


*Karl Landsteiner Institute  
for Neurorehabilitation  
and Space Neurology*


## Neurorehabilitation Traumatic Brain Injury

F. Gerstenbrand <sup>1),2)</sup>, H. Binder <sup>1),3)</sup>,  
 Ch. Kurzmann <sup>1)</sup>

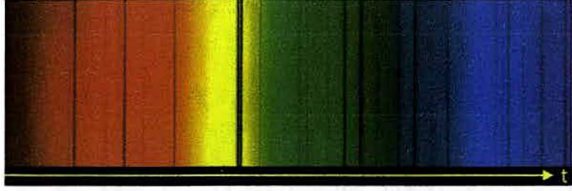
<sup>1)</sup> Karl Landsteiner-Institute for Neurorehabilitation and Space Neurology, Vienna, Austria  
<sup>2)</sup> Department of Neurology, Medical University Innsbruck, Austria  
<sup>3)</sup> Neurological Department of Otto-Wagner-Krankenhaus, Vienna, Austria

**Neurological Teaching Course**  
**World Federation for Neurology**  
 February 1, 2013,  
 No.2 Military Hospital Yangon/Myanmar

### Spectrum of Neurorehabilitation (v. Wild 1993)

Patient's individual course in CNS – PNS lesions (WHO – ICF)

Site of accident	Resus- citation	Early -	Postacute -	Reintegration
Acute lesion				Mobility, Play, Fun



Continuous fluctuation of rehabilitation in analogy to the solar spectrum  
 Hospital care    First aid    OR    ICU    Ward    Hospital    Out-Patient    Nursing-home

**Neurorehabilitation requires a multidisciplinary team approach aiming at the victim's social reintegration**

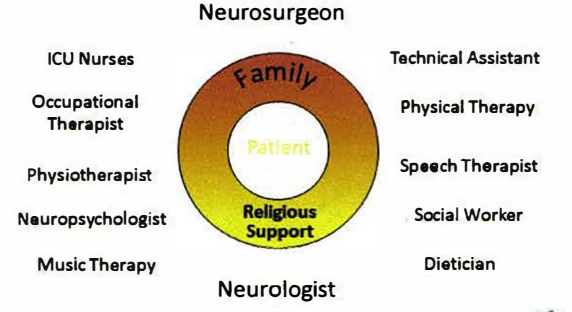
## Different Issues In Neurosciences


Clinical neurology – lesions in CNS & PNS

- Acute neurology, diagnosis and treatment
- Neurorehabilitation: → the principle aim of resocialization
- Neurological care in „end-of-treatment“-state, amelioration of quality of life

Basis: Research in neurosciences, evidence- and experience-based medicine

## The Interdisciplinary Team




Source: K. v. Wild 

## Classification of Neurorehabilitation WHO-Statement

- Actual neurorehabilitation (stroke, traumatic brain injury, etc.)
- Temporary neurorehabilitation (Parkinson Disease, MS, etc.)
- Palliative neurorehabilitation (malignant brain tumor, ALS, etc.)
  
- Early neurorehabilitation
- Repetitive neurorehabilitation

## Neurorehabilitation

- **Individuum**
  - Patient with neurological impairment and disability
- **Service by intensive knowledge:**
  - Intensive contact and great variety of variation
- **Group**
  - Patient as part of a group
  - Immediacy: "face to face"
  - No indefiniteness because limited to specific goals.
  - Durability: spatially concentrated encounters
- **Professionalism**
  - Knowledge
  - Skills
  - Values, standardization, conducting and point of view during every days life regarding the benefit to patient and society.
  - communication





- To develop as best as possible the potential of
  - physical
  - psychological
  - social and if at all possible
  - vocational means
- which are reachable by
  - remaining disturbance caused by illness and
  - under given environmental conditions

## Statistics

- Traumatic injuries accounted for 16% of adult burden of disease in the world in 2002.
- Increase of burden of road traffic accidents, especially in the developing countries of sub-Saharan Africa, and southern Asia and South-East Asia, particularly affecting males.

