonary edema develops in approximately 5% of these patients.

Causes:

- inactivity after SCI
- lack of pumping action of large muscle groups, which causes pooling of blood in the veins and trauma.

  Signs and Symptoms : The signs and symptoms of DVT are varied and it depends upon the severity.

- Pain and tenderness in the leg mainly in ankle and foot, it often starts in the calf area and feels like cramping. However majority of the paraplegics are unable to feel the pain, therefore one has to look for other symptoms to diagnose and treat it immediately.
- **Swelling:** around the affected calf muscle in the affcetdd leg, including the swelling arounf ankle and foot
- **Skin discoloration:** like the limb may turn pale, red or blue.
- Increased warmth of the affected area.

Although the various methods of DVT detection will be discussed, it is very important for the health care professionals, patients, family members and care givers to be educated regarding the early signs and symptoms.

What to do if I have signs of DVT:

1) Call doctor or got to the emergency roomk
2) Elevate the affected leg/arm.
3) Remove the stockings
4) DO NOT MASSAGE or exercise the affected leg/arm.
5) Doctor will advice tests and give instructions. Always follow them.

Preventive measures:

1) Regular inspection twice daily for any unusual increase in the calf/ thigh

circumference, low grade fever of unknown origin and/or pain, tenderness or heaviness of the affected extremity.

2) Routine practice of passive and active ROM exercises. Mobilization and movement of the extremities should be essential in the prevention of DVT after SCI.

3) Routine use of graduated compression stockings is common in people with paralysis.

Treatment : treatment of DVT is aimed at

1) Prevent the further increase in the size of the clot

2) Prevent the clot from dislodging and causing subsequent pulmonary embolism

3) Reducing the chances of a recurrence of DVT.

Various treatment options include

1) **Blood thinners:** Doctors use anticoagulants, commonly called blood thinners, to prevent blood clots. In spinal cord injury, anticoagulants are generally given with the first 72 hours after injury to all patients. The thinners are usually given for about eight weeks. The most common type of blood thinner used in SCI is a low molecular weight heparin such as enoxaparin or dalteparin. These medications slow the time it takes for blood to clot and also prevent growth of a clot. Blood thinners do not remove existing clots; that sometimes involves surgery, they can prevent clots from getting bigger or reduce the risk of developing additional clots.

   As soon as a patient is suspected to have DVT, infusion of blood thinner like heparin is given for a few days. After the course of the heparin injections, oral medications like warfarin are usually given. Oral blood thinners are required for at least a minimum of 3 months. However, these blood thinners have serious side effects like risk of bleeding especially with higher doses, however if the dose is too low there can be chances of getting additional blood clots. Hence it is necessary to get a periodic check up of the blood clotting and bleeding time , so that the physician can accordingly adjust the dosages. In the event of a paraplegic getting a life threatening complication like pulmonary embolism, the physician may give other medicines like tissue plasminogen(TPA)

2) In cases where one cannot be given blood thinners, filters are inserted in the vena cava, the IVC filter is designed to capture blood clots from deep veins (mostly commonly from the leg) that would otherwise travel to the heart and lungs. A vena cava filter is a cone shaped medical device that is inserted into the inferior vena cava (IVC), the largest vein in the body, to prevent devastating pulmonary embolisms.

3) Routine use of graduated compression stockings helps in preventing the swelling that is associated with DVT. The stocking are worn on the leg from foot to knee. They are to be worn for duration of approximately 1 yr.

Postural Hypotension

Postural or Orthostatic hypotension is a sudden drop in blood pressure caused by moving from a lying to a sitting or standing position. The patient complains of feeling dizzy or light headedness with fast changes in position and it often occurs after spending a long time in bed and then suddenly getting up. Although orthostatic hypotension can happen to anyone, it is more common following a spinal cord injury (SCI) and in the first few weeks of rehabilitation. This is because of the loss of nervous system control which works to keep the blood pressure stable, as veins and arteries can't tighten or widen like they used to below the level of injury, also the muscles in the arms/trunk/legs aren't working, to help return the blood to the heart.

Orthostatic hypotension is defined by The Consensus Committee of the American Autonomic Society and the American Academy of Neurology (1996) as a decrease in systolic blood pressure of 20 mmHg or more, or in diastolic blood pressure of 10 mmHg or more, upon the assumption of an upright posture from a supine position, regardless of whether symptoms occur.

Postural Hypotension is more commonly experienced by cervical SCI and high thoracic (levels 1- 6) spinal cord lesions. In most cases, it resolves and happens only after being in bed for long periods of time, and in the morning, however it can continue in few and medications may be necessary. Different patient react differently with postural hypotension. Higher level injury patients suffer with postural hypotension for a longer time after the injury.

Signs of Postural Hypotension

- Dizziness
- Lightheadedness
- Nausea
- Fainting
- Sweating
- Cool, clammy skin
- Fatigue
- Muscle Weakness
- Syncope (temporary loss of consciousness)

How to Prevent and Manage Postural Hypotension?

- Initially, you may need a wheelchair that leans back, reclining chair or ask somebody to tip you back. The first few times you get out of bed the back of the chair will be tilted back and then slowly raised to an upright position as you are able to tolerate sitting up.

- Check your Wear TED hose, ACE wraps, abdominal binder, and stockings and make sure it is tight enough. They may help to stop the blood pressure from dropping as you sit up.
- Move SLOWLY (especially in the morning`): gradually come to sitting or standing positions once the dizziness has gone, do this for few times until your body becomes used to it. If it continues, return to bed
- Elevate head of bed and sit up in bed for long time before transferring to your wheelchair (progressive sitting)
- Stay active and hydrated, and avoid staying in bed for long periods of time unless medically necessary.
- There are medications that may help raise the blood pressure. If hypotension continues to occur, consult your doctor.

Pharmacological Management:

- Fludrocortisone acetate (Florinef)

Mechanism: Salt and water retention/ delayed action

Side effects: HTN, CHF, hypokalemia, hypernatremia, weight gain, edema

- Ephedrine sulphate (Ephedrine)

Mechanism: Alpha & beta sympathetic agonist

Side effects: Tachycardia, arrhythmias, HTN, palpitations, urine retention, insomnia, sweating, tremors, tachyphylaxis, abuse potential

- Midoridinehcl (ProAmitine)

Mechanism: Alpha-1 adrenoreceptor agonist

Side effects: Headache, paresthesias, dysuria, pruritis, piloerection, supine HTN

Non Pharmacological Management:

- Regulating Sodium and fluid intake: Increases in fluid intake and a diet high in salt/sodium can expand extracellular fluid volume and improve orthostatic responses. Though no sufficient evidences are available
- Use of abdominal binders or elastic stockings improves the cardiovascular responses during the sub maximal arm exercises. Although there are insufficient evidences on the same.
- Whole Body Vibration: it is found to increase the mean arterial pressure in individuals with SCI.
- Use of FES (Functional Electrical Stimulation) can be used as an adjunct to minimize the cardiovascular changes that occur during Postural hypotension.

- Evidence shows that exercise training enhances the sympathetic outflow in individuals and makes them more tolerable to OH as compared to inactive individuals with SCI.
- Also regular standing training has shown to improve the tolerance to OH.

IMPORTANT NOTE:

- Attempting to fight with dizziness is not a matter of will power,if you ignore these early signs you might faint. If this happens and you are not able to assume a reclined position then you will deprive your brain of blood and oxygen and possibly cause brain damage.
- If you find yourself getting dizzy suddenly after a very long time, this might be a sign that you have an infection or some other medical problem. Call your doctor.

Edema:

Edema is the medical term for swelling which simply means collection of fluid under the skin.

Causes:

- Swelling in lower limbs is caused by gravity. While sitting up in a wheelchair, legs and feet dangle and gravity pulls everything down towards the earth, including blood. Blood pools in the feet and this fluid moves from the blood vessels into the tissues of the feet and ankles. Thus, swelling is usually worse at the end of the day when legs and feet have been hanging down all day.
- Swelling is also made worse when paralyzed muscles in the feet and legs don't work to help veins push blood back to the heart. Injury or surgery can also cause damage to the valves in veins making it even easier for blood to pool in the feet and ankles.

How to Prevent Swelling/ Edema?

- Wear TED hose or compressive stockings
- Elevate the legs and feet throughout the day and when it is possible
- MOVE as much as possible (exercise, propel wheelchair, range of motion, walk if possible)
- For quadriplegia: prop hands up on pillows when sitting or massage hands from fingers towards arm

Note: DON'T MASSAGE FEET/LEG, that would dislodge a blood clot and might cause a pulmonary embolism or stroke.

Side-effects of Edema: chronic swelling can lead to

Pressure ulcers

- Soft tissue infections like cellulitis
- Skin becomes fragile and it is more prone to splitting and cracking

Impaired temperature Regulation:

The body regulates temperature by sweating to cool off, shivering to warm up, and by shrinking or expanding blood vessels to give off heat or keep heat in. After a spinal cord injury, the body's ability to control temperature is affected, which can lead to hypothermia or heat stroke. It is due to the loss of internal thermoregulatory responses, due to which there is absence of thermoregulatory sweating. The higher the injury level and the more complete an injury is, the greater it is difficult for temperature regulation. Due to the decreased sensation patient can become severely sunburned or frost bitten. The following precautions are to be taken in extreme conditions to regulate the body temperature.

In Cold Weather:

- Wear warm clothing, hat, gloves and socks
- Use extra blankets
- Drink warm fluids
- DON'T use heating pads, electric blankets on skin if sensation is affected. There are chances of burns.
- Don't keep hot plates or cups on the lap without a towel. The skin on your thighs is more sensitive than the skin on your hands. Also check the seat with hands for temperature before transferring on the car seat.

In Hot Weather:

- Don't stay out in Sun.
- Use hats and stay in shade
- Spray self with cool water at regular intervals.
- Drink cool fluids
- Use fan or air conditioner
- Avoid hot tubs for bathing
- Be careful not to put your bare feet on hot pavement
- Watch out for decreased urine output, this could signal dehydration, which can contribute to all kinds of other secondary problems/complications.

Neurogenic Pain:

After a spinal cord injury, pain is experienced by many paraplegics at or below their level of injury. It is the most challenging medical problems. This neuropathic pain is very difficult to treat and patients spend many sleepless nights. Many of them may experience pain immediately after their injury and then as the body heals the pain subsides. Musculoskeletal, neuropathic, and pain from the trauma related to the injury are common. A lot of individuals with a spinal cord injury suffer with chronic pain to the extent that it may affect their ADLs.

Types Of Pain:

Musculoskeletal Pain: It usually occurs above the level of injury in complete injuries and below the level in incomplete injuries. It occurs in parts of the body

like the bones, joints, and muscles. And ususlaly it is worsened by movement and eased with rest. This type of pain is usually dull achingin nature.

Causes:

- overuse of joints and muscles
- Overuse syndrome/ pressure syndrome eg: rpotator cuff tendinitis seen in individuals using manual wheelchair
- Muscles spasms pain
- Mechanical instability of spine around the operated site

Management: anti inflammatory medications

Neuropathic Pain

Neuropathic pain can occur anywhere at or below your injury. There are 3 types, SCI central pain, Segmental, nerve root entrapment pain, pain due to syrinx

Causes: The cause is not really understood. It is believed that neuropathic pain is related to the nerve endings at the site of the injury. It is felt that because the brain cannot receive and send messages through the nerves, that it may think that there is pain below the level of injury when it is not..

Central pain:

- described as sharp, shooting or burning pain, tingling numbness or throbbing
- it is very disturbing in nature.
- It can begin within weeks or months after the injury and is felt at the level of injury or below the level where there is no touch sensation.

Segmental Pain:

It often occurs slightly above the level of injury or slightly below. It is often associated with hyperalgesia in the painful region. Hyperalgesia is pain caused by something that does not normally cause pain. E.g., something cold, warm or very light touch to the skin can cause pain.

Nerve root entrapment pain

It occurs at or just below the level of injury and has a distant pattern like brief waves of stabbing or sharp pain or a band of burning pain at the point where the normal feelings stops.

Pain due to syrinx:

A Syrinx is a hollow fluid filled space in the spinal cord. It develops months and years after the injury. As the syrinx expands it may move up and down the spinal cord and can result in pain along with increased loss of sensory and motor function.

Treatment:

Neuropathic pain is very difficult to treat because each individual responds to treatment differently.

Pharmacological Treatment:

- Anticonvulsants
- Antidepressants

Non Pharmacological Treatment:

- Exercise
- TENS
- Psychological counseling
- Relaxation techniques
- Graded motor imagery
- Breathing Exercises
- Cognitive behavioral therapy/ supportive psychotherapy

Surgical Treatment:

- Dorsal root rhizotomy
- Cordotomy
- Lumbar sympathectomy

Osteoporosis:

Osteoporosis occurs due to loss of mineral from the bone, causing bone tissue to break down. This occurs normally in individuals as they age. An individual's

metabolism changes after suffering from SCI. Osteoporosis is one of the inevitable complications seen in individuals after SCI, and it is mainly seen in pelvis and lower extremities. Osteoporosis is due to prolonged bed rest, no weight bearing on lower limbs and lower motor disorder.

Causes:

- Disuse
- Disordered Vasoregulation:
- Poor Nutrition
- Hormonal changes
- Metabolic disturbances
- Autonomic Dysregulation

Factors that affect Bone Loss:

- **Level of Injury:** The severity of the bone loss varies in paraplegics and quadriplegics. Paraplegics usually have bone mineral density preserve din their upper extremities.
- **Type of Injury:** Individuals with complete injuries have more bone loss than those with incomplete injuries.
- **Duration of injury:** the longer the time since injury, the greater the bone loss.

How it is detected?

- X-rays
- Bone Density testing (Dexa Scan)
- Blood Calcium, phosphorous levels and blood alkaline phosphatase levels
- 1,25- dihydroxyvitamin D and calcitonin levels
- Urine Calcium levels

Management:

- Exercise: weight bearing exercises using standing frame or harness, treadmill training and functional electrical stimulation helps prevent demineralization of bones
- Increase dietary Calcium intake and Vit D levels: calcium helps build strong bones and Vit D improves the absorption of calcium
- Stop Smoking
- Limit Caffeine

- Stop Alcohol
- Medications: biphosphonates can help prevent bone loss and increase the bone density
- Protect the bones: by doing regular ROM exercises. Spasticity can put some force on the bones that helps to strengthen them, however strong spasms can make the bones weak and hence make it more susceptible to fractures.

Note: Report any concerns to your physician immediately

Heterotopic Ossification:

Heterotopic ossification (HO) is a frequent complication in spinal cord injury (SCI). It was first described by Deejerine and Ceillier in 1918 as paraosteoarthropathy. It is characterized by the formation of new extra osseous (ectopic) bone in soft tissue surrounding peripheral joints in patients with neurologic conditions. Heteretopic Ossification is also seen in other neurologic conditions such as Traumatic Brain Injury (TBI) and Stroke, as well as after thermal injuries and other orthopedic procedures (e.g., total hip replacement).

Incidence:

In SCI patients, the incidence ranges from 16%-53% depending on the incidence reports from various institutions. Clinically significant HO develops in about 20% of patients with a SCI. Fortunately, only 3-5% of cases involve joint ankylosis. In SCI, HO always occurs below the level of the lesion, most commonly at the hip (70-97%). Other body segments, including the knee, elbow, shoulder, hand, and spine (in decreasing incidence), may also be involved.

There is no known race or sex predilection for Neurogenic HO, however, the incidence of Neurogenic HO after SCI is less common in children than in adults with an incidence generally ranging from 3% to 10%. In addition, spontaneous resorption/ regression of the Neurogenic HO is often reported in pediatric patients and young adults than in older adults. HO may develop within days following the spinal cord injury or several months later. HO usually occurs 3-12 weeks after spinal cord injury yet has been known to also develop years later.

Causes:

The specific cause of HO after spinal cord injury is unknown, however there are many theories about why it develops after spinal cord injury including:

- Trauma or injury
- Immobilization or paralysis
- Muscle spasms
- Loss of oxygen

- Severe bleeding
- Inflammation - the body's natural response to injury
- Genetics
- Prolonged pressure on the hips

Symptoms:

- Decreased Range of the motion
- Swelling and warmth around the joint
- Fever
- Increased Spasticity
- Joint pain, Muscle pain, and Autonomic Dysreflexia

Secondary Effects on the body from HO:

It is a viscious cycle that affects the body after one or more joint of the body is affceted with HO. HO causes restriction of the joint, affecting the ability to do transfers, bowel and bladder care and will overall affect the performance of ADLs. Also, HO can increase the amount of pressure applied to tissue under certain boney areas, skin breakdown can occur. Pain in the joint can lead to increased spasticity and/or autonomic dysreflexia. Blood clots or deep vein thrombosis (DVT) can also develop due to decreased movement and problems with circulation around the joints. One will have to work closely with a physician to treat HO and prevent its potential complications.

How is it Diagnosed?

HO is often diagnosed after you have some or all of the symptoms listed above. Your doctor will order some tests to confirm the symptoms are related to HO. Some of the tests that may be ordered include:

- Blood tests
- CT-scan
- Ultrasound
- Three-Phase Bone Scan
- X-rays

How is it treated?

- Work out a treatment plan with the physician and therapist
- Gentle range of motion of the joints and some physical therapy.
- Medications to slow down or stop the abnormal growth of bone.

When HO severely affects your movement or causes excruciating pain, surgery may be needed. Also, radiation has been used in some cases to stop the growth of bone. All other treatment options are explored first before considering surgery and/or radiation.

Preventative Measures:

Since the cause of HO is currently unknown, preventive measures are limited.

- Medications to prevent bone growth. The blood thinner Coumadin (Warfarin) is sometimes prescribed because it decreases the activity of Vitamin K, an important component in the development of bone.
- Another type of medication often prescribed is non-steroidal anti-inflammatory (NSAIDS) drugs. These medications prevent formation of bone growth by blocking prostaglandin cells from forming bone.
- Depending on the individuals health and needs, the physician will develop a plan that is right for you. All medications come with side effects, however never start or stop a medication without consulting with your doctor first.

Contractures:

What causes Contractures?

- Lack of active muscle function due to imbalance in muscle pull
- Spasticity and muscle spasms
- Flaccidity
- Improper positioning
- Heterotopic Ossification
- Edema
- These cause prolonged shortening of structures across and around the joints and hhese cause limitation of joint ROM

How to manage contractures?

- Normalization of Tone
- ROM exercises
- Stretching exercises
- Positioning in bed, chair etc
- Splinting

Chapter 6
Bed sore management

Pressure Ulcers commonly known as bed sores are called as decubitus ulcers. It is defined as a localized area of tissue necrosis that tends to develop when soft tissue is compressed between a bony prominence and an external surface for a prolonged period of time.

Incidence: It is one of the most common complications seen in individuals after Spinal Cord injury along with Urinary Tract Infection. It is the most limiting squeal that can confine an otherwise independent individual to bed rest. But 39% of people rehospitalized in the first year after their SCI are admitted for pressure ulcers. And about one-third, or 34% of people with an SCI end up requiring three or more hospitalizations throughout the rest of their lifetime for treatment of pressure sores. About 7-8% of deaths in the SCI population are related to a pressure sore. These deaths most likely result from sepsis, an infection that spreads throughout the body in the blood and tissues, causes of loss of income due to increased care costs, also causing prolonged bed rest and inactivity.

Risk Factors:

- Paralysis and sensory loss causing inability to feel irritants to the skin.
- Due to muscle atrophy there is less padding on the bony prominences, which causes more shear stress on these areas.
- Impaired sensation causing reduced blood supply to the tissues, which delays the healing process.
- Delayed wound healing due to altered collagen metabolism
- Low testosterone (common in male SCI) inhibits or delays wound healing
- Diabetes
- Malnutrition may cause impairment in the protein stores, vitamin C and zinc levels that are important to maintain the skin integrity.

- Smoking contributes to peripheral vascular disease causing delayed wound healing
- Aging causes the skin to get thinner and more prone to skin breakdown and less tolerant to the shearing forces (dragging/ rubbing).

What Causes Pressure Ulcers in SCI.?

1) Pressure
   - Persistent pressure for long duration: constant low pressure for long duration can cause tissue damage
   - Recurrent pressure: e.g., bumping the elbow many times a day against the edge of a table
   - Short periods of high pressure e.g., accidently hitting yourself hard against a surface while performing transfers.
2) Abnormal Shear Forces: dragging skin or body parts
3) Abnormal positioning while in wheel chair, vehicle or in bed can cause pressure on the bony prominences.
4) Exposure to moisture for long period can cause maceration and skin breakdown

   Common Areas for Pressure Sores
   - Heels
   - Sacrum
   - Ischial tuberosity
   - Hip bones
   - Other Bony prominences like knees, shoulder blades, elbows, spine, pelvis, back of head etc.

How to prevent pressure ulcers??

- Inspect the skin for any signs of inflammation

Methods to do Skin Checks

- Should be done twice daily , first thing in morning and last thing before bedtime
- Use long handled/ angled mirror for areas that are difficult to visualize or ask for caregiver help
- Check for common areas of skin breakdown
- Check for signs of inflammation,
- If any areas are seen, perform blanch test
- Follow the instructions as to how to take care of various stages of pressure sores

- Consult physician, if the wound is oozing and has a foul smell.
- Perform regular pressure relief techniques, after every 15-30 min

Pressure relief maneuvers:

1. Push-ups after every 15 minutes by taking support of the armrest of the wheelchair. Triceps strength should be adequate for this maneuver.
2. Forward leaning: For active forward leaning trunk muscles, pectoral muscles, triceps are essential. However, if weakness persists, passively leaning forward can also relieve pressure to some extent.
3. Side lean by hooking on the rim of the wheelchair on the opposite side and leaning to one side and then the other. For doing this he needs strong biceps.
4. Electrically operated reclining wheelchair can also relieve the pressure.
    - Frequent change in position in bed, turning almost after every 2 hrs in bed.
    - Use of good wheelchair cushions and mattresses that evenly distribute the pressure
    - Keep clothing wrinkle free
    - Perform good transfer techniques with good pushups and ground clearance
    - Protect the hands, legs and feet from trauma
    - Proper posture and positioning in bed, chair
    - Maintain proper skin hygiene after bowel and bladder management
    - Pat the skin dry
    - Stop on habits like smoking and drinking
    - Check testosterone levels every few years
    - Diet high in protein, iron and vitamin C

What does it look like when the ulcer is starting?

- The skin gets reddish/ pinkish
- Shiny
- Skin texture changes- cracked, dry, hard, soft, warm

What to do if you suspect an Ulcer/Bedsore?

- Remove the pressure immediately
- Look for the source of pressure
- Perform blanch test : press on the discolored area, the skin should turn pale, remove finger and it will return to normal in a few sec, if not that means the blood flow to that area is interrupted. And if the area is still discolored then that means the ulcer has started.

Note: What you see on the surface of the skin is often the smallest part of the pressure ulcer.

Stage Wise Ulcer Management:

Stage 1: Non Blanchable Erythema: in this stage the skin is intact with no blanching redness over the bony prominence. This stage is difficult to detect on dark skin tones. Individuals are at the risk of developing pressure sore. The skin is red and there is no change in color even after 30 min of pressure removal.

Management:

- Keep the pressure off the sore
- Maintaining good hygiene
- Evaluate the diet
- Review the cushions and mattresses
- Also review the turning, transfer and pressure relieving techniques
- If sore doesn't heal in few days even after following these measures then consult your physician

Stage 2:Partial thickness: in this stage there is partial thickness loss of dermis with a red pink shallow open ulcer without slough

Management:

- Follow the same management of ulcer as done for the stage 1
- Keep the wound sterile and dry and use a hydrocolloid dressing or gauze dampened with saline.
- Check for signs of wound healing with every dressing change.
- If signs of infection are seen consult the physician.

Stage 3:Full thickness skin loss: there is full thickness tissue loss with visible subcutaneous fat and ample slough. The depth of the ulcer varies depending on the anatomical site of ulcer. The ulcer extends into the subcutaneous and fat tissues.

Management:

- Follow the same steps of maintaining wound hygiene
- Frequent wound cleaning and debridement should be done
- Antibiotics will be required
- Special pressure relieving mattress will be required

Stage 4: Full thickness tissue loss: the ulcer in this stage has extended to the level that

underlying bone, muscle and tendon are visible. The depth of the ulcer varies depending on the anatomical site of ulcer

Management: wound is so big that a surgical procedure like flap surgery will be required to close the wound.

Complications caused by Pressure sores:

- It can be a life threatening event if infection spreads to blood, heart and bones
- Amputations
- Prolonged bed rest
- Autonomic Dysreflexia

Chapter 7
Spasticity Management

The most important of the symptoms that requires a lot of attention and may hinder the day to day working of the patients is muscle spasticity and spasms. Various exercises and techniques can reduce and control spasticity. But sometimes spasticity can also be used by the patients to improve their functional performance. A therapist should therefore carefully assess the patient's functional abilities and how these abilities will be altered by spasticity before prescribing exercises to reduce tone. Patients should also take care to prevent some triggering factors that may increase the spasticity and spasms. Let us first understand what spasticity is and how it can be managed and used to the patient's advantage.

What is spasticity?

Spasticity is uncontrolled as well as sustained contraction of the muscles. It is very common in individuals with Spinal cord injury 8 out of 10 individuals with spinal cord injury have some grade of spasticity. Depending upon the level and site of injury the grade of spasticity may change. The spasticity is usually more if the injury is at higher level like that of cervical level and sometimes in the upper thoracic regions but as the level of injury moves lower the grade of spasticity also generally reduces.

How to identify spasticity?

Spasticity exhibits differently in different people and could present as a combination of symptoms that are mentioned below.

- The most common symptom is resistance to the movement in the opposite group of muscles leading to slow movements
- There could be sudden jerks in the muscles that have spasticity
- Spasms, i.e. sudden flexion (bending) and extension (straightening) of the whole body or some parts of the body
- Uncontrolled movement of the body while initiating a voluntary movement.

- Inability to control the speed and the direction of the movement of the limbs.
- Inability to relax the muscles leading to stiffness and tightness at rest.
- Resistance to a passive movement

What is the reason for spasticity?

Brain controls the body movements. These movements are generated in response a stimulus. However sometimes there is a need for a quicker response. Spinal cord is responsible for these quick responses and such responses are called reflexes. These reflexes are protective. An example of reflex is withdrawing the hand when touching a hot object. Such reflexes are inhibited by brain and therefore such sudden, violent and continuous muscle contractions are prevented. In spinal cord injury the communication between the spinal cord and brain is lost. Therefore the muscles can be in a state of continuous contraction under the influence of uninhibited spinal cord. This gives rise to jerks, spasms and spasticity. Therefore any external stimulus like touch, movement or any irritation can trigger and sustain an unwanted muscle contraction.

What can trigger unusual responses of spasticity?

- Suddenly stretching a muscle
- Initiating a body movement
- Skin irritation
- Pain
- Urinary infection
- Full bladder
- Constipation
- Bed sore
- Tight clothing
- Uncomfortable clothing causing skin irritation in the area with impaired sensations
- Uncomfortable footwear
- Fracture, muscle, tendon or ligament injury

What are the harmful effects of Spasticity?

- Pain
- Contractures i.e. loss of joint mobility due to muscle stiffness. If this persists adhesions can be formed in other tissues like fascia, ligaments and other connective tissues. Skin shortening may also occur. This can result in permanent loos of

range of motion in a joint requiring surgical intervention.

- Sudden and uncontrolled spasms are a risk to the safety while performing transfers and gait training. A spasm compromises the safety while driving.
- Breathing may be restricted due to spasms and spasticity in the chest muscles; this may further reduce the endurance for performing day to day activities as well as training exercises.
- Sleep disturbances
- Skin irritation and abrasions
- Difficulty in performing movements of daily activities.

What care to take for preventing harmful effects of spasticity?

- From the safety perspective it is important to anticipate spasms when driving on an surface or wheeling the wheelchair on an uneven surfaces. Adequate safety measures like putting the seat belt and wheelchair belt should be followed. In case of severe spasm it is advisable to halt the car by the side of the road till the spasm wears off.
- During therapy, therapists should be aware of the movements trigger spasms and should avoid any unnecessary jerky movement and sudden stretching of the muscles. Also during training for transfers and gait training adequate safety measures should be taken to prevent falls in case of spasms.
- Regular passive stretching of the muscles is essential to avoid joint stiffness and muscle contractures.

How can Spasticity be used for the benefit of the patient?

- Spasticity can be used to trigger muscle contraction and thereby to perform certain tasks of daily activities as shown in the table below. Certain muscles can be triggered to give rise to the spastic contraction helping to perform a task.

Muscle	Trigger movement	Functional movement
Finger flexors	Wrist extension	Gripping an object
Hip flexors	Backward or sideways leaning of the trunk	Walking
Trunk flexors	Pushing back with head	Supine to sit
Elbow flexors	No particular trigger movement	Eating

- In absence of pain spasticity is a warning sign for infection, pain, bed sore and bowel or bladder infection and brings about the attention to such issues which can be treated promptly.

- Spasticity is also a sign of bowel and bladder fullness and therefore can be utilized functionally for toileting activities.

Management of spasticity

Spasticity management is multidisciplinary and may require medical, surgical as well as rehabilitative intervention. It is crucial to understand what treatment should be one at what time, for optimal outcome.

- Early phase of spasticity -
    - o Grade 1 and1+ on Modified ashworth scale

      Prescribe regular passive slow and sustained active or passive stretching exercises, strengthening of antagonists, facilitation of active movements primarily with antagonists and weight bearing exercises to control the spasticity.

      If the antagonists can be trained in weight bearing position after the stretching has been performed it may give optimum results.
    - o Grade 2 and 3on modified ashworth scale

      Oral medicines should be given in addition to physiotherapy exercises. For oral antispastic medication refer the patient to a physician or neurologist with a detailed evaluation of spasticity. Dosages of oral medication should be titrated to get optimal results and therefore advice your patient to keep up with the follow up appointments. A therapist should also carry out follow up evaluation of the patient's spasticity and consult with the concerned physician.

      Before starting the oral medication rule out any triggering factors for spasticity like urinary tract infection, urinary blockage, systemic infections, bowel impaction, bowel abnormalities and bed sores. If any of these triggering factors are detected it is important to manage them medically before increasing or starting the oral medication.
    - o Grade 4 on modified ashworth scale

      When the affected part is rigid and passive movement is impossible or very painful. It is important to address the spasticity in the early phase itself before tissue shortening occurs. Intramuscular injection of botulinum toxins may be considered for this. This will also ensure inhibiting pathological movement patterns caused by spasticity as well as tissue contractures.

      Physiotherapists should take care to not over stretch severely spastic muscles to avoid muscle and soft tissue tearing and damage.
- Chronic phase spasticity
    - o Grade 1 and 1+ on modified ashworth scale

      Continue with rehabilitation exercises and titrate the dose of oral medication.

- Grade 2 and Grade 3 on modified ashworth scale

  Rehabilitation management and medical management must be adhered to, to prevent the harmful effects of spasticity. Weight bearing exercises and slow and sustained active or passive stretching should be the mainstay for spasticity reduction.

  Intramuscular botulinum toxin injections can be considered even in this stage. The muscles should be carefully selected to break the synergic movement patterns, which by now are learned as new motor patterns of the movement. After the injections physiotherapist must retrain the motor patterns to break the synergic movements and rigorous slow and sustained active stretching should be taught to the patient and patient's relatives or caretakers. Weight bearing exercises should also be emphasized. Strengthening of the antagonists is very important in this phase and active strengthening should be compared with the weight bearing to inhibit over activity of the agonists with spasticity.

  With higher grades of spasticity at a chronic phase it is important to identify the time for stopping the treatment due to non-responsiveness. For example if there is generalized spasticity which has not reduced with oral medication, oral medication can be discontinued. The decision to discontinue the medication must be taken after consulting with the prescribing physician.

  Repeated injections of botulinum toxin can be considered in case of smaller number of muscle groups. However if there is generalized non responsive spasticity then intrathecal baclofen can be considered. This decision should be taken as a multidisciplinary team in consultation with physician and neurosurgeon. Generally the pump is considered within one year of the injury. Although in incomplete spinal cord injury if initiation of voluntary movement is limited or inhibited by spasticity an earlier installation of pump device or earlier injection may be considered.

- Grade 4 spasticity on modified ashworth scale

  For rigidity unresolved by medical and rehabilitative management surgical management like rhizotomy and baclofen pump installation can be considered. This decision should be taken in consultation with treating physician and surgeon.

Neurorehabilitative management of spasticity

Neurorehabilitation of spasticity is multidisciplinary and involves good nursing care, physiotherapy an occupational therapy intervention and psychological counseling to the patients and family education.

Nursing care:

1. Preventing pressure sores by regular skin inspection and decompression of the pressure areas.

2. Appropriate positioning in bed and wheelchair
3. Good techniques for catheterization and monitoring patient's catheterization technique.
4. Monitoring sleep patterns
5. Monitoring pain

Physiotherapy intervention:

1. Slow sustained passive stretching and active stretching whenever possible.
2. Teaching correct positioning to caregivers and relatives
3. Facilitating antagonists active movements
4. Inhibiting the synergy patterns
5. Weight bearing exercises
6. Use of ice to reduce spasticity and facilitate voluntary control there after

Occupational therapy intervention:

1. Teaching correct patterns for performing activities of daily living and activities relate to personal hygiene
2. Devising an exercise program with the physiotherapist to reduce spasticity so that functional movements can be trained

Spasticity management should be undertaken by multidisciplinary team of professionals including physician, nurse, physiotherapist, occupational therapist, urologist, psychologist and care givers. A good communication within the team is key to facilitating appropriate management strategies at the correct time. Patient's counseling regarding the adherence with the treatment is very important as spasticity management is a long term process.

Chapter 8
Bladder and Bowel management

Spinal cord injury at any level almost always affects bladder and bowel function. This is because of injury to the spinal cord and there is cut off from brain input. A wide range of techniques and tools are available to manage bladder and bowel function.

Changes in bowel function after SCI has a considerable impact on the quality of life of individuals with spinal cord injury. Bowel problems experienced by spinal cord injured patients include prolonged evacuation time, poorly localized abdominal pain, hemorrhoids, abdominal distension, fecal incontinence, and chronic constipation. Bowel Dysfunction is the most significant problem than loss of ambulation in SCI and managing this change is important for an individual's independence and autonomy. Therefore it is an important area of care and rehabilitation for individuals with SCI for community reintegration and long term health.

Bowel Management:

Injury to the spinal cord has a profound impact on the function of the large bowel and on the maintenance of fecal continence. The following are the reasons of bowel incontinence in SCI

- Slow transit of stool through the bowel causing constipation
- Loss of sensory and motor control of ano-rectum causing an inability to feel the need to evacuate the bowel

With no intervention the individual will be chronically constipated with all the secondary complications, hence it is important to manage the function of the large bowel and minimize the health issues.

Keeping in mind the rehabilitation of an individual, the bowel management programme is a process that focuses on the needs and promotes autonomy in an individual with SCI... The individualized programme is supported by educating the injured individual, their family and any carers who may be involved in that person's care. Bowel management program is an ongoing process for lifetime that changes according to the needs of an individual.

Aims of Bowel Management:

- To enhance safety, privacy, comfort and dignity of SCI individuals during bowel management episodes
- To assess the needs of the SCI individual in regard to bowel care and to develop and maintain an appropriate individualized bowel management routine.
- To avoid incontinence, constipation, diarrhea and autonomic dysreflexia, and minimize the development of secondary ano-rectal complications associated with bowel management (rectal over-distension, hemorrhoids, anal fissure etc.)
- To achieve a satisfactory bowel management with minimum necessary physical and pharmacological interventions before the discharge from initial rehabilitation
- Identify appropriate transfer methods, equipment and adaptive devices to promote independence in bowel management for the individual.
- To evaluate the outcomes of bowel management. The Bristol Scale. Duration of bowel management episodes and any unplanned bowel evacuations should be recorded
- To educate the individual with a 'toolkit' of knowledge with which they can manage and adapt their bowel care in the long-term

Assessment of the individual, planning interventions and evaluation of outcomes is required for developing an individualized bowel management program. The need for a bowel management programme after spinal cord injury is life-long, and regular re-evaluation and modification of the programme will be required over the years post injury.

Factors to be considered while assessing an SCI individual for their bowel management and rehabilitation:

- Current bowel function
- Pre-injury bowel habit
- Past medical history - including obstetric history, chronic bowel disease, cancer, any abdominal surgery
- Medication
- Diet and fluid intake
- Ability to eat a full diet
- Activity, general mobility, exercise, standing, passive movements
- Communication
- Cognitive ability
- Level of independence

- Lifestyle - cultural, sexual, work or educational roles
- Psychological and emotional factors
- Manual handling risk assessment
- Home and care circumstances

Outcome measures for evaluating bowel management are:

- Duration of management episodes
- Stool form recorded using the Bristol Scale
- Frequency of episodes of incontinence
- Have pharmacological interventions been minimized as far as possible?
- Is the patient as independent as possible?
- Feedback from the patient regarding satisfaction and perceived autonomy

How Frequently of bowel care should be re-evaluated for an individual undergoing initial rehabilitation or in community living?

