

Review article ■

Assessment and Treatment of Spasticity in Children with Cerebral Palsy

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SUMMARY

Spastic cerebral palsy (CP) is the most common type of CP. Up to 80% of all individuals with cerebral palsy suffer from some degree of spasticity. Spasticity adversely affects muscles and joints of the extremities, causing abnormal movements, and it is especially harmful in growing children.

Several methods have been developed and used to assess spasticity. The most commonly used test in clinical practice is the Modified Ashworth Scale (MAS). The test is based on the assessment of resistance to passive stretch of muscle group at one nonspecified velocity.

Management of spasticity in CP involves multidisciplinary intervention intended to increase functionality, sustain health, and improve quality of life for children and their carers. This may include: oral medications, intrathecal medications, physiotherapy, occupational therapy, orthoses, surgical interventions, and pharmacological agents such as botulinum toxin.

Key words: cerebral palsy, children, spasticity, assessment, treatment

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INTRODUCTION

Cerebral palsy (CP) is a syndrome of motor impairment that results from a lesion occurring in the developing brain. The disorder varies in the timing of the lesion, the clinical presentation and the site and severity of the impairments (1). Spastic CP is the most common type of CP (2, 3). Up to 80% of all individuals with cerebral palsy suffer from some degree of spasticity. The degree of spasticity can vary from mild muscle stiffness to severe, painful, and uncontrollable muscle spasms (4, 5).

Spasticity is a velocity-dependent increase in resistance of a muscle when the muscle is moved passively or stretched. Individuals with spastic CP experience stiffness in affected limbs due to focal muscular hyperactivity, resulting in limited or awkward movements.

Spasticity refers to increased tone, or tension, in a muscle. Normally, muscles must have enough tone to maintain posture or movement against the force of gravity while at the same time providing flexibility and speed of movement.

The command to tense, or increase muscle tone, goes to the spinal cord via nerves from the muscle itself. Since these nerves tell the spinal cord just how much tone the muscle has, they are called "sensory nerve fibers." The command to be flexible, or reduce muscle tone, comes to the spinal cord from nerves in the brain. These two commands must be well coordinated in the spinal cord for muscles to work smoothly and easily while maintaining strength.

In a person with CP there is the damage in the brain which is usually in the area of the brain that controls muscle tone and movement of limbs. Therefore, the brain is unable to influence the amount of flexibility a muscle should have. The command from the muscle itself dominates the spinal cord and, as a result, the muscle is too tense or spastic.

I EFFECTS OF SPASTICITY

Spasticity adversely affects muscles and joints of the extremities, causing abnormal movements, and it is especially harmful in growing children (3, 5). The known adverse effects of spasticity include:

1. Inhibition of movement
2. Inhibition of longitudinal muscle growth
3. Inhibition of protein synthesis in muscle cells
4. Limited stretching of muscles in daily activities
5. Development of muscle and joint deformities

Spasticity may affect any muscle group in the body, however, there are some common patterns that are seen in cerebral palsy. *Effect on the upper limbs: flexion at the elbow, wrist and fingers. Effect on the lower limbs: flexion at the hip, adduction or 'scissoring' of the thighs,*

flexion at the knees, equinovarus foot posture, hyperextension of the big toe. Spasticity can also be present in smaller muscles such as tongue and facial muscles.

Although the damage to the brain that causes spasticity does not change over time, the effects of spasticity on the body can result in changes. Effects of spasticity over time:

- Changes in soft tissues (muscles, tendons and ligaments) leading to muscle stiffness, atrophy and fibrosis.
- Muscles that are affected by spasticity have difficulty stretching out to keep up with bone growth - resulting in muscles that are shorter than they should be. This prevents a joint achieving its normal full range of movement - a contracture.
- Shortened, contracted muscles can pull on the bony structures of the body leading to bone deformities such as scoliosis of the spine and hip dislocation.
- Pain - persistent overactivity in spastic muscles can cause pain in the muscle. Pain can also occur as a result of changes in the joint position and deformities due to the abnormal pull of the spastic muscle.

