Department of Physical Medicine and Rehabilitation/UAMS IDHI Brain Injury Program

TELE-REHABILITATION GUIDELINE

Medical Management of Spasticity in Spinal Cord Injury

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Drafted:	June, 2024	Date:		Published:	June, 2024

I. Definition, Assessment, Diagnosis

A. Definition

1. Spasticity is a motor disorder that is characterized by a velocity-dependent increase in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks, resulting from hyper-excitability of the stretch reflex, as one component of the upper motor neuron syndrome (Nance, Satkunam, &Ethas, 2011; Yulia Rivelis; Nowera Zafar; Karen Morice 2023; Marc Christopher Emos; Sanjeev Agarwal. 2023).
   a. Spasticity is influenced by posture/positioning, comfort of the individual and absence of painful input.
   b. It may be due to "disorganized" neurological output in response to altered sensory input in recovering incomplete injuries. Antigravity muscles of upper and lower extremities are most affected (Upper extremity flexors and lower extremity extensors)
   c. Spasticity results from the loss of the inhibitory and excitatory balance influencing the stretch reflex.
   d. Inhibition of spasticity can be accomplished by:
      1) Slow, passive movement of extremity through the spasm.
      2) External rotation, abduction of extremity; trunk/hip flexion.
      3) Standing position (prolonged stretch).

B. Assessment (Priebe, Sherwood, Thornby, et al., 1996; Young, 1994; Marc Christopher Emos; Sanjeev Agarwal 2023)

1. Positive Signs of spasticity:
   a. Clonus
   b. Rigidity
   c. Increased cutaneous and muscle stretch reflexes.
   d. Spasms
   e. Preserved muscle mass/increased muscle activity.
2. Negative signs of spasticity
   a. Weakness
   b. Easy fatigability
   c. Lack of dexterity
   d. Loss of selective control of limb movement
3. Modified Ashworth Scale (Ashworth, 1964; Lee, Carson, Kinnin, et al., 1989; Yulia Rivelis, Nowera Zafar, Karen Morice 2023)

0	No increase in muscle tone
1	Slight increase in muscle tone, manifested by a catch and release
1+	Catch early in joint range nearer to midpoint (modified Ashworth) (Bohannon & Smith, 1987)
2	More marked increase in muscle tone through most of the range of motion, but affected limb is easily moved

3	Considerable increase in muscle tone; passive movement difficult
4	Limb rigid in flexion or extension

4. Spinal Cord Assessment Tool for Spastic Reflexes (SCATS) (Lanig, 2018)
    1. Clonus (Score from 0-3)
    2.Flexor Spasms (Score from 0-3)
    3. Extensor Spasms (Score from 0-3)
5. Spinal Cord Independence Measure (SCIM) (Lanig, 2018)
    1. Self-Care (Score from 0-20)
    2. Respiration and sphincter management (Score from 0-40)
    3. Mobility-Room and Toilet (Score from 0-40)
    4. Mobility- Indoors and Outdoors (Score from 0-40)
6. Modified Tardieu Scale (P. Akpinar, 2017; Yulia Rivelis, Nowera Zafar, Karen Morice, 2023)
    1. Quality of Muscle Reaction: (0-5) with 0 being no resistance to passive ROM. 5 indicates an immobile joint
    2. Angle of Muscle Reaction: describes R1 and R2, with R1 being the angle in which a catch or clonus is found during a quick stretch. R2 is the full passive ROM, taken at a very slow speed.
    3. Velocity assessment: V1 to V3. V1 being as slow as possible with stretch; V3 being as fast as possible with stretch.
    -Used increasingly for spinal cord injury patients, especially in the pediatric population

7. Consider the following if spasticity increases:
    a. Painful stimulation
        1) Urinary tract infection or kidney stones
        2) Pressure ulcer
        3) Tight shoes, clothing, or leg bag
        4) Bowel impaction
        5) Syringomyelia
        6) Heterotopic Ossification
        7) Stress
    b. Spontaneous
    c. New neurologic injury
        1) syringomyelia
        2) meningitis
        3) recurrent stroke
    d. Infection
    e. DVT