- After the stoppage of spinal shock phase
- When starting with mobilization
- When the patient is ready to begin bowel management on the toilet
- During general routine follow up
- If duration of management regularly exceeds an hour following a sudden change in bowel function i.e. Incontinence, change in stool form, color or odor or bleeding per rectum and if these changes persist for more than 4 weeks and have not responded to changes in the usual programme may be indicative of bowel cancer and should be investigated immediately. Rapid appropriate referral for investigation is essential.
- In the light of changing levels of independence/dependence

Importance of early bowel care for an individual with SCI

For an early reintegration into the society following an SCI an optimal bowel function and management is required in the longer term immediately following an injury. Prompt and effective bowel management will avoid over distension of the bowel with constipated stool which is thought to result in damage to stretch receptors which in turn may adversely affect the return of reflex ano-rectal activity, decreasing the future capacity for effective reflex evacuation of stool.

Assessing Bowel Function:

Individuals with complete spinal cord injury will have no sensation of the need for evacuation of the bowel and no control of the bowel. Depending on the level of

injury there are different types of bowel seen

- Reflexic Bowel (also called upper motor neuron or spastic): seen usually in injuries at or above T12 vertebrae. The bulboanal reflex and the anal wink are present if the patient has a reflexic bowel.
- Areflexic Bowel (also called lower motor neuron or flaccid): usually seen in injuries at or below the L1 vertebrae. The bulboanal reflex and the anal wink will be absent if the patient has an areflexic bowel.

For incomplete SCI, the residual bowel function is less predictable and will be established only through examination by a medical practitioner.

Bowel Management Program:

The bowel management programme will specify the following:

- Specific interventions to be used
- The frequency (twice daily, daily, alternate day) and timing (morning, evening) of the bowel program.
- The location for bowel management (bed, toilet etc.)
- Who will perform bowel care (the patient, a specific relative, care staff, community nurse)
- Equipment and adaptations required (shower chair, padded toilet seat etc.)

Factors to be considered when forming a Bowel Programme.

- Level of injury
- Type of Bowel Dysfunction
- Evaluation of bowel care during the acute stage
- Mobility of the individual
- Limiting factors such as spasticity and poor balance
- Self-care abilities of the patient
- Age of the patient
- Weight of the patient
- Cultural requirements
- Domestic circumstances
- Availability of carers
- Availability of bowel care aids and equipment
- Accessibility and suitability of facilities at discharge destination

- Any pre- or post-injury bowel related complications
- Pre-injury bowel habit
- Relevant medical history
- Prevention of dysreflexia in susceptible patients
- Supervision requirements (is it safe to leave the patient during bowel management episodes?)
- Planned future family commitments, employment or education
- Other lifestyle considerations

Guidelines for patients:

- Patient education regarding the bowel management, its importance, obtains an informed consent. Also if patient is unconscious Gain verbal consent perform procedure as long as it is in the best interest of the patient after discussion with the multidisciplinary team
- Ensure privacy for performing bowel management and that the individual's dignity is maintained at all times. Consider the practicality of moving the patient (on his bed) to a more private area for bowel care
- Procedure should be performed only by a competent nurse.
- Remove feces from rectum prior to inserting prescribed mild rectal stimulant to assist in removing feces.
- During spinal shock use mild rectal stimulant to lubricate the stool prior to digital evacuation if constipated, or to aid in release of flatus in individuals with any type of bowel function
- Wait for approx. 20 minutes and allow the mild rectal stimulant to work - time bowel management to coincide with log rolling the patient for hygiene and skin checking suppositories can be given whilst patient is flat on bed and bowel emptying can be performed when rolled.
- Maintain spinal alignment at all times and ensure correct positioning when finished
- Check skin around peri-anal area and make sure skin is cleaned and dried adequately and use barrier creams if necessary, especially if bowel movements are loose
- Record bowel management interventions used, duration

Note: A routine and timely follow-up for bowel care is required to achieve an early identification of potential problems, and to promote timely intervention in order to reduce the incidence of chronic bowel complications.

Reflexic Bowel Management:

- Establishing a Routine
- Diet and Fluids
- Digital rectal stimulation
- Pharmacological rectal stimulation: suppositories, micro enemas
- Oral laxatives

Areflexic Bowel Management:

- Establishing a Routine
- Diet and Fluids
- Manual removal of stool from rectum
- Abdominal massage
- Valsalva maneuvers/straining

Non-conservative options:

- Trans-anal irrigation (Rectal Irrigation/Anal Irrigation)
- Ante grade Continence Enema (ACE)
- Percutaneous Endoscopic Colostomy (PEC)
- Colostomy
- Sacral Anterior Root Stimulator (SARS)
- Sacral Nerve Stimulation (SNS)

Diet and bowel management in spinal cord injury

Food and fluid intake have a major effect on the bowel actions that affect the bowel management. Fecal weight and consistency is affected by the amount and water-holding capacity of the remaining undigested material that passes into the colon, the amount of bacteria present and colonic transit times. Diet assessment and alteration in diet is required to help maintain appropriate stool consistency while maintaining a balanced diet for life.

Dietary factors that affect the stool consistency:

- Enteral tube feeding
- Fluids
- Manipulate diet to alter stool consistency

Bladder Management:

How the bladder normally works:

The Urinary System has three major functions to perform:

- Makes Urine in kidneys
- Stores Urine in bladder
- Expel urine from body through urethra.

How the bladder works after SCI?

After SCI the bladder is usually affected in one of two ways depending upon the level of injury:

- Spastic (reflex) bladder/ Upper Motor Neuron type: seen in injury above T12 level. In this type, when your bladder fills with urine and a reflex automatically triggers to empty the bladder. With a spastic bladder you do not know when, or if, the bladder will empty.
- Flaccid (non-reflex) bladder/ Lower motor Neuron type: seen in injury below T12 level. In this type the reflexes of the bladder muscles are sluggish or absent. You will not feel when the bladder is full and the bladder can become over-distended, or stretched. The urine can back up into the kidneys (called reflux). Stretching also affects the muscle tone of the bladder.
- Dyssynergia occurs when the sphincter muscles do not relax when the bladder contracts. The urine cannot flow through the urethra, which can result in the urine backing up into the kidneys. The bladder may also not empty completely.

Bladder Management: A bladder management is important to empty your bladder when it is easy for you and helps you avoid bladder accidents and prevent UTIs.

Points to keep in mind when following a bladder management:

- Preparing and following a regular schedule
- Emptying the bladder completely without any residual

Nonsurgical Management for Bladder Dysfunction:

1. Continuous Intermittent Catheterization (CIC)
    - Urine is drained out of the bladder using a catheter on regular fixed intervals (usually every 4 to 6 hours).
    - Advantage: - No need to wear a catheter and urine bag all the time. It is done on need basis. It is more convenient and healthier and UTIs are less common with this method.
2. Indwelling catheter (Foleys): A catheter is left in place in bladder along with a bag for urine collection. There are two basic types of indwelling catheters:
    - Urethral indwelling catheters are inserted into the bladder through the urethra. This is a good option for people with poor hand functions or who have limited assistance.

- Suprapubic indwelling catheters are inserted into the bladder through a surgical opening in the lower abdomen, just above the pubic bone. It's recommended for individuals with bladder neck obstruction or urethral abnormalities.

  Complications of Indwelling Catheter: bladder or kidney stones (especially in females), deterioration of the upper urinary tract (including increased reflux), and increased risk for bladder cancer especially used for longer than 10 years.

3. External condom catheter (for men only): condom catheters are worn and it is attached to a bag that collects the urine.
4. Crede Maneuver is used to empty the bladder by manually applying pressure to the lower abdomen, with a closed fist to manually push the urine out through the urethra. This method is used when the bladder cannot contract on its own or has weak contractions and needs extra pressure to push out urine.
5. Valsalva maneuver: is used in flaccid type bladder. In this type abdominal muscles are used along with diaphragm (the muscles directly below your rib cage) to push down on the bladder in order to empty it.
6. Reflex Voiding: it's used by males with an overactive bladder. There are involuntary contractions of bladder. After SCI, a contracted bladder muscle is not always coordinated with a relaxed sphincter muscle. So the sphincter relaxes and tightens intermittently, the flow of urine stops and starts involuntarily and thus unpredictably. Reflex voiding can be used in combination with intermittent catheterization or and external condom catheter.

Medical Management of spinal cord injury

1. Alpha Blockers: Helps to improve urination in males who have a lack of coordination between the bladder and sphincter by relaxing the sphincter and prostate. It helps to lower the pressure in the bladder during voiding, relaxes certain muscles and helps small blood vessels remain open and relaxed. This improves blood flow and lowers blood pressure.
2. Anticholinergic Drugs: Commonly prescribed for people who use intermittent catheterization. These drugs help relax the bladder, thus increasing its capacity and reducing contractions that might cause leakage. They work by blocking certain nerve signals that activate muscle activity. Side effects of anticholinergic drugs can include dry mouth, blurred vision, drowsiness, and constipation.

Note: Complications like high bladder pressure causing back pressure on the kidneys, abdominal bruising when using the Crede method, hernia, pelvic organ prolapse, or hemorrhoids are all associated with Crede and Valsalva. They are generally not recommended as primary methods of bladder emptying.

Surgical Management for Bladder Dysfunctions:

- A Mitrofanoff procedure: in this procedure a new passageway for urine is constructed using the appendix, which allows catheterization to be done through the abdomen to the bladder. This procedure is of great advantage for women and for individuals with limited hand function.
- Bladder augmentation/ Cutaneous Ileovesicostomy: this procedure is done to reduce the need for frequent catheterization by surgically enlarging the bladder (using a portion of the intestines).
- Sphincterotomy:Transurethral Sphincterotomy (TURS) is done to reduce the pressure on the valve and allow easy flow of urine out of the bladder. This operation is not normally carried out on women.
- Botulinum Toxin injections: Can be used by individuals using intermittent catheterization to relax an overactive bladder. Botox is injected directly into the bladder muscle, effectively reducing contractions increasing bladder volume and thus reducing leakage.
- Functional Electrical Stimulation and Posterior Sacral Rhizotomy

Common Issues and Concerns with bladder management:

1. Residual Urine: it is seen when there is inadequate bladder emptying causing some amount to be left in the bladder. This is a major cause of UTIs in individuals with SCI.
2. Urinary Tract Infection: Individuals with SCI are at a high risk of developing UTIs. Bacteria from the skin and urethra get into the bladder with all forms of bladder management.

Symptoms of UTI:

- Fever
- Chills
- Nausea
- Headache
- Increased Spasms
- Autonomic Dysreflexia

In incomplete injuries one may also be able to feel

- Burning while urinating
- Pain/ Discomfort in Pelvic area
- Abdominal Pain/ Discomfort
- Lower Back Pain/ Discomfort

Warning Signs of UTI:

- Sediment(gritty particles) or mucus in the urine
- Cloudy Urine
- Foul odor of Urine
- Blood stained Urine (pink or red urine)

Note: One may experience one or more signs/symptoms when having an UTI. An immediately consult your Urologist

Preventing UTIs: UTIs can be prevented by keeping your urinary system "clean"

- Clean the skin regularly
- Wash your hand before and after performing catheterization
- Wash area around the genitals regularly with soap and water
- Change the linen after every urine or bowel accidents
- Drink plenty of fluids helps in washing out the bacteria from the bladder which can help prevent UTIs and other problems of urinary system. Individuals undergoing intermittent catheterization are advised to take 8-10 glasses of liquid per day(primarily between breakfast and dinner)
- Stop drinking beverages with sugar, caffeine and alcohol
- Frequent catheterization for at least every 4-5 hrs.

Treatment of UTI:

Medical Management: Antibiotics

Note: If UTI is left untreated, bacteria can travel further up multiply, and infect the kidneys. Kidney infectionwas once a leading cause of death after spinal cord injury and is still a danger.

3. Autonomic Dysreflexia: AD is often triggered by an overly filled bladder or a bladder infection in individuals with SCI at or above T6 levels. It is an important concern for individuals with SCI. Autonomic dysreflexia is a potentially dangerous spike in blood pressure that can be accompanied by pounding headache, sweating, "goose bumps," and blurred vision.
4. Bladder cancer is another concern for some individuals with spinal cord injury. Research shows an increase in the risk of bladder cancer among those who have been using indwelling catheters for a long period of time. Smoking also increases the risk for developing bladder cancer.

Things to be done

1. Regular Urologic Check Up: A complete medical check-up is recommended at least once a year. This should include a urologic examination, including a

renal scan or ultrasound to know the kidneys are working properly. The examination may also include a KUB, an X-ray of the abdomen that can detect kidney or bladder stones. An Urodynamic study that will tell how much urine your bladder can hold and how much urine in the bladder can cause the bladder to reflex. Even with a regular bladder management program and proper prevention methods, the risk remains for urinary tract infection. Treatment for a UTI almost always includes an antibiotic medication prescribed by a doctor.

2. Cleaning and Storing the Urinary catheters

Rubber Catheters

- After using the catheter, wash it with warm soapy water, rinse under warm running water, lay it on a clean towel to dry and then place it in a plastic bag.
- After you return home, the rubber catheters should be placed in a pan of water on the stove and boiled for 20 minutes, then placed on a clean towel to dry and then stored in a plastic bag.
- These catheters should be cleaned as instructed above after each use. One can continue to use these catheters until signs of wear such as discoloration or cracking is noted.

Long or Short Clear Catheters

- After using the catheter wash it in warm soapy water, rinse under warm running water, lay it on a clean towel to dry and place it in a plastic bag.
- After you get home, the catheters should be cleaned again in hot, not boiling, soapy water, rinsed well under hot running water and place on a clean towel to dry. Then place in a plastic bag for storage.
- These catheters should be cleaned as instructed above after every use. One can continue to use these catheters until signs of wear such as discoloration or cracking is noted.

Chapter 9
Bed mobility training

Bed mobility training is the first step towards independence for the patients of spinal cord injury. From not being able to move the body at all to managing all the activities in bed independently boosts the confidence. Bed mobility training strengthens the muscles and increases the endurance for performing subsequent tasks of transfers and walking.

This chapter will be a step by step guide for training of the bed mobility activities. The sequence in which these are given should be followed but alterations can be made based on therapist's judgment. Although these are in sequence the activities should be more or less trained simultaneously and the therapist need not wait for the completion of one activity before starting to train for the next.

Some of the points to note for the therapists are

- muscle strengthening exercises should be performed at the same time as that of the training for bed mobility
- Bed mobility exercises should be functional and compensations by patients can be allowed and encouraged
- care should be taken to not encourage abnormal postures and sudden explosive movements

1. Rolling

There are two components in rolling. Rolling to turn to one side and rolling to turn to prone position. The first task is rolling to the side. The technique to teach the patient is to roll from one side to the other using the momentum of arm movements (Figure 9.1 and 9.2).

Figure 9.1 Side to side movement of arms to facilitate rolling

Figure 9.2 Side to side movement of arms to facilitate rolling

Log rolling to the side:

In the acute phase the twisting movement may put tortional forces on the surgical fixation and therefore log rolling should be encouraged. Log rolling can only be achieved when the therapist and the patient perform the act together. Patient should be advised to move the arms with force and speed from one side to the other, 2 to 3 times and to then to use the momentum to turn to one side. The therapist should ensure that the lower body is turned at the same time to prevent tortional forces. To make it easier to turn the body the contralateral knee should be bent (Figure 9.3 and 9.4). To further ensure safety of the spinal fixtures and bones, rolling can be carried out with the protective closed contact spinal brace for first 3 to 6 months after injury. The decision to remove the brace while performing exercises should be taken after consulting the surgeon.

Figure 9.3 Contralateral knee flexion during log rolling

Figure 9.4 Log rolling with therapist assistance

Segmental rolling:

Segmental rolling is a technique where the upper and lower part of the body rolls separately one after the other creating a twisting action at the spine (Figure 9.5 and 9.6). After the initial 3 to 6 months of injury, segmental rolling can be encouraged.

Figure 9.5 Assisted Segmental rolling

Figure 9.6 Assisted Segmental rolling

To facilitate rolling first let the patient perform sideways arm movements as shown in figures 1 and 2. If the patient is unable to roll with this technique, weights can be added to the arms to increase the momentum Figure 9.7 and 9.8.

Figure 9.7 Sideways movement of arms with weight cuffs to facilitate rolling

Figure 9.8 Sideways movement of arms with weight cuffs to facilitate rolling

In case of cervical injuries where the triceps are not working, patients can wear elbow splintsto keep the arms straight for gaining momentum.This movement strengthens the shoulder muscles and an alternate pattern for movement is generated for turning. Once this pattern is learnt the splints can be removed and patients can turn on their own (Figure 9.9 and 9.10).

Figure 9.9 Turning to one side without splints or assistance by a patient with quadriplegia

Figure 9.10 Turning to one side without splints or assistance by a patient with paraplegia

Rolling to prone:

The progression from side rolling is rolling to prone position. Care should be taken to lift the arms above head while rolling to clear the arms from under the body while turning.

2. Supine to side lying to long sitting

The next step after rolling is to be able to sit up from supine. There are two techniques for this, turning onto one side to sit up and sitting up straight from supine.

Once the patient learns to turn to one side, patients can sit up using elbow extension where the triceps is preserves. The therapist should strengthen triceps, all the three parts of deltoids, side flexors of the trunk and abdominals to facilitate ease in performing this movement.

To attain long sitting patients with quadriplegia should be encouraged to make use of both the arms and facilitate elbow extensions to maintain the stability of the trunk while sitting up. Patients with higher thoracic injuries may also be taught this technique for better stability.

Figure 9.11, 9.12 and 9.13 show a patient with quadriplegia resulted from injury at the level C6-7 performing this movement

Figure 9.11 Supine to side lying

Figure 9.12 Pushing on the elbows using triceps to come to long sitting

Figure 9.13 Long sitting

For lower thoracic and lumbo-sacral injuries one arm can be used to push up as the trunk strength and stability is fairly good.

Figure 9.14 to 9.20 show a patient with paraplegia performing the movement of side lying to sitting

Figure 9.14

Figure 9.15

Figure 9.16

Figure 9.17

Figure 9.18

Figure 9.19

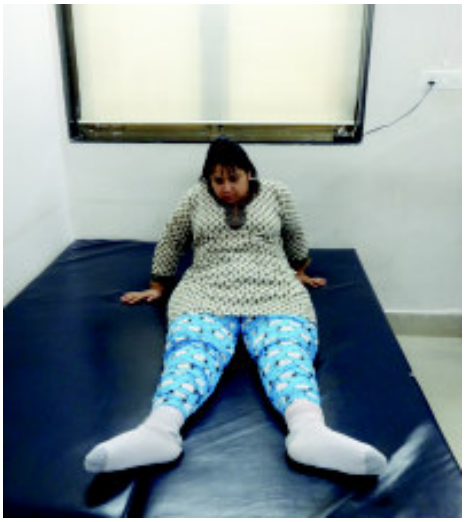


Figure 9.20

Figure 9.14 - 9.20 Patient transitioning from supine to side lying and then pushing on the elbow unilaterally to come up to long sitting.

3. Supine to long sitting

Patients can choose to sit up from the supine position itself, making use of the shoulder rotators and triceps in case of cervical injuries. In case of higher cervical injuries where the triceps is not preserved biceps can be strengthened so that patients can pull themselves up to sitting. A rope, side rail or human support can be given so that patients can pull onto it sit up. In thoracic and lumbosacral injuries patients can sit up using the triceps, shoulder rotators and upper abdominals.

Fig 9.21- 25 Patient transitioning from supine to long sitting

Figure 9.21

Figure 9.22

Figure 9.23

Figure 9.24

Figure 9.25

4. Balance training in long sitting

Achieving the position of long sitting can be challenging for the patients with higher thoracic and cervical level injuries due to weakness and impairment of the back extensors. As the legs are stretched the pelvic position can only be controlled by the spinal muscles. To be able to sit erect keeping the center of gravity within base of support too much slouching is not helpful. Therefore training in long sitting is very crucial for patients with higher level injuries.

Training the patients to move in the bed forward, backward, sideways and in circles improves their mobility in bed and the spine mobility as well as stability. Initially the movements can be performed using the push up bars and then slowly as the shoulders and elbow muscles strengthen perform these movements without push up bars.

Balance training in long sitting must include movements that move the pelvis and hip joints through the whole range of motion and in various directions.

Long sitting facilitated stretching of hamstrings and helps to reduce the flexor spasticity of the lower limbs

Figure 9.26 Rotation from one side to another with weights

Figure 9.27 Rotation from one side to another with weights

Figure 9.28 Forward bending in Long sitting

Figure 9.29 Backward bending in Long sitting

Figure 9.30 Arm flexion - extensionis long sitting with weights

Figure 9.31 Arm flexion - extension is long sitting with weights

Figure 9.32 Arm flexion with side rotation with weights

Figure 9.33 Arm flexion with side rotation with weights

5. Balance training on the edge of the bed

Once the patient is sitting on the bed i.e. long sitting is achieved ask the patient to grip the legs with arms and move the led sideways. After repeating this couple of time the can legs can be pushed out of the bed to sit on the edge of the bed. Sitting on the edge of the bed should only be facilitated after training for balance in long sitting.

Figure 9.34 Patient transitioning from side lying to sitting on the edge of the bed

Figure 9.35 Patient transitioning from side lying to sitting on the edge of the bed

Figure 9.36 Patient transitioning from side lying to sitting on the edge of the bed

Figure 9.37 Patient transitioning from side lying to sitting on the edge of the bed

Balance training at the edge of the bed is extremely important for functional tasks as well performing exercises in sitting. In the traumatic injury patients are apprehensive of falls. In training balance there are two components involved strengthening of the muscles and developing new motor patterns.

The strengthening of 2 group of muscles is required, stabilizers and movers. Stabilizers are trunk and proximal muscles that will provide stability for the peripheral joint movements. For balance training key muscles are the back extensors and scapular retractors. If these muscles are weak patients can attain balance through slouching which may lead to awkward bending of the spine and scoliosis.

Therefore training for balance with active exercises in sitting should be combined with strengthening of back extensors and scapular muscles in lying down and sitting position.

Factors that hinder the sitting balance are the spasms and tightness of the muscles of lower extremity. Spasm can give rise sudden push or pull difficult to counter if the muscles are weak and if the patient is unable to anticipate the jerk. Balance training

with perturbations either by therapist or generated through activities like throwing and catching, rebound from the spring activities etc. should be incorporated in the balance training.

Figure 9.38 Arm flexion and extension sitting at the edge of the bed without support

Figure 9.39 Arm flexion and extension sitting at the edge of the bed without support

Figure 9.40a Trunk rotation with weights sitting at the edge of the bed without support

Figure 9.40b Trunk rotation with weights sitting at the edge of the bed without support

Figure 9.41 Supported forward bending and sitting up at the edge of the bed without support

Figure 9.42 Supported forward bending and sitting up at the edge of the bed without support

Figure 9.43 Supported forward bending and sitting up at the edge of the bed without support

6. Prone extension

Prone extension exercise should be performed only after consulting with the surgeon in the acute phase of spinal cord injury. Due to the extreme extension motion there is a risk of loosening the surgical fixation if performed before the bone healing can take place. This posture should also be avoided for the lumbar spinal cord injury patients as it may loosen the surgical fixation. Although functionally not essential the prone extensions must be trained to strengthen the upper extremity muscles, back extensors, scapular muscles and pectoral group of muscles and to maintain the joint range of motion of the spine.

Fig 9.44 to Fig 9.46 Prone extension from Supine position

7. Prone to quadruped

To build a good control of the shoulder, weight bearing exercises such as quadruped help a lot. Especially in higher cervical injuries when the shoulder proprioception may be affected weight bearing facilitates the proprioception as well. It is important to first train for the prone extensions, back extensors strengthening and then progress to quadruped position.

At first therapist should stand behind the patient and support at the pelvis and give a backward pull to the pelvis to come to the quadruped position. Ask the patients to perform this movement several times and slowly reduce the support given.

Fig 9.46

Fig 9.47

Fig 9.46 to 9.47 Patient with paraplegia transitioning from prone to quadruped

To unlock the hips from the prone extension position patient would need to bend the neck down and give a backward thrust with arms so that hips can unlock and go in flexion.

Fig 9.48

Fig 9.49

Fig 9.50

Fig 9.48 to Fig. 50 Patient with quadriplegia bending down to unlock the hips before pushing up to quadruped position

Once the patients are able to attain the quadruped position the progression will be to maintain this position and build the endurance for the same to up to 30 seconds before progressing to next level.

8. Quadruped to side sitting

As the endurance to hold the quadruped positions increases to 30 seconds, the next progression will be to move forward and backwards in quadruped further strengthening the shoulder muscles and scapular muscles. Once the patient is able to perform this movement independently, progress to side sitting in quadruped. This position is of importance to strengthen the pectoral group of muscles, trunk side flexors and abdominals in addition to the deltoids.

Start with giving a support of a bolster or a stool on the side to achieve partial range of side sitting followed by complete side sitting on the plinth.

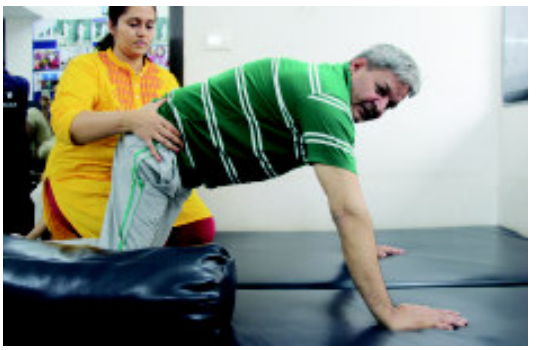


Fig 9.51

Fig 9.52

Figure 9.51 to 9.52Supported quadruped to side sitting in partial range

Figure 9.53 Supported quadruped to side sitting through full range

9. Quadruped to kneeling

Kneeling position simulates walking but due to the lower center of gravity it is easier to perform. The trunk muscles can be strengthened in this position to achieve better balance in standing. The transition from quadruped to kneeling is crucial for back extensor strengthening. Several progressions are possible in kneeling position. Kneeling also facilitates the hyperlordotic posture that enables the patients to lock the hips in standing.

For higher thoracic and cervical level injuries assisted kneeling can be trained by resting the arms on a stool or a platform and supporting the pelvis to achieve the anterior tilt.

10. Kneelsitting to kneelstanding

Kneelsitting to kneelstanding helps to strengthen the abdominal muscles and hip extensors. It can be performed independently only in case of lumbosacral injuries. For higher level injuries assisted movement can be performed. Patients can hold onto a hand rail or push down on the stool or a platform to perform the movement. In assisted exercises, scapula depressors and the shoulder muscles are strengthened these muscles are key to gait training and to maintain the balance in standing. This exercise also develops the pattern for achieving the lordotic posture by pulling on hands. This movement pattern is very important for standing balance.

Important muscles to be strengthened are:

Fig 9.54

Fig 9.55

Fig 9.56

Figure 9.54 to 9.56Assisted transition from kneel sitting to kneel standing

11. Kneel walking

A progression of kneel standing is kneelwalking in the sideways and rarely in forward direction. This exercise cannot be performed by patients with injuries of the thoracic and cervical spine.

12. Sitting on the edge of the bed to supine

Finally the bed mobility exercises end with being able to lie down in supine position from sitting position. This requires eccentric contraction of the abdominal muscles and trunk side flexors. A therapist should be careful to train these muscles to facilitate a smooth and controlled movement.

Patients should be taught to lift the legs and throw when lying down. Easiest and most energy efficient techniques is to grip the legs under the knee with hands and then to turn backwards with force. This momentum can be used to lift the legs with hands as the patient achieves lying position ask them to throw their legs out and straight holding on the back side of the calves.

Alternatively patients can also lift the legs and keep them on the bed back in long sitting. This can only be performed by patients who have a good sitting balance.

Fig 9.57

Fig 9.58

Fig 9.59

Fig 9.60

Relevant strengthening exercises

The bed mobility training should be accompanied with the relevant muscle strengthening exercises. Following are the examples of some of the exercises. The exercises are not limited to the below exercises.

Important muscles to be strengthened are:

1. Deltoids
2. Rotator cuff muscles
3. Shoulder rotators
4. Scapular muscles
5. Lattisimusdorsi
6. Triceps
7. Biceps
8. Abdominals
9. Back extensors
10. Trunk side flexors
11. Obliques (Internal and External)

Fig 9.61a

Fig 9.61b

Figure 9.61a and 9.61b: Strengthening of external rotators of the shoulder

Fig 9.62a

Fig 9.62b

Figure 9.62a and 9.62b: Strengthening of internal rotators of the shoulder

Figure 9.63 Strengthening of abdominals

Figure 9.64 Strengthening of abdominals

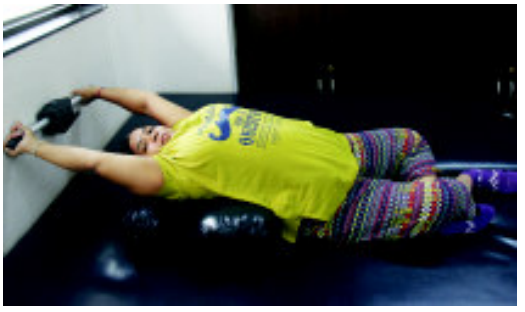


Figure 9.65 Strengthening of abdominals

Figure 9.66 Strengthening of abdominals

Figure 9.67 Strengthening of back extensors

Figure 9.68 Strengthening of back extensors

Figure 9.69 Strengthening of back extensors

Figure 9.70 Strengthening of back extensors

Figure 9.71 Prone pushups for strengthening scapular muscles, deltoids, pectoralis group, serratus anterior and abdominals

Figure 9.72 Prone pushups for strengthening scapular muscles, deltoids, pectoralis group, serratus anterior and abdominals

Figure 9.73 Strengthening of quadrates lumborum in supine lying

Figure 9.74 Strengthening of quadrates lumborum in supine lying

Practicing and repeating the movements several times in a day is very important. The exercises should be practiced even in the absence of the therapists throughout the day. It is also important to educate the patient relatives and care takers to not help the patient unless essential to do so and to have patience to let the patients carry out the movements on their own even if it is slow.

Bed mobility training is essential for the patients to carry out activities of daily living. The therapist should take care to inhibit wrong postural patterns but should encourage the muscular compensations. Further if the patient is unable to use the compensatory movements, therapist should teach these movements and guide them.

Chapter 10
Transfer Training

Ambulation in most of the patients with spinal cord injury is wheelchair dependent except for the patients with incomplete and lumbosacral injuries. To be able to get into wheelchair independently the patients require training of special techniques. It is important to train the patients, rather than the patients exploring it on their own, to prevent secondary injuries. Techniquesused for transfers should be most energy efficient and safe, not harming the integrity of other joints and soft tissues.There are different transfers that the patients need to do, we can simply classify these in same level transfers, transfers to the surface below, transfers to the higher surface and corner transfers. However therapists should also focus on functional transfers.

Prerequisites to the transfer training are:

- Patients should be independent in bed mobility
- Sitting balance at the edge of the bed should be good
- Strength of the shoulder stabilizers, triceps, pectoralis and abdominal muscle strength should be adequate

Physiotherapy training prior to transfers

Training for same level transfers involves strengthening of the deltoids, rotator cuff muscles, shoulder depressors, triceps, pectoralis, abdominals and back extensors. Following are some of the training exercises to be performed in bed before training for transfers.

Training for transfers is a long term process and the exercises must be practiced repeatedly. The patients must first learn to maneuver their bodies in bed itself and then as the arms strengthen transfers training can be started. Training can be started with push-ups in various positions like long sitting, sitting at the edge of the bed, sitting with legs crossed on the bed and prone push-ups. Once the patients are able to perform push-ups therapist may choose to progress to dynamic movements while performing push-ups like rocking forward backward after lifting the body up for the

push up. This can earlier be done with the legs in suspension followed by, a bolster under the legs and eventually without any leg support.

After the shoulder control improves, patients can be taught to shift from one side to the other on the edge of the bed. Before teaching patients the transfer activities patient should be able to shift sideways at the edge of the bed without losing their balance throughout the whole length of the plinth. Prior to learning any transfers the patient must be able to control their body well with the shoulders by lifting themselves with a push up with or without push up bars. They must have a good sitting dynamic balance. Patients should be able to perform a smooth and controlled forward bending and straightening movement by weight bearing on their arms. At the same abdominal muscle strengthening must continue. Strong abdominals are very important while performing transfers. The therapist may always feel the need to strengthen some muscles more even after the transfer training is initiated. Strength training is an ongoing process in spinal cord injury.

Patients must understand that the exercises are not for a few months but it is lifelong process. The exercises should be integrated in the daily routine of the patients. The intensity and the time spent on the exercise training reduce as they learn the skills, but to maintain these abilities they must exercise. It is in fact applicable to everybody to maintain the functional abilities regular exercise is a must.

Once the patient is able to accomplish shifting independently from one edge of the plinth to another without support, the training for same level transfers can be started.

For higher level transfers, shifting up on a bolster of a foot stool is a good exercise. Initially the patient can start with a shorter object to shift onto but later on the height can be increased (Figure 10.1 to 10.7). Initially patients can be given some support to the legs in suspension (Figure 10.3 and 10.4).

Figure 10.1 Push-ups in long sitting

Figure 10.2 Push-ups in long sitting

Figure 10.3 Assisted push-ups on a higher surface

Figure 10.4 Assisted push-ups on a higher surface

Figure 10.5 Unassisted push-ups to higher surface

Figure 10.6 Assisted push-ups to a higher surface

Figure 10.7 Assisted push-ups to a higher surface

Figure 10.8 Moving legs with hands

Head hip strategies should be learnt before starting the transfer training. Head-Hip strategy for transfers means that the head and shoulder movements compensate for the hip movement by moving in opposite directions. When a backward movement of hips is required that can be achieved through forward movement of shoulders and head or neck flexion by locking the elbow joints (Figure 10.5)

Handling the legs with hands is crucial and must be practiced several times in a day (Figure 10.8). For improving trunk stability exercises on the vestibular ball and exercises in suspension with spring resistance should also be incorporated (Figure 10.12 to 10.15).

Figure 10.9 Prone push-ups with push up bars

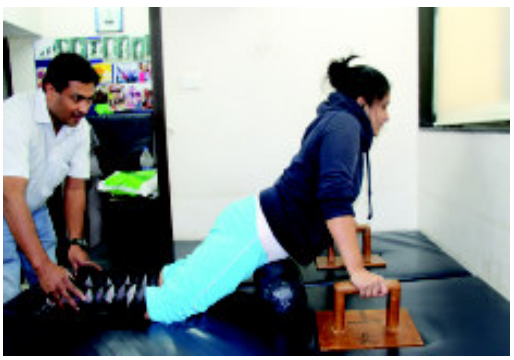


Figure 10.10 Prone push-ups with push up bar

Figure 10.11 Prone push-ups to quadruped

Figure 10.12spring exercises for strengthening of back extensors and hip extensors

Figure 10.13 strengthening for trunk, abdominals, back extensors and shoulder stabilizers

Figure 10.14 strengthening for trunk, abdominals, back extensors and shoulder stabilizers

Figure 10.15 strengthening for trunk, abdominals, back extensors and shoulder stabilizers

Same level transfers with equipment:

- Transfer board
- Push up bars

  Training for transfers can initially make use of transfer boards of various sizes and shapes to suit the patient needs.

Transfer technique

- Keep the wheelchair at 45 degree angle / 90 degree angle if the shoulder strength is adequate
- Make sure that the breaks of the wheelchair are on
- Remove the hand rest near to the side of the transfer
- Remove the foot rests
- Shift as close to the wheelchair as possible
- Place the transfer board underneath your thighs
- Lift the legs with hands and keep it slanting, to align to the wheelchair
- Lock the elbows using substitute muscles when triceps are weak or impaired due to injury. (Substitution can be done by putting weight on the forearm ensuring the wrist extension and then perform shoulder external rotation to lock the elbow. Supination can also aid in locking of the elbow.)
- With one quick movement of push-up (in case of preserved triceps) and turning the trunk slide onto the transfer board.
- When triceps is impaired move the head and shoulders away from the wheelchair and push the chin downwards to lift the hips and push the hips towards the wheelchair / on the transfer board (Head-hip relationship). Use the same technique to slide down the transfer board by adjusting the direction of arms

and relocking the elbows using compensatory mechanisms. (Take precaution to not perform internal rotation of the shoulder as it may unlock the elbow).