## Neurorehabilitation

is defined as the

- *development of a person to the fullest*
  - physical,
  - psychological,
  - social,
  - vocational,
  - avocational and
  - educational potential

Source: J.A.DeLisa, G.M.Martin, D.M.Currie: Rehabilitation Medicine: Past, Present, and future. In: Rehabilitation Medicine: Principles and Practice. Lippincott Company, Philadelphia, 1993

- Earlier initiation enhances efficacy of rehabilitation
  - ER5 animals
    - were significantly improved in skilled forelimb reaching and
    - in tests of coordinated forelimb use during locomotor activity relative to animals that received the same therapy beginning 1 month later.
    - also showed qualitative gains such that reaching accuracy and affected-limb use during postural support were both improved.
  - In contrast, ER30 animals did not differ from social-housing animals on any task, with the exception of ladder-rung walking, although this improvement was delayed relative to ER5.
- Early rehabilitation (ER5) does not exacerbate infarct size or behavioral impairment

## Neurorehabilitation

- consistent with his or her
  - physiological or anatomical impairment and
  - environmental limitations.
- It should be comprehensive and include
  - prevention,
  - early recognition and
  - outpatient, inpatient and extended care programs.

Source: J.A.DeLisa, G.M.Martin, D.M.Currie: Rehabilitation Medicine: Past, Present, and future. In: Rehabilitation Medicine: Principles and Practice. Lippincott Company, Philadelphia, 1993

### Definition:

- Early rehabilitation in the course of neurological-neurosurgical intensiv therapy describes philosophy of an inbuilt interdisciplinary treatment beginning from the first of central lesion and seamlessly accomplished with variable key aspects of activity.
- The purpose is on the one hand promotion of spontaneous recovery booting remaining cerebral plasticity and on the other hand to avoid or reduce the impact of secondary complications for smooth transition to rehabilitation from the earliest possible moment.
- Strength and extent of these increasing early rehabilitative endeavour run parallel to progressive stabilisation of body state and outlasts the at the same time decreasing intensiv care.
- Commencement of early neurorehabilitation must be declared from the moment of sufficient stabilisation of vegetative functions in particular cardio-vascular functions able to withstand stress and without abnormal increase of ICP endangering cerebral blood flow.
- Early neurorehabilitation comprises the whole nervous system including spine and extremities..

©Wiley & Sons 1993  
Neurologische, neurochirurgische Frührehabilitation: Konzeptionelle, organisatorische und praktische Aspekte  
In: J. von Kries, H.-J. Gans (Hrsg.): Neurologische Frührehabilitation, 1993. W. de Gruyter Verlag, Berlin

## Rehabilitation Concepts

- “neurophysiological” *treatment*
- task-specific repetitive concepts of motor learning
- cognitive program
- sensory restoration

## “Neurophysiological” Treatment Concepts Proprioceptive Neuromuscular Facilitation (PNF) (Kabat 1950)

- Improvement of muscular function by **temporal and spatial summation of different stimuli**
  - **Exteroceptive** (tactile, visual, vestibular, verbal)
  - **Proprioceptive** (stretch, traction and approximation, resistance)
- Techniques:
  - Hold Relax
  - Agonist Contract
  - Hold-Relax with Agonist Contract
  - Rhythmic Initiation
  - Slow Reversal
  - Rhythmic Stabilization

Voss D, Ionta MK, Meyers BJ (1985). Proprioceptive Neuromuscular Facilitation. New York: Harper & Row

## Rehabilitation Concepts I

- “*Neurophysiological*” *treatment concepts*
  - Restoration of a most physiological movement pattern,
  - inhibit an increased muscle tone (spasticity) by gently mobilizing the paretic limbs and opposing synergistic movements,
  - repeat in short form the *statomotor* development of a child as prerequisite for the final goal of a most natural walking habit,
  - Accordingly, tone-inhibiting maneuvers and motor tasks while lying, sitting or standing dominate therapy sessions of patients, who desperately wished to walk.

## “Neurophysiological” Treatment Concepts

- Sensomotoric facilitation (Janda)
- Reflexlocomotion (Vojta)
- Other techniques:
  - Brunkow – Concept
  - Hippotherapy
  - Klein-Vogelbach – Concept („Funktionelle Bewegungslehre“)

## “Neurophysiological” treatment concepts Bobath - Concept

- Principles:
  - Sensomotor recovery
  - Promotion of disturbed perception by regular appropriate stimuli
  - Inhibition of pathologic posture and movement pattern
  - Inhibitory positioning
  - Tonus reducing activities (stretching, manual mobilisation of muscles)
  - Facilitation of physiologic movement pattern:
    - Normalizing the posture tone of trunk, deduced top down exercises of paretic extremity
    - Avoidance of co-contractions and associate reactions **countering pathologic movement patterns**
    - implement the **contra-lateral extremity** to promote physiologic movement patterns
    - promotion of movement by **proprioceptive and exteroceptive facilitation** in terms of repetitive phasic stretching or stroking the skin

Bobath B (1978) Adult hemiplegia: Evaluation and Treatment. London: Heinemann Medical Books.

