Neurorehabilitation in childhood

Zsuzsanna Vekerdy MD, PhD.
Special features of pediatric rehabilitation

- Age-related diseases and developmental issues
- Importance of family (mom, etc).
- Nurturing / care needs are extreme
- Pedagogical aspects have to take into consideration
- Goal attainment is different
Children with special health care needs

Children with special health care needs are those who have, or are at risk for, chronic physical, developmental, behavioral, or emotional conditions and who also require health and related services of a type or amount not usually required by typically developing children.
Main etiological categories causing disabilities

- Birth defects, genetically determined disorders
- Acquired disabilities
  - Neurotrauma
  - Brain damages of perinatal origin
  - Sequelae of acute / chronic diseases
MAIN CATEGORIES of children with developmental disorders and other disabilities eligible for early intervention or/and rehabilitation

- Cerebral palsy
- Mental retardation – Learning disability
- Visual Impairment
- Hearing impairment
- Behavioral problems
- Autism
- Neurological disorders frequently causing developmental problems: epilepsy, hydrocephalus, spina bifida (MMC), muscle dystrophy, spinal muscle atrophy, etc.
Neurotrauma (spinal cord, brain, periferial nerve injury)
Neuropathic bowel / neurogenic bladder
Burns
Arthrogryposis
Limb deficiency
Osteogenesis imperfecta
Spinal deformity
„The medically fragile” / the ventilator dependent child
Rehabilitation for children

• What does that mean??

• https://www.youtube.com/watch?v=rm4zpFbi8YI
Cerebral palsy

Cerebral palsy (CP) refers to a non-progressive group of syndroms of posture and movement disorders, which is caused by the damage of the developing brain (intrauterine, perinatal or later in childhood) and interfering with the everyday life activities. The disorder of the motor system is often accompanied by the problems of reception, cognitive skillles, communication and or the disorders of behaviour or seizure disorders and which is often lead to orthopedic complications.

The diagnostics, treatment and rehabilitation of all forms of cerebral palsy needs multidisciplinary approach.

*Dev Med Child Neurol 2005. 47:571-6*

For CP there are no specific treatments available, therefore there are number of non-pharmacological, pharmacological, surgical, alternative, and other therapies, in most of the cases the best outcomes are involving combined therapies and the combinations had to be changed time by time
Etiology

- Genetic causes
- Infections beginning in intrauterin life
- Risk factor: immaturity
- In the postnatal period: periventricular whitematter damage, steroid therapy, infections

Population incidence: 1 / 3-500 children
Clinical forms of CP

- Pyramidal - spastic
  - **Diplegia**
  - Hemiplegia
  - Tetraplegia
- Extrapyramidal
  - Choreo-athetoid
  - Dystonic
  - Ataxic
- Mixed
Clinical forms of CP

- Pyramidal - spastic
  - Diplegia
  - Hemiplegia
  - Tetraplegia
- Extrapyramidal
  - Choreo-athetoid
  - Dystonic
  - Ataxic
- Mixed

Pathological involuntary movements due to upper neuron paresis
Symptoms of CP

- Abnormal movement pattern
- Delayed motor milestones
- Alterations in speech, cognitive, behavioral development
- Exaggerated tendon reflexes
- Visual, hearing problems
- Epileptic activity
- Problems with bowel and bladder control
- Growth failure
Natural course of cerebral palsy

Growth

Fixed contractures

Secondary influence of spasticity
– Growing energy expenditure of movements
– Difficulties in fitting of orthoses
– Fixed contractures and pain

“beneficial effect”:
supports the antigravity control
Gross Motor Functional Classification System (GMFCS)

I independent walking indoors, outdoors, jumping, climbing stairs
II independent walking indoors, limited outdoors, holds on while climbing stairs
III may walk short distance indoors, using assistive mobility device
IV may need adaptive equipment for sitting, propels WCh
V no self mobility needs assistance for moving

Types of the most common therapies in CP for improving **physical condition**

- **Non-pharmacological**
  - PT wide variety of methods (early therapies: Vojta, Katona; later: NDT, Kabbat, etc.)
  - Sensory integration therapies
  - Frunctional strength training
  - Orthotics
  - Electric therapy (low frequency)