- Make sure to keep your balance forward
- Make sure to keep weight on your arms at all times, as that is the only way to control the movement
- Once you are on the transfer board slide slowly onto the wheelchair
- Ensure you are sitting properly in the wheelchair
- Now lean on the back of the wheelchair and on the hand rest on the opposite side
- Lift the leg near to hand rest that was removed with opposite arm
- Remove the transfer board
- Put the arm rest back
- Put the foot rest
- Remove the breaks

Once good shoulder and trunk control is developed, the same transfer can be performed without the transfer board (Figure 10.16 to 10.18)

Figure 10.16 Training for same level wheel chair transfer by a patient with paraplegia

Figure 10.17 Training for same level wheel chair transfer by a patient with paraplegia

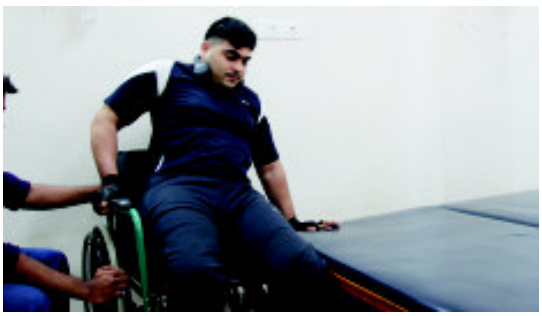


Figure 10.18 Training for same level wheel chair transfer by a patient with paraplegia

Same level transfer without equipment

With practice patients won't require equipment like transfer board and push up bars. This is applicable even for the higher level injuries resulting in quadriplegia.

For patients who do not have good trunk control either due to higher level of injury or due to poor training and muscle weakness, the wheelchair should be kept at an angle of 45 degrees to the bed. For patients with higher levels removing and putting the foot rest back may have to be done by others (Figure 10.19 to 10.25)

Figure 10.19

Figure 10.20

Figure 10.21

Figure 10.22

Figure 10.23

Figure 10.24

Figure 10.25

Figure 10.19 - 10.25 Transfer from bed to wheelchair by a patient with quadriplegia

The same technique can be used to shift onto the wheelchair in the reverse order (Figure 10.26 to 10.30)

Figure 10.26

Figure 10.27

Figure 10.28

Figure 10.29

Figure 10.30

Figure 10.26 - 10.30 Transfer from bed to wheelchair by a patient with quadriplegia

Transfers to higher level

Training for transfers to higher level has been described earlier. The higher level transfers should first be initiated only in the bed making use of equipment like bolsters and stools. Patients can be taught to transfer up on these surfaces in bed. This training is beneficial to train for head hip strategy.

Another techniques useful to be taught before moving on the higher level transfers is shifting on the corners (Figure 10.31 and 10.32). By aligning the therapy beds differently patients can be trained to shift from one corner to the other by performing a push up movement. Initially till a good trunk control has been developed therapists can support the knees to prevent forward slipping on the knees and sudden loss of balance. In case of such an accident there is a risk of damage to the shoulders sometimes even dislocation of the shoulder joint. The corner shifting is important to master maneuvering the body onto a surface at an angle. Performing it on a plinth allows for a safer environment to the patient. There is more space to perform the movement. Once corner shifting has been practiced and learnt several times, shifting of a higher surface can be trained.

Figure 10.31 Corner transfer with knee support

Figure 10.32 corner transfers with knee support

Training for higher level transfers starts again on the bed. Therapist can choose to keep a small stool next to the bed which is 3 to 4 inches shorter than the height of the bed and train the patient to transfer up and down. Once this is performed with ease, speed and control, the difference between the heights can increased. Eventually training can be performed for shifting up from the bed to the floor and back (Figure 10.33 - 10.41). In the initial phases therapists should support the legs to generate the shoulder motor patterns. Later on this support can be discontinued.

Figure 10.33

Figure 10.34

Figure 10.35

Figure 10.36

Figure 10.37

Figure 10.38

Figure 10.39

Figure 10.40

Figure 10.41

Figure 10.33 to 10.41 Transfers from bed to floor and floor back to the bed

Functional transfers:

Along with the training for transfers onto higher surfaces, lower surfaces, same level transfers and corner shifting; functional transfers like commode transfers and car transfers must also be taught and practiced. Figure 10.42 to 10.51 show the patient with quadriplegia transferring from the wheelchair to the car.

Figure 10.42

Figure 10.43

Figure 10.44

Figure 10.45

Figure 10.46

Figure 10.47

Figure 10.48

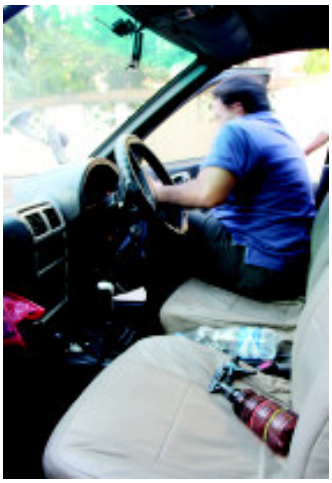


Figure 10.49

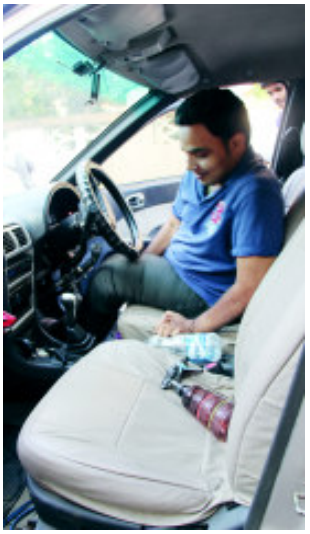


Figure 10.50

Figure 10.51

Figure 10.42 to 10.51 Transfers to the higher level car seat

Safe Transfer Technique

Transferring in and out of the wheelchair and onto different level surfaces puts a high stress on the joints of upper extremities. Learning the correct technique to transfer and practicing it every time while transferring is very important; especially to prevent soft tissue injuries and other painful disorders of shoulder.

Rules for safe transfers

- Transfer when necessary
- Perform more of downward than upward transfers, adjust the height of your bed, chairs and sofas at home in a way that the transfers will be at the same level or at a lower level minimizing the transfers at a higher level.
- Move as close as possible to the surface you want to move to.
- Keep the arms close while lifting your weight, if you cannot then shift with in many small steps.
- Don't always shift from one side only, alternate the arm leading the transfer
- Lock the wheels and remove the hand rest before transferring
- Lean forward
- Grip the wheelchair arm rest rather than putting weight on the flat palms and stretched wrist

- Clear any obstacles in the way before you begin to transfer
- When sliding on the transfer board, mind the speed.
- Take care not to put on weight and maintain ideal body weight.
- In case of pain consider mechanical transfer lifts and rest adequately to give enough time for healing
- In case of injury consult a physician and a physiotherapist right away.

Chapter 11
Gait Training

There is an ongoing debate about whether it is advisable to teach the paraplegics to walk or not? If you ask the patients they would want to walk. In the initial days there is poor acceptance of wheelchair use for ambulation but later after experiencing the energy expenditure for walking, patients may choose wheelchair for long distance ambulation as well as indoor mobility. This debate has not settled even amongst the clinicians. Weight bearing exercises especially standing and walking were thought to prevent osteoporosis but recent investigations have suggested that weight bearing is not the only factor preventing osteoporosis. Only if there is muscle activity and contractive forces of muscles the bone growth is stimulated and osteoporosis is prevented. It was further noted that non-weight bearing does not alter the calcium excretion in the manner it is altered in neurotypical adults. This has been attributed to the neural feedback for calcium excretion and absorption which is absent in individuals with spinal cord injury. There is unequivocal evidence for the benefits and shortcomings of gait training.

Therapists should make patients aware of the advantages and shortcomings of ambulation with orthotic devices and walker or crutches. Whether to ambulate with orthotic devices and walker and crutches is patient's choice and it should be respected. For functional and strength gains therapists should undertake gait training for patients with spinal cord injury.

Before the gait training can begin, it is important to determine the orthotic devices that are required for the patient.

Lower Extremity Orthosis for SCI

Occurrence of pressure sores can be reduced by standing using the lower extremity orthotic devices.

Goals of Splinting:

- To prevent contractures

- To prevent compartment syndromes
- To maintain alignment

Benefits of orthosis assisted standing

- Prevent joint contractures.
- Decrease osteoporosis.
- Prevent UTI.
- Enhance cardiopulmonary endurance by allowing freedom of movement
- In pediatrics, it enhances the development of trunk and head control.

Types of orthosis

- Hip knee ankle foot orthosis (HKAFO) - HKAFO is an extension of a KAFO with a pelvic band. The support provided by the pelvic band improves standing balance for spastic patients.
- Knee Ankle Foot Orthosis (KAFO): - provides stability at knees and ankles. KAFO is prescribed in case of
  1. Hip and trunk extensors weakness
  2. Weak quadriceps muscles
- Ankle foot orthosis (AFO): Both static and dynamic AFO are available. In case of complete foot drop one may consider static AFO but for foot drop due to spasticity that affects the knee joint control and alignment, a dynamic KFO may be considered.

There are many other orthotic devices available for the patients. Factors to be taken into consideration before choosing the orthotic devices are,

- Ease of availability.
- Accessibility
- Durability
- Safety
- Comfort
- Cost

Therapist should take an informed decision with the patient about the use and type of orthosis. Therapist may also choose to give orthotic devices that are different from the conventional KAFOs, where the knee orthosis and ankle orthosis are separate and therefore are easier to put on. The weight is also considerably less.

The first step towards gait training is the ability of the patients to wear their own orthoses. Patients need a good sitting balance and a good hip range for wearing the orthoses and therapist should target to achieve these before beginning the gait training.Figures 11.1 to 11.6 show a patient with paraplegia wearing a KAFO.

Figure 11.1

Figure 11.2

Figure 11.3

Figure 11.4

Figure 11.5

Figure 11.6

Figure 11.1 to 11.6 Patient of paraplegia wearing her KAFO

Tolerance to vertical position must be developed for patients with higher thoracic and cervical injuries before making them stand. This can be achieved with tilt table in the initial phases. Once the tolerance has been developed, passive standing can be

performed with the help of standing board. Exercises can be performed to train for trunk balance and shoulder stability in the standing board. Figures 11.7 to 11.12 show a patient with quadriplegia performing exercises in the standing frame.

Figure 11.7

Figure 11.8

Figure 11.9

Figure 11.10

Figure 11.11

Figure 11.12

Figure 11.7 to 11.12 Trunk stability and strengthening exercises in standing board

Parallel bar exercises before gait training

Patients have to first learn the paraplegic stance or develop hyperlordotic stance to maintain the hip stability. This posture is already taught and practiced during bed mobility training. However once the patient is made to stand in the parallel bar this posture should be reemphasized. Patient can be supported at the pelvis and asked to perform forward and backward movements thrusting the hips back and forth (Figure 11.13 and 11.14)

Figure 11.13

Figure 11.14

Figure 11.13 and 11.14 Facilitation of the hyperlordotic posture

Once the hyperlordotic posture has been learnt, shifting weight sideways is facilitated by holding at the pelvis and by guiding the sideways movement of the pelvis. This maneuver is called weight shifting and it is essentially to be able to propel forward.

Figure 11.15

Figure 11.16

Figure 11.15 and 11.16 Weight shifts in hyperlordotic posture

As the patients learn to do the weight shifts slowly the trunk rotations are facilitated to be able to propel the legs forward for mimicking walking. For this the therapist should stabilize the pelvis on the contralateral side of the movement, ask the patient to side flex on the contralateral side and move the leg forward (Figure 11.17 and 11.18). As the hip flexors and hikers are not functional in paraplegics with higher thoracic injury; internal and external obliques must be used for moving the leg forward and clearing the ground. Therefore these muscle patterns must be developed and muscles should be trained. Once the pelvis is stabilized the muscles can contract to bring about unilateral movement of the lower extremity with trunk rotation. Support given by the therapist at the pelvis acts as a fulcrum for this movement. Slowly as the muscles learn this pattern, trunk rotation and leg movements can be carried out independently.

Figure 11.17 Forward stepping using trunk rotation assisted by a therapist

Figure 11.18 Backward stepping using trunk rotation assisted by a therapist

Therapist should guide not only the forward and backward movement but also the movement of the legs sideways (Figure 11.19 and 11.20)

Figure 11.19

Figure 11.20

Figures 11.19 and 11.20 Sidestepping using trunk side flexors

Gait training

Depending on the patients muscle power, swing to and swing through gait can be taught instead of the 'alternating four point gait'. For swing to and swing through gait very strong shoulder and trunk muscles are required.

For teaching the swing through and swing to gait, support the patient at the pelvis and ask to perform a push up on a parallel bar and propel the body forwards and backwards (fig 11.21 to 11.23)

Figure 11.21

Figure 11.22

Figure 11.23

Figure 11.21 to 11.23 Training for Swing through and Swing to gait

Once the guided movements are practiced patients are encouraged to perform push-ups on the parallel bars and maintain the position (Fig. 11.24 and 11.25). As the endurance increases swinging movements are added to the push-ups.

Figure 11.24

Figure 11.25

Figure 11.24 and 11.25 sustained push up at the parallel bar

Alternatively patients can also be given advanced strengthening exercises like pull up in the parallel bars (Fig 11.26)

Figure 11.26 Assisted pull ups

Once good shoulder strength is achieved the forward backward bending of the trunk and the forward, backward and sideways movement of the legs can be performed by the patient independently (fig. 27 to 33)

Figure 11.27

Figure 11.28

Figure 11.27 and 11.28 forward and backward bending of the trunk

Figure 11.20 to 11.33 Leg movements using trunk rotation and side flexion performed independently by the patient.

Parallel bar training continues to develop the alternate gait pattern. Common exercises to be performed by the patient are forward, backward walking and side walking. These exercises can be performed independently by the patients with lower thoracic and lumbosacral injuries. Patients with higher thoracic injuries may need continued assistance for these exercises. Patients with complete cervical injuries will not be able to perform these exercises independently.

Gait training in walker

Once the gait training in parallel bar develops adequate trunk and shoulder control, patients can be trained to walk using a walker. First task before learning to walk with a walker is to be able to stand up from bed with the walker. A stable position is to turn in prone and pushing up to stand up. Initially the legs can be supported and guided to prevent slipping (Fig. 11.34 to 11.39)

Figure 11.34

Figure 11.35

Figure 11.36

Figure 11.37

Figure 11.38

Figure 11.39

Figure 11.34 to 11.39 standing up from bed onto the walker with assistance

With practice patients can perform most of the tasksindependently (Fig 11.40 to 11.47).

Figure 11.40

Figure 11.41

Figure 11.42

Figure 11.43

Figure 11.44

Figure 11.45

Figure 11.46

Figure 11.47

Figure 11.40 to 11.47standing up from bed onto the walker with assistance

The exercises performed in parallel bar should be repeated in the walker as well i.e. sustained push-ups and weight shifts. To begin with 'swing to' gait can be used on the walker while training for alternate gait pattern. In the same manner as that in parallel bars patients can walk using alternate gait patterns (Fig. 11.48 and 11.50)

Figure 11.48

Figure 11.49

Figure 11.50

Figure 11.48 to 11.50 walking with the help of a walker wearing push knee splints and high boots with posterior steel shanks

Patients with better trunk and shoulder control can stand up from the chair may choose to stand up by pulling onto the walker and then pushing down on the walker to perform a push uplifting the legs up and keeping them in desired place (fig 11.51 to 11.53).

Figure 11.51

Figure 11.52

Figure 11.53

Figure 11.51 to 11.53 standing from the chair using a walker

It is also important to learn correct techniques of sitting down to prevent injuries. The patient should slowly lean back still holding onto the parallel bars with arms (Figure 11.54 and 11.55). Once they are seated on the wheelchair or bed, they can let go of the hands. A quick push up and shifting back will ensure that the patient is securely seated. Once this is achieved orthotic devices can be taken off.

Figure 11.54

Figure 11.55

Figure 11.54 to 11.55 Sitting down on a wheelchair

Gait training in the crutches

Crutch walking is usually possible for patients with lower thoracic and lumbosacral injuries. Some patients with higher thoracic injuries may also be able to learn crutch walking (figure 11.56 to 11.60). The training for crutch walking remains the same as that of walking in the parallel bar and walker.

Figure 11.56

Figure 11.57

Figure 11.58

Figure 11.56 to 11.58 Standing up wih the help of Elbow crutches

Figure 11.59

Figure 11.60

Figure 11.59 and 11.60 Gait training with the help of Elbow crutches

Stair climbing

Patients choose to stand up by pulling onto the walker and then pushing down on the walker to lift the legs up and keep them in desired place.

Patients with lower thoracic injuries can climb up the stairs using hip hikers and trunk side flexion to be able to clear the stairs (Fig 11.61 to 11.64)

Figure 11.61

Figure 11.62

Figure 11.63

Figure 11.64

Figure 11.61 to 11.64 Training for stair clamping

Another method is facing the railing and holding it with both hands, swing one limb in one pendulum cycle and then hike the hip and place the foot on the higher step; then bring the other foot up. This is possible only if he has strong hip flexors or quadratus lumborum. There is yet another way of climbing up i.e. Jack kniving, Here the patient has to lift him up higher than the height of a step with back facing the staircase and swinging both legs backwards so as to reach the higher step. The person has to use one crutch in one hand and holding the railing with the other hand or using crutches in both hands. This is possible only for patients who have very good control of the trunk as well as very strong Triceps and shoulder muscles.

Kunming Locomotor Training (Kunming Walking therapy)

This locomotor training has been developed in Kunming china and moves through 10 stages of Kunming locomotor scale. The patients undergo extensive walking therapy unassisted by any orthotic support. The walking program essentially discourages the use of orthosis. As more and more weight bearing is facilitated, reduced spasticity allow for movement through the motor patterns of walking. These patterns are first stimulated by therapists carefully assisting the leg movement and later on the patients perform the movement themselves. The training progresses through 10 stages:

Level I : Able to sit in wheelchair

The first stage of training includes training for wheelchair mobility with upper extremity strengthening benefits.

Level II : Able to stand with support of the wheeled walker?with one person supporting both knees

In the second stage patients stand with the help of a forearm walker with one person supporting the knees and trunk in the initial phase and later on knees alone. This is repeated for several hours a day till patients develop some control for the knee extension and are able to lock the knee.

Level III : Standing independently with the support of the wheeled walker

Once the patients are able to do so, they stand without any knee support with the help of a forearm walker. This also should be repeated for several hours a day.

Level IV : Walking with the support of the wheeled walker and a person pulling strips of cloth wrapped around the knees

Slowly as the trunk and knee control in standing improves, patients are facilitated for stepping forward. Initially a person supports the knees from front and the therapist prevent buckling of the knees with two nonelastic bands tied to the knees. Will more and more practice, the person sitting in front eventually need not give any support but the therapist continues to hold the bands to prevent buckling. Patients walk in this manner for several hours a day. 6 hours a day/ 6 days a week is a recommended schedule.

Level V : Walking independently with the support of the wheeled walker

If patients practices for several hours slowly the control of the knee improves while walking and therapist no longer needs to support the patient with the nonelastic bands. Patients in this stage are able to walk independently with a forearm walker. The subsequent stages involve change in the orthosis and with more practice patients can achieve this change from forearm walker to standard walker to crutches.

Level VI : Walking independently with a four-point walker

Level VII : Walking independently with crutches

Level VIII : Walking independently with a four point cane

Level IX : Staggering along independently

Level X : Normal walking

The level of walking that the patients can achieve on the Kunming Locomotor Scale (KLS) as described above is dependent on the level of the injury, associated injuries and adherence to the training protocol. It is important not to discontinue training and walking once discharge from the hospital as if discontinued patients lose the ability to walk, however retraining the patients with the locomotor training can recover this ability.

Figure 11.65 Kunming Locomotor scale

Figure 11.66 Kunming locomotor training program implemented in India

Chapter 12
Spinal cord Injury and Activities of Daily Living

Activities of daily living are defined as activities that are oriented towards taking care of one's own body. Activities are divided into Basic and Instrumental ADL.

BADL

It includes the following activities bathing, showering, bowel and bladder management, dressing, eating , feeding, functional mobility, personal device care, personal hygiene and grooming, sexual activity, sleep / rest and toilet hygiene.

IADL

These are the activities which are performed by a person to live independently in community. These activities require advanced problem solving skills.

Instrumental ADL

IADL also include 11 activity categories : care of others, care of pets, child rearing, communication device use, community mobility, financial management, health and maintance, home establishment and management, meal preparation and cleanup, safety procedures and emergency response, and shopping.

Evaluation of ADLs and IADLs

1. Identify the overall purpose of the evaluation
2. Have clients identify their needs, interests and perceived difficulties with ADLs and IADLs as part of the occupational profile.
3. Further explore the clients relevant activities so that the activities are operationally defined.
4. Estimate the client factors that affect occupational performance and /or the

assessment process.

5. Identify the contextual features that affect assessment.
6. Consider the features of assessment tools
7. Integrate the information from step 1-6 to select the optimal ADL ad IADL assessment tools.

Examples of Standardized ADL assessments for ADL and IADL

- **ADL:**

  Functional Independence measure

  Klein Bell ADL scale

- **Instrumental ADL :**

  Assessment of Motor and process skills (AMPS)

  Kitchen task assessment (KTA)

- **Measures of ADL and IADL:**

  Canadian occupational performance measure COPM

  Kohlman Evaluation of living skills (KELS)

Home Assessment :

Home assessment play a vital role in improving the functional independence The client and his family members should be interviewed to identify their expectations regarding the functional independence. Cultural and family values should be taken into account. While doing home assessment , the therapist should consider the safety factors.

Establishing the clients Goals: Bridge between Evaluation and Intervention

This is an important step as it serves as a transition from evaluation to intervention. Establishing goals require analysis of the evaluation results in conjunction with additional factors that influence outcome, namely clients ability to to learn, the client's prognosis, the time allocated for intervention, the clients discharge disposition, and the clients ability to follow through with new routines or techniques.

Identifying appropriate goal behaviors

Value

It is has been observed that, for some clients, ADLs and IADLs are not the immediate priorities.

Patients with severe disability may seek assistance from the caregivers for doing BADL or IADL tasks.

So while deciding the goals, the therapist has to be careful. So, that they select the goal behaviors, that is ADL and IADL tasks, that reflect the values that client defined during the evaluation.

Eg. Caregiver assisting the client with C6 Quadriplegia in doing self care tasks as attempt at self care retraining were being met with resistance and frustration by the client. As the activities most valued by the client were computer access and home mobility.

Difficulty

It is always important to determine the prognosis for functional difficulties of the patient. Communication of the deermined functional difficulties with the client is the next important step.

The perceived ease with which a client completes an activity and the projected difficulty that will remain after intervention are important considerations in selecting goal behaviors (Thornson and Grimbley , 2001).

Eg. Client (school going child) with T4 spinal cord injury with a neurogenic bladder requires a self catheterization finds it difficult task for fulfilling his role as self carer and a student as he would prefer not to take help from his family members or school professionals for doing the task of catheterization an he will need to do self catheterization independently and efficiently to fit into his school day. The therapist believes that, the client will be able to do achieve independence in that particular task after a period of practice.

Fatigue and Dyspnoea

Use of activity analysis is essential to find out the effort and duration required to complete the tasks. Each and every activity which the client does daily should be analyzed with respect to fatigue level and energy expenditure

Eg. For clients with spinal cord injury, fatigue and energy expenditure varies as the level of injury varies from lumbosacral level to higher cervical level0.

Identifying appropriate goal Levels

Independence

Te commonly used performance parameter is Independence in activity performance. Across all the ages and disabilities, the ultimate goal is to increase the level of independence.

Independece can be divided into three phases :

Initiation of the task , continuation of the task and completion of the task. Therapist may write independence goal that includes initialtion such as "Client may able to initiate and complete bathing independently three to seven times a week by the end of 3 months.

Safety

Safety is a quality of a person - task - environment transaction so it is always associated with the independence. (Letts, scott, Burtney, Marshall & McKean 1998 ; Russel, Fitzgerald, Williamson, Manor & Whybrow, 2002) Independence performance is assured to be safe. When the therapist has to decide about the independence goals it is always advisible to take into consideration of clients comfort level with the risk, clients ability to analyze the risk factor which are associated with a particular activity an d finding out the plan for managing them so that it can be implemented successfully despite of the impairments.

Eg. The goal of doing transfer training for a person who demonstrates good judgement and a realistic perception of his skills would be, ''client will be independent in sliding board transfers from wheel chair to / from bed within three therapy sessions''.

Adequacy

Several aspects of activity performance contribute to the adequacy or quality of the behavior stated in the goal, which can also be reflected as the degree to which the behavior is expected to be done.

Pain

The source of pain and prognosis for it must be considered in establishing the goals and selecting an appropriate intervention approach. Both the evaluation and the goal must have an index of pain so that intervention rmains focused on achieving the projected level of independence while simultaneously reducing the presence of pain.Eg. Client will prepare a simple meal independently with maximum pain level of 2cm on 10 cm visual analogue scale within 2 weeks.

Fatigue and Dyspnoea

when fatigue or dyspnoea can be reduced through task adaptation or conditioning, goals can be established that use these performance parameters as performance outcomes.The initial evaluation should include baseline data for comparision. Eg. The client will complete morning care routine with mazimum score of 6 on Borg reported Perceived Exertion Scale (Borg 1998) by the end of November.

Duration

The duration of daily livig activities depends highly on the nature of the activity and the task objects that people choose to use in performing the activity. It takes more time to do dressing when going out for dine in an elegant restaurant than we do when we are going to fast food restaurant. So, it is difficult to establish meaningful norms for ADL activities. Establishing appropriate and acceptable time frames for ADL goals must be done collaboratively with clients and their significant others. Social and cultural standards also need to be taken into consideration in establishing outcomes for activity duration

Eg. The client will independently complete a simple cash transaction in one minute within three weeks to support participation in shopping.

Satisfaction

Satisfaction is a subjective feeling and it varies from person to person. Successful participation of the client in a desired activity reflects their satisfaction level. Clients have their own set of standards for performing ADL activities. So, it is important to add a tool which gives an objective information regarding performance of the client and satisfaction level in that particular task. COPM is a tool which can be used to measure the satisfaction level.Goals can be set once satisfaction level is measured

Eg. Client will become indepent in locating items needed for doing ADL activities at house with satisfaction rating from 8/10 within 3 weeks t to support participation in ADL.

Different Approaches used:

1. Modify / Compensatory
2. Establish / Restore

Modify / Compensatory approach :

Compensatory strategies are used to improve activity performance. If restoration of the previous function Is not possible then this approach can be used.

1. Alter the task Method

A particular method of performing activity is altered by keeping the objects and the context same.

Eg. For a person who has difficulty in bathing (unable to get in / out of the tub) can substitute the washing part by doing the activity at sink.

2. Adapt the task objects or prescribe adaptive devices :

Altering the use of objects which are used for performing a particular task can help to facilitate the performance.eg. Use of enlarge handle spoons or universal cuff for those clients with quadriplegia who have poor hand functions.

For a person who has difficulty in bathing , use of a bath mitt would be advisable.

Clients satisfaction level should be taken into consideration as sometimes use of an adaptive device decreases the satisfaction with the task performance level of the client.

3. Modify the task environment :

Environmental modification are used to enhance the task performance. The As environmental modifications are fixed in place, the client do not have to remember the necessary adaptations to be carried out for doing the activity.

Eg. Installing ramp for the wheelchair mobility.

Installing grab bars and transfer seat so that client can remain seated while performing bathing activity.

Establish / Restoration approach :

This approach basically focuses on the restoring the lost functions of people with disabilities.

Eg. Restoring the functions like muscle strength, endurance, range of motion.

ADLs for person with Quadriplegia

Clients with lower cervical injury level can do ADL acivities same as paraplegic clients except the fact that they have poor fine motor functions.

Clients with C6 level injury can live independent lives by using various adaptations.

Whereas upper cervical quadriplegic clients requires specialized equipments and special care.

Dressing

It is always advisable to put underwear and trousers when the client is still in the bed, after which he can perform transfers to wheelchair and then he can put on the shirt, socks and shoes.

Clients with C7 and below level injuries can become totally independent in UB and LB dressing.

For clients with C6 injuries it is difficult to do LB dressing because of the energy expenditure.

Clients with C5-C6 lesion can learn some components of UB dressing.

It is always advised to use a loose clothing with a front opening

For lower body dressing the trouser used should be one size larger.

Lower body Dressing :

i. Position of the pant should be at the foot of the bed,and front side up.

ii. Place one hand below the knee and flex the knee. Put the pant over the foot and then extend the leg.

iii. Pull the pant up using the palms

iv. Insert dressing stick in front belt loop and pull the pant further up by doing trunk extension.

v. Lean on one side , take weight on the elbow and pull the pant up over the gluteal region.

vi. for clients who have poor trunk balance, this can be done in supin epiosition and by doing rolling , then by keeping the arem behind the back the client grabs the belt loop by thumb and slides the pant up over the gluteal region

vii. Next step is to straighten the legs wit hthe help of palms.

viii. Then in supine position the client has to fasten the pant by thumb, pull the zip u with the modifiesd zipper.

ix. Fro removing the pant, the client has to unfasten and unzip the pant in supine position first.

x. Pant is slided downwards over the hips by holding the beltloops by thumb and by scooting the body forwand and maintaining shoulders into extension.

xi. Dressing stick can be used to push off the pant over the legs.

Fig 12.1:LB Dressing

Fig12.2: LB Dressing

Fig12.3: LB Dressing

Fig12.4: LB Dressing

Upper Body Dressing

1. Keep the shirt across the thighs with back side up.
2. Place both arms under the shirt and push the sleeves up.

   By using wrist extensors and shoulder adductors and external rotators along with elbow flexion, pass the shirt over the head.
3. once it reaches over the head, keep the shoulders and wrist relaxed .
4. Shoulder shrugs and leaning forward along with elbow flexion and wrist extension will help to move shirt down over the body.
5. Adaptive devices like button hook or wrist driven flexor hinge splint can be used for doing buttoning.

Fig 12.5: UB Dressing

Fig12.6: UB Dressing

Fig12.7: UB Dressing

Fig12.8: UB Dressing

Eating

Different options available for performing eating activity are :

1. Use of mobile arm support or externally powered split is recommended for clients with C5 quadriplegia.
2. Wrist flexon hinge spint
3. Use of wrist splint along with the universal cuff
4. Use of nonskid mat and a plate with a plate guard.
5. Combination of swiwel fork snd spoon. (for clients with c4-c5 level injury)
6. Bilateral or unilateral cup holder.
7. Built up utensils for those who have tenodesis grasp.
8. Use of quad quip knife for cutting the food. (for those who have adequate arm strength)
9. Electric self feeder for upper cervical level injuries.
10. Long plastic straw with a straw clip to stabilize it in the cup.

Fig 12.9: Wrist flexion Hinge Splint

Fig 12.10: Plate with a plate guard

Fig 12.11: Swivel spoon and fork

Fig 12.12: Universal cuff

Hygine and Grooming:

1. Use of shower and bath tub seat along with the transfer boards.
2. Use of long handle scrubber and reacher.
3. Use of bathing mitts for clients who have poor hand muscle strength.
4. Universal cuff for doing combing, brushing.
5. Wall mounted hair dryer.
6. Clip type holder for electronic razor
7. Use of supposatory inserts for managing bowel careindependently.
8. Use of skin inspection mirror with a along stem and looped handle.
9. Elastic leg bag straps to empty catheter leg bags.

Fig 12.13: shower and bath tub seat

Fig 12.14: Wall mounted hair dryer.

Fig 12.15: Universal cuff

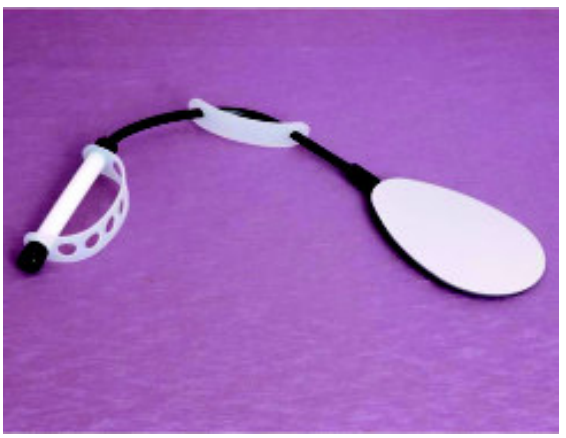


Fig 12.16: Self inspection mirror

Communication and Environmental adaptations

1. Elecronic page turner for turning pages.
2. Typing stick for doing typing activity.Use of universal cuff for doing painting.
3. Speaker phone with mouth stick to push or press the button
4. Use of specialized mouse for computer use.
5. Electronic communicating devices controlled by mouth ,pneumatic controls and head controls for clients wit hupper cervical level injuries.
6. Use of environmental controls to run tv, radio, telephones.

Fig 12.17: Electronic page turner

Fig 12.18: Typing stick

Mobility and transfers

For clients with higher cervical injuries, hoists are used for doing the transfers sip and puff wheelchair, powered wheelchair is advisable.

Mobility can be further enhanced by using electric wheelchairs operated by hand, chin or pneumatic controls.

Home management activities:

Clients with c6 cervical level injuries can perform light home making tasks by using adaptations and environmental modifications.

ADL for person with Paraplegia

Dressing :

LB dressing becomes easier if the button is at the front.

Wide bottom slacks, stretch fabric are recommended.

Method:

Lower Body dressing :

1. Use of siderails to pull up to sitting position.
2. Reach forward to feet by sitting on the bed.
3. Flip the pant down to feet.
4. Work pant leg over feet and pull up to hips and pull up the garment.
5. Use of land handel reacher can make the activity easier.
6. Reverse the procedure for removing or undressing.

Upper Body Dressing :

1. By keeping the palms on maresss on eitherside, maintain the balance of your body,back support is needed for those who have poor balance.
2. Open thegarment on the lap with the collar forwanr chest.puth the arms into the sleeves and pull up over elbows.
3. Removing the shirt :
4. Lean forward, duck the head and pull the dhirt over the head.
5. Remove the sleeve forst from supporting arm and then from working arm.

Shoes:

1. Flex the knee with other hand while the person is sitting on the bed.
2. Use one hand to support the knee which is in flexed position, at the same time use other hand to slip shoe into foot.
3. For removing the shoe,use one hand to remove the shoe while supporting the flexed leg with the other hand.

Eating :

1.Use of wheelchairs with desk arms

2.Use of swing away footrests so that the person can sit close to the table.

Fig 12.25: Wheelchair with desk arm

Fig 12.26: Swing away footrest

Fig 12.19-Fig12.24: Removing Shoes

Grooming :

1. Use of hand held shower.
2. Use long handle bath brushes
3. Use shower chairs or bath tub seats
4. Install the grab bars in the bathroom which will increase the safety.
5. Use of non skid mat
6. Replace doors of the bathroom by shower curtains.

Fig 12.27: Hand Held Shower

Fig 12.28: Long Handle Brush

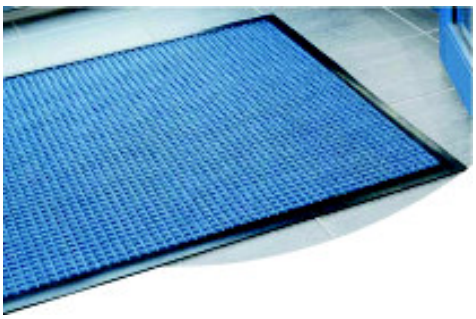


Fig 12.29: Non skid Mats

Fig 12.30: Grab bars

Communication:

1. Use a cord less phone or a mobile.
2. Use of short handle reacher to grasp the receiver.

Environmental Adaptations :

1. Approach the door from the side at which door knob is present.
2. Open the door as far as possible.
3. Start closing the door when half waly through
4. Use the elbow to keep the door open.

Home management activities :

1. Remove the cabinet doors and keep the frequently needed items in the front.
2. Use of offset hinges to replace standard door hinges. Which increase the door width by 2 inches.
3. Use of wheelchair cushion to increase the users height.Use of lapboard which can serve as a work surface for doing different ADL tasks.
4. Use of drop leaf board or a side out board to provide a work surface.
5. Use of front loading washers and dryers.

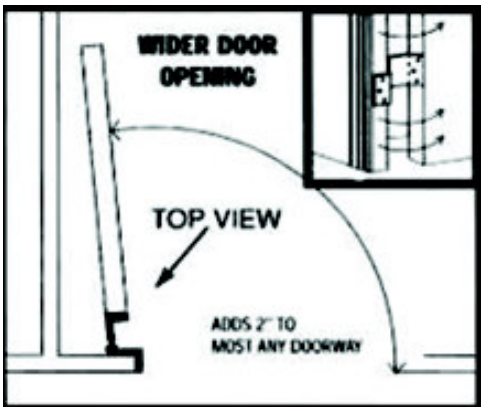


Fig 12.31: offset hinges

Fig 12.32: drop leaf board

Fig 12.33: front loading washers

Fig 12.34: wheelchair cushion

To summarize, the ultimate goal of ADL training is to make client independent in basic and instrumental activities of daily living leading to successful participation of the client in desired activities and roles.