II CLINICAL ASSESSMENT OF SPASTICITY

Diagnostic definition: 'a motor disorder characterised by a velocity-dependent increase in tonic stretch reflexes that results from abnormal intra-spinal processing of primary afferent input' (Young 1994)(6).

Functional definition: the abnormal motor control caused by an upper motor neuron (UMN) lesion (as in spastic paraparesis).

The most commonly used definition of spasticity is described by Lance (1980): „Spasticity is a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex, as one component of the upper motor neuron syndrome“ (7).

Several methods have been developed and used to assess spasticity, and can be classified into: clinical, biomechanical and neurophysiologic methods.

All scales used for clinical assessment of spasticity could be categorized into three main groups (7):

I Ashworth-like Scales:

Ashworth scale	AS	Ashworth, 1964
Modified Ashworth scale-Bohannon	MAS-B	Bohannon and Smith, 1987
Modified Ashworth scale-Peacock	MAS-P	Peacock and Staudt, 1991
New York University tone scale	NYU	Johann and Murphy, 1990

II Tardieu-like Scales:

Tardieu scale	TS	Held and Pierrot-Deseilligny, 1969
Modified Tardieu scale	MTS	Boyd and Graham, 1999

III Other Clinical Grading Scales

Spasticity Grading	Sindou and Jeanmonod, 1989
Modified Composite Spasticity Index	Levin and Hui-chan, 1992
Duncan Ely Test	Bleck, 1987
Nameless clinical grading scale	Trombly, 1953
Nameless	No references
Nameless	No references
Nameless	No references

The most commonly used test in clinical practice is the MAS (8). The test is based on the assessment of resistance to passive stretch of muscle group at one nonspecified velocity. The lack of standardization in the velocity makes this method not completely consistent with Lance's definition of spasticity.

Grade Description (MAS-B)

- 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, affected part(s) easily moved
- 3 - Considerable increase in muscle tone, passive movement difficult
- 4 - Affected part(s) rigid in flexion or extension

MTS use at list two different velocities of passive muscle stretch (slow and fast). The MTS appears to be preferable because it can differentiate between spasti-

city and contracture. Several studies noted the limitations of both the Tardieu and Ashworth scales in children with CP (6-8).

III TREATMENT OF SPASTICITY

CP rehabilitation programs for children utilize a multidisciplinary approach where members of a team are selected with respect to a child's age, developmental level, severity of impairment, and availability of services. Yet, in all cases, the child's family remains at the center of the treatment team and a child's challenges can be a great source of stress to the family that may impact quality of life (9-11).

Management of spasticity in CP involves multidisciplinary intervention intended to increase functionality, sustain health, and improve quality of life for children and their carers. This may include: oral medications, intrathecal medications, physiotherapy, occupational therapy, orthoses, surgical interventions, and pharmacological agents such as botulinum toxin.

Medications

Medications that can lessen the tightness of muscles may be used to improve functional abilities, treat pain and manage complications related to spasticity. The selection of medications depends on whe-

ther the problem affects only certain muscles (isolated) or the whole body (generalized). Drug treatments may include the following:

- **Oral medications**

If the whole body is affected (generalized spasticity), oral muscle relaxants may relax stiff, contracted muscles. These drugs include diazepam, dantrolene and baclofen.

There is some risk of dependency with diazepam, so its not recommended for long-term use. Its side effects include drowsiness, weakness and drooling.

Side effects of dantrolene include sleepiness, nausea and or diarrhea.

Side effects of baclofen include sleepiness, confusion and nausea. Baclofen may also be pumped directly into the spinal cord with a tube. The pump is surgically implanted under the skin of the abdomen.

- **Injections of botulinum toxin type A (BTA)**

Injections of botulinum toxin A(BTA) are recommended for isolated (focal) spasticity. BTA is a serotype of botulinum toxin, produced by the Gram-positive bacterium *Clostridium botulinum*. This potent neurotoxin selectively inhibits the release of acetylcholine from peripheral nerve terminals by binding to synaptic vesicles. Interruption of neuromuscular conduction by BTA induces a temporary weakness, which reduces focal spasticity. Early treatment of spasticity with BTA prevents contractures and deformities, in order to delay or avoid surgical treatment.