- **Pharmacological**
  - Systemic oral
  - Intrathecal
  - Local – Botulinum toxin A

- **Surgical**
  - Orthopedic
  - Neurosurgical
Physical therapy

- „Neurodevelopmental therapy“ (NDT - Bobath)
- Delacato - „patterning“
- Subaqual therapies
- Hyppoterapy
- Vojta treatment
- Special manual technic, Deveny (HU)
- Constraint induced movement therapy (CIMT) - Taub

„best practice physiotherapy“
Orthoses of the lower limb

AFO Ankle-Foot Orthoses

Improving functions

- Heels down, foot correction
- Walking is more stabilized and faster
Special orthotics

The „ring”
S.W.A.S.H

- Adductor spasticity
- Scissoring gait
- Hip dysplasia over 10 degrees of lateral hip migration
S.W.A.S.H.

Improving functions

- Reduces adduction and internal rotation
- Better rhythmicity of walking, sitting is more stable and sitting position is better
Deformities of spine
TLSO: thoraco-lumbar-sacral orthosou/braces
Positioning

• TLSO, sitting module, custom moulded seats

• Standing devices

• Supine devices
Electrotherapy

Functional electric stimulation: aim the strengthening of the weak antagonist muscles. The muscle activities can easily be seen during therapy.
Functional strength training (FST)

- CP impairs motor performance by reducing muscle strength and motor control. Over time, the deficits can negatively affect bone and muscle growth, range of motion, and the acquisition of motor skills and due to the reduced activities weakness is the leading problem of children with CP.

- While PT/pharmacological treatments/surgery focuses on motor control and flexibility to limit or reduce muscle stiffness/spasticity and soft tissue contracture, training programs are aimed at improving strength, endurance, and overall physical fitness.

- Types of FST:
  - Body weight support treadmill training, which is an intervention that uses theories of motor learning and the importance of early task-specific training
  - FST by computer—assisted walking training
  - FST with using TheraSuit therapy
Thera suit therapy is defined by FDA as a soft, dynamic, and proprioceptive orthotic, is full-featured dynamic correction clothing.

www.suittherapy.com
Indications for children >2,5 y
Cerebral Palsy, Developmental delay, TBI, Post-stroke condition, Ataxia, Athetosis, Spasticity, Hypotonia

Contraindications
HIP subluxation (>50% lateral migration of femoral head; Severe scoliosis

Precautious
Heart conditions; uncontrolled seizure activities; hip subluxation; hydrocephalus (VP shunt); diabetes; kidney problems; high blood pressure.

• The invention of the TheraSuit can be tracked back since the 60’s; the United States and the Soviet Union compete to develop space science and technology, and similar closing was used against zero-gravity.
• Earlier devices were The ‘Penguin suit’ and ‘Adeli-suit’
• This device was developed by parents of a child with CP, Richard and Isabella Koscielny, both PT-s, and named as TheraSuit in 2002. (U.S. Patent US 7,153,246, International Patent PCT/US2008/051458)
• They are the owner of Therasuit LLC company, having the executive right for dealing
Benefits of the method

**Improves body and spatial awareness;**

**Supports weak muscles;**
Provides resistance to strong muscles to further enhance strengthening;

**Improves speech production and its fluency through head control and trunk support;**

**Promotes development of both fine and gross motor skills;**

**Improves bone density;**

**Helps to decrease contractures;**

**Helps improve hip alignment through vertical loading over the hip joint.**

- Re-trains central nervous system;
- Restores ontogenic development;
- Provides external stabilization;
- Normalizes muscle tone;
- **Aligns the body to as close to normal as possible;**
- Provides dynamic correction;
- Normalizes (corrects) gait pattern;
- Provides tactile and proprioceptive stimulation;
- Influences the vestibular system;
- Improves balance;
- Improves coordination;
- Decreases uncontrolled movements in ataxia and athetosis.
Technical details

TheraSuit Method is a 2-4-week program that combines strengthening and fine skills training with frequency of 3 to 4 hours a day, 5 days a week and claims to improve function at a faster rate than other therapy programs.