Hand Rehabilitation in SCI:

Loss of hand function is one of the most devastating consequences of spinal cord injury for a motor complete or incomplete SCI at the neurological level from C2 to T1. More than one third of the individuals sustain acervical spinal cord injury resulting in quadriplegia. Individuals withquadriplegia remain wheelchairbound and reliant on others for physical care. For a quadriplegic individual limited hand and upper limb function is more disabling and devastating than their inability to walk. Hence even a slightest improvement in hand functions has a major change in their quality of life. Eg.

- Even a slight amount of finger movements enables a quadriplegic individual to manipulate a key board, press buttons, open bottle lid, scratch on face, wipe hands and turn the book pages. (Figure12.35, 12.36, 12.37)

Figure12.35

Figure12.36

Figure12.37

(Figure12.35, 12.36, 12.37) Opening Bottle Lid, Wiping Hand, Typing on Keyboard)

- Slight thumb movements have helped individuals to grasp on objects, pull on clothes while dressing etc. wrist extension enables a quadriplegic individual to wear on t-shirt, apply brakes to wheelchair, etc. (Figure 12.38 and 12.39)

Figure12.38

Figure12.39

(Figure12.38, 12.39) Applying wheelchair brakes, Upper Body Dressing)The ability to perform these simple tasks by themselves reduces on the dependency levels on the care givers and it improves their self esteem and improve s their potential for employment

The role of occupational therapy in upper extremity rehabilitation is to return the individual to meaningful participation in his or her daily activities.

Assessment tools:

- Modified Action Research Arm Test (ARAT): standardized measure of unilateral hand and upper limb function for assessing grasp, grip, pinch and gross movement
- Graded and Redefined Assessment of Strength, Sensibility and Prehension (GRASSP) used to assess upper limb strength
- AIS sensory assessment for assessing the Pin-prick and light-touch sensation of each dermatome
- AsTex® Sensory Test assesses the texture discrimination capabilities of the thumb and fingertips.
- AuSpinal Hand Assessment is a unilateral measure of hand function using a key, nut/bolt, coin, credit card, sweet, telephone receiver and soft drink can
- Capabilities of Upper Extremity (CUE) is an interview-based questionnaire about perceptions of upper limb function specifically designed for participants with quadriplegia

Management:

- Strength training
- Passive or assisted active movements (e.g. provided by therapists, family, carers or devices)
- Arm ergometry

- Stretching provided by therapists, family, carers or devices
- Training for activities of daily living like upper body dressing, cooking or self care activities like eating, brushing etc.(Figure12.40 and 12.41)

Figure 12.40 Eating

Figure 12.41 Bathing

- Task specific training to enhance the hand functions eg: including reaching, grasping, manipulating, pulling, rotating and releasing objects, handwriting training, use of keyboards, etc.
- Functional Electrical Stimulation can be used as an adjunct to improvethe hand functions
- Use of computer based games that involve hand and upper limb movement, for example games associated with Nintendo Wii®, PlayStation® or similar equipment. toimprove on the grasp, release, pinch, squeeze, twist, push and pull function of the hand. Also progressing to more difficult games as hand functions improve.
- Practicing functional activities: moving checkers, grasping and releasing therapy ball, manipulating objects, turning keys, pouring water, holding cup, holding fork and opening jars.(Figure 12.42 and 12.43, 12.44)

Figure 12.42

Figure 12.43

Figure 12.42 and 12.43 holding cup

Figure 12.44 holding fork

- Spasticity in the hand and fingers affects the hand function training and it further affects the optimal recovery of hand functions.
- computer training (e.g. training in the use of word processors, internet or computer games)
- splinting (e.g. functional splints, resting splints, active-assist splints or hand orthosis')
- pressure garments or bandaging for edema management or for the promotion of a passive tenodesis grip (e.g. JOBST gloves or pressure bandaging)

Chapter 13
Home and Environment Accessibility

Access is defined as the means or opportunity of an individual to approach or enter a place. Access of home and work environment is important and it facilitates maximum independence of an individual with SCI. An occupational therapist will assess and survey the barriers and potential barriers; and device strategies and implement solutions to promote maximum accessibility and safety.

Why Access is important?

- There are legislative laws that are developed for individuals with disability to provide with equal opportunities and full participation.
- Ease accessibility would make life easier.
- People with disabilities add to the diversity of the community. It will increase an individual's ability to mix normally with the rest of the community people so that more people will have the opportunity to know them..

When to ensure Access?

- When new public facilities are being designed or built like parks, sports stadiums, theatres, shopping malls etc
- When there are chances of renovation of structure eg, historic building being rehabilitated for public use.
- When a community group is working on improving or rehabilitating a public facility or space
- When a service providing organization, institution, or agency is moving or renovating its facility
- When there is lack of access

Note: taking help from people with disabilities to help on these projects

Who should ensure access ?

- People with disabilities themselves
- Organizations that are concerned disability rights
- Legislators and other public officials
- Enforcing agencies
- Employers
- Educators
- Public services proving organizations
- Developers

Living in Home:

¢ Architectural Barriers and Restrictions: Architectural barriers are required to be taken care to improve the accessibility at home e.g.:

- Narrower hallways and doorways restrict the accessibility of an paraplegic individual using a walker.

A United Nations initiative for barrier free environment with access to all has published guidelines for the architectural considerations. It is a design manual for accessibility for the disabled and can be accessed online at

http://www.un.org/esa/socdev/enable/designm/index.html

Architectural barriers in an Outdoor Environment like street furniture, traffic signs, direction signs, street plans, bollards, plants, trees, and advertising signs, etc. should be placed in such a way that a clear path will be available for passage of the wheelchair.

¢ Home Safety: Home accessibility is an important aspect for an individual with paraplegia or quadriplegia because the condition almost remains the same over a long course. As individuals with SCI cannot negotiate stairs and ambulating indoors and outdoors on wheelchair simple basic changes like

- repositioning the furniture,
- removing rugs,
- eliminating clutter,
- reposition the electrical boards and switches and keep it at an accessible height for wheelchair users
- keeping the kitchen table height low so that a female with paraplegia can easily operate in the kitchen,
- shelves, sink and basins should be placed at an optimal height for wheel chair users

Important aspects of home architecture:

- Entrances: wide entrances with clear passage to allow free movement of the wheelchair.

  The UN guidelines suggest following standards for the entrances.

  New constructions can comply with following suggestions

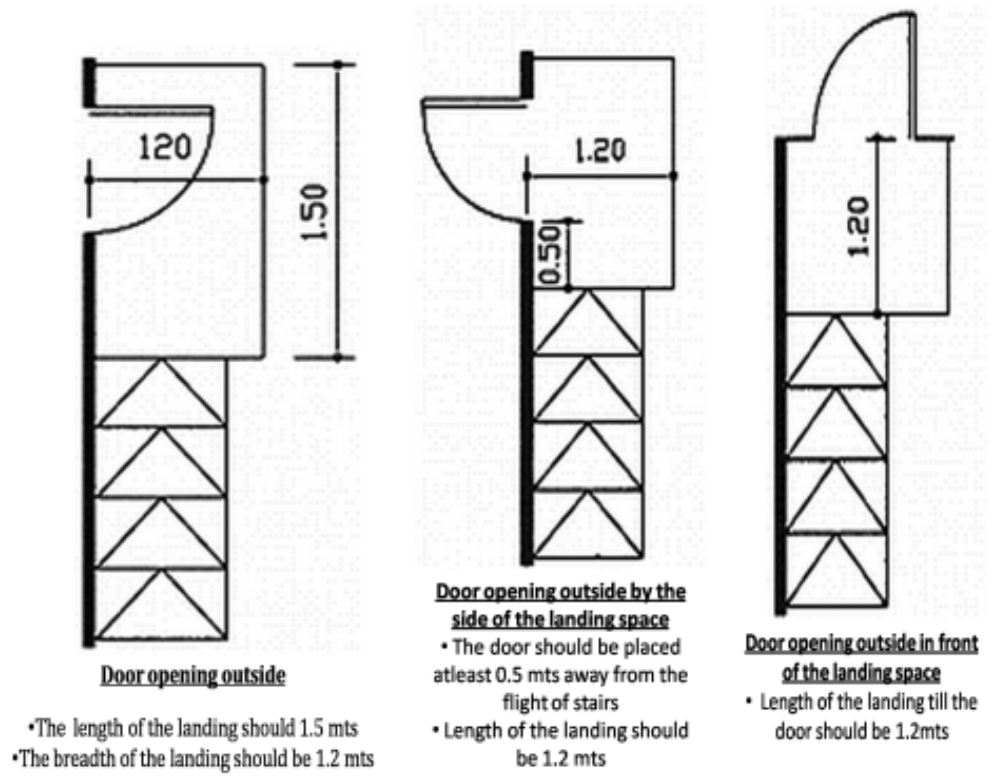


Figure 13.1 shows the recommended dimensions for the landings and entrances with doors opening inward and outwards

Following structural recommendations have to be considered

- Avoid curbs and thresholds
- Nonskid tile flooring
- The entrance door should be of different color than that of the surrounding walls for easy identification

Doors:

- Doors should be wide enough, placed appropriately to allow for a single motion passage of the wheelchair with minimal contours and maneuvering.
- Doors must have a handle and extra pull handle and proper sign.
- If the door is automatic it should remain open for a longer time than usual to allow for passage of the wheelchair completely.
- Front opening doors, automatic sliding doors are suitable for wheelchair friendly access however revolving doors should be avoided.
- In narrow spaces sliding doors may be useful.
- For self sliding doors pull handles should be placed at the lower level and should protrude out for easier grip for an paraplegic sitting in the wheelchair.

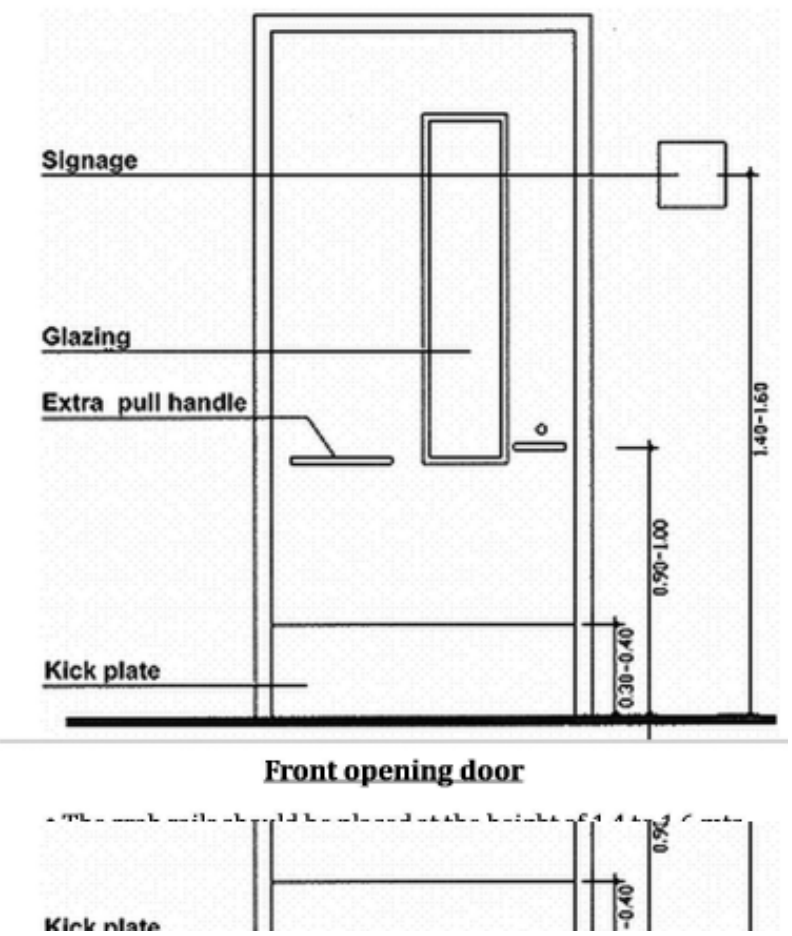


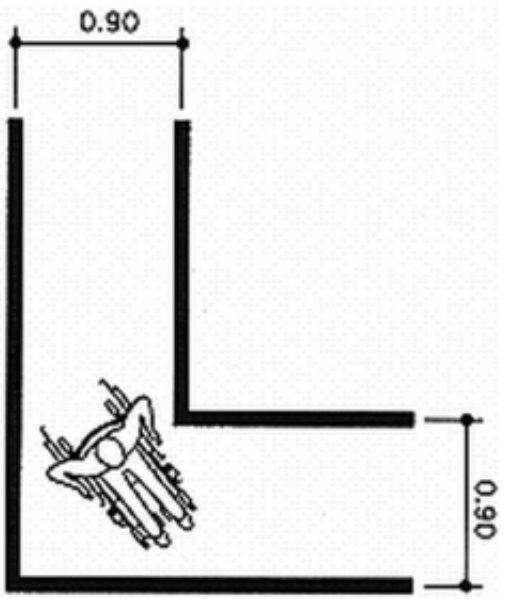
Figure 13.2 shows the architectural recommendations for the doors

Corridors:

- Corridors should be wide and there should be straight length of the corridor available with minimal turns.
- If there are doors opening into the corridors then the corridors should be wider to allow free passage of the wheelchair with doors open.
- For any given corridor there should be a free passage space of 0.9 mts must be available.
- Sharp angulated turns should be avoided. Corridors should not be too long but long enough to prevent turning very frequently.

While designing and modifying the corridors following must be taken into consideration

- The traffic in the corridor
- One way or two way corridor
- Number of turns possible
- Essential obstacles like doors opening in the corridor, drinking water, seating arrangements etc.

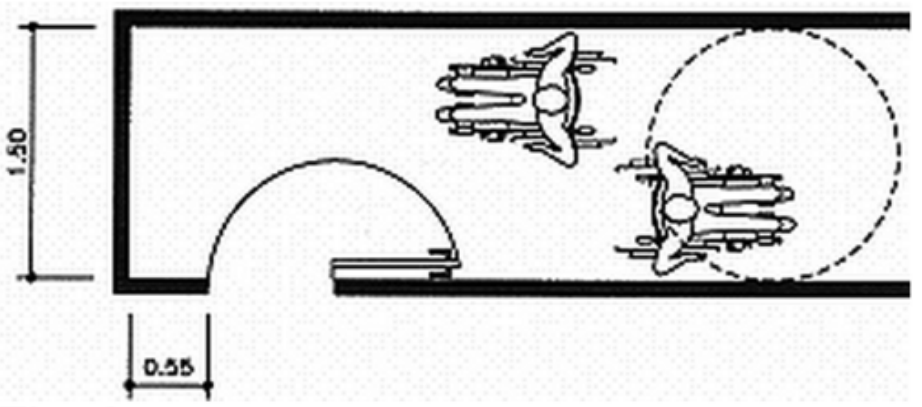


Low traffic, one way corridor with passage of single wheelchair at a time

•The length of the corridor at entrance should be 0.9 mts

•The length of the corridor at the exit should be minimum 0.6 mts

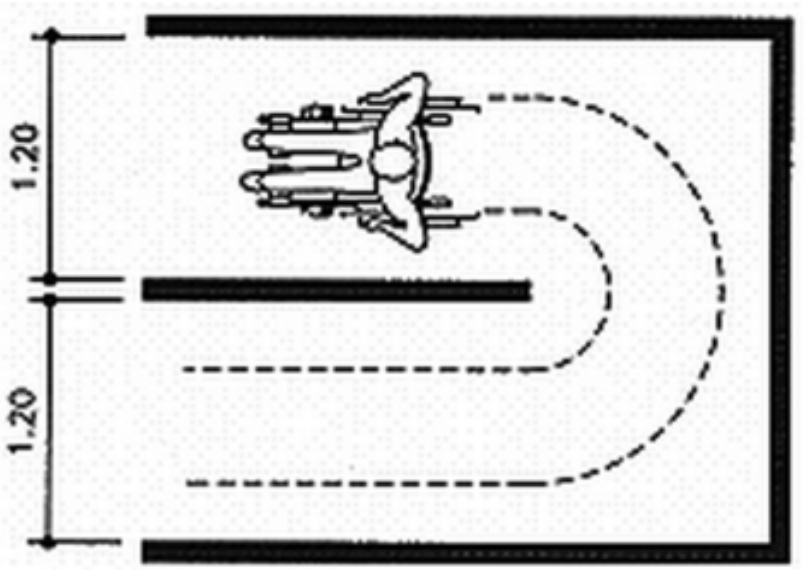
Figure 13.3



Two way, heavy traffic corridor

- The corridor length should be 1.5 mts
- The door placement should be a tleast 0.55 mts away from the end of the corridor

Figure 13.4



Low traffic, one way corridor turn

- Avoid sharp andulated turns
- A U shaped turn is recommended
- Length of the corridor must be 1.2 mts

Figure 13.5

Figure 13.3, 4 & 5 illustrate the structural considerations for the corridors.

Stairs: for low level paraplegics who can walk with help of splints in lower limbs

- Staircases should not be too steep
- The height of steps should be uniform
- There should be grab bars or railings on either side of the stairs.
- Staircase should be wide enough to allow for two people stand side by side
- Spiral staircases are not recommended
- The width should be 0.9 mts for one way traffic and 1.5 mts for two way traffic
- Flooring should be non-slippery
- The grab bars should be continuous around the circumference of the landing
- Alternate elevator, ramp or lift for staircase should be available.

Railings and Handrails:

- Railings should be present to prevent risk of slipping.
- Handrails should not obstruct the path of travel
- The height of the handrails should be between 0.85 to 0.95 mts above the finished floor levels
- For the benefit of wheelchair users a second handrail at the height of 0.70 and 0.75 mts should be placed
- Railings should be mounted on proper support structures to withstand heavy load
- The end the railings should bend and blend into wall and not left open ended.
    - o Bathroom Modifications: Solutions to bathroom accessibility can range from adding innovative or usage of portable equipment to work with the existing bathroom.
- Wall mounted benches or bath chairs at same height of wheelchair
- Use of long handled reachers for retrieving items off the floor to prevent bending over or reaching.
- Placing toiletries at the appropriate height from the floor to prevent unnecessary bending and turning
- Grab bars around the commode area to facilitate easy transfers from wheelchair to commode.
- Hand held shower
- Plastic non skid chairs with arm support can be used instead of bath chairs.

There could be several modifications made to the bathroom and toilets Figures 13.6 - 11 suggest the simple modifications.

Minor modifications include small, low-cost aids and equipment to improve accessibility.

Figure 13.6: Bath chairs

Figure 13.7: Bath tubs

Figure 13.8: Soap on Rope

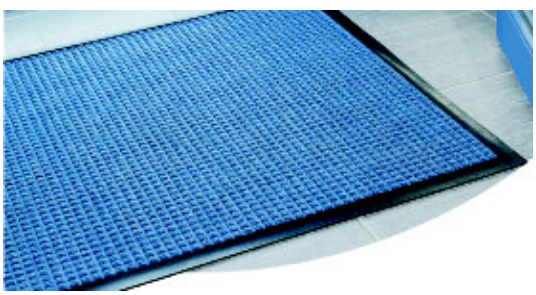
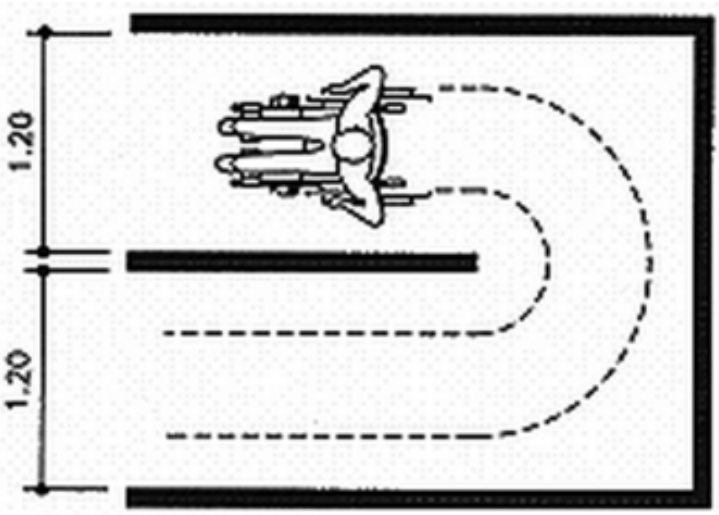


Figure 13.9: Non skid floor mats

Figure 13.10: Hand held shower

Structural recommendation for the bathrooms

- Sufficient space at the entrance and inside the bathroom is required to maneuver the wheelchair
- The access to the restroom should ideally be parallel to the toilet seat. Diagonal approach can be given while modifying the existing space however perpendicular approach should not be used (Figure 13.11)



Low traffic, one way corridor turn

- Avoid sharp andulated turns
- A U shaped turn is recommended
- Length of the corridor must be 1.2 mts

(Figure 13.11)

¢ Flooring: Some types of flooring may not hold up under the weight of the power wheelchair. Flooring changes include

- Installation of nonskid mats.
- Nonskid tiles on the walking surfaces to prevent slip and trips.
- Nonskid mats
- Avoid curbs and thresholds

Fall Prevention techniques:

¢ You can reduce the risk of slipping on wet flooring by:

- paying attention on the floor surface and floor height while walking
- adjust and modulate walking pace that is suitable for the walking surface
- walking with a slightly broader broad base of support
- making wide turns at corners

¢ You can reduce the risk of tripping by:

- keeping walking areas clear from clutter or obstructions
- keeping flooring in good conditon
- proper lighting
- using a flashlight in dark room where there is no light
- Proper footwear and appropriate pace of walking

In the work place:

¢ Ergonomically designed work station:

- consider the height and width modifications for wheelchair access
- consider to accommodate assistive and external devices used.

¢ Ergonomically designed chairs

- Consider chairs with adjustable arm, back and footrest and chairs with adjustable height.
- Contoured back support to accommodate the spinal curvature.
- Custom made chairs for individuals with spinal deformities

¢ Assistive Technology: Assistive technology includes any piece of equipment or device that helps to increase the independence of a disabled person. While assistive technology is not new, it is an ever changing and growing type of technology. Assistive technology has helped to enormously increase the ability of paraplegic individual to lead more independent lives. Assistive technology devices enable disabled people to do all sorts of tasks such as turning on lights and appliances and opening doors while in a wheelchair, speak through synthetic speech systems.

¢ At Public Places: This focuses on accessibility to public areas like shopping mall, theatres, public buildings etc.

- Ramped entrances and elevators
- Trained staff to communicate effectively with people who have disabilities
- Elevators should be wide enough to accommodate two wheelchairs at one time.

Chapter 14
Vocational Rehabilitation

One of the most important occupations in which an adult engages is WORK.

Work is important for people to

- To become financially independent and contribute as an earning member of family
- Receive health insurance and other benefits
- It gives an opportunity for them to meet and interact with other people
- It gives them a sense of belonging and self esteem and overall life satisfaction.

This is also true for individuals suffering from SCI. Barton stated "the purpose of work is to divert the mind, exercise the body, relieve the monotony and boredom of illness."

Work gives them a sense of purpose to their life. It is consistent that individuals who are employed after SCI live longer as compared to individuals who don't work.

What is Vocational Rehabilitation?

Although individuals with SCI go on to have active work lives and successful careers, they have more barriers to overcome than those without disabilities. Vocational rehabilitation programs help individuals with disabilities to

- Indentify their career interests and skills
- Acquire relevant education and training
- Find new employment opportunities and apply for jobs
- Overcome accessibility issues that act as barrier in post injury gainful employment
- Additional training may be required by many individuals to sustain the employment

- Also VR programs help with work site assessments and onsite work task analysis at clients workplace

An Occupational therapist should

- Interview the individual during the inpatient rehabilitation regarding the previous jobs for the purpose of future planning and sharing information regarding the vocation with the rehabilitation team, so that vocational goals can be incorporated early in the rehabilitation plan.
- A work site assessment and onsite work task analysis performed at the client's workplace as well as examination of the worker and the work environment will provide the therapist valuable insight about the present skills of the patient.
- If a patient is considering returning to work an Occupational Therapist can assist him by assessing his work abilities in a simulated work environment.
- Patient will have build up his strength and stamina and both he and the staff will have a clearer idea of his employment capabilities.
- The patient should be taught proper body mechanisms and energy conservation to perform work in a safe manner.

Types of accommodations/ Getting support at work

Job accommodations can include modifying work schedules, tasks or the work environment. Solutions can range from simple to complex. Examples:

- Removing a desk drawer or raising the height of a desk with four wood blocks so a wheelchair can fit underneath.
- Special software and hardware so a person with no hand function can work on a computer.
- A private changing area for someone who may have occasional bladder accidents.
- Shifting work hours to a later start and end to the work day to accommodate a worker's lengthy morning care needs.
- If a person has both SCI and a brain injury, he or she may need additional support in the form of extra supervision or personal care assistance during the work day.
- Someone with high-level quadriplegia, for example, may need help with positioning or personal care assistance during the work day.
- To prevent pressure sores the individual has to do frequent weight relieving measures like pushups in wheelchair or chair
- Also there should be facility to lie down in prone position for a short period at the workplace.

Many individuals suffering from SCI have differences in the due to considerable functional limitation post injury. Most patients do not return to work after SCI, not even in physically less demanding jobs, causing a dramatically decrease in employment rates. Return to gainful employment is seen in only those individuals who are minimally disabled and who have light physical demand and those who have followed a retraining program. Post injury individuals prefer to starting up a new job rather than continuing on with the pre injury employment or they prefer to work part time, are the major obstacles an individual faces that prevent them for returning to work. Continuing education in school is important for children with SCI as it helps in early integration and acceptance with positive attitude among the teachers and peers.

Following are the contributing factors that influence the employment after SCI

- Inadequate educational opportunities appropriate to the individuals abilities causes job discontent and job dissatisfaction
- Insufficient health care insurance
- financial disincentives to work
- physical barriers
- and inability to access effective employment training and placement services
- Inaccessibility of the work places and lack of enabling technology to allow competative work output.
- No accessible transportation to and from work.
- inconsistent attendant care that affects the work attendance
- Negative attitude about the employers and prospective employers about the abilities and inabilities of a paralyzed individual.
- Poor self image, fear of failure, lack of working peer role models and low self expectations off potential workers.

Role of Computer Technology in Vocational Rehabilitation and Return to Work

Computer use and training is of special benefit to individuals with SCI because computer technology may help lessen the impact of mobility limitations that are inherent with this disability. High probability of positive employment outcome is seen in individuals who have good computer training skills. The use of assistive devices such as hands free telephones, environmental control systems and mouth sticks also play an important role. However, the utilization of these assistive technologies is one of the major challenges that influence the employment success.

If employment is not possible

There are bare employment prospects for older individuals in their mid to late 50's who have suffered injury, hence rehabilitation professionals need to provide with

realistic information regarding the probability of returning to pre injury job. Unless there are opportunities to get back to pre injury employment, it will be better to help the individual plan for a meaningful retirement rather than retraining. People who live in rural areas may not have access to transportation or employment. If paid employment is not possible, one can consider getting involved in a volunteer activity. Volunteering provides enjoyment and a sense of accomplishment; it can give you the skills, confidence and professional contacts that might eventually lead to paid employment some day.

Sheltered workshops represent the earliest form of vocational rehabilitation, where persons with severe disabilities are given tasks to perform in a workshop managed by vocational specialists. Vocational options for paraplegic individuals who cannot get back to their original job

- Volunteering and helping individuals with similar conditions in sheltered workshops
- Paper work
- Tailoring and Basket Weaving
- Candle Making
- Painting/ Art
- Cooking
- Baking
- Gardening
- Computer training
- Book Binding
- Greeting card Production.

Legislative Acts

1) The Person's with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act 1995.

   Function of the act -

   a) develop a national policy to address issues faced by individuals with disability
   b) Take steps to ensure barrier free environment in public places work places utilities schools etc.
   c) monitor and evaluate the impact of policies program designed for achieving equality full participation of with disabilities
   d) design schemes, projects, national plan for the individuals with disability

2) The Workers Compensation Act 1923

Workers compensation is a form of insurance providing wage replacement and medical benefits to employees injured in the course of employment in exchange of mandatory relinquishment of the employees right to her employee's right to sue his or her employee for the sort of negligence.

3) The National Trust for the Welfare of Persons with Autism, Cerebral Palsy, Mental Retardation and Multiple Disability Act, 1999.

Objective of the trust -

- To enable and empower persons with disability to live as independently and as fully as possible within and as close to the community to which they belong.
- To strengthen facilities to provide support to persons with disability to live within their own family.
- To deal with problems of person with disability who do not have family support.
- To facilitate the realization of equal opportunities, protection of rights and full participation of persons with disabilities requiring such protection.

4) National Policy for Persons with Disability was announced in 2006

- It recognizes that persons with disabilities are valuable human resources for the county seeks to create an environment that provides them equal opportunities.

Salient features -

- Physical rehabilitation, which includes early detection and intervention counseling and medical interventions
- Educational rehabilitation including vocational training
- Economic rehabilitation for dignified life in society

5) Guidelines and Space Standards for Barrier free built environment for disabled elderly persons

- The Central Public Works Department under the ministry of urban development has issued guidelines to achieve barrier free environment thus enhancing independent functioning.

Role of Occupational Therapist

- An occupational therapist plays an important role as one of the member for disability evaluation and for rehabilitation
- It is mandatory on the part of the therapist to have expertise and skills in clinical evaluation along with knowledge of rules, legislative laws and policies for individuals with disabilities

- An Occupational Therapist should form an important core member for policy making guideline for disability evaluation
- An Occupational Therapist should make his patients aware about his/her rights and various concessions and opportunities available

Use of Disability Certification:

The disability certification makes individual with disability eligible for the opportunities under various laws policies

It helps to avail facilities and concessions for

- reservation of jobs in Government Sector
- travel concession
- soft loan for entrepreneurship development
- scholarship
- income tax exemption
- age relaxation in employment

Welfare Schemes for Physically Challenged Persons:

The following schemes are being implemented by the Government for the welfare of the persons with disabilities:-

- Assistance to Disabled Persons for Purchase/Fitting of Aids and Appliances (ADIP):- Under the scheme, aids/appliances are distributed to the needy persons with disabilities
- The National Handicapped Finance & Development Corporation provides concessional credit to persons with disabilities for setting up income generating activities for self employment
- Scheme for Implementation of Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act, 1995 (SIPDA):- Under this Scheme, assistance is provided for setting up of District Disability Rehabilitation Centres, Regional Rehabilitation Centres, creating barrier free environment in public buildings, awareness generation etc.
- Government of India has introduced several other schemes to promote employment/self-employment among disabled population - Government provides assistance to Voluntary Organization for training and Sheltered workshops. Banks Provide loans at low interest rates to promote Self-employment. Certain Categories of handicapped are allotted public telephone booths and other types of shops such as tea stalls.
- Residential houses are allotted to the handicapped persons who are in Govt. service on a priority basis. The Delhi Development Authority has reserved 5%

of shops, 10% residential plots and 1% flats in each housing scheme for the disabled persons

- Ministry of Welfare provides assistance to disabled persons for purchase and fitting of aids and appliances for their physical rehabilitation in order to increase their capacity to participate in economic activities.
- There are several national bodies that are looking after the training and service programs for the handicapped e.g. All India Institute of Physical Medicine and Rehabilitation, Bombay
- Institution that are importing equipment and apparatus for education and training of the handicapped are exempted from Custom duty including the Braille wrist watches.

Chapter 15
Learning To Drive Again

Driving is a serious and highly skilled activity. It requires adequate visual, physical and thinking skills. Following a spinal cord injury, some of these may be impaired which may impact one's ability to drive safely, or may require them to learn to drive in an alternate way.

Why return to driving is important?

- Increases the independence level and gives an essence of personal freedom
- It has a social, health, economic and symbolic functions
- Helps the individual with SCI to create and develop new connections with people and increase the social, community and vocational participation.

When to consider for driving?

An injured persons early and safe return to driving should be addressed early in the recovery and the injured person, family members, care givers and health professionals should be included in this important decision.

Who all are involved in the process of driving evaluation?

- Physician
- Driver Occupational Therapist Assesor
- Driving instructor

What is driving evaluation?

It is complete evaluation of an individual's potential to drive a motor independently. The driving assessment will determine readiness to resume driving and recommend modifications that are required to enable safe and functional driving, e.g. hand controls.

Medical Concerns:

- Vision
- Seizures
- Low or High BP
- Alcohol intoxication
- Fatigue
- Fluctuating heart rate.

What is the Process of getting a Drivers Evaluation?

- Source of referral can be a doctor, therapist, school. Vocational rehab centre.
- Clinical Assessment/ Off road Assessment: knowing about medical history, previous driving history, physical evaluation (ROM, Muscle strengt), visual evaluation, visual perceptual and cognitive evaluation and knowing about previous valid driver's license or permit.
- On Road assessments: depending upon the clinical evaluation, an in vehicle evaluation is done to determine the various types of adaptive driving equipment needed. An On road performance evaluation is done to judge an individual's driving capabilities in a variety of traffic and road way environment assessment. On road assessment is conducted jointly by an OT driving assessor and a driving instructor and It focuses on the practical assessment of the issues that are covered in off road assessment. Depending upon the requirements of the individual with SCI the assessment vehicle can be automatic or manual and will be set up with modifications as required e.g. spinner knob, left foot accelerator, hand controls.
- Training is based on the client's performance during initial evaluation and it is graded based on skill level.
- Adaptive equipment prescription is supplied to the referral source. E.g. for steering tri pin steering orthotic mounted at 3 o' clock position for right hand use, accelerator/brake controls.
- Final Inspection entails equipment inspection and fitting which is conducted at the vendors' workshop. Before completion the client demonstrates ability to use equipment in the driving environment
- FU training in individual's vehicle is performed, where a certain comfort level is desired in client's vehicle prior to independent driving. During this period, the passenger side training brake is removed temporarily for training purposes and removed at the completion of training.

Factors to consider while considering for Adaptive Driving Equipment

- Side doorway clearance height: 52 ¾ "to 56"
- Ramp width : 29"to 30"

- Points to consider are feel of vehicle, gas mileage, vehicle height, interior room, payload capacity or weight limitations, ground clearance, vehicle seating(front passenger and middle row), adaptive driving requirements
- Other personal access like notched transfer board for easy transfer, adjustable transfer seat
- Other points to consider include caster clearance width, footrest clearance height, battery/ frame clearance, clearance of tiedown bracket, impact on a manual wheelchair

Common car adaptations include

- Hand controls to operate accelerator and brake
- Handles to assist in transfers from a wheelchair to a car or van,
- Ramps
- Wheelchair and transfer lifts
- Raised ceilings
- Lowered floors and
- Wheelchair carriers attached to the outside of the car or van

Steering:

- coloumn extensions and different sized steering vehicles
- Digital Steering

Brake:

- Electronic Gas and brake Controls
- hand controls that allow braking and acceleration, easy-touch pads for ignition and shifting, and joysticks and spinner knobs

Orthotics:

- Tri- Pin
- Spinner Knob
- Steering Cuff

Secondary Controls include turn signals, horn, lights/dimmer switch, gear shifter, park brake etc.

Various Funding Options for Modifying and Purchasing the Vehicle

- Tax exemption for handicap individuals
- Subsidy of some amount is provided by various government schemes.

Note: If an individual with SCI is unable to drive the alternate ways to access the community should be considered.

Chapter 16
Assistive Devices for Spinal Cord Injury

Assistive technologies may be defined as "any item, device, or piece of equipment that is used to increase, maintain, or improve the functional abilities of persons with disabilities"1.The most important role of the assistive technologies is as follows

1. for participation;
2. to protect, support, train, measure or substitute for body functions / structures and activities; or
3. to prevent impairments, activity limitations or participation restrictions.

According to the definition of assistive product in ISO 9999

Assistive technology services are "any services that assist an individual with a disability in the selection, acquisition or use of an assistive technology device." This umbrella term includes multidisciplinary intervention, which allows people to participate in activities and roles which are important to them by using compensatory strategies.

The Human Activity Assistive Technology (HAAT) Model:

This model based on general system theory was designed by occupational therapists and engineers, which states that, change in one element causes consequences in another, represents performance as an interaction between the person, the person's activities, the assistive technology and the environment.

HAAT model describes interaction between four components of an assistive technology device.

1. The human technology interface: Eg. A computer key board and a video monitor (key board providing input and monitor providing output)
2. The processor: it acts on a user input and follows instructions or programm to produce an activity output.
3. Activity output: Eg. Motor powered movement in the direction of the joystick is pushed.