The effects of BTA last for approximately three months as the muscle will recover via proximal axonal sprouting, the formation of new neuromuscular junctions, and the regeneration of the original neuromuscular junctions. The efficacy of BTA in the management of individuals with CP has been widely reported in the literature (12-15) (Figure 1, Figure 2).



Figure 1. *Pes equinus spasticus* („toes walking“) - before BTA treatment



Figure 2. *Full standing plantar surface* - three weeks after BTA treatment

Side effects may include pain, bruising or severe weakness (16). Other more serious side effects include difficulty breathing and swallowing.

Surgical interventions

- **Baclofen pump - intrathecal baclofen (ITB)**

ITB Therapy uses a surgically implanted programmable pump and catheter that delivers medication which helps relieve severe spasticity. This medication is a liquid form of baclofen (baclofen injection) that goes directly into the intrathecal space where fluid flows around the spinal cord.

Because baclofen is delivered directly to where it is needed most in the spinal fluid, it relieves spasticity with smaller amounts of medication than when baclofen is taken orally. This method of delivery may help minimize side effects that can result from oral baclofen.

This form of therapy is most appropriate for children with severe hypertonia and uncontrolled movement disorders throughout the body. The baclofen pump must be filled with medicine every one to six months, depending on child's dose. The pump lasts about five years. Afterward, it must be removed and replaced during another surgery. However, baclofen infusion is not effective permanently; when it is stopped, spasticity recurs. Also, the baclofen infusion carries risks of overdose, meningitis, and other complications (17).

- **Orthopedic surgery**

Orthopedic surgery is used to lessen muscle tightness or correct bone abnormalities caused by spasticity. Orthopedic operations includes soft tissue procedures (muscle release, tendon and muscle lengthening, tendon transfers) and osteotomies (cutting a bone to change its alignment). Orthopedic surgery can correct severe contractures or deformities, lessen pain, improve

mobility. These procedures may also make it easier to use a walker, braces or crutches (18).

Orthopedic surgery is often recommended when spasticity and stiffness are severe enough to make walking and moving difficult or painful. Commonly, surgery involves lengthening muscles and tendons that are proportionately too short. Orthopedists generally time surgeries to coincide with a specific stage of the child's physical development.

Spasticity in the upper leg muscles, which causes a "scissor pattern" walk, is a major obstacle to normal gait. The optimal age to correct this spasticity is 2 to 4 years of age with adduction release surgery. On the other hand, the best time to perform surgery to lengthen the hamstrings or Achilles tendon is 7 to 8 years of age. If adduction release surgery is delayed so that it can be performed at the same time as hamstring lengthening, the child will have learned to compensate for spasticity in the adductors. By the time the hamstring surgery is performed, the child's abnormal gait pattern could be so ingrained that it might not be easily corrected.

- **Selective dorsal rhizotomy (SDR)**

Selective dorsal rhizotomy is a surgery done on the lower spinal cord to reduce spasticity or high muscle tone in the legs. Certain nerve fibers that lead to high muscle tone are cut. The goal of a selective dorsal rhizotomy is to relax the muscles by identifying and cutting those nerve fibers that are causing the abnormal tone. This provides a long-term improvement in muscle tone, because the nerves do not grow back together. SDR is a surgical procedure recommended only for cases of severe spasticity when all of the more conservative treatments have proven ineffective (17).

Physiotherapy

Physiotherapy for spasticity refers to a range of physical treatments. It is the most common form of treatment for spasticity in children. The treatment should be designed to meet child's specific needs and should reduce muscle tone, maintain or improve range of motion and mobility, increase strength and coordination, and improve care and comfort (19, 20).

Conventional rehabilitation. Stretching forms are the basis of conventional rehabilitation for treating spasticity. Stretching helps to maintain the range of motion in joint and helps prevent contracture. To be effective, the prescribed stretching routine must be done regularly, usually once or twice a day.