Its major goal is to improve and change proprioception, reduce patient's pathological reflexes, restore physiological muscle synergies (proper patterns of movement) and load the entire body with weight.
Steps of the suit therapy
- „Warming up”, massage, passive ROM, elongation of muscles
- Series of active movements without suit
- Active movements in the Thera-suit
- Training in the Thera-Suit
The „thera-Tog” version

Inner layer: foam
Outer layer: Velcro sensitive

Breathable „second skin” Undergarment with elastic strapping Posture and Torso Alignment (PTA)
Home usage of the thera-tog

ACCESSORIES

Universal Exercise Unit (UEU) and the optional equipment for the UEU.

1) Pulley System with Suspensions.

2) Suspension System (called “Spider Cage”)
summary

- Thera suit therapy is a new approach addressing the improvement of postural and balance control.
- It is basically a special functional strength training which includes many elements of PT, proprioceptive stimulation.
- Although, there is no clear evidence on its effectiveness but in practice, there are a lot of beneficial effects.
history of the parapodium

1971
Motloch

1974
adult version

1981
with hip and knee flexing modifications

1984
Rochester PP

Nowadays
thank for your attention

nagy.adel1108@gmail.com
Assistive devices for walking
• https://www.youtube.com/watch?v=R8VuA8yVBv8
# Treatment modules in CP

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<td>• PT, OT, Speech T</td>
<td>• Oral GABA agonists</td>
<td>Dorsal rhyzotomy DBE</td>
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<tr>
<td>• electric stimulation, orthoses, serial casting, adaptive devices (standing, sitting posturing and walking aids)</td>
<td>• $\alpha$2 adrenerg agonists muscle relaxants antiepileptic drugs</td>
<td>Orthopedic: Soft tissue and bony surgery of extremities</td>
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<td>• Intramuscular Alcohol Phenol Botulinum toxin A, B, E</td>
<td>Spine deformities</td>
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<td>• Intrathecal baclofen</td>
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Main goals of therapy in CP

- Reducing spasticity
- Stretching of myotendinous unit
- Training of weak (antagonist) muscles
Important

With reducing spasticity selective motor control can be improved and consequences of natural course of CP can be eliminated or reduced such as contractures, pain etc.
Pharmacological treatment

• Oral medication
• Intrathecal
• Local
**Intrathecal baclofen**

- Gaba B agonist – inhibits outflow of excitatory neurotransmitters (glutamat, aspartat) - NEUROMODULATION
- Many muscles are involved – focal therapy is insufficient
- Primarily in spasticity due to spinal cord and brain injuries
ITB pump intraoperative filling up

ITB pump insertion (subcutan – andominal)
Chemodenervation

Botulinum toxin (A,B,E)
Phenol (3-7%)
Alcohol (45-100%)
Botulinum toxin

Mechanism of action
Inhibits Acetylcholin release in neuro-muscular junction and blocks stimulus transmission

7 serological subtypes
A, B, C, D, E, F, G

- 150 kDa dimer

- 100 kDa membrane-bounded heavy chain

- 50 kDa Zn-dependent protease

light chain
Botulinum-A toxin (BTX-A)  
Most frequently treated muscles

- **Lower extremity**
  - Gastrocnemius /soleus - calf
  - Hamstrings
  - Adductors
  - Iliopsoas
  - Rectus femoris

- **Upper extremity**
  - Pronator teres
  - Flexor carpi radialis
  - Flexor carpi ulnaris
  - Flexor digitorum longus
Effects of BTX-A treatment on children with CP

- Reduces spasticity in treated muscles
- Promotes normal or close to normal motor learning
- With training of antagonists newly learned motor skills are maintained causing a prolonged beneficial effect of BTX-A treatment - "window of opportunity"
- BTX-A helps muscles growing and developing
- Causes pain release with reducing stiffness and spasticity
Combinations of BTX-A treatment

S.W.A.S.H. and AFO: Streches the muscle-tendon unit and keeps the leg or arm in correct position during movements

„best practice physiotherapy”: active PT, electrotherapy: strengthen weak muscles
S.W.A.S.H.
# Treatment modules in CP