4. Environmental interface: This interface supports sensory performance

   Seeing - Camera capable of imaging information used for mobility
   Hearing - Microphones

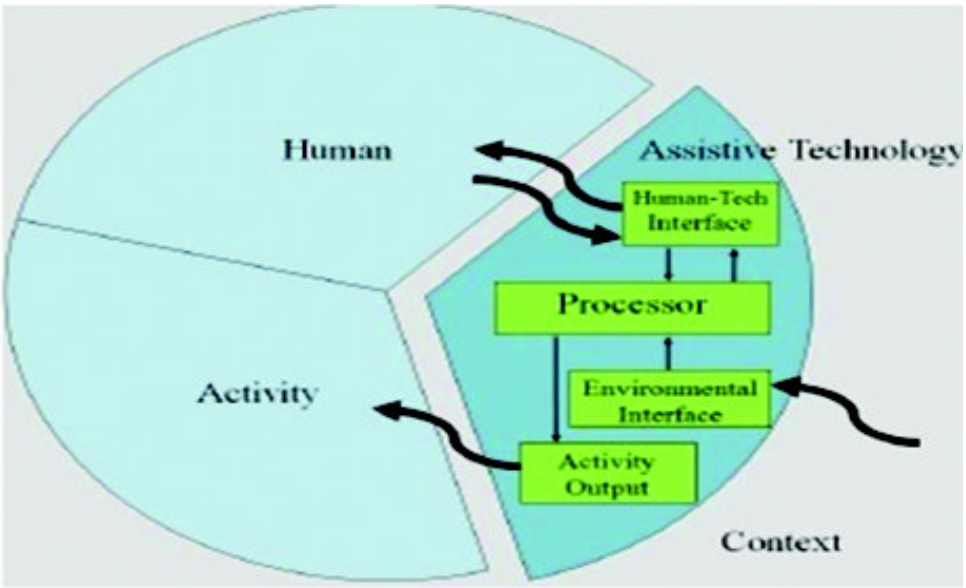


Fig. 16.1:- The Human Activity Assistive Technology (HAAT) Model

Client Centered Intervention

If the client is well motivated for activity and participation by using assistive devices, we can expect the best results from him. The desire for meaningful occupation helps to motivate the client and assists him for successful use of assistive devices. The desire for meaningful occupation facilitates motivation and the potential for successful use of an assistive technology device. The positive experience of using Assistive technology to engage in valued occupations often opens the door to considering other forms of assistive technology.

How does the Assistive Technology relates to patients with Spinal Cord Injury?

Spinal cord injury is a condition which affects person's physiological, psychological and social health. These changes in social role affect the activity participation of the person.

The aim behind use of assistive devices is to enhance the functional independence and productivity of persons with disabilities and to increase their ability to participate in social activities and integration. This ultimately improves the quality of life of a person with disabilities.

Classification of Assistive devices

National Classification System for Assistive Technology Devices and Services divides assistive technology into the following classes:

- Architectural elements
- Sensory elements
- Computers
- Controls
- Independent living
- Mobility
- Orthotics/prosthetics
- Recreation/leisure/sports
- Modified furniture/furnishings

Each general category has a numeric code, as do the subdivisions of the categories

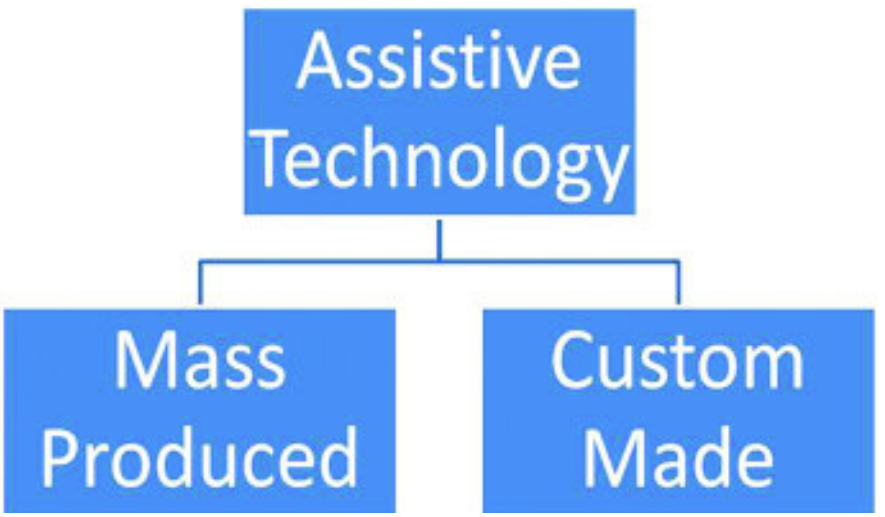


Fig. 16.2:- Classification of Assistive Technology

Types of assistive technology devices used for Spinal cord Injury patients

C1 - C4 Tetraplegia

These patients hardly have muscle power in upper and lower limbs. They can do movements of head and neck muscles and shoulder elevation. They require long term mechanical ventilation as loss of innervations to the primary muscle of respiration (diaphragm).

Assistive Devices Used:

Fig. 16.3: Power wheelchair with chin control

Fig 16.4: Power wheelchair with sip and puff control

Balanced Forearm Orthosis (BFO) or Mobile Arm Support (MAS)

Fig 16.5:- Mobile Arm Support

Fig 16.6:- Suspension Mobile arm support

If patient has shoulder and elbow flexor muscle power (Grade 2-3) It will assist them with feeding and grooming activities.

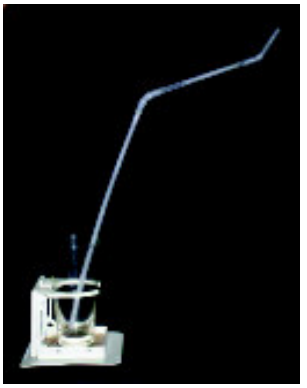


Fig. 16.7Long Bottle straw

EADL (Electronic aids for Daily Living)

Communication

Assistive devices send radio waves, infrared light or ultrasonic waves to improve patients control over the environment.

Brain Computer Interface (BCI)

A person with tetraplegia can use computer to operate power wheelchair. Brain activity of a person with tetraplegia can be interpreted with the help of computer.

Fig. 16.8:- Voice activation

C5 Tetraplegia

These clients have intact elbow flexors. Functional activities can be incorporated by making use of elbow flexors. These persons can achieve independence in feeding and grooming.

Assistive Devices used:

EADLs

Aim is to help the patient to adjust bed height, answer phones, and use computers, lights, and television

Fig. 16.9:- Power wheelchair with hand controls

Fig. 16.10:- Manual wheelchair with grip enhancements

Fig. 16.11:- Rim projections

C6 Tetraplegia

These clients have the added function of wrist extension. Tenodesis action is possible. Active wrist extension can cause passive thumb adduction. This function can be utilized for improving hand functions.

Wrist Hand orthosis (Tenodesis Splint)

Fig. 16.12: Wrist Tenodesis Splint

Fig. 16.13 Transfer Board

Fig. 16.14:- Wheelchair to Bed Transfers

Fig. 16.15: Car To Wheelchair transfers.

Fig.16.16: Manual wheelchairs with enhancement for gripping

Vehicle with adaptations

Fig. 16.17

Fig. 16.18

Custom lift and hand controls.

Fig. 16.19

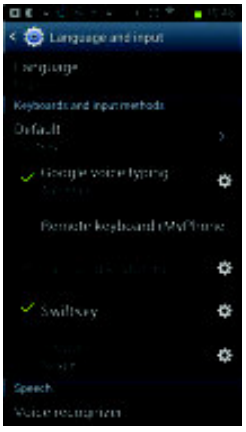


Fig. 16.20

Fig. 16.21:Page Turner

Writing Device

Fig. 16.22

Fig. 16.23

C7 Tetraplegia

For individuals with C7 tetraplegia elbow extension, facilitates the mobility and self-care skills. Clients with C7 injury can still be able to live independently. They may achieve independence in feeding, upper extremity dressing, bathing, bed mobility, transfers (although they may require assistance with moving over uneven surfaces), and manual wheelchair propulsion in the community (with the exception of going over curbs).

With the use of assistive devices, patients may also become independent with regard to grooming, lower extremity dressing, and bowel care. Individuals with a C7 injury, especially women, may need help with bladder care (eg, intermittent catheterization). These clients can drive modified car. These clients can achieve independence by using adaptive devices, in writing, typing, turning pages, answering phones, and using computers.

Fig. 16.24: Driving a specially modified or adapted van

C8 Tetraplegia

These clients have finger flexion, which improves their independence in terms of hand grasp and release. They can achieve independence in feeding, grooming, upper and lower extremity dressing, bathing, bed-mobility transfers, manual wheelchair propulsion, and bladder and bowel care, as well as in typing, writing, answering phones, and using computers. These persons can also drive independently using an adapted van or a car that has been adapted with hand controls.

Thoracic Paraplegia

Clients with T1-T12 paraplegia have good upper extremity functions and good hand functions. They can achieve functional independence in self-care, in bladder and bowel skills, and, at the wheelchair level, in all mobility needs. With the help of advanced wheelchair training they can maneuver the wheelchair on uneven, rough surfaces. These clients can do transfers from floor to wheelchair and back.

Clients with T2-T9 injuries can be made to stand with the help of walker and KAFOs as they have variable trunk control. Persons with a T10-T12 injury have better trunk control than do patients with a higher injury, and they may be able to walk household distances independently with KAFOs and assistive devices; they may even attempt to walk up and down stairs.

Lumbar Paraplegia

These clients can retain functional independence for all mobility, self-care, and bladder and bowel skills. Car adapted with hand control can make them independent for outdoor mobility. These individuals can do household work and community ambulation (unassisted ambulation for distance more than 150 feet). Commonest orthotic devices prescribed to clients with lumbosacral injury are as follows:

1. Orthotic devices (KAFOs and ankle-foot orthoses [AFOs])
2. Full- or part-time use of a manual wheelchair is often necessary.

Assistive Devices for Self-care, Transfers and Mobility:

I. Self-care

Fig. 16.25

Fig. 16.26

Fig. 16.27

II. Eating

Fig. 16.28

Fig. 16.29

Fig. 16. 30

III. Grooming

Fig. 16.31

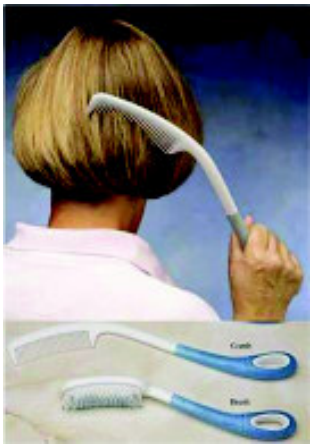


Fig. 16.32

Fig. 16.33:- Modified Zipper

Fig. 16. 34 Modified Cleaner

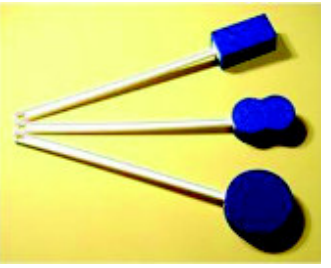


Fig. 16. 35

IV. Dressing:

Fig. 16.36:- Upper Body Dressing

Fig. 16.37:-Lower Body Dressing

V. Transfers:

Slide sheet:

- Low friction material sheet:-Kept under the client for easy repositioning in the bed, sling attachment, transfers.

Fig 16.38: Slide Sheet.

Transfer belt

- Used for transfers and assisted walking.
- A belt placed around a client's waist level

Fig 16.39:Transfer Belt

Transfer boards

- It is made up of wood or plastic.
- It serves as a bridge between a client and a surface where client is getting transferred.
- Smaller transfer boards can also be used for lateral, seated-to-seated transfers

Fig 16.40

Fig 16.41

Fig 16.42

Air-assisted transfer device

It includes inflatable mattresses for lateral (bed-to-bed) transfers and air-assisted lifting devices or 'jacks'

Fig 16.43:Air-assisted transfer device

Fig16.44:Air-assisted transfer device

Electric profiling bed

- It;s an electrically operated bed.
- The mattress platform gets divided into two, three or four parts,
- A control handset or panel is used for the adjustments.

Fig 16.45: Electric profiling bed

Fig 16.46: Electric profiling bed

Mobile hoist

- They are used for lifting a client inside a sling or on a stretcher
- A hoist with wheels that can be moved along the floor

Fig 16.47

Fig 16.48

Standing hoist

- A special type of mobile hoist.
- Used to assist client in standing.

Fig 16.49:-Ceiling hoist

Fig 16.50

A hoist attached to permanently mounted ceiling track that moves a client inside a sling.

Fig 16.51

Fig 16.52

Stretcher

- A rigid frame used to carry a client in a lying or supine position.
- It is usually made of lightweight material.
- Commonly used in ambulances and by emergency services.
- Wheeled stretchers are used in hospitals for transporting clients between locations

Fig 16.53

Fig 16.54

VI. Wheelchair

It's an assistive device commonly used for the purpose of mobility.

Wheelchair Drive Controls

Drive controls are the controls used to actually drive a power wheelchair.

Proportional Controls

Moving the joystick in a desired direction causes movement of the wheelchair in that particular desired direction.

Fig 16.55:- Conventional Joystick

Conventional Joystick

It consists of:

- gimbal knob:- The client has to push the gimbal in the direction the client wants to go and the further they push in that direction the faster the wheelchair will move
- on/off switch,
- speed control
- Battery gauge.

Sometimes, program indicators, power indicator lights are also a part of it.

Compact Joystick

- Chin is used to control the movement.
- Position of the gimbal is below and slightly front to the chin.
- The client has to push the gimbal in the direction where he wants to go.
- A conventional gimbal is usually replaced by a small cup or other shaped piece which depends upon the need of the client.

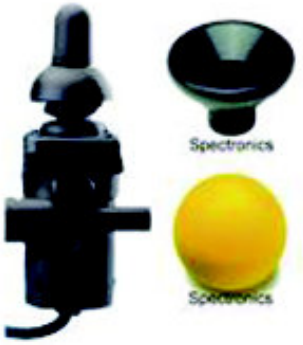


Fig 16.56:-Compact Joystick

Head Control:

- Gimbal is placed behind the head and positioned over the headrest.
- The client has to push the gimbal in the direction where he wants to go.
- Activation of the switch is essential if the client has to go backward..

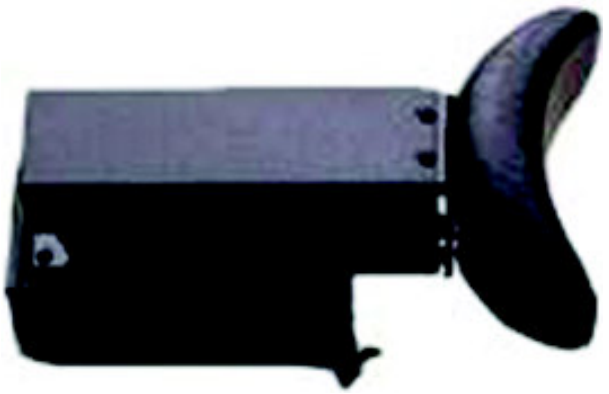


Fig 16.57:-Head Control

Finger Control

- It's a square box with diamentions 3" x 3" x 1 1/2" with a 2" hole in the top of it.
- The finger control box is placed over it according to the comfort of the client.
- The movement of the wheelchair is controlled by the movement and the direction in which the user's finger move.

Fig 16.58:-Finger Control

Touchpad Drive Control

- Finger is used to drive the power wheelchair.
- Depending upon the user's ability, the placement of the touchpad drive control can be done on various places of the wheelchair.

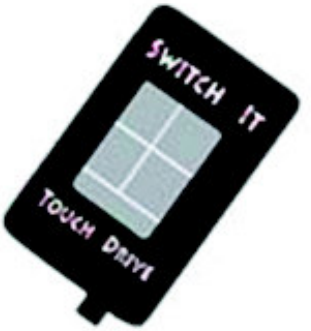


Fig 16.59: Touchpad Drive Control

Non-Proportional Drive Controls

- Non proportional drive controls auses chair to move at one pre-programmed speed in one direction
- There is no speed control
- They are less fine tuned for steering and course correction

Proximity Switch Drive Controls

- Proximity switches do not require pressure to be activated.
- The client has to move some part of their body near the switch to activate them.

- According to convenience of the client, proximity switches can be mounted on the wheelchair.
- Usually these are mounted on the underside of a tray.

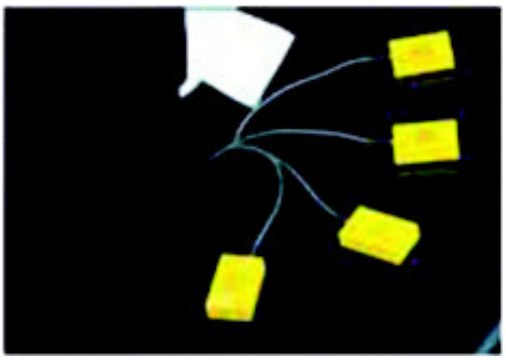


Fig 16.60:-Proximity Switch Drive Controls

Head Control

- If added proximity switches, head control can become non proportional drive control
- Proximity switches are usually added to the headrest
- As with the proportional system, the user must activate another switch to change directions from forward to reverse.
- The user does not have to hold constant pressure on the switches to drive the chair.
- Disadvantage: Speed cannot be controlled.

Fig 16.61:-ASL Digital head array

Wafer Boards

- The function of the wafer board is similar to the function of the non proximity head control.
- Wafer boards are placed on the users lap or on the wheelchair tray.
- The switches are placed on a board which can be controlled by the user's hand.
- This can be used for someone who has partial control of a hand but who is not able to maintain the constant control required to move a joystick.

Fig 16.62

Scanner Drive Control

- It includes display with multiple lights to control the wheelchair.
- When the wheelchair stationary, the lights on the scanner blink on and off and the user activates the switch when the light desired is lit.
- If the client has to go forward, the client has to activate the switch when the forward light is lit. Similarly for the backward direction.

Fig 16.63:-ASL Single Switch Scanner

- The chair will perform as commanded until the switch is hit again to cancel the movement of the power wheelchair.

Sip'n'Puff Drive Control

- These drives are used for those who have no upper extremity strength to control device on their power wheelchair (for higher cervical spinal cord injury clients)
- It requires regular practice to get good control of driving.
- The client has to either puff air into the tube or sip on the tube.

Fig 16.64:ASL Sip N Puff/Head Array

- The hard sip/ puff will cause different movement and soft sip /puff will cause different.

Wheelchair Accessories

These are the different wheelchair accessories which enhance the functional independence and assist in fulfilling the role of the clients in the society to improve quality of life.

Fig 16.65

Fig 16.66

Fig 16.67

Fig 16.68

Fig 16.69

What are the benefits of using assistive devices?

1. Improving functional independence.
2. Improving quality of life.
3. Saving money by reducing caregiver time.
4. Maintaining physical, social, emotional well being of the patient.

Can assistive technology replace caregivers?

1. The type of assistance that a device provides depends on the level of impairment.
2. Devices able to help eliminate the need for human assistance in for people with mild impairments, but assistive devices rarely replace human help.
3. In most cases, assistive devices supplement personal care for persons with moderate impairment

Disadvantages of Assistive Devices

1. The mismatch between the person and the assistive technology device.
2. Mismatches result in difficulty with using a device, in having the device perform differently than expected, in frustration, and even in stopping use of the device.
3. A mismatch of technology can be costly and time consuming.
4. Inadequate training of the person with the device is also a barrier to proper use and acceptance of the device.
5. Certain assistive devices may not be as effective for people with multiple impairments.

Steps to overcome barriers:

1. To find out resource on assistive technology and receiving information on assistive technology and services.
2. Finding support and advocacy group for assistive technology.
3. Finding a rehabilitation specialist can help in overcoming barriers to assistive technology
4. Train the person who is going to use assistive device and provide follow up services to ensure comfort satisfaction and safety and continued use of the device.

Paying Options for Assistive technology:

Third party payment for assistive technology is required. As majority of individuals with disability survive on low income and assistive devices are proportionally expensive. There is always a continued resistance to paying for AT devices. More studies are needed to demonstrate the outcomes of the long term economic benefits to society that accrue when AT devices enable better education, improve or create

skills for employment and reduce the costs of dependent care. There are also the individual benefits of participation, expanded social networks and improved emotional and mental health.

Mobile Applications for people with spinal cord injury:

Dragon Dictation:

For anyone unable to use their hands to write or type, this is a PC application that allows one to write by talking, while the app puts it into written form. It also allows you to search for the web and send emails.

Essential Accessibility:

Essential Accessibility is a website that offers a free technology, which allows those living with paralysis to access enabled websites. This is done using various keyboard and mouse replacement solutions, including a webcam-based, hands-free movement tracking system.

Eye Writer:

For the artistic type who would like to create graffiti art, this technology was created for just that. Using only your eye movement, draw and create images that are reflected back on a computer screen.

Tobil Eye Control Module:

This technology allows one with limited mobility and difficulty speaking to communicate using their eyes alone. Using a device that tracks eye movement, the movement connects to a computer, which can be operated using said movements. The computer now becomes a means for further communication.

Summary

In short, this gives you an idea about the use of the assistive technology. Even experts must constantly update their skills through continuing education. AT oriented conferences, and advanced education. Often powerful motivator for learning more about AT is meeting a client who could really benefit from AT intervention. Either refer your client to AT expert or work collaboratively with your client to gather information and learn more.

References

1. Willard and spackman 10 th edition, chapter 61, Page 850-867
2. Weaver FM, Hammond MC, Guihan M, Hendricks RD. The Department of Veterans Affairs Quality Enhancement Research Initiative for spinal cord injury. Med Care. 2000;38(6 Suppl 1):I82-91.

3. Heinemann AW, Pape TLB. Coping and adjustment. In: Scherer M, editor. Assistive technology: Matching device and consumer for successful rehabilitation. Washington (DC): American Psychological Association; 2002. p. 123-41.

4. Pape TLB, Kim J, Weiner B. The shaping of individual meanings assigned to assistive technology: A review of personal factors. Disabil Rehabil. 2002;24(1-3):5-20.

5. http://www.britannica.com/

6. https://mobilitybasics.ca/

7. http://www.acc.co.nz/

9. The Journey Through Caregiving Assistive Technology and Older Adults 2. Josh Baker, MOTS and Gail Bass, OTR/LUniversity of North Dakota Grand Forks, ND

Chapter 17
Wheel chair Selection, Management and Wheelchair Training

A wheelchair is the most important mobility device used by persons with SCI and the one that users most associate with barriers. Spinal Cord Injury (SCI) individuals comprise only 1.3% of the wheelchair-using population and they depend entirely on the wheelchair for their mobility, and as active users they require sophisticated, high-performance wheelchairs that enhance their remaining independence. In addition to the mobility, wheel chairs can substantially influence the total body positioning, skin integrity, overall function, psychological and social well-being of the individual. Owing to the complexity of the needs of many SCI individuals, these clients need to be assessed in specialist seating clinics where a holistic approach, with an emphasis on the education of clients and carers, can ensure that the most suitable equipment is provided for each individual.

The evaluation, measurement, and selection of wheel chair and seating systems are carried out by a team of occupational therapists, physiotherapist, nurses, and rehabilitation technology supplier and it can be done on an outpatient basis when required. This multidisciplinary skill mix promotes a holistic approach to the assessment of the client's needs.

Wheel chair Assessment:

Why Wheelchair Assessment is Important?

- To correct or prevent the development of postural deformity
- To change the configuration of existing equipment
- To recommend alternative equipment to accommodate alterations in function
- To reassess the whole seating system following the development and treatment of pressure sores.

Points to keep in mind while assessing an individual for wheel chair and before making any recommendations:

- Who will pay for the wheelchair?
- The immediate and long term need of the wheel chair
- Clients present clinical status
- Understand the clients functional and environmental needs
- Who will propel the wheel chair?
- Duration for which the wheel chair will be used? Both on daily basis as well as long term basis
- How will the dimensions of the chair affect the client's ability to transfer to various surfaces?
- Where is the primary use of the wheel chair (indoors / outdoors)
- Which mode of transportation will be used? Will the client be driving a van from wheelchair? How will it be loaded and unloaded from the car?
- Which special needs (e.g., work heights, available assistance, accessibility to toilet facilities and parking facilities) are recognized in the work or school environment?
- Does the client participate in indoor or outdoor sports activities?
- How the wheelchair will affect the client psychologically?
- Can accessories and custom modifications be medically justified or are they luxury items?
- What resources does the client have for equipment maintenance (e.g., self, family and care givers)?

Types of Wheelchairs:

- Conventional wheelchair, rigid frame, fixed arm rests, small castors. (Figure 17.1)
- Conventional wheelchair, foldable frame, fixed arm rests, small castors (Figure 17.2)
- Folding, detachable arm rests, flip away or elevating foot rests (Figure 17.3)
- Semi reclining wheel-chair(Figure 17.4)
- Reclining wheel-chair (manual and powered) (Figure 17.5)
- Stand-up wheel-chair (Figure 17.6)
- Manual wheel-chair with add on power unit.

Figure 17.1 Conventional wheelchair, rigid frame, fixed arm rests, small castors

Figure 17.2 Conventional wheelchair, foldable frame, fixed arm rests, small castors

Figure 17.3 Folding, detachable arm rests, flip away or elevating foot rests

Figure 17.4 Semi reclining wheel-chair

Figure 17.5 Reclining wheel-chair

Figure 17.6 Stand-up wheel-chair

Figure 17.7 Electric Wheelchair

Figure 17.9 Electric Carts

Figure 17.8 Tricycle

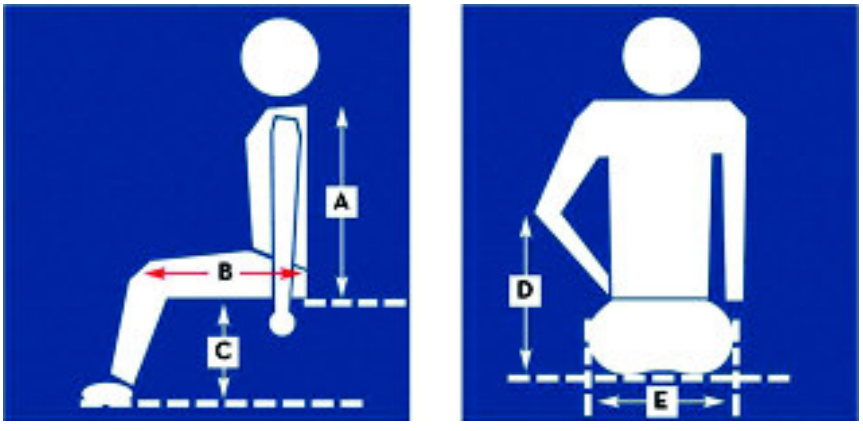


Figure 17.10 Wheelchair measurement

- Electric wheel-chairs (Figure 17.7)
- Tricycles (Figure 17.8)
- Electric carts.(Figure 17.9)
- Adapted vehicles.

Wheelchair Measurement:

A) Back height distance from buttocks to level of scapulae.

B) Seat depth: it is distance from back of buttocks to popliteal fold, add 1-2 inches.

C) Seat height: it is distance from heel to popliteal fold, add 2 inches to provide clearance of foot rests when approaching slope, ramps.

D) Arm rest height: distance from buttocks to olecranon, elbows flexed 90 degrees.

E) Seat width: it is the widest distance across hips, add1- 2 inches for clothing, splints

The following are the goals of a comprehensive seating and positioning assessment:

- To prevent deformity
- To normalize the tone
- To manage the pressure sores and healing ulcers
- Promote optimum function
- Maximize the Sitting Tolerance
- Optimal Respiratory Function
- Provision for proper body alignment

Wheelchairs features:

General features:

- Pressure cushions (Figure 17.11)
- Customized seating
- Axle position
- Tires
- Materials used e.g. frame or seat.

Manual wheelchairs

- Anti-tip devices (Figure 17.12)
- Push rims (Figure 17.13)

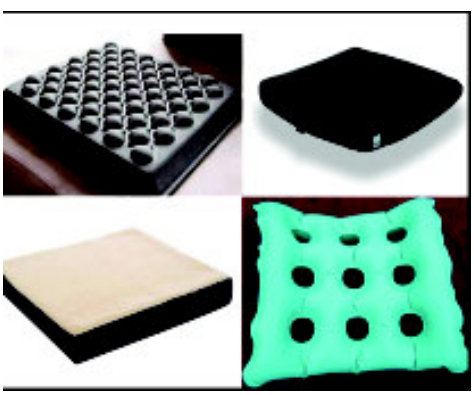


Figure 17.11 Cushions

Figure 17.12 Wheelchair anti-tip devices

Figure 17. 13 Push Rims

- Type and material of frame
- Wheel camber
- Wheel type and size, castors
- Footplates and hangers.

Power wheelchairs

- Head rest (Figure 17.14)
- Controller options (Figure 17.15)
- Armrests (Figure 17. 16)
- Footplates and hangers
- Ventilator attachments (Figure 17.17)

Figure 17.14 Head rests

Figure 17.15 Controller options

Figure 17.16 Arm rests

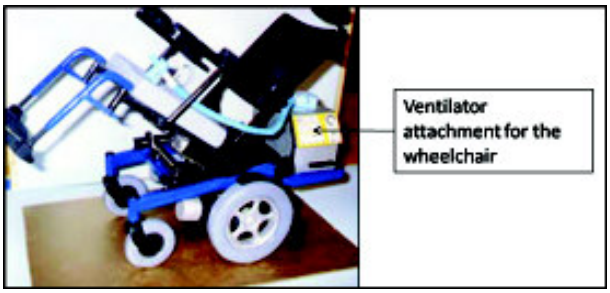


Figure 17.17 Ventilator attachement

Accessories:

Wheelchair accessories are used to make your everyday life more convenient and easier. These accessories help entering homes, rooms and building in different areas easier. Additionally, they are also used as a fashion statement for the wheelchair user. Choosing a wheelchair accessory can be crucial decision for anyone who is in a wheelchair.

- Special Hand rims (Figure 17.18)
- Trays and Desks (Figure 17.19)
- Restraining and Positioning Systems
- Anti-Tipping Devices (Figure 17.20)
- Grade Aids (Figure 17.21): device attached to wheel locks on manual wheel chairs to prevent wheelchair from rolling backwards, beneficial when climbing ramps or propelling up slopes.
- Accu-Grips (Figure 17.22): oversized yellow brake tips for easy gripping the wheel lock handles comfortably.
- CARE-E ride a long platform (Figure 17. 23): ride-a-long platform, keep up with any motorized or electric wheelchair
- Propulsion Levers (Figure 17.24): for kids and teens to propel, steer and brake manual wheelchairs with greater ease.
- Custom Design Cushion Covers (Figure 17.25)
- Frog Legs Casters (Figure 17.26): improve the steering capability of the wheelchair and gives the ultimate smooth ride.
- Light-Up Casters (Figure 17. 27): for safety and makes the wheel chair more visible
- Tow-Mo Wheel drawn wagon (Figure 17.28): it is a collapsible wheelchair-drawn wagon designed to pull larger loads for ease of transport and storage.

Figure 17.18 Special hand rims

Figure 17.19 Trays and desks

Figure 17.20 ANti Tipping Device

Figure 17.21Grade Aids

Figure 17. 22 Accu grips

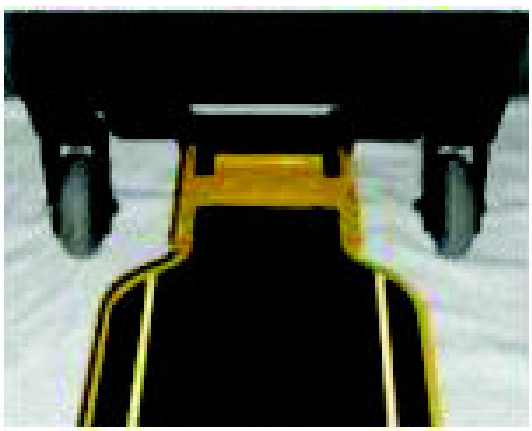


Figure 17.23 Care E long a ride platform

Figure 17.24 Propelling Levers

Figure 17.25 Cushion Covers

Figure 17.26 Frog Leg Castors

Figure 17.27 Light Up Casters

Figure 17.28 Tow Mo Wheel drawn wagon

Figure 17. 29 Weelchair Slippers

Figure 17.30 Wheelchair lap belt

Figure 17.31 Wheelchair strap

- Wheelchair Slippers (Figure 17.29)
- Wheelchair lap belt (Figure 17.30)
- Wheelchair strap (Figure 17.31)
- Silicon Push Rim cover (Figure 17.32)

Figure 17.32 Silicon Push rim Cover

Wheel chair Safety

Wheelchair parts tend to loosen over time and should be inspected and tightened on a regular basis.

Safety elements for the wheelchair user and the caregiver to follow

- Lock the brakes during all transfers
- Never stand on the foot plates while transferring
- Swing away the footrests during transfers if possible
- Check the position of the clients feet and arms before proceeding, they should not protrude out from the arm rest and also check that the clients hands are not on the hand rims.
- Push the client up the ramp in the normal forward direction. If the client is negotiating the ramp independently then he/she should lean slightly forward while propelling up the incline.
- Push the client down the ramp (Figure 17.33) by tilting the w/c backward by pushing the foot down on tipping levers to its balance position of approximately 30 degrees. If the client is negotiating the ramp independently then he/she should

move down the ramp facing forward while leaning backward slightly and maintaining the control of the speed by grasping the hand rims. Hand gloves can be helpful to reduce the friction.

- Manage ascending the curbs from forward, tipping the wheel chair back and pushing the foot down on tipping levers, thus lifting the front casters onto the curb and pushing forward
- Descend the curb using the backward approach

Figure 17.33 Coming down the ramp

Important muscle strengthening and strategies for wheelchair training: Proper techniques of wheel propulsion are of great importance in individuals with spinal cord injury in helping them with their daily activities and recreation and sports. Majority of the individuals with SCI prefer using a manual wheelchair. Hence knowledge of movement and muscle activation pattern is of utmost importance in rehabilitation, in training individuals for wheel chair and also preventing overuse syndromes.

Wheelchair Propulsion:

The whole arm movement pattern while wheelchair chair propulsion is divided in into two phases: Rim phase and Recovery phase.

- The Rim phase start with the contact between the hand and the rim of the wheelchair and its further divided in to pull and push phase, during which the elbow angle increases and decreases respectively. The muscles important for the push phase of wheelchair propulsion include anterior deltoid, pectoralis major, serratus anterior, biceps brachii, and the muscles of the rotator cuff. The brachial biceps muscle was predominantly active during the pull phase. The major pectoral and anterior deltoid muscles were active during both the pull and the push phases.
- Recovery phase, the middle and posterior deltoid , supraspinatus , subscapularis, middle trapezius and triceps are predominantly active.

Trunk and hip extensors paralysis after SCI leads to spinal instability, contributing to increased risk of rotator cuff injuries and other chronic health problems with long term manual wheelchair. Paraplegic patients are at a greater risk of developing rotator cuff injuries and tetraplegic patients are at a much greater risk due to increased trunk

instability. Propulsion speed and stroke distance again decreases as SCI increases from lower thoracic level to cervical levels. Exaggerated trunk flexion may be an effective compensatory strategy to create additional forces helpful to propulsion. Similarly, forward trunk lean is beneficial while ascending the ramp and the trunk muscle activity increases with propulsion speed. As the slope of the ramp increases the trunk flexion and shoulder muscle activity also increases.

Wheel chair Skills and Training: "From Rehab To The Real World"

Goals of the wheelchair skill training program:

- To safely and effectively use the wheelchair.
- Provide an evidence-based means for wheelchair skills training
- Overcome indoor and outdoor barriers in the environment and facilitate "participation" in society.

Indoor Skills include crossing thresholds, thick carpet, tight spaces (restrooms, elevators), stairs, escalators.

Outdoor Skills include crossing uneven terrain, depressions, freeing wheels from being struck, raised obstacles, crossing a slope, going up and down hills and ramps, going up and down the curbs.

Note: Wheelchair training trial should be done both indoors and outdoors by patient and care-givers

Following are the brief wheelchair skills required

- Stationary wheelie & pop-ups
- Dynamic wheelie: A dynamic wheelie is moving or propelling while balancing on your rear wheels. You can go forward, backward, turn, and pivot in place.

The wheelie:

A "wheelie" is the act of balancing on your rear wheels in your wheelchair. Wheelies may look like tricks, but "they are the essential building blocks of community wheelchair".

Why learn wheelies?

- To choose the best wheelchair, learning this skills helps the individual best understand the fit of the wheelchair and understand what kinds of features and accessories are essential
- Learning to wheelie helps a paraplegic improve his quality of life and helps to increases the independence level and improve the community participation like going to school, work etc.
- Helps to engage in outdoor sport activity.

Chapter 18
Sexual rehabilitation

Sexuality and sensuality is an important part of quality of eachperson's life. Physical limitations may cause an individual with disability to question his/her ability to experience sexual pleasure. An individual with disability is often seen as asexual, object of pity and unattractive. Thus there will be a feeling of despair which may lead to decreased self-esteem and sexual satisfaction and therefore sexual depression. However, it is seen that individuals with mild impairments suffer from lower self esteem and high sexual depression as comparedto Individuals with severe physical impairments. Thus an occupational therapist and other health professionals must address self perception, belief and needs related to sexuality. One of the most important members of the spinal cord injury rehabilitation team is an Andrologist. As a treating therapist one must arrange for a consultation with an Andrologist. This gives patients an opportunity to discuss their questions, inhibitions, worries and seek advice for maintaining the sexual health.