Facilitation. This includes neurodevelopmental therapy (also known as Bobath approach) aimed at reducing inappropriate reflexes and training muscles to achieve normal balanced reactions. Proprioceptive neuromuscular facilitation seeks to retrain spastic muscles for normal motion. Sensory integration involves continually repeating tasks, often with the therapist directing the limb while child remains passive, so that child's brain is "retrained" in the proper movements.

Hydrotherapy. Aquatic exercise programme may be useful for improving gross motor functioning, for reducing spasticity and for increasing cardiorespiratory endurance in children with spastic CP (21).

Orthoses. Also known as casts, braces, or splints, orthoses include any device that is used to support, align, prevent, or correct deformities, or improve the function of movable parts of the body. When used to treat spasticity, orthoses may reduce muscle tone and increase or maintain motion.

IV CONCLUSION

Cerebral palsy describes a group of permanent disorders of the development of movement and posture causing activity limitation, that are attributed to non-progressive disturbances that occur in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, behavior, epilepsy, and secondary musculoskeletal problems. Up to 80% of all children with CP suffer from some degree of spasticity. It is important to note that once spasticity has developed with CP, it never resolves spontaneously. Currently, oral medication, botulinum toxin A injection, baclofen infusion, orthopedic surgery, selective dorsal rhizotomy surgery, physical therapy and braces are employed to treat CP spasticity and related problems. CP cannot be cured, but treatment can help a child manage the condition.

References

1. Colver A, Fairhurst C, Pharoah P. Cerebral palsy. *Lancet* 2014; 383: 1240-49. [http://dx.doi.org/10.1016/S0140-6736\(13\)61835-8](http://dx.doi.org/10.1016/S0140-6736(13)61835-8)
2. Rosenbaum P, Paneth N, Leviton A et al. A report: the definition and classification of cerebral palsy. *Dev Med Child Neurol Suppl* 2007, 109: 8-14.
3. Parkinson KN, Gibson L, Dickinson HO, Colver AF. Pain in children with cerebral palsy: a cross-sectional multicentre European study. *Acta Paediatr* 2010; 99: 446-51. <http://dx.doi.org/10.1111/j.1651-2227.2009.01626.x>
4. Ramstad K, Jahnsen R, Skjeldal OH, Diseth TH. Characteristics of recurrent musculoskeletal pain in children with cerebral palsy aged 8 to 18 years. *Dev Med Child Neurol* 2011; 53: 1013-18. <http://dx.doi.org/10.1111/j.1469-8749.2011.04070.x>