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Idegsebészeti műtétek

• Dorzális rhizotómia: spasticus diplegia, jó szelektív mozgáskontroll, jó izomerő az extenzorokban, járásanalítika, **GMFCS II-III**

  **Evidencia (II) jobb mint a fiziotherápia egymagában**

Dorsal rhizotomy and intrathecal baclofen fpr lower Extremity spasticity assoitated with cerebral palsy
Bloomington MN
Health Technology Assessment Database 2008 Issue 1

• Dorzális és ventrális rhizotómia
  Spasticitás + dystonia és ITB nem lehetséges

Combined ventral and dorsal rhizotomies for dystonic and spastic extremities.
Report of six cases.
Albright AL, Tyler-Kabara EC.
Videók
Debbie
http://www.youtube.com/watch?v=IsaNdElpmQw
Megan
http://www.youtube.com/watch?v=wA7TKfl2WeM
Carter
http://www.youtube.com/watch?v=blvi_UcANA0
Emily
http://www.youtube.com/watch?v=hxFIqxC2wJ-U
Functional outcomes of childhood dorsal rhizotomy in adults and adolescents with cerebral palsy

Hurvitz EA, Marcziniak CM, Daunter AK, Haapala HJ, Stibb AM, McComick SF, Muraszko KM, Gaebler-Spira D
(Univ of Michigan Ann Arbor, Rehab Inst NW Univ, Chicago)

Eighty-eight participants, mean age 25.6 ± 4.8 years (mean ± standard deviation), were interviewed at a mean of 19.6 ± 3.0 years after surgery. The distribution of current reported Gross Motor Function Classification System levels was as follows: I, 7%; II, 18%; III, 23%; IV, 36%; and V, 16%. Moreover, 56% of respondents were living with parents and 25% were living alone. Thirty-five percent were employed, and 39% were still in school. The mean overall SWLS score was 26.0 ± 7.3, indicating a high level of satisfaction with life. According to 65% of the patients, the SDR was helpful; 31% were uncertain about the procedure’s efficacy. Sixty-five percent would recommend the procedure to others.

Additional interventions were frequently performed after the SDR. Seventy-four percent of participants underwent orthopedic surgery. Thirty-eight percent were currently taking oral medications for tone, and 53% had received botulinum toxin injections for spasticity treatment. Thirteen patients (15%) had an intrathecal baclofen pump placed.
Effect of selective dorsal rhizotomy in the treatment of children with cerebral palsy

Jack R. Engsberg, Ph.D., Sandy A. Ross, P.T., M.H.S., D.P.T., David R. Collins, Ph.D., and Tae Sung Park, M.D.

Seventy-seven ambulatory children with spastic diplegic CP were recruited for this investigation. The SDR-PT group initially included 37 children (mean ± SD, 9 ± 5.3 years of age) and the PT group included 40 (9.7 ± 4.5 years).

Criteria for participation in the CP groups included the following:

✓ a diagnosis of spastic diplegic CP;
✓ classification in Levels I to III in the GMFCS;
✓ the ability to walk (with or without orthoses, including crutches and canes);
✓ a minimum level of cognitive skills for active participation;
✓ no surgical intervention within the preceding year;
✓ hypertonicity of the lower extremity measured with the modified Ashworth scale; ankle clonus; exaggerated deep tendon reflex in the legs; Babinski sign; and
✓ abnormal postures while sitting, standing, and walking.
✓ participants had to be able to perform six to eight repetitions of barefoot walking for approximately 8 minutes.

✓ They were not permitted in the study until 6 months after any casting procedures or injections of botulinum toxin serotype A (Botox; Allergan, Inc., Irvine, CA).
✓ We established a minimum participant age of 4 years to facilitate cooperation with the collection of gait, spasticity, and strength data. This age requirement excluded approximately 40% of the patients who were being screened for and ultimately underwent an SDR.
• **Intensive Physical Therapy**
  • After discharge, the members of the SDR-PT group received PT from therapists in their hometowns **four times per week for 8 months**. Subsequently, treatments were reduced to three times per week for an additional 12 months. Members of the PT-only group received the same number of PT sessions. The physical therapists for both groups **focused their treatment on the trunk and lower extremities, on strengthening, and on functional activities**.