Sexuality can be addressed by practitioners in any setting. Intervention can occur in homes, group homes, nursing homes, rehabilitation centers, community mental health centers, pain centers, senior centers, hospitals, retirement communities, and other venues.

The following are types of interventions can be offered by practitioners

Health promotion: This approach consists of support groups, educational programs, and stress-relieving activities.

Remediation: This approach consists of restoring skills, such as range of motion, strength, endurance, effective communication, and social engagement, as part of meeting sexual needs.

Modification: This approach consists of changing the environment or routine to allow for sexual activity. Examples include resting prior to sexual activity for those with poor endurance; placing pillows under stiff or painful joints or preceding sexual activity with a warm bath; learning new positions to compensate for immobile limbs; and

using positions that incorporate weight bearing to compensate for tremors

In Females

What are the various sexual dysfunction experienced after SCI?

- Inability to produce vaginal lubrication
- Lack of arousal
- Decreased frequency of orgasm
- Failure to achieve satisfaction
- However, ability to conceive, carry and give child birth is not affected

Areas of concern about sexual activity

- Urinary Accidents
- Bowel Accidents
- Not satisfying a partner
- Feeling sexually unattractive
- Others viewing patient as asexual
- Body image, feeling unattractive
- Not getting enough personal satisfaction
- Combustive preparation
- Hurting self
- Loss of interest
- Not liking methods for satisfaction

Other potential problems include

- Autonomic Dysreflexia
- Physical and verbal abuse
- Aging

Management:

- Good communication with the partner
- Consider for alternate change in position
- Use of lubricants
- Use of various birth control methods like, use of condom by the partner , sponge or diaphragm or jelly, IUDs(not advised due to lack of sensation), birth control pills(vascular complications)
- Consult your gynecologist for guidance regarding the problems concerning libido and sexuality

In Males

What are the various sexual dysfunction experienced after SCI?

- Erectile Dysfunction
- Male infertility

Erectile dysfunction and impaired ejaculation:

Loss of Erection in erectile dysfunction makes sexual intercourse difficult or impossible.

Treatment available:

- **Tablets:** various tablets are available that can help for erection but they do not enhance the libido or help the erection to last longer. There are some side effects of the tablets and must always be taken only after consulting your Andrologist.
- **Self-Injection:** various medicines can be injected directly into the penile area before commencing sexual activity by the patient himself or his wife. The effect of the injection is temporary the drug to be given will be decided by the doctor. Doctor will provide adequate assistance regarding the procedure of injection.
- **Vacuum Pump:** for selective population vacuum pump can be used to elicit erection. This is a non-invasive and safe procedure.
- **Surgery of Penile implant:** Surgery and prosthetics can also be advised by the Andrologist these are invasive modalities but provide a long term effect.

Male infertility

Male infertility encompasses following disorders:

- Inability to perform coitus
- Inability to ejaculate intra-vaginally
- Altered Seminal parameters due to Infection

This hinders the ability to have a child.

Treatments available:

Assisted reproductive techniques, these are the techniques where the process of fertilization occurs outside the body and the embryos are implanted the wife's womb for gestation and pregnancy and child birth.

As the patients are unable to ejaculate various other techniques can be used to retrieve sperms as follows

1. Vibration therapy:
2. Electro-ejaculation:
3. Testicular sperm aspiration
4. Surgical retrieval of sperms

Enhancing an individual's ability to participate in sexual activities can have a profound effect on that person's life. By acknowledging the importance sexuality plays in all of our lives and displaying sensitivity to the personal nature of this activity, occupational therapy practitioners help ensure that all aspects of their clients' lives are addressed in therapy. Providing empathy and appropriate information, devising adaptations, and encouraging experimentation to find resolutions can be invaluable services to clients. When practitioners routinely discuss sexuality as an activity, clients can talk about and address any issues in this area. Collaborative problem solving can empower clients to gain control over this most intimate of areas. It can be self-validating, allow personal expression of sexuality in ways that are meaningful, strengthen self-esteem, and allow that person to become whole again. It is important to assure patients that there are treatments to take care of the problems associated with sexual performance and ability to have children. A multidisciplinary sexual rehabilitation can be achieved with the help of an andrologist or gynecologist, an occupational therapist and patient's partner.

Chapter 19
Cardiopulmonary Rehabilitation

Individuals with spinal cord injury (SCI) have impaired motor control and sensation deficits that limit not only the performance of daily tasks but also the overall activity level of these persons. These populations have been characterized as extremely sedentary with an increased incidence of secondary complications. Physical inactivity is highly prevalent in persons with sci and it appears that activities of daily living are not sufficient to maintain cardiovascular fitness and health.

Due to increasing movement limitation and skeletal deformities there is indirect impairment of the cardio-respiratory function. Therefore early cardio-respiratory endurance training exercises are recommended. These exercises have many beneficial effects on the respiratory system and cardiac system which prevent rapid deterioration and secondary complications. Cardio-respiratory endurance exercises are the exercises that are performed to improve the capacity of the heart to circulate blood and capacity of the lungs to improve oxygenation of the blood during increasing physical effort.

Attention has turned to the introduction of interventions that encompass the neuromuscular, cardiovascular, and pulmonary systems and promote a more holistic approach to neurorehabilitation. Cardiopulmonary rehabilitation is therefore an integral part of their rehabilitation.

Benefits of cardio-respiratory endurance exercises

1. Heart and lungs

- Increased blood pressure as immediate response to exercise improving the blood circulation
- Reduction in the blood pressure as a late response to exercises reducing the cardiac stress
- Improved capacity of the heart to pump blood
- Improved return of the blood from extremities to heart preventing stagnation of the blood in extremities

- Improved capacity of the lungs to breath in the air
- Improved oxygenation of the blood
- Improved clearance of carbon dioxide from the blood
- Ability to breath air out more forcefully
- Prevention of aspiration and secondary respiratory infection
- Improved ability to clear secretions by coughing, preventing secondary respiratory infection

2. Blood vessels and blood circulation

- Formation of new blood vessels
- Improved connections and network of blood vessels
- Improved circulation to the deep muscles of the body, brain, lungs, liver and kidney
- Improved clearance of toxic waste substances from the blood

Breathing exercises

Goal is to strengthen diaphragm, intercostals if innervated, or accessory muscles for a deeper inhalation or to focus on intercostals if inervated for a more forceful exhalation needed for a productive cough.

1. **Diaphragm position for maximum contraction -** patient is supine with a pillow, and posterior pelvic tilt, with arms resting at the sides in shoulder adduction and internal rotation will slacken the accessory muscles and enhance diaphragmatic function. Patient is told to take deep breath from the belly, and to relax the shoulders, also therapist can provide firm manual pressure to the shoulders

   In the inferior direction. Weights can be used on the abdomen, but we should get correct motor performance, and discourage accessory muscle breathing. Later diaphragmatic activities in other functional positions used.

2. Strengthening the accessory muscles

The muscles in the neck and pectoral regions should be strengthened. Position that facilitates their activation is by not using a pillow, bring shoulders in abduction and external rotation, and anterior pelvic tilt, mirror can be used to give feedback. Therapist can apply manual pressure at exhalation to inhibit diaphragmatic contraction. Prone on elbows is a diaphragmatic inhibiting position that allows the patient to better use accessory muscles.

3. Glossopharyngeal breathing

If only accessory muscles used, it is tiring. Patient should be taught glossopharyngeal breathing, also called frog breathing or air stacking. Muscles of the tongue, soft palate, pharynx and larynx work together to create a pumping

action that forces gulps of air into the trachea and lungs. Patient traps air in a pocket of negative pressure within their mouths, which allows them to maximize that space, pulling in more air, then closing their lips, and forcing the air back and down the throat with stroking maneuvers of the tongue, pharynx and larynx. More than 60 % of patients with high sci who are unable to breathe without the ventilator, can achieve autonomous breathing for hours or even all day with this technique.

4. Incentive spirometry:

Incentive spirometer (Fig 19.1) is a small portable device which helps to keep the lungs clear. It helps to strengthen the chest muscles. It is important that wheelchair bound patients use spirometer to maintain their respiratory functions for as long as possible.

Assisted cough techniques

- heimlich assisted cough
- costophrenic cough
- anterior chest compression
- tetraplegia long-sit assist
- prone on elbows, self assist
- huffing and coughing

1. Heimlich assisted cough

It is also called abdominal thrust assist.

i. Therapist places the heel of one hand just proximal to the patient's navel and the xiphoid process.

ii. Instruct the patient to take deep breath or air stack with hold for several seconds.

iii. Instruct the patient to cough, therapist simultaneously applies an anterior and superior force to increase the expiratory effort of the patient.

iv. Also can be done in sitting in a wheel-chair or when in a postural drainage position, including supine or side lying (with one hand on the posterior thorax for stability)

2. Costophrenic assisted cough (for those who cannot tolerate heimlich assisted cough) this maneuver functions in the same manner as innervated intercostal muscles.

i. The therapist places the palmar surface of hands along the costophrenic angles of the rib cage with fingers laterally spread in the direction of the ribs.

ii. Quick stretch is given downwards and inwards on exhalation.

iii. This quick stretch can facilitate an improved contraction of the diaphragm and the intercostals muscles.

iv. After inspiration hold air and instruct to cough.

v. Quickly apply a lateral and inferior manual force to enhance the force of the patients exhaled air flow.

vi. Best position is side-lying.

3. Anterior chest compression

It is modification of the costophrenic assist, which facilitates the upper chest rather than the lower.

i. The therapist places one hand or entire forearm across the chest wall and the other across the lower chest wall.

ii. As the patient coughs, the lower hand or forearm still compresses to assist exhalation while the upper hand stabilizes and compresses the upper chest as well.

4. Counter-rotation assisted cough

It is also called massery's counter rotation assisted cough technique.

i. The counter-rotation assisted cough compresses the thorax in 3 planes for a maximal exhalation.

ii. It is performed in side-lying, for patients where there is no contraindication for spinal rotation.

iii. When patient is left side-lying with 45 degrees of hip flexion, therapist kneels behind the patient diagonally facing patient's shoulder.

iv. The therapist's left hand should be on patient's right scapula and right hand on patient's asis.

v. Patient is instructed to take a deep breath, therapist pushes the upper thorax superiorly and anteriorly with the left hand and pulls the pelvis inferiorly and posteriorly, with the right hand the therapist pulls the upper chest inferiorly and posteriorly with the left hand and simultaneously pushes the gluteal region superiorly and anteriorly with the right, patient is told to cough.

vi. This maneuver functions in the same manner innervated intercoastal muscles.

5. Huffing and coughing

Take a deep breath. Make sure that your belly rises outwards as you breathe in. Hold your breath for 2 seconds. Open your mouth wide and forcefully breath out squeezing your belly. You may also apply some pressure on your belly with your hands. Huffing is different from forced exhalation. In huffing you open your mouth wide in forced expiration mouth is pursed. Perform 8 - 10 huffs, if any secretions are mobilized cough and spit it out. Perform more huffs, if more secretions are present or chest congestion is persistent. Make sure to perform deep breathing exercises after coughing. Perform 2 to 3 cycles or till the secretions are cleared

Benefits:

- helps to mobilize secretions from the deeper regions in the lungs
- airways are cleared
- improved oxygenation of the blood
- improved throwing out of the carbon dioxide
- reduced risk of infections

Combination of breathing exercises and secretion drainage and removal:

1. Active cycle of breathing techniques

Active cycle of breathing technique consists of various performing breathing control (deep breathing), huffing and coughing in a cyclic pattern. It helps for best mobilization and removal of the secretions. Breathing control is relaxed breathing mainly used to control the speed and depth a breath. During the ACBT technique a person performs, 3 deep breaths (as explained in deep breathing exercises) followed by 1 breathing control and 3 huffs/forced exhalation finally cough. 3 - 4 such cycles are repeated till the secretions are cleared out. Frequency: 1 -2 cycles / day or as and when secretions accumulate

Benefits:

- helps to mobilize secretions from the deeper regions in the lungs
- airways are cleared
- improved oxygenation of the blood
- improved throwing out of the carbon dioxide
- reduced risk of infections

Positional drainage

Positional drainage includes positioning a patient in a position conducive for mobilization of secretions depending upon the lobe of the lungs involved. It will be suggested to you by your therapist after detailed respiratory assessment and auscultation. The positions are simple achieved using stack of pillows for support. After each position perform ACBT or forced exhalation to clear secretions. Each position should be maintained for 10 to 15 mins / twice a day when secretions are accumulated causing chest congestion.

Benefits:

- helps clear the lung secretions
- passive relaxation
- better oxygenation of the blood

Patients should be vigilant to prevent chest infections

How to recognize chest infection?

- breathing difficulty
- breathing by mouth
- dryness of mouth
- changes in the quality of voice
- frequent sneezing and coughing
- increased secreations with mild, moderate or high fever
- chest pain
- lethargy
- general body pain

Treating chest infections:

Recurrent chest infection may be a secondary complication of the spinal cord injury. To prevent recurrent chest infection maintaining regular hygiene and performing exercises that aid in deep breathing and clearing out the secretions is advised.

In an event of a chest infection consult your physician immediately.

Cardiovascular endurance training:

Cardiovascular endurance training is achieved through graded physical activities and prescribed based on the heart rate, blood pressure response to exercise and rate of perceived exertion. Physiotherapist will first conduct an arm ergometer stress test to measure these responses. A simple scale called borg's rate of perceived exertion scale (Fig 19.2) will be used during the day to day exercise training. Physiotherapist should choose the intensity depending on the goal of training the cardiovascular endurance or mentainance of cardiovascular endurance. The training should be conducted for 3 to 5 days a week for min. 40 mins in each session.

Rating	Description
6	No Exertion
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very Hard
18	
19	Extremely hard
20	Maximum exertion

Examples of cardiovascular endurance training activities are: cycling, swimming, walking, arm cycling, seated aerobic exercises, and rowing.

Chapter 20
Psychological Rehabilitation in Spinal Cord Injury

A spinal cord injury is a traumatic event which leaves a major psychological impact on the individual. A new spinal cord injury patient finds it extremely difficult to accept the sudden loss and come to terms with his physical disability. A person who had been leading a well functioning independent life now requires assistance for all the basic activities of daily living. There is loss in terms of all the major areas of life such as walking, sexual functioning and bowel and bladder control. The person experiences loss not only in terms of his physical abilities but also his self-confidence, self-esteem and self- worth. There are instances of increased irritability and anger outbursts which start affecting their relationships with family and friends. Many patients with the injury also tend to experience suicidal tendencies. Therefore, optimal emotional adjustment is imperative in the process of recovery as tremendous psychological strength and motivation is required for an SCI patient to learn self care, independence and coping skills.

Psychological Adjustment

Psychological adjustment to spinal cord injury can be divided into three major theories.

The first is referred to as the "stages theory" derived from the work done by Lindeman and Kubleross. According to this theory, an individual with spinal cord injury undergoes various psychological stages in the process of readjustment. These include (1) shock and denial, (2) depression, (3) anxiety, (4) anger and (5) adaptation.

1. Shock & Denial

Shock is the first and foremost natural reaction that an individual undergoes after spinal cord injury. Psychologically, shock acts as an "unconscious protection against too massive or too rapid a perception of the traumatic and overwhelming reality" as described by Gunther (1969). The patient also tends to be in denial, a defense

mechanism which helps the victim to avoid accepting the loss and keep the pain away.

2. Depression

After going through the first stage of shock and denial, the patient slowly comes to terms with the loss due to which he/she can get into depression. It in fact contributes to the disability and handicap of the patient with SCI. Therefore, early diagnosis and treatment of depression is instrumental in improving the patient's response to rehabilitation as well as in reducing the psychosocial sequelae of the injury. If clinically appropriate, the patient should be started on psychopharmacological treatment along with a referral to a mental health provider for supportive counseling.

3. Anxiety

A patient with Spinal cord injury often re-experiences the whole trauma through flashbacks and nightmares. He may have difficulty falling asleep, be irritable and hyper vigilant. This can lead to withdrawal and isolation which may impact the process of rehabilitation. Seeking professional help through counseling and psychotherapy can help minimize the level of anxiety.

4. Anger

In this emotional stage of recovery, the patients may blame others, throw tantrums or become extremely frustrated. Anger, aggression and rebellion are necessary to move towards maturity. However, most of their anger is also turned inwards, blaming themselves for the injury and loss. This is a critical time to offer emotional support and clear communication emphasizing realistic expectations before starting the process of treatment.

5. Acceptance

As time goes by, slowly and steadily the patient comes to terms with his injury. When they develop a healthy acceptance of their condition, they gain a positive attitude and a hope for the future which helps in the process of recovery and rehabilitation. This is the time when they can plan for the future, along with the family and the therapists figuring out options keeping into consideration their upper body functioning, strengths and possibilities.

It is important to note that not all patients will undergo all the above stages or in the same order. It is also possible that they may go through a stage more than once. This model is helpful in understanding the normal emotions that an SCI patient experiences as a part of adjustment to his injury.

The second model is referred to as the "developmental "theory derived from Erikson's work on psychosocial stages of development, from infancy to adulthood. As applied to Spinal Cord Injury, the developmental theory suggests that the trauma leads to a natural regression, followed by a reworking of some developmental tasks which

were earlier mastered in childhood, starting with (1) basic trust, (2) autonomy and (3) initiative. Physically and psychologically, SCI patients must progress through tasks of infancy and childhood again. Like infants, they initially may be unable to verbally communicate or express themselves, need to be fed and moved, have no bowel and bladder control, and are totally dependent. As they progress through rehabilitation, they relearn childhood tasks such as rolling, feeding, developing a bowel and bladder routine, mobility, and other basic activities of daily living. They experience the adolescent task of separation from parental figures as they work toward the independence of adulthood. The rehabilitation program can be seen as facilitating achievement of these developmental landmarks.

The third model is the 'individual differences" theory according to which the process of adjustment to spinal cord injury is related to the patient's pre morbid personality. Traits such as emotional lability, frustration tolerance, impulsivity, perseveration and mental stamina determine the progress in his/her recovery.

Psychological Aspects in the Rehabilitation Setting

In an ideal setting, psychological rehabilitation begins in the ICU soon after the injury. At this time in the ICU, many patients with SCI are intubated and are unable to communicate verbally. They often experience disorientation, depression and anxiety and at times, sensory and sleep deprivation. This is a crucial time to offer emotional support, have clear communication and reassurances to the patient that their emotional responses and concerns are absolutely normal and accepted. As the patient progresses towards the rehabilitation setting, regular sessions of counseling and psychotherapy can help cope up with the transition and deal with the emotions effectively.

During the psychotherapy sessions, many patients with SCI can exhibit a range of ego defenses such as denial and repression. These ego defenses actually help the psyche deal with the material that is too traumatic consciously, which prevents decomposition. Denial and repression in this situation act as adaptive coping mechanisms which helps the patient to function in a stressful rehabilitation setting so soon post injury. As the level of denial decreases over time, depression, anger and anxiety increase which again needs to be managed with the help of a psychologist or the primary caregiver through supportive counseling.

It is also important to note that some of the emotional responses exhibited during the process of adjustment to spinal cord injury may impede progress in rehabilitation. Depression may cause psychomotor slowing, social withdrawal, decreased motivation and feelings of helplessness due to which the patient may not feel motivated to exercise. Anxiety may create psychogenic somatic symptoms and poor attention and concentration. Anger may lead to temper tantrums and rebellious behavior. Psychotherapy can help the patient learn new coping strategies to deal with these emotions. The psychologist can work with the interdisciplinary team of occupational therapists and physiotherapists to develop behavioral modification programs to reduce these behaviors. Positive reinforcement used to shape desired behaviors is particularly

found to be effective in such cases.

Psychological Response to Orthotic devices

A spinal cord injury patient in the rehabilitation setting has to also get adjusted to using orthotic devices, which is also referred to as "gadget tolerance" in order to carry out his activities of daily living. This adjustment is primarily related to the type of orthosis, pre morbid personality factors and stage of emotional adjustment.

Orthoses which is used to stabilize the spine after surgery can sometimes become the target of patient's emotional distress. Anger that is expressed toward an inanimate object is safe whereas anger expressed towards a family member or the therapist can have negative repercussions. Understanding of these psychodynamic issues can help the orthotist deal with anger issues post surgery.

Upper and lower limb orthoses which are used to enhance the level of independence in a patient of SCI can elicit a variety of positive emotional responses as well. The potential for increased and independent functioning often provides a major psychological "lift", enhancing patients' sense of confidence, self-esteem and competence. However, it is critical to take into consideration the patient's psychological factors before introducing them for orthoses. A patient who is not emotionally ready to get adjusted to the addition of devices for his functioning can result in a rebellious or destructive behavior and a failure of experience for all concerned.

There are various reasons why SCI patients may not get adjusted to using orthotic devices:

Body Image: Many patients of SCI agree that they look "normal" except for the wheel chair. However, with the inclusion of orthoses, patients sometimes become conscious of their appearance as they notice people staring at them more and making judgments. As a result, it tends to increase their social anxiety and discomfort. Cognitive therapy in this aspect can help the patient deal with this negative belief system in a better way.

Independence: dependence conflicts: As a spinal cord injury patient is recovering, he/ she tends to get used to all the attention and assistance of caregiver, family and friends. These are called secondary gains in their dependent state, which the patient may or may not be consciously aware of. Therefore, if an upper limb orthosis significantly increases his level of independence in carrying out his basic activities of daily living, the patient may experience withdrawal of the valued reinforcers (time, attention and concern of the caregiver at every point of time). This can lead to not accepting the orthosis. However, these issues can easily be resolved with the significant caregiver being aware of these emotions and providing the patient with attention and positive reinforcement for the new independence behavior. It is important to be insightful of the fact that the patient does not feel neglected or rejected in this process.

Self-concept: Becoming wheel chair bound after spinal cord injury can drastically change the self concept of a patient. He/ she might have never imagined himself

being confined to a wheel chair. As a result, they may not integrate disability into their self concept for some time. Orthosis may conflict with this self image as a result of which, he/she may not cooperate with the therapists for the use of new compensatory mechanism or devices.

Denial: As an SCI patient is still in the phase of denial, introducing orthosis may threaten his denial system significantly. Patients who have not yet acknowledged or accepted the extent of their damage or loss or the permanence of their disabilities may very easily reject the use of orthoses. In such cases, patient needs to be given more time and understanding from the family and the therapists to adjust emotionally to their disability. On the other hand, some patients may exhibit unrealistically high goals for orthoses. For example, a patient using lower limb orthoses may find it impractical for use in pre-injury activities. As a result, he could feel more depressed and angry leading to decreased motivation and rejection of orthoses. Clear communication and empathy, emphasizing realistic expectations before using orthoses may prevent some of these responses.

Pre-morbid personality: Long standing personality traits such as poor frustration tolerance, impatience, risk-taking behavior, substance abuse and stage of emotional adjustment - especially depression can lead to poor self care resulting in pressure sores. Attention to these psychological factors in selecting patients for orthoses becomes an important part in the process of recovery. Therefore, opinion of a Psychologist and timely consultation while discussing patients in the multi-disciplinary team of rehabilitation becomes extremely crucial for the progress and benefit of the patient, both physically and psychologically.

Psychological Intervention:

Psychological intervention plays a very important role in the rehabilitation of a patient with Spinal cord injury. The combination of depression with spinal cord injury can be lethal. Therefore, it is of vital importance that it must be assessed quickly and addressed with skill, knowledge and therapy.

Cognitive Therapy

Cognitive therapy is an active, directive, time-limited treatment based on the rationale that a person's depressed mood and behavior are determined by cognitive or automatic thoughts, derived from previous experiences in life (Beck et al., 1979). The inaccurate thinking pattern that predisposes a person to depression includes a tendency to view ongoing experiences in a negative way, negative sense of self and negative sense of future. In cognitive therapy, the depressed person is helped to recognize these negative irrational thoughts, and challenged to identify the rigid belief system about himself. The therapist helps the person to think in more flexible ways, challenge old beliefs and change old behavior. He helps the patient make goals for himself which acts as a boost for his motivation. The therapist also helps the SCI patient identify his strengths, physical abilities and accordingly plans for the future.

Group Therapy

Group therapy is another form of psychotherapy wherein the patients come together as a small group and share their experiences and difficulties. Patients at various stages of development and recovery can be inspired and encouraged by another member who has overcome his difficulty. This gives them a platform to express all their feelings, emotions and concerns and a supportive environment where they will be understood. This recognition of shared experiences helps them to come out of their isolation, develop more adaptive coping skills and raise their self-esteem. They can get inspired and motivated from a successful SCI patient who is living an independent life, with a job of his own, despite his disability. This brings a sense of realization in other struggling patients who think that "if he can do it, even I can do it". He can now learn to take responsibility of his life once again and start making changes in his thinking, behavior and functioning.

Sexual Counseling

A person who has suffered spinal cord injury still has all the same emotional feelings and physical needs as before injury, even though he is physically different. Emotional distress and depression following spinal cord injury leads to low self esteem and feelings of being physically unattractive which in turn leads to withdrawal from social and sexual relations. The patient starts feeling inadequate about himself and harbors doubt in terms of satisfying his partner. There is fear of being abandoned by one's partner as well. This leads to increased anger outburst and frustration, affecting the husband-wife or couple relationship. In such cases, it is important to have separate individual counseling sessions for the patient and his partner. Timely consultation with an Andrologist and an Urologist also plays a very important role in terms of getting the male SCI patients' concerns clarified with respect to erectile dysfunction, ejaculatory dysfunction or semen abnormalities. Alternatives in sexual expression should be discussed without any pressure to experiment. The importance of communication skills with an emphasis on touching forms an important aspect of treatment.

Vocational Rehabilitation

Employment provides a means of financially supporting one's self and the family, and serves as a basis of personal relationships and identity. It has been found that patients with Spinal cord injury who are employed tend to have fewer problems, are behaviorally more active, are more satisfied with their lives, have fewer medical treatments, complete more years of education and rate their overall adjustment higher than those who are unemployed. They tend to exhibit positive psychological traits such as higher self-esteem, optimism and are more achievement oriented. Therefore, it is highly recommended for patients with spinal cord injury to consider various employment options utilizing the functions that are still present along with their skills, strengths and potential. Employment options can be discussed with the Psychologist and other therapists in the team, keeping into consideration the patient's

level of emotional adjustment, socio-economic background, educational qualification, cooperation and support from the family and their field of interest. Patients with spinal cord injury need to start the process of seeking employment, in parallel with their treatment and not keep waiting for things to change and then start working. With the advancement of assistive technology, there are many options available in the present time that an educated spinal cord injury patient can avail of.

Psychological Assessments:

Psychological assessments are conducted on the patient to gauge the level of impact that the injury of the spinal cord has caused. As, this is a life changing event which causes the patient to make constant adjustments and impacts all the sphere of life, hence evaluation of all the aspects is required to see the coping mechanisms of the patient.

Becks Depression Inventory (BBDI - II): This is a 21-question multiple-choice self-report inventory, one of the most widely used instruments for measuring the severity of depression. Each answer is scored on a scale value of 0 to 3. The cut-offs used differ from:

0-13: minimal depression

14-19: mild depression

20-28: moderate depression

29-63: severe depression.

Higher total scores indicate more severe depressive symptoms.

Stress: The Depression Anxiety Stress Scales (DASS): [1] is made up of 42 self report items to be completed over five to ten minutes, each reflecting a negative emotional symptom [2]. Each of these is rated on a four-point Likert scale of frequency. These scores ranged from 0, meaning that the client believed the item "did not apply to them at all", to 3 meaning that the client considered the item to "apply to them very much, or most of the time". It is also stressed in the instructions that there are no right or wrong answers.

Quality Of Life Questionnaire: The SF-36: This is a multi-purpose, short-form health survey with only 36 questions. It yields an 8- scale profile of functional health and wellbeing scores as well as psychometrically-based physical and mental health summary measures and a preference-based health utility index.

Suicide Risk Questionnaire to assess the suicidal ideation in a person with spinal cord injury.

Hamilton's Psychiatric Rating Scale for Depression to assess the severity of depression.

Hamilton Anxiety Rating Scale is conducted on the patients to gauge the level of anxiety in the patients.

Section C

Recent Advances in Spinal cord Injury

Chapter 21: Robotics

Robotics in spinal cord injury rehabilitation is used to remediatethe sensoryand motorimpairments and improve physical abilities required for independent mobility and self-care at home, in the community, at work, and during the performance of recreational activities. It is also known as computer-assisted technology, mechanotronics, biomechanotronicsetc,.Robotics in spinal cord injury rehabilitation uses brain and sensory-motor interfaces, virtual reality (VR) environments, and learning-based gaming programsto maximize independence and quality of life people with moderate to severe physical impairments.Robotics is not a replacement for individual therapy but is considered supplemental to "one-on-one rehabilitative therapy.

Therapeutic robots help the clinicians' goal of facilitating recovery not only by delivering measured therapy but also by affording new ways to evaluate patients' progress.It can allowclinicians and individuals to take responsibility andcontrol the environment according to patients need andaidfor physical and cognitive recovery. It complies with learning-based practice to drive neural adaptation and neural reorganization.

Robotics in spinal cord injury rehabilitation can provide

- service unweighting,
- passive assistance,
- active assistance,
- variable and on-demand assistance,
- a combination of service and assistance.

Most of the robotic systems are electromechanical systems controlled by the patient or the therapist. Robotic interfaces, actuators, and controllers can convertsensory, physical, and cognitive signals to control robots,permit perception of relationship in spatial, mobilize individualsin space, assist in object manipulation, provide emotionalsupport, and allow individuals to call for help and communicatewith others. Various studies have showed there emergence of roboticsin the field of rehabilitation and the benefits in recovery of functions in patients with spinal cord injury.

Uses of robotics

1. It can indirectly augmentingfunctional independence by:
    a. performing mobility tasks for individuals at thehome (e.g., using automatic motorized wheelchairsto move from room to room;transitioning individuals from bed to chair andfrom chair to standing; moving patients who arestanding)
    b. minimizing the need for assistance from care giver
    c. performing functional activities of daily livinglike getting objects, cooking food, doingdishes, bathing, transferring
    d. helping perform difficult or repetitive tasks atwork (e.g., assembly line tasks; lifting and movingheavy objects)
2. Improving motor skill capabilities directlyand enable individual to:
    a. perform functional tasks independently
    b. improve voluntary control
    c. perfection in quality of movement
    d. learn new skills

Roboticsshould be

A. task and goal oriented,

B. repetitive, progressive and purposeful,

C. fun, interesting, and practical

D. provide feedback on accuracy of task completioncan be matched to patient abilities

E. safe for training

F. reliable in performance

G. able to reduce risks of injury (e.g., falls)

H. able to minimize injury during use

I. reasonably priced and cost-effective

J. versatile& easy to use

K. durable&repairable

With the recent advancement in the technology and proliferation of innovativehardware, new control strategies, improved compliance systems,error amplification strategies, adaptive controls, and optimization of neurocomputational modeling, robotics andtechnology can provide assistance within virtual environmentsto speed up learning and recovery which helps the patient to live a near normal and independent life.

Rehabilitation robots include:

1. Service robots for movement
2. Service robots for physical assistance and indoor and outdoor navigation
3. Nonwearable robotic assistive device for mobility, unweighting, and object manipulation
4. Wearable robotic assistive device for upper-limb object manipulation
5. Wearable robotic assistive device for lower-limb mobility and gait training
6. Communication robotics to enable interpersonal interaction
7. Interactive entertainment robotics for companionship and emotional support

Robotic rehabilitation is an emerging field and it is important to know that there are a number of motorized chairs, lifts, and walkers available that can be used to transition a patient from sitting to standing, or provide unweighting while walking or working on balance.

Types of robotics

Service robots usually focus on task performance,movement assistance, and stability. These devices can befixed, can be movable, or can be attached to a wheelchair.

These modalities can help us to perform are ADLs without any efforts. It can assist us in feeding by taking the food from the plate to mouth, grooming, brushing etc. The robotics used are Handy 1, Neater Eater, My Spoon etc.

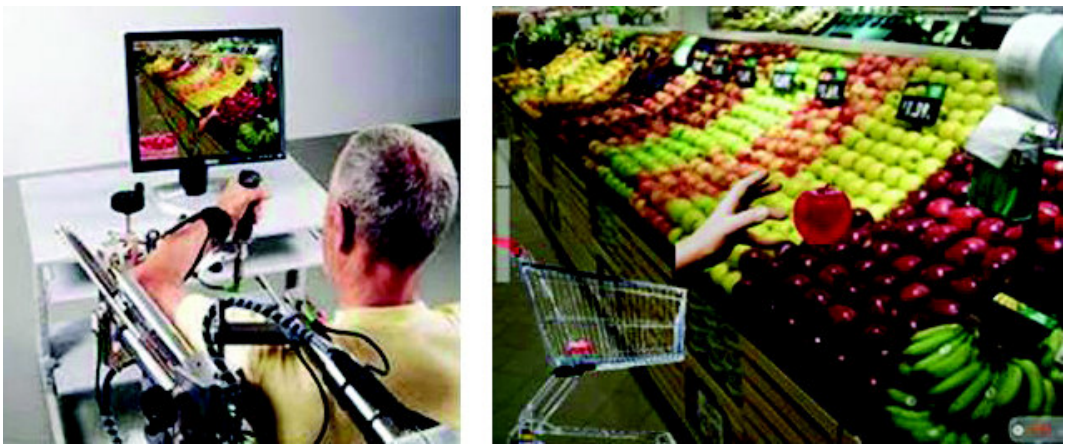


Fig 21.1: Service robots a) Neater Eater b) My Spoon c) Handy 1.

Assistive robotic devices help patients performa task with direct or indirect assistance. Some of the assistiverobotics are nonwearable but assist through unweightingor movement assistance.Wearable roboticsis specifically designed to be worn by patients to assistmovements. These are designed for the upper limb, trunkand lowerlimb.

Fig 21.2WearableAssistive robotics for upperlimb trunk and lower limb.

Erigo includes verticalisation of leg movement and loading on an adjustable tilt table with a robotic stepping mechanism. The Hybrid Assistive Limb (HAL)exosuit can help SCI patients to regain some mobility whichwas developed in Japan. In normal individual, when we want to move the brain sends a signal through the spinal cord and the nerves to a muscle in a body part such as a leg or an arm. However, in paralyzed limb, these spinal nerve structures are damaged, and the muscles operate with signals that are too weak to reach the leg or the arm. Because of this patients cannot walk or move certain body parts. But the HAL robot suit can actually use these weakened signals through sensors that are attached to a patient's skin, and can set its motors, located in the pelvic and knee-joint regions, in motion. This effectively connects the robotic suit to the patient's nervous system and helps the individual to regain some mobility.

Fig 21.3 a)Erigob)Hybrid Assistive Limb (HAL)

Lokomat is a combination of a robotic gait orthosis and an advanced body weight support system with a treadmill. The robotic arms helps to move the paralyzed hips and knees at an adjustable speed. Armeo has an adjustable arm support and a sensitive handgrip for upper limb retraining. These devices have advantages like improvement

in a patient in a shorter span, better gait and symmetry and reduced manpower. EKSO 2020 (exoskeleton) is an upcoming robotic suit for paraplegic patients on whhhelchair. This will help an individual for active motions beyond their limit and is designed with remote control system for easier and faster application.

Fig 21.4 a)Lokomatb)Armeo

Vocational robotics can enhance performance atwork either in terms of repetitive motions or high-forcetask production that would otherwise be dangerous tohumans.

Emotional support roboticsisdesigned to provide emotional support for isolated individualsat home.

Virtual Reality training technology (with and without robotics)provides the opportunity to simulate simple and complexenvironmental and clinical situations to facilitate learning in a virtual environment.

It can help by

- movement control
- Creating simulated environments for teaching patientshow to perform different tasks, such as driving
- Using gaming computerized technology to facilitateneural reorganization
- Using computer technology to teach how to do homeexercises

Game-oriented computerized learningsystems are popular for fun and recreation,but they can also facilitate sensoryand motor skill development.