## Rehabilitation Concepts I

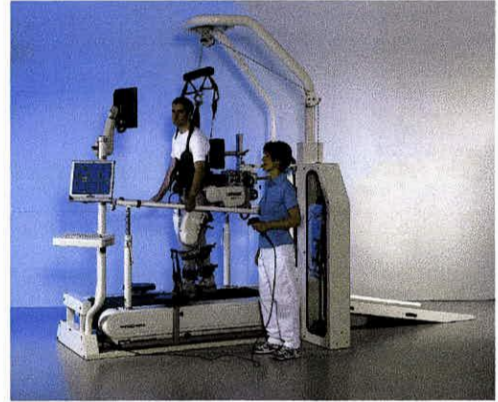
- *task-specific repetitive concepts of motor learning*
  - a)
    - Locomotor therapy by treadmill training with partial body weight support
    - harness to substitute for deficient equilibrium reflexes,
    - part of his body weight was relieved to compensate for the paresis of the impaired lower limb, and the
    - motor-driven treadmill enforced locomotion.
    - Wheelchair-bound patients up to 1000 steps during a 30 min session as compared to 50 to 100 at maximum during a conventional therapy session.

## Rehabilitation Concepts II

- *task-specific repetitive concepts of motor learning*

b)

- two therapists assisted the patients' gait, sitting alongside to place the paretic limb, to ensure an initial contact with the heel, to prevent a knee hyperextensor thrust and to control for a symmetric step length. Standing behind the patient, a second therapist shifted the weight according to stance/swing phase, promoted hip extension and trunk erection.
- The concept of locomotor therapy
  - massive gait practice to activate spinal and supraspinal pattern generators
  - efficient cardiovascular training of the deconditioned and often multimorbid patients.



## Different Robotic Systems

- Locomatic, HOCOMA System
- Gait Training, HESSE System
- Robotics, MAURITZ System
- Foot Sole Stimulation System, KORVIT

## System after Mauritz, Berlin



## KORVIT SYSTEM; System Kozlovskaya

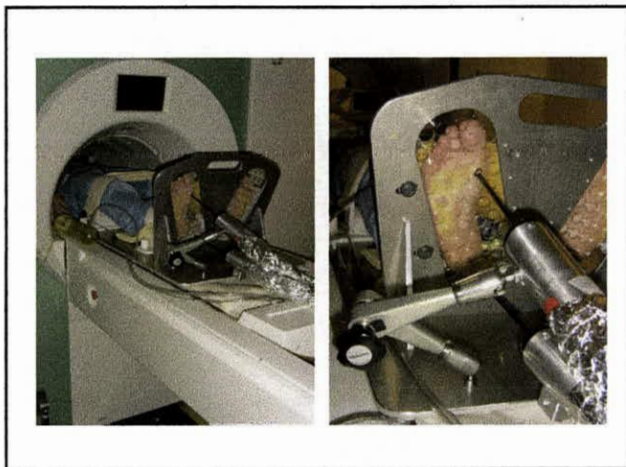
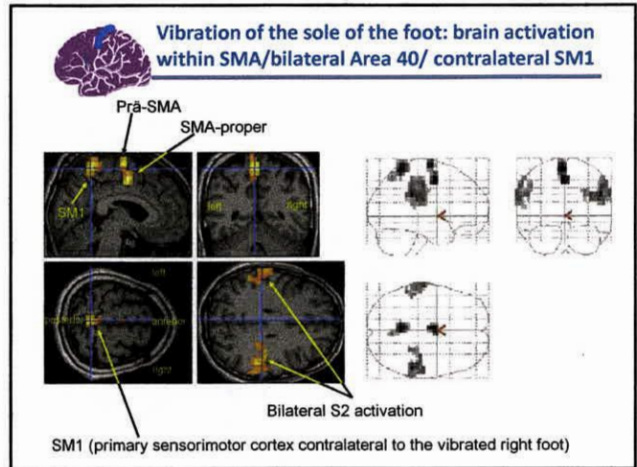
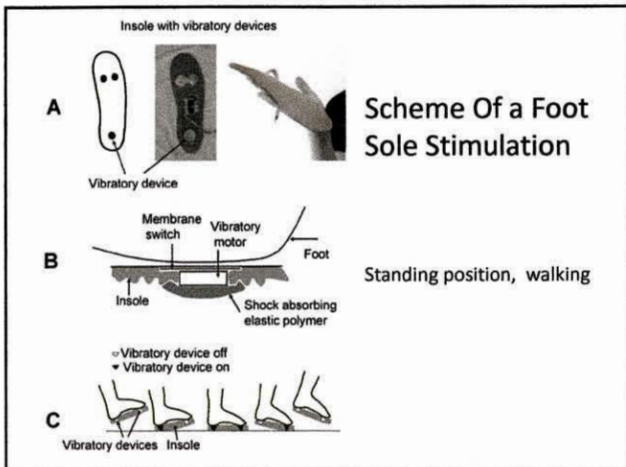
Korvit - Foot loading imitator