5. Parkinson KN, Dickinson HO, Arnaud C et al. Pain in young people aged 13 to 17 years with cerebral palsy: cross-sectional, multicentre European study. Arch Dis Child 2013; 98: 434-40.
<http://dx.doi.org/10.1136/archdischild-2012-303482>
6. Van den Noort JC, Scholtes VA, Becher JG, Harlaar J. Evaluation of the catch in spasticity assessment in children with cerebral palsy. Arch Phys Med Rehabil 2010; 91:615-23.
<http://dx.doi.org/10.1016/j.apmr.2009.12.022>
7. Scholtes VA, Becher JG, Beelen A, Lankhorst GJ. Clinical assessment of spasticity in children with cerebral palsy: a critical review of available instruments. Dev Med Child Neurol 2006; 48:64-73.
<http://dx.doi.org/10.1017/S0012162206000132>
8. Alhusaini AA, Dean CM, Crosbie J et al. Evaluation of spasticity in children with cerebral palsy using Ashworth and Tardieu scales compared with laboratory measures. J Child Neurol 2010; 25: 1242-1247.
<http://dx.doi.org/10.1177/0883073810362266>
9. Dimitrijevic L, Jovic-Jakubi B. The importance of early diagnosis and early physical treatment of cerebral palsy. Facta Universitatis 2005; 12:119-122.
10. Borzoo S, Nickbakht M, Jalalian M. Effect of Child's Cerebral Palsy on the Mother: a Case Control Study in Ahvaz, Iran. Acta Fac Med Naiss 2014; 31: 75-79.
11. Jeong YG, Jeong YJ, Bang JA. Effect of Social Support on Parenting Stress of Korean Mothers of Children with Cerebral Palsy. J Phys Ther Sci 2013; 25: 1339-1342.
<http://dx.doi.org/10.1589/jpts.25.1339>
12. Molenaers G, Fagard K, Van Campenhout A, Desloovere K. Botulinum toxin A treatment of the lower extremities in children with cerebral palsy. J Child Orthop 2013; 7:383-387.
<http://dx.doi.org/10.1007/s11832-013-0511-x>
13. Pin TW, Elmasry J, Lewis J. Efficacy of botulinum toxin A in children with cerebral palsy in Gross Motor Function Classification System levels IV and V: a systematic review. Dev Med Child Neurol 2013;55:304-313.
<http://dx.doi.org/10.1111/j.1469-8749.2012.04438.x>
14. Mikov A, Dimitrijevic L, Sekulic S et al. Use of botulinum toxin type A in children with spastic cerebral palsy. Healthmed 2011;5:922-928.
15. Dimitrijevic L, Stankovic I, Zivkovic V et al. Botulinum toxin type A for the treatment of spasticity in children with cerebral palsy. Vojnosanit Pregl 2007;64:513-518 (in Serbian).
<http://dx.doi.org/10.2298/VSP0708513D>
16. Colovic H, Dimitrijevic L, Stankovic I et al. Estimation of botulinum toxin type A efficacy on spasticity and functional outcome in children with spastic cerebral palsy. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2012; 156: 41-7.
<http://dx.doi.org/10.5507/bp.2012.017>
17. Roberts A. Surgical management of spasticity. J Child Orthop 2013;7: 389-394.
<http://dx.doi.org/10.1007/s11832-013-0512-9>
18. Sees JP, Miller F. Overview of foot deformity management in children with cerebral palsy. J Child Orthop 2013; 7: 373-377.
<http://dx.doi.org/10.1007/s11832-013-0509-4>
19. Yalcinkaya EY, Caglar NS, Tugcu B, Tonbaklar A. Rehabilitation Outcomes of Children with Cerebral Palsy. J Phys Ther Sci 2014; 26: 285-289.
<http://dx.doi.org/10.1589/jpts.26.285>
20. Novak I, McIntyre S, Morgan C et al. A systematic review of interventions for children with cerebral palsy: state of the evidence. Dev Med Child Neurol 2013; 55: 885-910.
<http://dx.doi.org/10.1111/dmcn.12246>
21. Dimitrijevic L, Bjelakovic B, Lazovic M et al. Aquatic exercise in the treatment of children with cerebral palsy. Srp Arh Celok Lek. 2012;140: 746-50 (in Serbian).
<http://dx.doi.org/10.2298/SARH1212746D>

PROCENA I TRETMAN SPASTICITETA KOD DECE SA CEREBRALNOM PARALIZOM

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Sažetak

Najčešći tip cerebralne paralize (CP) je spastički tip. Kod oko 80% posto svih obolelih od CP registruje se izvestan stepen spasticiteta. Spasticitet nepovoljno deluje na lokomotorni aparat dovodeći do abnormalnog kretanja i deformacija, što remeti normalno funkcionisanje deteta.

Postoji više metoda za kliničku evaluaciju spasticiteta. U kliničkoj praksi najčešće je u upotrebi modifikovana Ashworth-ova skala (MAS). Test se zasniva na proceni otpora mišića na pasivno istezanje, pri čemu se brzina izvođenja pasivnog pokreta ne uzima u obzir.

Tretman spasticiteta sprovodi se timski, multidisciplinarno, sa ciljem da se poboljša funkcionalni status i kvalitet života deteta i njegovih roditelja. Tretman uključuje: lekove za oralnu, muskularnu i intratekalnu primenu, fizikalnu terapiju, primenu ortoza, hirurške intervencije.

***Ključne reči:* cerebralna paraliza, deca, spasticitet, procena, tretman**