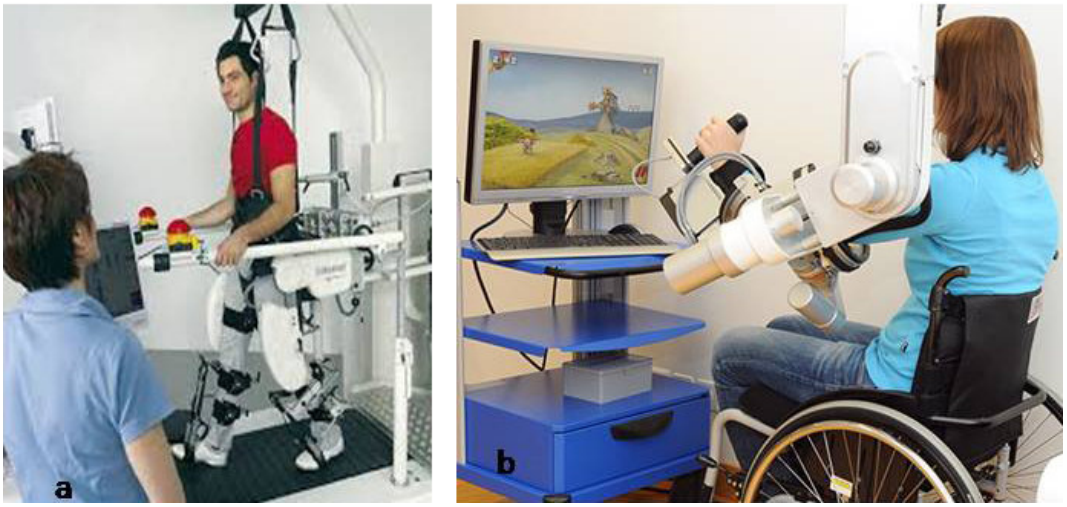


Fig 21.5 Virtual reality gaming system(improves hand function through minor hand movement to buy fruitsfrom the fruit shop visualized on the screen imitating the real environment)

The costs of these equipments are in million dollars. The hospital charges INR 1500 for a session of forty min and the total cost for the entire course of therapy is INR 25 000-40 000. Even though this seems like not a significant sum, it is a great deal of money for the average Indian.

Various robotic projects are undergoing in Indian Institute of Technology (IIT) though, but their applicability to rehabilitation is not clear. Although there have been research projects reported from various premier institutions in this area, none of the products have reached the mainstream.

Chapter 22 : Aquatic therapy

Aquatic therapy is one of the most widely used rehabilitative techniques for spinal cord injury. Aquatic therapy means making use of different physical and chemical properties of water to facilitate functional recovery, independence, prevent complications and allow for freedom of movement in individuals with spinal cord injury. Aquatic therapy is defined by The Aquatic Therapy and Rehabilitation Institute as "The use of water and specifically designed activity by qualified personnel to aid in the restoration, extension, maintenance and quality of function for persons with acute, transient, or chronic disabilities, syndromes or diseases".

Benefits of aquatic therapy in Spinal cord injury

- It improves the blood supply to the deeper muscles and helps to slow down the fibrotic processes.
- It provides a higher degree of freedom of movement which helps in boosting the morale, move the joints through their full range preventing secondary complications like muscle tightness, contractures and cardio-respiratory complications.
- It has a distinct physiological mood enhancing effect which may prevent negative emotional responses in individuals with spinal cord injury.
- Reduce the work of the muscles thereby preventing accelerated muscle damage.
- It prevents the eccentric contractions of the muscles while performing various movements and therefore helps reduce the muscle damage.
- Aquatic therapy also improves respiratory capacity and cardiovascular endurance.
- Aquatic therapy and warm water exercises have pain reducing effect while stretching the muscle contractures; it also makes the muscles more pliable and easy to stretch.
- Increased blood supply, hydrostatic pressure of the water, improved endorphins and serotonin levels also helps to improve appetite and bowel movements. It

can prevent complications like severe constipation.

- Aquatic exercises help reduce sleep disturbances.

Properties of water

1. Buoyancy

Buoyancy is the upward push that water exerts on the immersed body. It is responsible for the weightlessness experienced in water. Deeper the immersion greater is the weightlessness. If an individual is immersed till umbilical level then the effective weight on the legs is reduced by 50% and when immersed chest deep it is reduced by 75%.

Weightlessness is a very important phenomenon for therapeutic benefit. Weight bearing joints like ankle, knee and hip joints can be offloaded in water which helps reducing the stiffness of the muscles. Therapeutically this can be used to relieve the compressive forces on the joints.

2. Hydrostatic Pressure

Is the pressure exerted by water and depends upon the density as well as the depth of immersion. The deeper we immerse an individual the greater is the force. This is particularly helpful for reducing the swelling and providing passive relaxation through deep pressure. Hydrostatic pressure is also important to push the blood from the legs and thighs up increasing the blood returning to the heart. This also helps in increasing blood supply to the brain and therefore cognitive functions. The increased blood supply to heart is important for good cardiovascular health.

3. Density

Water is thicker or denser than the air. The density of water is more than the air and almost similar to human body. The density of water is important therapeutically as it is this quality of water that supports an individual once immersed in water and also exerts an upward force. Because of the difference in the densities of various tissues in the body, a leaner individual with lesser fat tissue will tend to sink more in the water whereas individuals with more fat tissue will tend to float.

4. Viscosity

Viscosity of water is the amount of friction generated with a movement in water. The friction is significantly higher in water than air which provides resistance to any movement of the body. This makes water an excellent strengthening tool. The Resistance provided by the water is dependent upon the speed of the movement and direction of the movements which are patient dependent. In painful conditions if the patient stops the movement the resistance drops to zero and therefore the strengthening activities can be performed within the limits of patient's tolerance.

These unique properties of water provide desirable environment for the individuals with spinal cord injury. Immersion in water brings about beneficial effects in various body systems of an individual with spinal cord injury.

Beneficial effects of water immersion

Muscles and bone

Immersion in the water increases the blood returning to the heart and in turn the blood delivered to all the organs. Most of this blood is supplied to skin and muscle tissue. Blood supply to the deep muscles increases nearly threefold during chest level immersion. Improved blood supply helps slow down the pro-fibrotic processes in the muscles. In addition to this as the muscles don't have to perform lengthening contractions for movements in water, the damage to the muscles is minimized and therefore the fibrotic processes are further slowed down. Immersion offloads the joints facilitating relaxation of the muscles and smooth movements. The resistance provided by viscosity of water for any kind of the movement helps in stabilizing the tone and strengthening the muscles. Improved circulation helps improve flexibility and pliability of the muscles. Reduced fibrotic processes, improved pliability and strength of the muscles, prevents the secondary tightness and contractures. Aquatic immersion also helps to reduce spasticity and the effect can incorporated to train new motor skills.

Most of the individuals with spinal cord injury develop osteopenia (reduced density of bones) or osteoporosis (brittle bones) in the later stage of the disease due to not bearing weight on their extremities. The bone density therefore is a concern. Aquatic exercise helps to increase the bone density.

Heart and lungs

Water exerts compressive pressure on the blood vessels and pumps up the blood from limbs to the heart. In individuals with spinal cord injury because of inactivity, muscle weakness and possible secondary contractures and tightness the blood circulation is sluggish. This causes the blood to be pooled in the extremities and toxic waste to be accumulated. Immersion in water helps clear the toxic wastes. Improved blood pumping in the heart also provides heart with more blood to pump out improving the blood supply to the lungs and better oxygenation of the blood.

Compressive forces of the water provide resistance to the respiratory muscles (muscles required for breathing) and help strengthening these muscles. Exhalation or breathing out is passive rebound compression of the rib cage. In spinal cord injury due to muscles weakness and deformities there is incomplete exhalation of the air. Air is exhaled from only the upper parts of the lungs but accumulates in lower parts. Such accumulation could have various detrimental effects on the body. Immersion in water compresses the rib cage helping in better exhalation and lesser accumulation.

Brain and Nervous system

Increased blood supply to the brain leads to improvement in memory and other cognitive symptoms. An individual is more attentive in the water. Water immersion facilitates stimulation of Para-sympathetic nervous system which facilitates relaxation of the body and suppression of the sympathetic nervous system that is responsible for the responses of anxiety. Immersion in water therefore facilitates relaxation and further suppression of the fibrotic processes.

Aquatic exercises increase serum endorphin (hormone responsible for mood elevation) levels and levels of neurotransmitter serotonin which are responsible for reducing pain and controlling many functions like sleep, appetite but mainly mood. Aquatic exercises have a psychological mood elevating effect.

These beneficial effects of water immersion are used by for therapeutic benefit by aquatic professionals. It is important to understand that although immersion in water is beneficial, goal oriented and targeted exercises are required for optimum recovery and maintenance of the individuals with spinal cord injury.

What to expect in an aquatic therapy session?

Aquatic therapy does not mean just swimming in water. Aquatic therapy includes purposeful therapeutic movements or exercises performed in order to achieve optimum benefits for the individuals with spinal cord injury. There are various techniques in aquatic therapy. An exercises session will consist of a combination of these techniques and approaches like Hall wick therapy; Bad-Ragas ring method, Clinical Ai-Chi, Aquatic exercises, Aqua aerobics and Passive relaxation or Watson. Mostly in spinal cord injury an exercise session will be conducted one - on - one by the therapist but group sessions may also be conducted to improve participation and peer interaction.

In the beginning the exercise session will emphasize on adaptation to water environment and being comfortable in water. Important aspect of the therapy is to

Figure 22.1 Completely supported entry into the pool

teach the patients to enter and exit out of the pool independently in the beginning therapist can give higher support to the patient (Fig 22.1) and then reduce the support as patient gets more comfortable (Fig 22.2).

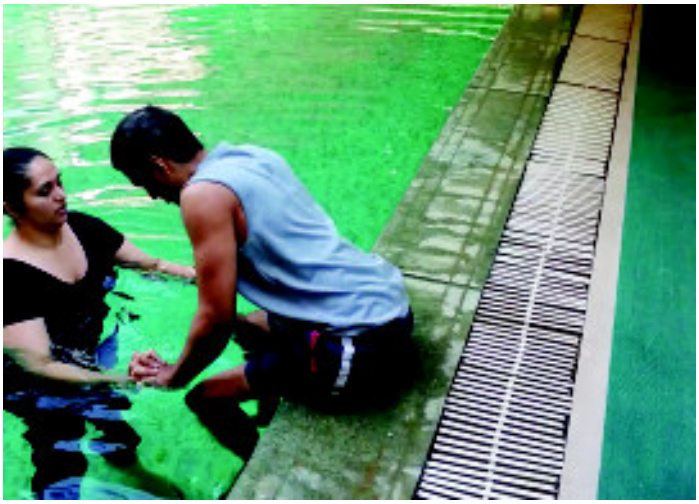


Figure 22.2 Minimally supported entry into the pool

Therapist may choose to engage the patient in various activities on the surface of the water. This will be followed by respiratory and oromotor control in water where an individual will slowly be introduced to under water environment facilitating better breath control. Various play activities like pushing the balloons, balls or other objects by blowing on them, making a well in the water, blowing bubbles in the water, flipping discs in the water by blowing on them may be used to improve the breath control.

The next step is to allow the patient to explore the body movements and response of water to those body movements. Initially a therapist should guide these movements and support the patient. Some techniques are taught to the patient to be able float independently in water and develop and come to the safe breathing position (supine in water) on their own.

These techniques are part of halliwick concept for teaching swimming to the disabled individuals. The techniques are based on three rotational controls in the water, Transverse rotation (Figure 22.3 and 22.4), sagittal rotation (Figure 22.5) and longitudinal rotation. Transverse rotation is rotation is rotation around the transverse axis of the body, the most common movement using this will be to assume vertical from supine position. Similarly saggital rotation involves side flexion of the trunk and longitudinal ratation involves rotation of the trunk along longitudinal axis. The control of the body in water requires combination of these rotations. A combined rotation is a movement along more than one axes of the body like shown in Figure 22.6 and 22.7 which shows a combined rotation of saggital and transverse rotation.

Once these rotations are learnt and practiced patients can come to the safe breathing position independently (Figure 22.8) after which they can be taught to float.

Figure 22.3

Figure 22.4

Figure 22.3 and 22.4 Transverse rotational control

Figure 22.5 Saggital rotational control

Figure 22.6

Figure 22.7

Figure 22.6 and 22.7 combined rotational control

Figure 22.8 Safe breathing position and floating

Once an individual is comfortable in water and has achieved good breathing control, various rigorous goal oriented activities will be performed during subsequent exercise sessions.

What precautions to take during and after an exercises session

- Consume plenty of water during the exercise session
- Make sure to empty the bladder and bowel of an individual before immersion to prevent accidents in water and soiling
- Patients with urine bags and catheter can also get in the water by undertaking precautionary measures suggested by their therapist.
- If an individual needs to sit on the edge, to enter and exit the pool then carry a mat on which an individual can sit to avoid aberrations and wounds
- Make sure that there is no open wound on the body or unhealed bed sore
- While entering in and out of the pool cover the pool surface well. Due to impaired sensations the rubbing on the surface will not perceived and cause a wound.

Is aquatic therapy an alternative to land based therapy?

No, aquatic therapy is not an alternative but a conjunct to it. Land based rehabilitation and aquatic rehabilitation needs to be performed together. Neither is alternative to the other. Although there are some advantages of aquatic rehabilitation as compared to the land based rehabilitation both are essential for optimum recovery.

Benefits of aquatic therapy over land based therapy

- There is less weight on the joints, an individual is well supported and joints are not under stress like on land. Therefore aquatic therapy helps achieve the benefits of land based therapy without causing any harm to the joints.

- As the individuals are able to perform the tasks in water much easier than on land, their confidence and activity participation increases.
- Activities in water are more fun and interesting for the individuals therefore there is better engagement of the individuals in a session and better adherence to therapy than on land.
- For individuals with severe movement restriction on land. Aquatic environment provides some freedom for movement.
- The risk of fall significantly reduces in aquatic environment
- It improves blood circulation to the deeper muscles better than on land and improves pliability of the muscles.

Therefore aquatic therapy may be preferred over land based therapy for some activities. It provides an excellent medium to train the individual and improve their motor impairments. It is fun and enjoyable ensuring long term adherence.It helps to maintain various cardio-respiratory health parameters. It is safe and very effective in improving the quality of life of individuals with spinal cord injury. However aquatic therapy alone is not sufficient and must be incorporated in the multidisciplinary rehabilitation program including land based exercises.

Chapter 23 : Stem cell therapy

Introduction

The field of regenerative medicine and the availability of different forms of cellular therapies such as stem cell therapy have opened a entire new dimension in the overall management of spinal cord injury . Whilst these are stil early times in this field the initial results are definitely encouraging and promising. One significant aspect of stem cell therapy is the important role rehabilitation therapists have to play in this aspect. Right from the initial clinical evaluations, assisting in the planning of the treatments to doing the post stem cell therapy rehabilitation , the role of physiotherapists and occupational therapists had now become very important. It is therefore necessary for therapists to have an understanding of all aspects of stem cell therapy . From how it is done to what are the expected improvements and how to evaluate and document these. Therapists also need to get actively involved in research in the form of participating in the clinical trials as well as in the publishing of the clinical results.

A review of published work in cellular therapy clearly estab- lishes the safety and efficacy of this treatment. In the case of SCI, there have been over 66 published papers in which 1,599 patients have been treated using various types of cellular therapies, and among these, 844 patients have shown functional and neurological improvements and with no major adverse events reported. In view of this we can now emphatically state that stem cell therapy is " An idea whose time has come ".

A prominent histologist and Nobel laureate Santiago Ramon y Cajal in 1928 stated in his work Degeneration & Regeneration of the Nervous System that "Once the development was ended, the founts of growth and regeneration of the axons and dendrites dried up irrevocably. In the adult centers, the nerve paths are something fixed, ended, and immutable. Everything may die, nothing may be regenerated. It is for the science of the future to change, if possible, this harsh decree."

Until recently, this central dogma of neurology, had a strong influence on the work conducted in the clinical and experimental field. However, the discovery of stem cells has revolutionized this long-standing, deep rooted perception about the repair and regeneration of central nervous system.

Stem cell therapy is an emerging field of modern medicine, which focuses on restoration, repair and replacement of damaged tissues using a safe and effective mode of administration of stem cells. It has opened up new avenues of therapeutic strategies for various neurological disorders such as spinal cord injury which has no definitive treatment or cure available,

What are stem cells?

Stem cells are unspecialized cells which have the ability to replicate indefinitely and have the capability of differentiating into almost any other type of body cell. A variety of stem cells are now being used from diverse sources for regeneration. The potency and plasticity of stem cells depends on the source or origin.

Types of Stem cells

Stem cells are categorized based on their potential to differentiate into other types of cells.

1. Totipotent cells: These cells have the ability to differentiate into all possible cell types of the human body including extraembryonic and placental cells.
2. Pluripotent cells: These cells have ability to differentiate into any of the three germ layers viz. endoderm, mesoderm and ectoderm.
3. Multipotent cells: These cells have the ability to differentiate into specialized cells.
4. Oligopotent cells: These cells have the ability to differentiate into a few cells.
5. Unipotent cells: These cells have the ability to produce cells only of their own type, but are capable of self-renewal to be classified as a stem cell.

Stem cells are broadly classified based on their origin, as follows:

1. Embryonic stem cells (ESCs): These cells are pluripotent cells derived from a 4-7 day old blastocyst stage embryo. These cells are the most potent but are associated with ethical issues and side effects like formation of teratomas.
2. Fetal Stem Cells: These cells are isolated either from the aborted fetus or from the extra embryonic structures of the fetal origin such as the amniotic fluid and placenta. These cells have better homing capacity, greater multipotentiality and differentiation potential and lower immunogenicity as compared to the adult stem cells. However, they are also more susceptible to infections.
3. Umbilical cord stem cells: Umbilical cord contains a heterogeneous mixture of stem / progenitor cells at different lineage commitment stages. Cells are isolated either from the cord blood or the Wharton jelly. They consist of embryonic stem cell-like and other pluripotential stem cells, which can give rise to hematopoietic, epithelial, endothelial, and neural tissues. Various banks have evolved to collect

and preserve the umbilical cord blood.

4. Induced pluripotent stem cells (iPSC) : Induced pluripotent stem cells are non-pluripotent adult cells (somatic cells) which have been genetically reprogrammed to form pluripotent cells. To circumvent the ethical issues involved in the use of embryonic stem cells, pluripotent cells were generated directly from the patients' own cells. However, the safety of these cells is yet to be established.
5. Adult stem cells: These cells are multipotent stem cells, isolated from adult tissues. They include hematopoietic stem cells, bone marrow derived stem cells, adipose tissue-derived stem cells, neural stem cells amongst others. Adult stem cells are found in almost all the tissues of the body and help to maintain and repair organs and tissues throughout a person's life. These cells are majorly derived from the bone marrow, brain, skeletal muscle, liver, pancreas, fat, skin and skeletal muscle. These cells have a relatively better safety profile and circumvent the ethical and moral issues.

Unmet Medical Needs

As discussed earlier in the previous chapters, spinal cord injury (SCI) often results in a severe neurological deficit. It damages the axons and disrupts myelination interrupting sensory and motor neuronal transmission to and from the brain, thus affecting the quality of life of these patients. Complete recovery of the damaged spinal cord is very difficult, as it does not have the ability to regenerate its lost or damaged neurons and re-establish the neural connections. The scar also consists of axonal growth inhibitors which further limit the repair and regeneration process. As a result, there is no cure for SCI available presently. The available treatments for SCI fail to repair the underlying neurological damage completely, leaving behind few deficits. Presently, all modalities aim at repairing the spine but no surgery or medication repairs the spinal cord. None of the treatments help in neuronal or axonal regeneration. Due to loss of functions, the SCI patients have a high level of dependency on the care taker. The currently available treatment modalities fail to improve these complications in case of severe injuries. Since, there is a global increase in the incidence of spinal cord injuries, establishing a standard treatment is the need of the hour.

Stem cell therapy in spinal cord injury

Stem cell therapy has a great potential as a treatment for spinal cord injury (SCI). Extensive research has been conducted in animal models and humans with SCI, to study the efficacy of this intervention. It mainly focuses on replacing the lost or damaged cells and promoting axonal growth and remyelination of axons. The cells migrate to the site of injury and initiate the repair process. They release trophic factors to stop neuronal degeneration and stimulate angiogenesis. These factors also activate the dormant cells and recruit them to the injured site. Experimental models have demonstrated the formation of functional neuronal circuits promoting functional

recovery. They also modulate the immune response after injury, induce breakdown of inhibitory scars within the spinal cord and eliminate cell debris and protect neurons.

Various animal studies have been conducted in the past to establish role of stem cell therapy in SCI. A number of different kinds of stem cells have been tested in basic research to study the safety and efficacy. The signaling pathways, protein interactions, cellular behavior, and the differentiated fates of experimental cells have been studied extensively in vitro. Moreover, the survival, proliferation, differentiation, and effects on promoting functional recovery of transplanted cells have also been examined in different animal SCI models. These pre-clinical studies have helped translate the use of stem cells in humans initiating an array of human clinical studies.

One of the earliest studies conducted by Rabinovich et al, used cells from the fetal nervous and haemopoietic tissues in 15 SCI patients with no side effects. These cells were implanted subarachnoidally. Following cell transplantation, six patients showed improvement in their neurological status from A to C grade of SCI, exhibiting incomplete restoration of both motor and sensory function. The status of other five patients was reported to be SCI grade B and was characterized by appearance of contracting activity in some muscles and incomplete restoration of sensitivity. The remaining four patients did not exhibit any clinical improvements. No serious complications were noted. However, due to various ethical and medical concerns over embryonic and fetal stem cells, adult stem cells have been tried extensively. In a comparison between a) transplantation of autologous bone marrow cells directly into the SCI sites and administered granulocyte macrophage colony stimulating factor (GM-CSF) {n=2} and b) only administration of GM-CSF{n=1}, sensorymotor improvements were noticed in all three patients at varied time points

Féron et al., assessed the safety and feasibility of cultured autologous Olfactory Ensheathing Cells injected directly into the injured spinal cord and around it in three paraplegics, between 6 and 32 months post complete SCI. No adverse effects were reported. Further in 2008, the same group (Mackay-Sim et al.) published the outcome after 3 years of follow up. Except sensory improvement in one patient, no significant improvements (functionally or neurologically) were noticed. Subbaiah et al in 2009 carried out transplantation of autologous cultured bone marrow derived stromal cells (BMSCs) in 5 cases of total transectional spinal cord injury. The report on the available data suggested that it was safe, efficacious and resulted in functional recovery in two patients.

To track the behaviour and the fate of the transplanted cells, Callera et al administered CD34+ cells labeled with nanoparticles via lumbar puncture and 6 patients received magnetic beads without stem cells. MRI done 20 and 35 days after transplantation showed that the magnetically labeled CD34+ cells were visible at the lesion site in 5 patients out of 10. These signals were not visible in the control group .

Comparitive studies were also carried out to find the optimum route of administration. Syková et al revealed intra-arterial transplants to show more improvements as

compared to those intravenous transplants. Chernykh et al, reported neurological improvements in 66.7% of chronic SCI patients who underwent autologous BMSCs transplantation intravenously as well as at the site of injury. Whereas, Saberi et al. in a similar clinical trial carried out in 4 patients, found improvement in only 1 patient. Geffner et al reported administration of BMSCs via multiple routes to be safe and feasible improved the quality of life in most patients. O.S Abdelaziz administered autologous adult bone marrow mesenchymal stem cell through open surgical intraparenchymal and intralesional injection into the site of cord injury followed by monthly intrathecal injection of stem cells through lumbar or cisternal punctures. Clinical improvement was observed in 30% treated patients. Intramedullary direct injection of MSCs into the injured spinal cord also resulted in changes in MRI and electrophysiological tests along with other functional improvements. However, direct injection is an invasive procedure involving risk of secondary injury. Saito et al, Pal et al and Kumar et al reported intrathecal administration to be the optimum route of administration.

Series of studies also demonstrated the benefits of bone marrow stem cells in SCI. In a Chinese language article, Zhou et al, briefly reported 70 cases following bone-marrow stem cell (BMSC) transplantation. 37 of these were SCI patients. After cell transplantation, the authors reported improved sexual function, sensation and functional improvement in five cases.

In a novel method, using combination of BM mesenchymal stem cells (MSC) and patient's autoimmune T cells, Moviglia et al demonstrated the regeneration phenomenon based on the controlled inflammatory activity at the injured site. Both the patients of the study showed both motor and sensory recovery with no adverse effects.

Pioneering and trendsetting paper by Park et al, is one of the earliest reports of intrathecal autologous bone marrow cell transplantation in conjunction with the administration of granulocyte macrophage-colony stimulating factor (GM-CSF). This therapy was carried out in six complete SCI patients. Sensory and motor recovery was noticed between 3 weeks to 7 months. Four patients showed neurologic improvements in their American Spinal Injury Association Impairment Scale (AIS) grades (from A to C). One patient improved to AIS grade B from A and the last patient remained in AIS grade A. No immediate worsening of neurologic symptoms was found. Radiological changes on MRI were also noticed. Serious complications increasing mortality and morbidity, however, were not found.

H. Deda et al used autologous bone marrow derived hematopoietic progenitor stem cells to treat 9 patients with chronic complete SCI. Post transplantation no patient experienced any complications. Three weeks after the operation all patients' movements and sensations were improved. To evaluate the patients, neurologic impairment scales (ASIA scores), pre- and post-operative Somato Sensorial Evoked Potential (SSEP) assessments and pre- and post-operative Magnetic Resonance Imaging

(MRI) were used. All patients had ASIA grade B or C after the operation. Frolov et al injected 20 cases of cervical SCI with autologous hematopoietic stem cells. After 1 year, improved motor and somatosensory evoked potentials were recorded

Dai G et al, studied the efficacy of autologous bone marrow mesenchymal stem cells (BMMSCs) transplantation in 40 patients with complete and chronic cervical SCI. 10 patients from the treatment group significant clinical improvement in terms of motor, light touch, pin prick sensory and residual urine volume, while nine patients showed changes in AIS grade. In the control group, no improvement was observed in any of the neurological functions. Jiang PC et al, enrolled 20 SCI patients in a clinical trial to study the effect of autologous bone marrow-derived mesenchymal stem cell transplantation. Analysis of subsequent treatment results indicated significant improvements in sensory, motor and autonomic nerve functio. 30 days after transplantation, a total of 15 patients (75%) demonstrated improvement, including four of the eight patients (50%) with grade A SCI, three of the four patients (75%) with grade B injury and all eight patients (100%) with grade C injury. El Kheir WA et al, conducted a phase I/II controlled single-blind clinical trial using autologous adherent bone marrow cells combined with physical therapy to improve motor and sensory functions in 70 early stage chronic SCI patients. At 18 months posttreatment, 23 of the 50 cell therapy-treated cases (46%) showed sustained functional improvement. Compared to those patients with cervical injuries, a higher rate of functional improvement was achieved in thoracic SCI patients with shorter durations of injury and smaller cord lesions.

Peripheral stem cells and macrophages have also been reported to show improvements of motor and sensory functions without any critical complications. Peripheral macrophages have also shown to synthesize nerve growth factor after peripheral nerve damage and eliminate myelin which inhibits neural regrowth. Knoller et al transplanted SCI patients with incubated autologous macrophages. Out of the 8 patients treated in this study, 3 patients showed improvements of motor and sensory functions without any critical complications. Cristante et al. reported the use of peripheral stem cell delivered intra-arterially in 39 patients of chronic SCI. SSEP evaluation after 30 months of cell transplantation showed improved latency in 66.7% of patient's evaluation.

Other sources such as cord blood, olfactory ensheathing cells, adipose tissue derived stem cells, etc also showed improvement in sensory-motor functional improvements. Ichim et al reported intrathecal administration of allogeneic umbilical cord blood ex-vivo expanded CD34 and umbilical cord matrix Mesenchymal Stem Cells, performed at 5 months, 8 months, and 14 months after spinal cord injury. Cell administration was found to be well tolerated with no adverse effects. Neuropathic pain subsided from intermittent 10/10 to once a week 3/10 VAS. Recovery of muscle, bowel and sexual function was noted, along with a decrease in ASIA score to "D". Lima et al. carried out a clinical trial in Portugal where in 20 patients who sustained a traumatic SCI underwent OECs transplantation. They found some neurological, functional,

electrophysiological and urodynamic improvements in all the patients. In a larger study, Huang et al transplanted 108 SCI patients with OECs. They were divided into group A (n = 79) who were given sufficient rehabilitation and group B (n = 29) with insufficient rehabilitation. On follow up, these patients showed changes in ASIA scale, walking ability, sexual functions. Comparing group A with group B, the increased scores in terms of motor, light touch, and pin prick were remarkably different. 29 out of 31 showed improvement in EMG examinations while 28 showed improvement in PVSEP.

Ra et al studied 8 SCI patients who underwent intravenous administration of autologous adipose tissue-derived mesenchymal stem cells and found that hAdMSCs were safe and did not induce tumor development.

Saberi et al enrolled 33 SCI cases to study the safety of intramedullary Schwann cell transplantation. After a 2 year follow up, there were no tumor formations or other adverse events recorded. Co-transplantation techniques have also been tested and found to be safe. Tianshen Sun et al, in their recent study have reported The synergistic effects of the combined use of olfactory ensheathing cells and Schwann cells enhancing functional recovery in SCI. Similarly, Chen et al in their study of 28 cases showed beneficial effects of OECs, SCs, or a combination of them in SCI. Al-Zoubi et al, demonstrated the positive effect of purified autologous leukapheresis-derived CD34+ and CD133+ stem cells in 19 cases of chronic SCI. Cheng et al, in a controlled study including 34 cases of thoracolumbar spinal cord injury, stated that umbilical cord mesenchymal stem cells effectively improve neurological functional recovery after spinal cord injury, and its efficacy is superior to that of rehabilitation therapy and self-healing. Hammadi et al, conducted a study on 277 patients suffering from spinal cord injury who underwent intrathecal transplantation of peripheral stem cells. The cells were harvested from the peripheral blood after a treatment with G-CSF and then concentrated to 4? 6 ml. 43% of the patients improved; ASIA score shifted from A to B in 88 and from A to C in 32. The best results were achieved in patients treated within one year from the injury.

Jarocha et al, administered a patient with total SCI at the Th2-3 level with BMNC and MSC transplantations followed with intensive neurorehabilitation treatment. The ASIA score improved from A to C/D (from 112 to 231 points). The sensation level expanded from Th1 to L3-4, and the patient's ability to control the body trunk was fully restored. Bladder filling sensation, bladder control, and anal sensation were also restored. Muscle strength in the left lower extremities improved from plegia to deep paresis (1 on the Lovett scale). The patient's ability to move lower extremities against gravity supported by the movements in quadriceps was restored. The patient gained the ability to stand in a standing frame and was able to walk with the support of hip and knee ortheses. Magnetic resonance imaging (MRI) revealed that at the Th2/Th3 level, where the hemorrhagic necrosis was initially observed, small tissue structures appeared. These results suggested that repeated intrathecal infusions of MSCs might have the potential to produce clinically meaningful improvements for SCI patients.

Bryukhovetskiy AS et al, evaluated the short and long-term effects of the hematopoietic cell therapy in 202 cases of spinal cord injury. Post intervention, the restoration of neurologic deficit was proved stable and evident in 57.4% of the cases. In 42.6% cases no neurologic improvement was observed. In 50% of the cases the motor restoration began after the first transplantation, which was confirmed in average by 9.9 points improvement in neurologic impairment as compared to the baseline ($P < 0.05$). Repair of the urinary system was observed in 47.7% of the cases. The sensitivity improved from baseline 124.3 points to 138.4 after the first and to 153.5 points after the second transplantations of HSCs and HPs ($P < 0.05$, between the stages of research). The evaluation with ASIA index demonstrated regress of neurologic symptoms in 23 cases. The number of the patients with the signs of locomotive repair was 56.9%.

Stem Cell Therapy at NeuroGen Brain and Spine Institute

At NeuroGen Brain and Spine Institute, we administer autologous bone marrow mononuclear cells, intrathecally. This procedure is safe and relatively minimally invasive as compared to other modes of transplantation.

Granulocyte-colony stimulating factor (G-CSF) is administered 72 and 24 h prior to the treatment to mobilize the granulocytes.

Step1: Bone marrow aspiration

Fig 23.1: Aspiration of cells from the bone marrow

80-120ml of bone marrow is aspirated from the posterior superior iliac crest using a standard bone marrow aspiration needle, under local or general anesthesia depending on the age of the patient. The bone marrow is then transported to the laboratory in a special transporter under sterile conditions for cell separation.

Step 2: Stem cell separation:

Fig 23.2: Separation and purification of stem cells

The mononuclear cells are separated from the bone marrow using density gradient centrifugation method. The viability of these cells is checked manually and also confirmed using TALI cell counter machine. They are also checked for CD34+ markers using fluorescence activated cell sorting (FACS) method.

Step 3: Stem cell injection

Fig 23.3: Intrathecal administration of stem cells

The separated mononuclear cells are administered intrathecally using a standard lumbar puncture procedure, performed at the L4-5 level. This procedure is usually done under local anesthesia/ sedation.

Our Published data:

1. A detailed analysis of chronic thoracolumbar SCI patients who underwent intrathecal administration of autologous bone marrow mononuclear cells followed by neurorehabilitation was conducted. The study sample included 110 thoracolumbar SCI patients. The outcome was recorded at a mean follow up of 2 years ±1 month. The outcome measures were Functional Independence Measure (FIM) score, American Spinal Injury Association scale (ASIA) and detailed neurological assessment. Data was statistically analyzed using McNemar's Test to establish significance between the change in symptoms and the intervention.

   100 out of 110 (91%) patients showed improvements. Improvement in trunk control was observed in 95.6% cases, bladder management in 33% with respect to shift from indwelling and condom catheter to self intermittent catheterization, partial sensory recovery in 27% and reduction of spasticity in 26%. All the patients showed improvement in postural hypotension. 38% wheelchair bound patients started walking with assistance. Functionally, 27% showed improved activities of daily living (ADLs) and 53.6% showed a positive change in FIM score. 10% cases showed a shift in ASIA scale. A statistically significant association of these symptomatic improvements with the cell therapy intervention was established using McNemar's Test. On electrophysiological studies, 2 showed improvement and 1 showed change in functional MRI.

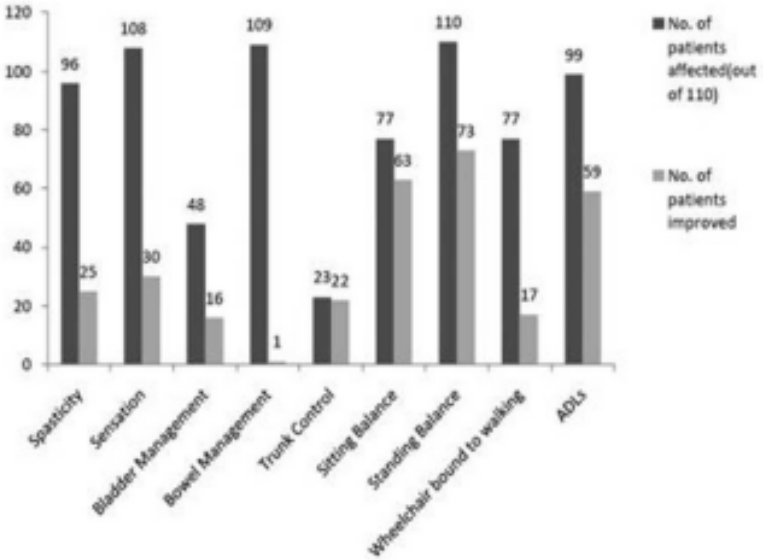


Figure 23.4: Graph representing improvements in thoracolumbar SCI after stem cell therapy

2. A detailed analysis of chronic cervical SCI patients who underwent intrathecal administration of autologous bone marrow mononuclear cells followed by neurorehabilitation was conducted. This study includes 50 patients of chronic cervical SCI. The outcome was recorded at a mean follow up of 2 years ±1 month.

The outcome measures were Functional Independence Measure (FIM) score, American Spinal Injury Association scale (ASIA) and detailed neurological assessment. Data was statistically analyzed using McNemar's Test to establish significance between the change in symptoms and the intervention. 37 out of 50 (74%) showed improvements. Sensation recovery was observed in 26% cases, improved trunk control in 22.4%, spasticity reduction in 20% and bladder sensation recovery in 14.2%. All the 50 cases had improvement in postural hypotension. 12.24% wheelchair bound patients started walking with assistance. Functionally, 20.4% patients showed improved ADLs and 48% showed a positive change in FIM score. 6% cases showed a shift in ASIA scale. A statistical analysis using McNemar's test established a significant association of these symptoms with the intervention. No major side effects were noted in the duration of 2 years in both the studies. A better outcome was observed in thoracolumbar injury as compared to the cervical injury suggesting that the level of SCI greatly influences the recovery of the patient. Both studies demonstrated statistically significant clinical and functional outcome.

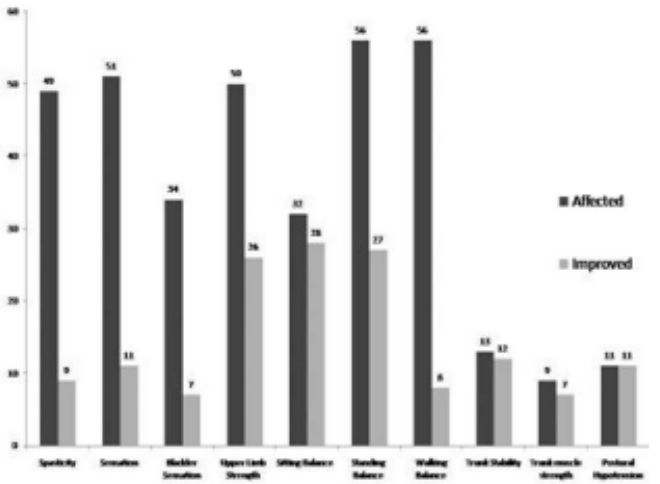


Figure 23.5: Graph representing improvements in cervical SCI after stem cell therapy.