Used in:  
Gait disturbances; Parkinson's disease;  
spasticity, different origin; spinal cord  
lesions; polyneuropathy

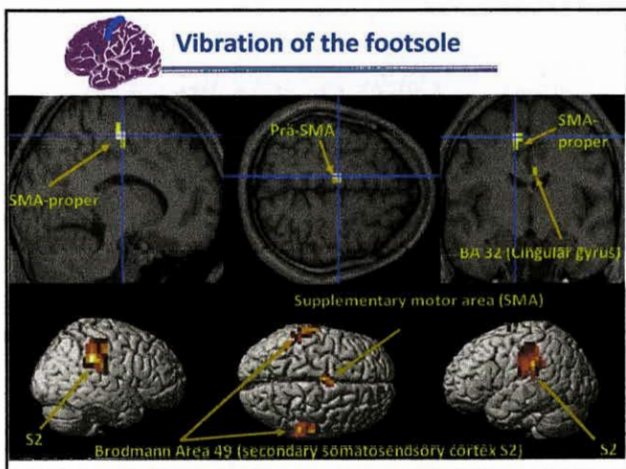
Planned: Dementia, geriatric institutions





**Results of Vibration**

- Vibratory stimulation of the sole of the foot revealed robust contralateral activation within the primary sensorimotor cortex (SM1), bilateral activation within the secondary somatosensory cortex (S2, Brodmann Area 40), bilateral within the supplementary motor area (SMA, BA 6) and ipsilateral within the cingulate gyrus (BA 32).



**Shrinking general conditions**

- **Comorbidity**
- **Fatigue**

### Comorbidity Assessed By Means of CIRS

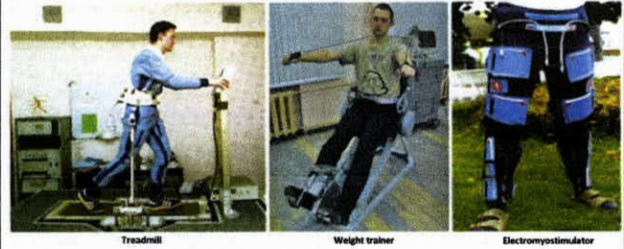
The scale identifies 14 items, corresponding to different systems

1. Cardiac,
2. hypertension,
3. vascular,
4. respiratory,
5. eye/ear/nose/throat,
6. upper gastrointestinal,
7. Gastrointestinal area,
8. hepatic,
9. renal,
10. other genitourinary,
11. musculoskeletal,
12. neurological,
13. endocrine/metabolic and
14. psychiatric/behaviour

Each system is scored as follows:

- 1 = none, no impairment to the specific organ/system;
- 2 = mild, impairment does not interfere with normal activity, treatment may or may not be required and prognosis is excellent;
- 3 = moderate, impairment interferes with normal activity, treatment is needed and prognosis is good;
- 4 = severe, impairment is disabling, treatment is urgently needed, prognosis is guarded;
- 5 = extremely severe, impairment is life threatening, treatment is urgent or of no avail and prognosis is not good.