**Spasticity**, characterized as a velocity-dependent resistance to passive stretch\(^5,19,21\) was measured with an isokinetic dynamometer (KinCom; Chattecx Corporation, Chattanooga, TN) for the ankle plantar flexors, knee flexors, and hip adductors.

**Strength** tests were designed to measure the maximum active resultant torque-generating capacity that the child could produce.

Gross Motor Function Measure (88, 66)

**Gait Analysis**

The purpose of this investigation was to compare multidimensional outcomes in a group of patients with CP undergoing SDR followed by intensive PT with outcomes in a group of similar participants undergoing intensive PT only. **The major limitation of the investigation was that it was not randomized**. Our strategy was to use the same inclusion and exclusion criteria for both groups to ensure a larger number of participants relative to the number in the three previously reported investigations

**2 year follow-up**
Discussion

we report a decrease in spasticity in the SDR-PT group. In patients in the PT-only group, we also report decreases in spasticity in the ankle plantar flexors as well as values for the ankle plantar and knee flexors that were not significantly different from those measured in patients in the ND group at any test session.

We have previously reported that children with CP undergoing SDR were weaker before the operation than children in the ND group, and remained weaker Despite the overall weakness—and contrary to prior reports about weakness after SDR, we have previously reported significant increases in knee flexor/extensor and hip adductor strength after SDR, with no significant change in the strength of the ankle plantar flexors. Results from the current investigation support some of this work, but they also show increases in strength for the ankle plantar flexors. The results of our investigation also support those of other investigations indicating that strength can be increased in children who have CP.

Gait speed: The increase in gait speed of 25 cm/second in the SDR-PT group was significantly greater than the increase of 3 cm/second in the PT-only group

GMAE scores: metaanalysis of the combined results of the three investigations* indicated that SDR followed by intensive PT was more effective in the improvement of GMAE scores than intensive PT alone

*ez másik három korábbi összehasonlító tanulmányra vonatkozó metaanalízis
Gait results

The results for gait kinematics further support results in previous studies that demonstrate improved gait characteristics. The results indicate that the postoperative gait pattern in the SDR-PT group was closer to that in the ND group than to its own preoperative pattern. The fact that no changes in gait kinematics were observed in the PT group means that despite the intensive PT, which resulted in some significant gains in strength, gait patterns in these patients did not change.

The answers to the following three questions may explain the lack of pattern changes and would also be extremely interesting to investigate:

1) Would gait reeducation based on a gait analysis improve gait kinematics?
2) Are there specific muscles that need to be strengthened (for example, plantar flexors) to improve gait? The SDR-PT group was the only group to achieve considerable gains in plantar flexor strength.
3) Would a specific rather than a generalized PT protocol (currently used in the SDR clinic) result in greater gains in gait?
Ortoped surgery

Soft tissue* (5-8 y)  
bony (7-12 y)

*Single event multilevel surgery (SEMLS)

Exception: danger of hip luxation – adductor tenotony
The effect of quantitative gait assessment and botulinum toxin A on musculoskeletal surgery in children with cerebral palsy
Molenaers G, Desloovere K, Fabry G, DeCock P.
J Bone Joint Surg 2006;88:161-70

1. csoport: szokásos orthopédiai ellátás (n=122)
2. Csoport: előző + computeres járás analízis (n=170)
3. csoport: előbbiek + botulinum toxin A kezelés (n=132)
1. csoport: szokásos orthopédiai ellátás
2. Csoport: szokásos orthopédiai ellátás + computeres járás analízis
3. csoport: előbbiek + botulinum toxin A kezelés
Neuromuscular Blocking Agents

Frequency of treatment

Botulinum toxin for spasticity

Surgery for contracture & deformity

Surgery for hip instability

Botulinum toxin for dyskinesia, analgesia & adjunct to surgery

Relative frequency of treatment type in CP management program

Table modified from Allergan training module 4
Critical issue in spasticity management
Keeping the hip status in balance

Without treatment in spastic CP the risk of hip dysplasia
  in quadriplegy 80%
  in diplegia 35 %
Thank you for your attention!

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