Unpublished data

Thoracic Spinal Cord Injury:

We analyzed 165 patients with chronic thoracic spinal cord injury to study the effect of stem cell therapy. Changes were recorded in symptoms like muscle tone, lower limb activity, sensory changes, bowel/bladder function, trunk activity, balance, standing, ambulation and activities of daily living. Analysis revealed that out of 165, 94.54% patients showed improvements while 5.45% of showed no improvements in any of the symptoms. Mild improvements were observed in 13.93% of patients, moderate in 55.75% of patients, whereas, 24.84% of patients showed significant improvements

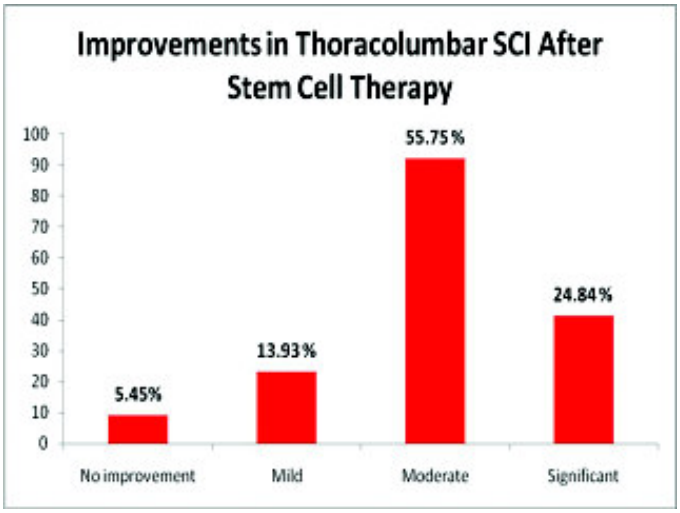


Figure 23.6 Graph showing overall percentage improment

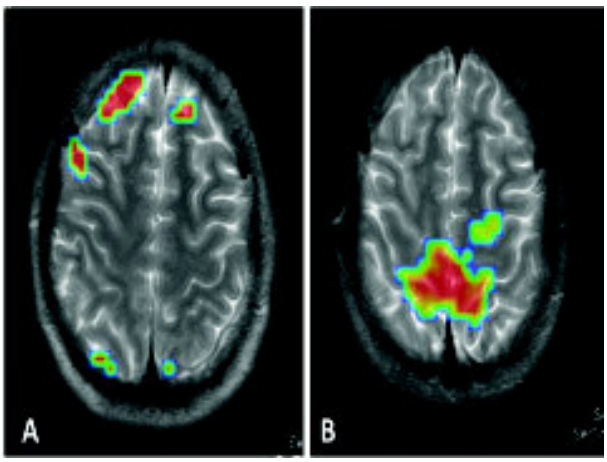


Figure 23.7: MRI imaging shows new areas of activation in the brain after stem cell therapy

Cervical Spinal Cord Injury:

70 patients with diagnosis of cervical spinal cord injury were included in the analysis. Symptomatic analysis was done for the common symptoms observed in these patients and was graded as no change, mild moderate and significant improvements. The symptoms included were muscle tone, upper limb activity, lower limb activity, sensory changes, bowel/bladder function, trunk activity, balance, standing, ambulation and activities of daily living. Analysis revealed that out of 70 patients, 97.14% patients showed improvements while 2.86% did not show any improvements. Mild improvements were observed in 24.28% of patients, moderate in 54.28% of patients, whereas, 18.57% of patients showed significant improvements.

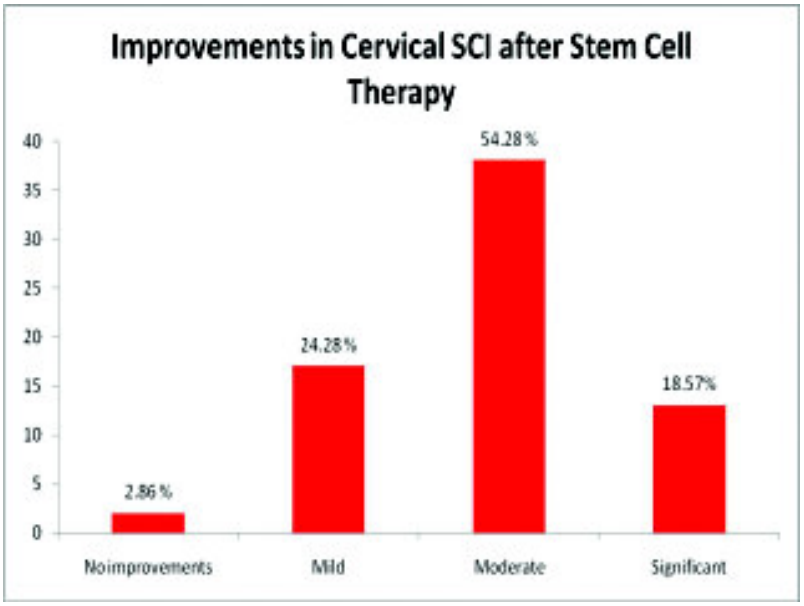


Fig. 23.8 Overall percentage improvements in the patients with cervical SCI

Neurorehabilitation and stem cell therapy

Neurorehabilitation is the clinical subspecialty that is devoted to the restoration and maximization of functions that have been lost due to impairments caused by injury or disease of nervous system. The goal of neurorehabilitation is to help patients with impairments and disabilities and to make them functionally independent, which requires team of rehabilitation specialists, such as nurses, physical therapists, occupational therapists, speech therapist, psychologist and others.

Importance of Rehabilitation:

Neurorehabilitation facilitates neural plasticity and improves neural connectivity. It stimulates neurons to function at their optimum capacity. It also activates the local resident stem cells to help repair the damaged areas. Similarly exercise also stimulates the injected stem cells and guides them towards their targeted functions. It helps the regenerated cells to gain maximum function. Neurorehabilitation has also been postulated to release growth factors, improve oxygenation and increase blood supply. Thus, the synergistic effect of stem cell therapy and neurorehabilitation brings about maximum benefits.

Advances in stem cell research have opened up doors for the use of different cell strategies for the treatment of SCI. Many clinical trials are being conducted in the USA, China, India, Switzerland to optimize the intervention, find the appropriate time of injection, type of cells, route of administration, etc. In 2016, A double-blind phase IIb clinical trial is going to commence to assess safety and efficacy of intraspinal transplantation of HLA-matched umbilical cord blood mononuclear cells randomized

to a 6-week course of oral lithium carbonate or placebo, followed by 6 months of intensive locomotor training of subjects with chronic spinal cord injury. The trial is multicentric with countries like India, USA, China participating together for the first time. The alliance for this trial is unique and has never been seen before in any trials of spinal cord injury. The hope is to combine the regenerative potential of the stem cells with the plasticity of the nervous system and evolve a definitive treatment for spinal cord injury.

REFERENCE

1. Ramon y Cajal, S. 1928. Degeneration and regeneration of the nervous system. Volume 2. Haffner Publishing Co. New York, New York, USA. p. 750.
2. Sanberg PR, Eve DJ, Cruz LE, Borlongan CV. Neurological disorders and the potential role for stem cells as a therapy. British Medical Bulletin. 2012;101(1):163-181.
3. De Wert, Guido, and Christine Mummery. Human embryonic stem cells: research, ethics and policy. Human reproduction 18.4 (2003): 672-682.
4. Ben-David U, Benvenisty N. The tumorigenicity of human embryonic and induced pluripotent stem cells. Nat Rev Cancer. 2011;11:268-77
5. Pappa KI, Anagnou NP. Novel sources of fetal stem cells: where do they fit on the developmental continuum? Regen Med. 2009 May;4(3):423-33.
6. Ilancheran S, Michalska A, Peh G, Wallace EM, Pera M, Manuelpillai U. Stem cells derived from human fetal membranes display multilineage differentiation potential. Biol Reprod. 2007 Sep;77(3):577-88.
7. Newcomb JD, Willing AE, Sanberg PR. Umbilical cord blood cells. Methods Mol Biol. 2009;549:119-36.
8. Stanevsky A, Goldstein G, Nagler A. Umbilical cord blood transplantation: pros, cons and beyond. Blood Rev. 2009 Sep;23(5):199-204.
9. Robbins RD, Prasain N, Maier BF, et al. Inducible pluropotent stem cells: not quite ready for prime time? Current Opinion in Organ Transplantation. 2010;15:61-67.
10. S. U. Kim and J. de Vellis, "Stem cell-based cell therapy in neurological diseases: a review," Journal of Neuroscience Research, vol. 87, no. 10, pp. 2183-2200, 2009
11. Zuk PA, Zhu M, Mizuno H, Huang J, Futrell JW, Katz AJ, Benhaim P, Lorenz HP, Hedrick MH. Multilineage cells from human adipose tissue: implications for cell-based therapies. Tissue Eng. 2001 Apr;7(2):211-28.
12. Gronthos S, Mankani M, Brahim J, Robey PG, Shi S (2000). Postnatal human dental pulp stem cells (DPSCs) in vitro and in vivo. Proc Natl Acad Sci USA 97:13625-13630.
13. Deumens R, Koopmans GC, Honig WM, Maquet V, Jérôme R, Steinbusch HW, Joosten EA. Chronically injured corticospinal axons do not cross large spinal lesion gaps after a multifactorial transplantation strategy using olfactory ensheathing cell/olfactory nerve fibroblast-biomatrix bridges. J Neurosci Res. 2006 Apr;83(5):811-20.

14. Wanner IB, Deik A, Torres M, Rosendahl A, Neary JT, Lemmon VP, Bixby JL. A new in vitro model of the glial scar inhibits axon growth. Glia. 2008 Nov 15;56(15):1691-709

15. Wright KT, Masri WE, Osman A, Chowdhury J, Johnson WEB (2011) Concise Review: Bone Marrow for the Treatment of Spinal Cord Injury: Mechanisms and Clinical Applications. Stem Cells 29: 169-178.

16. Coutts M, Keirstead HS (2008) Stem cells for the treatment of spinal cord injury. Exp Neurol 209: 368-377.

17. Reier PJ (2004) Cellular transplantation strategies for spinal cord injury and translational neurobiology. NeuroRx 1: 424-451

18. Tewarie RSN, Hurtado A, Bartels RH, Grotenhuis A, Oudega M. Stem Cell-Based Therapies for Spinal Cord Injury. The Journal of Spinal Cord Medicine. 2009;32(2):105-114.

19. John W. Mcdonald, Xiao-Zhong Liu, Yun Qu et al. Transplanted embryonic stem cells survive, differentiate and promote recovery in injured rat spinal cord. Nature Medicine. 1999; 5(12).1410-12

20. Bottai D, Cigognini D, Madaschi L, et al. Embryonic stem cells promote motor recovery and affect inflammatory cell infiltration in spinal cord injured mice. Experimental Neurology. 2010;223(2):452-463. (PubMed)

21. Nicolas Granger, Helen Blamires, Robin J. M. Franklin, and Nick D. Jeffery Autologous olfactory mucosal cell transplants in clinical spinal cord injury: a randomized double-blinded trial in a canine translational model Brain (2012) 135 (11): 3227-3237

22. Kumagai G, Okada Y, Yamane J, et al. Roles of ES cell-derived gliogenic neural stem/progenitor cells in functional recovery after spinal cord injury. PLoS ONE. 2009;4(11)e7706 (PMC free article) (PubMed)

23. Lowry N, Goderie SK, Adamo M, et al. Multipotent embryonic spinal cord stem cells expanded by endothelial factors and Shh/RA promote functional recovery after spinal cord injury. Experimental Neurology. 2008;209(2):510-522. (PubMed)

24. Fujimoto Y, Abematsu M, Falk A, et al. Treatment of a mouse model of spinal cord injury by transplantation of human iPS cell-derived long-term self-renewing neuroepithelial-like. Stem Cells. 2012;30(6):1163-1173. (PubMed)

25. Chen J, Bernreuther C, Dihné M, Schachner M. Cell adhesion molecule L1-transfected embryonic stem cells with enhanced survival support regrowth of corticospinal tract axons in mice after spinal cord injury. Journal of Neurotrauma. 2005;22(8):896-906. (PubMed)

26. Cui YF, Xu JC, Hargus G, Jakovcevski I, Schachner M, Bernreuther C. Embryonic stem cell-derived L1 overexpressing neural aggregates enhance recovery after spinal cord injury in mice. PLoS ONE. 2011;6(3)e17126 (PMC free article) (PubMed)

27. Perrin FE, Boniface G, Serguera C, et al. Grafted human embryonic progenitors expressing

neurogenin-2 stimulate axonal sprouting and improve motor recovery after severe spinal cord injury. PLoS ONE. 2010;5(12)e15914

28. Hatami M, Mehrjardi NZ, Kiani S, et al. Human embryonic stem cell-derived neural precursor transplants in collagen scaffolds promote recovery in injured rat spinal cord. Cytotherapy. 2009;11(5):618-630.

29. Niapour A, Karamali F, Nemati S, et al. Co-transplantation of human embryonic stem cell-derived neural progenitors and Schwann cells in a rat spinal cord contusion injury model elicits a distinct neurogenesis and functional recovery. Cell Transplant. 2012;21(5):827-843.

30. Rossi SL, Nistor G, Wyatt T, et al. Histological and functional benefit following transplantation of motor neuron progenitors to the injured rat spinal cord. PLoS ONE. 2010;5(7)e11852 (PMC free article)

31. Kim DS, Jung Jung SE, Nam TS, et al. Transplantation of GABAergic neurons from ESCs attenuates tactile hypersensitivity following spinal cord injury. Stem Cells. 2010;28(11):2099-2108.

32. Keirstead HS, Nistor G, Bernal G, et al. Human embryonic stem cell-derived oligodendrocyte progenitor cell transplants remyelinate and restore locomotion after spinal cord injury. Journal of Neuroscience. 2005;25(19):4694-4705.

33. Kerr CL, Letzen BS, Hill CM, et al. Efficient differentiation of human embryonic stem cells into oligodendrocyte progenitors for application in a rat contusion model of spinal cord injury. International Journal of Neuroscience. 2010;120(4):305-313.

34. Sharp J, Frame J, Siegenthaler M, Nistor G, Keirstead HS. Human embryonic stem cell-derived oligodendrocyte progenitor cell transplants improve recovery after cervical spinal cord injury. Stem Cells. 2010;28(1):152-163.

35. Erceg S, Ronaghi M, Oria M, et al. Transplanted oligodendrocytes and motoneuron progenitors generated from human embryonic stem cells promote locomotor recovery after spinal cord transection. Stem Cells. 2010;28(9):1541-1549.

36. Salehi M, Pasbakhsh P, Soleimani M, et al. Repair of spinal cord injury by co-transplantation of embryonic stem cell-derived motor neuron and olfactory ensheathing cell. Iranian Biomedical Journal. 2009;13(3):125-135.

37. Nakajima H, Uchida K, Guerrero AR, et al. Transplantation of mesenchymal stem cells promotes an alternative pathway of macrophage activation and functional recovery after spinal cord injury. Journal of Neurotrauma. 2012;29(8):1614-1625.

38. Karaoz E, Kabatas S, Duruksu G, et al. Reduction of lesion in injured rat spinal cord and partial functional recovery of motility after bone marrow derived mesenchymal stem cell transplantation. Turkish Neurosurgery. 2012;22(2):207-217.

39. Park WB, Kim SY, Lee SH, Kim HW, Park JS, Hyun JK. The effect of mesenchymal stem cell transplantation on the recovery of bladder and hindlimb function after spinal cord contusion in rats. BMC Neuroscience. 2010;11:p. 119.

40. Abrams MB, Dominguez C, Pernold K, et al. Multipotent mesenchymal stromal cells attenuate chronic inflammation and injury-induced sensitivity to mechanical stimuli in experimental spinal cord injury. Restorative Neurology and Neuroscience. 2009;27(4):307-321.

41. Kang ES, Ha KY, Kim YH. Fate of transplanted bone marrow derived mesenchymal stem cells following spinal cord injury in rats by transplantation routes. Journal of Korean Medical Science. 2012;27(6):586-593.

42. Osaka M, Honmou O, Murakami T, et al. Intravenous administration of mesenchymal stem cells derived from bone marrow after contusive spinal cord injury improves functional outcome. Brain Research C. 2010;1343:226-235.

43. Mothe AJ, Bozkurt G, Catapano J, et al. Intrathecal transplantation of stem cells by lumbar puncture for thoracic Spinal cord injury in the rat. Spinal Cord. 2011;49(9):967-973.

44. Boido M, Garbossa D, Fontanella M, Ducati A, Vercelli A. Mesenchymal stem cell transplantation reduces glial cyst and improves functional outcome following spinal cord compression. World Neurosurgery. World Neurosurg. 2014 Jan;81(1):183-190

45. Gu W, Zhang F, Xue Q, Ma Z, Lu P, Yu B. Transplantation of bone marrow mesenchymal stem cells reduces lesion volume and induces axonal regrowth of injured spinal cord. Neuropathology. 2010;30(3):205-217.

46. Alexanian AR, Fehlings MG, Zhang Z, Maiman DJ. Transplanted neurally modified bone marrow-derived mesenchymal stem cells promote tissue protection and locomotor recovery in spinal cord injured rats. Neurorehabilitation and Neural Repair. 2011;25(9):873-880.

47. Ban DX, Ning GZ, Feng SQ, et al. Combination of activated Schwann cells with bone mesenchymal stem cells: the best cell strategy for repair after spinal cord injury in rats. Regenerative Medicine. 2011;6(6):707-720.

48. Cho SR, Kim YR, Kang HS, et al. Functional recovery after the transplantation of neurally differentiated mesenchymal stem cells derived from bone barrow in a rat model of spinal cord injury. Cell Transplantation. 2009;18(12):1359-1368.

49. Pedram MS, Dehghan MM, Soleimani M, Sharifi D, Marjanmehr SH, Nasiri Z. Transplantation of a combination of autologous neural differentiated and undifferentiated mesenchymal stem cells into injured spinal cord of rats. Spinal Cord. 2010;48(6):457-463.

50. Liu WG, Wang ZY, Huang ZS. Bone marrow-derived mesenchymal stem cells expressing the bFGF transgene promote axon regeneration and functional recovery after spinal cord injury in rats. Neurological Research. 2011;33(7):686-693.

51. Zhang YJ, Zhang W, Lin C-G, et al. Neurotrophin-3 gene modified mesenchymal stem cells promote remyelination and functional recovery in the demyelinated spinal cord of rats. Journal of the Neurological Sciences. 2012;313(1-2):64-74.

52. Zeng X, Zeng YS, Ma YH, et al. Bone marrow mesenchymal stem cells in a three dimensional gelatin sponge scaffold attenuate inflammation, promote angiogenesis and

reduce cavity formation in experimental spinal cord injury. Cell Transplantation. 2011;20(11-12):1881-1899.

53. Kang KN, Kim da Y, Yoon SM, et al. Tissue engineered regeneration of completely transected spinal cord using human mesenchymal stem cells. Biomaterials. 2012;33(19):4828-4835.

54. Park SS, Lee YJ, Lee SH, et al. Functional recovery after spinal cord injury in dogs treated with a combination of Matrigel and neural-induced adipose-derived mesenchymal Stem cells. Cytotherapy. 2012;14(5):584-597.

55. Guo YW, Ke YQ, Li M, et al. Human umbilical cord-derived schwann-like cell transplantation combined with neurotrophin-3 administration in dyskinesia of rats with spinal cord injury. Neurochemical Research. 2011;36(5):783-792

56. Shang AJ, Hong SQ, Xu Q, et al. NT-3-secreting human umbilical cord mesenchymal stromal cell transplantation for the treatment of acute spinal cord injury in rats. Brain Research. 2011;1391:102-113.

57. Lee JH, Chung WH, Kang EH, et al. Schwann cell-like remyelination following transplantation of human umbilical cord blood (hUCB)-derived mesenchymal stem cells in dogs with acute spinal cord injury. Journal of the Neurological Sciences. 2011;300(1-2):86-96.

58. Eglitis MA, Mezey E. Hematopoietic cells differentiate into both microglia and macroglia in the brains of adult mice. Proc Natl Acad Sci U S A. 1997 Apr15;94(8):4080-5.

59. Kopen GC, Prockop DJ, Phinney DG. Marrow stromal cells migrate throughout forebrain and cerebellum, and they differentiate into astrocytes after injection into neonatal mouse brains. Proc Natl Acad Sci U S A. 1999 Sep 14;96(19):10711-6.

60. Brazelton TR, Rossi FM, Keshet GI, Blau HM. From marrow to brain: expression of neuronal phenotypes in adult mice. Science. 2000 Dec 1;290(5497):1775-9.

61. Mezey E, Chandross KJ, Harta G, Maki RA, McKercher SR. Turning blood into brain: cells bearing neuronal antigens generated in vivo from bone marrow. Science. 2000 Dec 1;290(5497):1779-82.

62. Priller J, Flügel A, Wehner T, Boentert M, Haas CA, Prinz M, Fernández-Klett F, Prass K, Bechmann I, de Boer BA, Frotscher M, Kreutzberg GW, Persons DA,Dirnagl U. Targeting gene-modified hematopoietic cells to the central nervous system: use of green fluorescent protein uncovers microglial engraftment. Nat Med. 2001 Dec;7(12):1356-61.

63. Wichterle H, Lieberam I, Porter JA, Jessell TM. Directed differentiation of embryonic stem cells into motor neurons. Cell. 2002;110(3):385-397.

64. Hofstetter, C. P., et al. "Marrow stromal cells form guiding strands in the injured spinal cord and promote recovery." Proceedings of the National Academy of Sciences 99.4 (2002): 2199-2204.

65. Quertainmont R, Cantinieaux D, Botman O, Sid S, Schoenen J, et al. (2012) Mesenchymal Stem Cell Graft Improves Recovery after Spinal Cord Injury in Adult Rats through Neurotrophic and Pro-Angiogenic Actions. PLoS ONE 7(6): e39500.

66. Cho SR, Kim YR, Kang HS, Yim SH, Park CI, Min YH, Lee BH, Shin JC, Lim JB. Functional recovery after the transplantation of neurally differentiated mesenchymal stem cells derived from bone barrow in a rat model of spinal cord injury. Cell Transplant. 2009;18(12):1359-68

67. Samuil S. Rabinovich, Victor I. Seledtsov, Olga V. Poveschenko. Transplantation treatment of spinal cord injury patients. Biomedicine and Pharmacotherapy. 2003;57(9): 428-433

68. Yoon Ha, Seung Hwan Yoon, So Ra Park. Treatment of Complete Spinal Cord Injury Patients Receiving Autologous Bone Marrow Cell Transplantation and Bone Marrow Stimulation with Granulocyte Macrophage-Colony Stimulating Factor - Report of Three Cases. J Korean Neurosurg Soc 2004; 35: 459-464.

69. Feron F, Perry, C, Cochrane, J, Licina, P, Nowitzke, A, Urquhart, S, Geraghty, T, Mackay-Sim, A. Autologous olfactory ensheathing cell transplantation in human spinal cord injury. Brain 2005;128(12):2951-60.

70. Mackay-Sim, F. Féron, J. Cochrane et al. Autologous olfactory ensheathing cell transplantation in human paraplegia: a 3-year clinical trial. Brain. 2008; 131(9): 2376-2386.

71. G. P. V. Subbaiah, V. Adavi, L. K. Chelluri, S. Laxman, K. S. Ratnakar, P. B. N. Gopal and K. Ravindranath. Preliminary report on the safety, efficacy and functional recovery of spinal cord injury with autologous bone marrow derived mesenchymal stem cells - a clinical trial. The Internet Journal of Spine Surgery. 2009;5(1)

72. Callera and R. X. do Nascimento. Delivery of autologous bone marrow precursor cells into the spinal cord via lumbar puncture technique in patients with spinal cord injury: a preliminary safety study. Experimental Hematology. 2006;34(2): 130-131.

73. Syková, P. Jendelová, L. Urdzíková, P. Lesný, and A. Hej?l, "Bone marrow stem cells and polymer hydrogels-two strategies for spinal cord injury repair," Cellular and Molecular Neurobiology. 2006; 26(7-8):1113-1129.

74. Eva Syková, Aleš Homola, Radim Mazanec et al. Autologous Bone Marrow Transplantation in Patients With Subacute and Chronic Spinal Cord Injury. Cell Transplantation.2006;15:1-100.

75. R. Chernykh, V. V. Stupak, G. M.Muradov et al., Application of autologous bone marrow stem cells in the therapy of spinal cord injury patients. Bulletin of Experimental Biology and Medicine 2007;143(4):543-547.

76. H. Saberi, P. Moshayedi, H.-R. Aghayan et al. Treatment of chronic thoracic spinal cord injury patients with autologous Schwann cell transplantation: an interim report on safety considerations and possible outcomes. Neuroscience Letters, 2008;443(1): 46-50.

77. L. F. Geffner, P. Santacruz, M. Izurieta. Administration of Autologous Bone Marrow Stem Cells Into Spinal Cord Injury Patients Via Multiple Routes Is Safe and Improves Their Quality of Life: Comprehensive Case Studies. Cell Transplantation2008;17:1277-1293.

78. Abdelaziz, Osama S. MD. Feasibility, Safety, and Efficacy of Directly Transplanting

Autologous Adult Bone Marrow Stem Cells in Patients With Chronic Traumatic Dorsal Cord Injury: A Pilot Clinical Study. Neurosurgery Quarterly: 2010; 20(3):216-226.

79. J. H. Park, D. Y. Kim, I. Y. Sung, et al., "Long-term results of spinal cord injury therapy using mesenchymal stem cells derived from bone marrow in humans," Neurosurgery, vol. 70, no. 5, pp. 1238-1247, 2012.
80. Saito F, Nakatani T, Iwase M, et al. Spinal cord injury treatment with intrathecal autologous bone marrow stromal cell transplantation: the first clinical trial case report. J Trauma. 2008;64(1):53-9.
81. R. Pal, N. K. Venkataramana, A. Bansal et al. Ex vivo expanded autologous bone marrow-derived mesenchymal stromal cells in human spinal cord injury/ paraplegia: a pilot clinical study. Cytotherapy. 2009;11(7): 897-911.
82. A. Kumar, S. R. Kumar, R. Narayanan, K. Arul, and M. Baskaran. Autologous bone marrow derived mononuclear cell therapy for spinal cord injury: a phase I/ II clinical safety and primary efficacy data. Experimental and Clinical Transplantation 2009; 7(4): 241-248.
83. Zhou Q, Zhang SZ, Xu RX, Xu K. Neural stem cell transplantation and postoperative management: report of 70 cases. Di Yi Junyi Daxue Xuebao 2004;24(10):1207-9
84. Moviglia GA, Fernandez Viña R, Brizuela JA.et al. Combined protocol of cell therapy for chronic spinal cord injury. Report on the electrical and functional recovery of two patients. Cytotherapy. 2006; 8(3):202-9.
85. Hyung Chun Park, Yoo Shik Shim, Yoon Ha et al. Treatment of Complete Spinal Cord Injury Patients by Autologous Bone Marrow Cell Transplantation and Administration of Granulocyte-Macrophage Colony Stimulating Factor. Tissue Engineering. 2005, 11(5-6): 913-922.
86. Deda H, Inci MC, Kürekçi AE, Kayihan K, Ozgün E, Ustünsoy GE, Kocabay S. Treatment of chronic spinal cord injured patients with autologous bone marrow-derived hematopoietic stem cell transplantation: 1-year follow-up. Cytotherapy. 2008;10(6):565-74.
87. Frolov AA, Bryukhovetskiy AS. Effects of hematopoietic autologous stem cell transplantation to the chronically injured human spinal cord evaluated by motor and somatosensory evoked potentials methods. Cell Transplant. 2012;21 Suppl 1:S49-55
88. Dai G, Liu X, Zhang Z, Yang Z, Dai Y, Xu R. Transplantation of autologous bone marrow mesenchymal stem cells in the treatment of complete and chronic cervical spinal cord injury. Brain Res. 2013 Oct 2;1533:73-9.
89. Jiang PC, Xiong WP, Wang G, Ma C, Yao WQ, Kendell SF, Mehling BM, Yuan XH, Wu DC. A clinical trial report of autologous bone marrow-derived mesenchymal stem cell transplantation in patients with spinal cord injury. Exp Ther Med. 2013 Jul;6(1):140-146
90. El-Kheir WA, Gabr H, Awad MR, Ghannam O, Barakat Y, Farghali HA, El Maadawi ZM, Ewes I, Sabaawy HE. Autologous bone marrow-derived cell therapy combined with physical therapy induces functional improvement in chronic spinal cord injury patients. Cell Transplant. 2014 Apr;23(6):729-45.

91. N. Knoller, G. Auerbach, V. Fulga et al., Clinical experience using incubated autologous macrophages as a treatment for complete spinal cord injury: phase I study results. Journal of Neurosurgery Spine. 2005; 3(3): 173-181.

92. F. Cristante, T. E. P. Barros-Filho, and T. E. P. Barros-Filho. Stem cells in the treatment of chronic spinal cord injury: evaluation of somatosensitive evoked potentials in 39 patients. Spinal Cord. 2009; 47(10):733-738.

93. Thomas E Ichim, Fabio Solano, Fabian Lara et al. Feasibility of combination allogeneic stem cell therapy for spinal cord injury: a case report. International Archives of Medicine 2010; 3:30.

94. Lima, P. Escada, J. Pratas-Vital et al. Olfactory mucosal autografts and rehabilitation for chronic traumatic spinal cord injury. Neurorehabilitation and Neural Repair 2010;24(1):10-22.

95. Huang H, Xi H, Chen L, Zhang F, Liu Y. Long-term outcome of olfactory ensheathing cell therapy for patients with complete chronic spinal cord injury.Cell Transplant. 2012;21 Suppl 1:S23-31.

96. Ra JC, Shin IS, Kim SH, Kang SK, Kang BC, Lee HY, Kim YJ, Jo JY, Yoon EJ, Choi HJ, Kwon E. Safety of intravenous infusion of human adipose tissue-derived mesenchymal stem cells in animals and humans.Stem Cells Dev. 2011 Aug;20(8):1297-308.

97. Saberi H, Firouzi M, Habibi Z, Moshayedi P, Aghayan HR, Arjmand B, Hosseini K, Razavi HE, Yekaninejad MS. Safety of intramedullary Schwann cell transplantation for postrehabilitation spinal cord injuries: 2-year follow-up of 33 cases. J Neurosurg Spine. 2011 Nov;15(5):515-25.

98. Yazdani SO, Hafizi M, Zali AR, Atashi A, Ashrafi F, Seddighi AS, Soleimani M. Safety and possible outcome assessment of autologous Schwann cell and bone marrow mesenchymal stromal cell co-transplantation for treatment of patients with chronic spinal cord injury. Cytotherapy. 2013 Jul;15(7):782-91.

99. Sun T, Ye C, Zhang Z, Wu J, Huang H. Cotransplantation of olfactory ensheathing cells and Schwann cells combined with treadmill training promotes functional recovery in rats with contused spinal cords. Cell Transplant. 2013;22 Suppl 1:S27-38

100. Chen L, Huang H, Xi H, Zhang F, Liu Y, Chen D, Xiao J. A prospective randomized double-blind clinical trial using a combination of olfactory ensheathing cells and Schwann cells for the treatment of chronic complete spinal cord injuries. Cell Transplant. 2014;23 Suppl 1:S35-44.

101. Al-Zoubi A, Jafar E, Jamous M, Al-Twal F, Al-Bakheet S, Zalloum M, Khalifeh F, Radi SA, El-Khateeb M, Al-Zoubi Z. Transplantation of purified autologous leukapheresis-derived CD34+ and CD133+ stem cells for patients with chronic spinal cord injuries: long-term evaluation of safety and efficacy. Cell Transplant. 2014;23 Suppl 1:S25-34

102. Cheng H, Liu X, Hua R, Dai G, Wang X, Gao J, An Y. Clinical observation of umbilical cord mesenchymal stem cell transplantation in treatment for sequelae of thoracolumbar spinal cord injury. J Transl Med. 2014 Sep 12;12:253

103. Hammadi AA, Marino A, Farhan S. Clinical response of 277 patients with spinal cord injury to stem cell therapy in iraq. Int J Stem Cells. 2012 May;5(1):76-8.

104. Jarocha D, Milczarek O, Wedrychowicz A, Kwiatkowski S, Majka M. Continuous improvement after multiple mesenchymal stem cell transplantations in a patient with complete spinal cord injury. Cell Transplant. 2015;24(4):661-72.

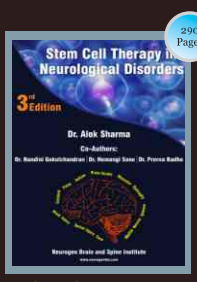
105. Bryukhovetskiy AS, Bryukhovetskiy IS. Effectiveness of repeated transplantations of hematopoietic stem cells in spinal cord injury. World J Transplant. 2015 Sep 24;5(3):110-28

106. Sharma A, Gokulchandran N, Sane H, Badhe P, Kulkarni P, Lohia M, Nagrajan A, Thomas N. Detailed analysis of the clinical effects of cell therapy for thoracolumbar spinal cord injury: an original study. Journal of Neurorestoratology. 2013;1:13-22

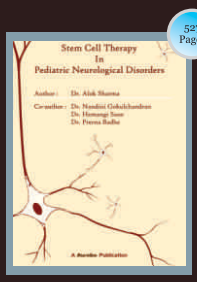
107. Sharma A, Sane H, Gokulchandran N, Kulkarni P, Thomas N, et al. (2013) Role of Autologous Bone Marrow Mononuclear Cells in Chronic Cervical Spinal Cord Injury-A Longterm Follow Up Study. J Neurol Disord 1: 138.

108. Clinicaltrials.gov

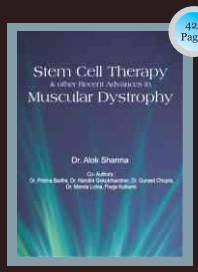
Other Books Published By Neurogen Brain and Spine Institute



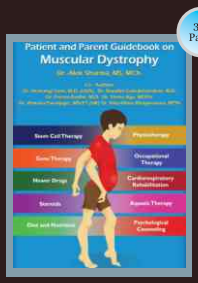
Stem Cell Therapy Neurological Disorders 3rd Edition



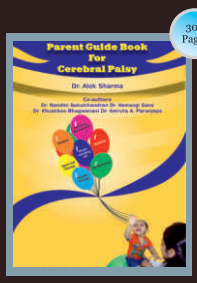
Stem Cell Therapy In Pediatric Neurological Disorders



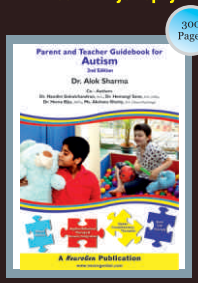
Stem Cell Therapy & Other Recent Advantages in Muscular Dystrophy



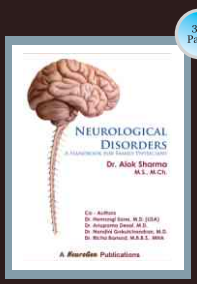
Parent & Parent Guide Book on Muscular Dystrophy



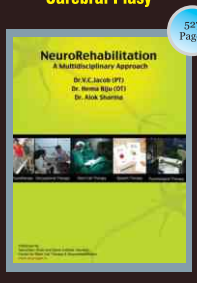
Patient Guide Book for Carebral Plasy



Parent & Teacher Guide Book for Autism 2nd Edition



NeuroRehabilitation A Handbook for Family Physicians



NeuroRehabilitation A Multidusciplinary Approach

પેશન્ટ અને પેરન્ટ માર્ગદર્શિકા મસ્કુલર ડીસ્ટ્રોફી વિશે

Neurogen Brain and Spine Institute offers a comprehensive NeuroRegenerative Rehabilitation programme for patients suffering from incurable neurological disorders. The aim is to provide these patients a relief from their symptoms & physical disabilities, using the safest & most effective available treatments & technologies from the field of neurosciences and regenerative medicine in a professional, scientific as well as holistic & caring manner.

Published By

Neurogen Brain and Spine Institute,
StemAsia Hospital and Research Centre, Plot 19, Sector 40, Nerul West,
Near Seawoods Station, Palm Beach Road, Navi Mumbai-400706, India
Tel: +91-9920200400, +9122-41136565
Web: www.neurogen.in, Email: contact@neurogen.in