### Prevention Methods During Space Flights



The same methods used in neurorehabilitation: neurological disturbances (spasticity, cerebellar disturbances, Parkinson Disease, polyneuropathy, early dementia state) Geriatrics wellness training

Source: Manned Mission to Mars, Russian Academy of Cosmonautics, 2006

### Task Specific Approach Paradigm for Motor Rehabilitation

- train as many as possible different daily life walking situations during gait rehabilitation
- Haptic Walker
  - programmable footplates to train arbitrary gait trajectories and daily life walking situations.

### New Neurorehabilitation Methods

#### Pressure shoe Austrian model

Used in:

- long-lasting coma states (intensive care units),
- Prevention of bedrest syndrome
- Apraxic syndrome
- Locked-in syndrome
- Severe stroke defects
- Severe states after traumatic brain injury



Planned: Dementia, Geriatric institutions

### Different devices as spin-off effect of space neurology

- Prevention tools for space missions:
  - treadmill
  - weight trainer
  - trousers with electrostimulator, etc.
- Tools used in neuro-rehabilitation
  - Pressure shoe – Austrian model
  - Pressure shoe – Russian model
  - Korvit System – Foot loading imitator
  - Regent – treatment suit
  - Penguin System
  - ADEL System

### New Neurorehabilitation Methods

#### Mechanical Stimulator, „Artificial Foot“ Russian model



Used in:

- Prevention for bedrest syndrome (ICU)
- Parkinson's Disease (mild form), spasticity (mild form), cerebellar symptoms, etc.

Source: Manned Mission to Mars, Russian Academy of Cosmonautics, 2006

## New Neurorehabilitation Methods



### Regent Treatment Suit

Used in:

Spasticity  
Spinal cord lesions  
Parkinson's Disease  
Polyneuropathy  
Stroke, severe defects

Planned In:

Cerebellar ataxia, Dementia,  
Geriatric institutions

## Scuba Diving – a new Neurorehabilitation method – 1

Partial microgravity,  
influence to proprioceptive system

- Diminishing stimulation of the proprioceptive system
- Diminishing of the vestibular system
- Relaxation of vertebral spine system
- Pathophysiological explanation open
  - Reduced stimulation of the proprioceptive system

## New Neurorehabilitation Methods



### Penguin Suit

Used in:

Cerebral palsy  
Spastic spinal  
paralysis

Planned: Parkinson's  
Disease, Dementia



## Scuba Diving – A New Neurorehabilitation method - 2

Partial microgravity,  
influence to proprioceptive system

- Indications:
  - minimal spinal cord lesions (traumatic, MS, etc.)
  - vertebral spine disturbances
    - cervical myelopathy
    - lumbalgia with radicular/pseudo-radicular symptoms

## New Neurorehabilitation Methods



Source: ADELI Flyer

### ADELI SYSTEM

Used in:

Cerebral palsy  
Spastic spinal paralysis  
Stroke  
Vertebral spine  
decompensation

Planned:  
M. Parkinson  
Dementia



Source: ADELI Flyer

## Scuba Diving – A New Neurorehabilitation method - 3

Partial microgravity  
influence to proprioceptive system

- Additional method in neurorehabilitation
  - Mild Parkinson Syndrome
  - Mild spasticity (after stroke, TBI, etc.)
  - Mild form of cerebellar ataxia

## Scuba Diving in Depth 4 - 5 m



Precondition:  
Always in pairs  
with special  
trained physio-  
therapist

## Future Outlook in Neurorehabilitation

- Actual neurorehabilitation of all acute conditions of CNS & PNS, continued as long as improvement can be expected, even for years
- Temporary neurorehabilitation is an ethical obligation for patients with chronic conditions
- Palliative neurorehabilitation is a possibility according to clinical course and condition
- Transfer at the end of neurorehabilitation program to long-term nursing home care only according to prognostic values
- Obligation of amelioration of quality of life

### • Summary:

- Optimal **timing** of rehabilitation is **modifiable**, unlike other predictors
- early rehabilitation may start **as early as possible** anywhere **from 3 to 30 days after stroke**.
- Surrounding a cerebral infarct is a **zone of cells** that potentially are **salvageable** but are more **vulnerable**. These cells may or may not recover, depending on a number of physiologic factors.
- Increased potential for **cortical plasticity** in the **7 to 18 days** after injury
- Rehabilitation in the very early stages after stroke theoretically may harm vulnerable cells, but **increases in infarct volume have not** always been shown to **correlate predictably with functional outcomes**.