C. Diagnosis
1. Spasticity is easier to recognize than characterize and is perhaps more difficult to treat successfully.
2. If the person has a spinal cord injury with the positive and negative signs above, is velocity-dependent, and is worsened with painful stimulation, then it meets the diagnostic criteria of spasticity. (Y. Cha and A. Arami, 2020)

II. Management and treatment recommendations

A. Medical management/treatment recommendations: Minimize the positive signs, while not worsening the negative signs of spasticity.
1. Non-pharmacologic treatments

a. Regular exercise routine that includes daily range of motion exercise with a focus on muscle stretching (1-2 hour effect) (Odeen & Knutsson, 1981; Skold, 2000; J M Gracies, 2001)
   1) Physical therapy–short term to teach to teach patient and caregiver.
   2) Self-stretching program–long term to maintain joint and muscle range and decrease spasticity.

b. Casting and splinting to maintain muscle and tendon length, and serial casting if the tendon has become shortened. A meta-analysis of Cerebral Palsy (CP) children found that serial casting helped with functionality of lower extremities by reducing hypertonicity (N. Milne, M. Miao, E. Beattie, 2020).

c. Externally applied repetitive cycling (Kakebeeke, Lechner, & Knapp, 2005; S. ABE; Y. Yokoi; N. Kozuka, 2023)

d. Hippotherapy to decrease spasticity in lower limbs with rhythmic movements associated with riding a horse to regulate muscle tone (Lechner, Kakebeeke, Hegemann, et al., 2007). Notably researched in children with CP showing positive effects on lower limb muscle spasticity (C. Hyun, K. Kim, S. Lee, N. Ko, I. Lee, S Koh, 2022).

e. Electrical stimulation to the spinal cord (Barolat, Myklebust, & Wenninger, 1988; B. Karamian, N. Siegel, B. Nourie, et al 2022).

f. Physical modalities–application of tendon pressure (Leone & Kulkulka, 1988), cold, warmth, vibration, bandaging, massage, low-power laser and acupuncture (Gracies, 2001) as well as serial casting with or without BTX-A (N. Milne, M. Miao, E. Beattie, 2020).

g. Magnetic stimulation over the thoracic spinal cord (Nielsen, Klemar, & Hansen, 1995; C. Chalfouh, C. Guillou, J. Hardouin, et al 2020)

2. Medications (Note: Selective serotonin reuptake inhibitors [SSRI's] such as Prozac, Lexapro, Celexa, etc. may make spasticity worse.)

a. Baclofen (Lioresal®): Binds to and activates the $GABA_B$ receptors post-synaptically, which inhibits calcium conductance and causes inhibition of gamma-motor neuron activity, reduced drive to intrafusal of muscle fibers, and reduced muscle spindle sensitivity.
   1) Initiate dose at 5 mg three times a day; maximum dose is limited by side effects of drowsiness. (The literature limits to 80 mg a day in divided doses but significantly higher doses are tolerated and effective (Bianchine, 1985; Kirklan, 1984). It is normally taken four times a day.
   2) Average therapeutic half-life is 3.5 hours but ranges from 2 to 6 hours
   3) It cannot be stopped suddenly or there is a risk of hallucinations, seizures and confusion.

b. Tizanidine (Zanaflex®): An imidazoline derivative and agonist that binds to $alpha_2$ receptor sites both spinal and supraspinal and enhances the presynaptic inhibitory modulation of spinal reflexes in patients with spasticity. It has been shown to decrease reflex activity, especially polysynaptic reflex activity (Davies & Johnston, 1984; Stein, Nordal, Oftedal, et al., 1987;T. Fuchigami, O. Kakinohana, M. P Hefferan, etc. 2011).
   1) Starting dose is 2mg nightly. Maximum dose is limited to 36 mg per day.
   2) Side effects are drowsiness, dry mouth, hypotension and hallucinations (rare).

3) Liver functions must be followed at least annually.
4) Drug interaction with ciprofloxacin, an antibiotic that inhibits P450 1A2 hepatic metabolism, resulting in an increased tizanidine plasma concentration with increased risk of hypotension and bradycardia.

c. Gabapentin (Neurontin®): An adjunctive treatment for epileptic seizure disorder. It is a structural derivative of GABA. It has been used off-label for spasticity, spastic hypertonia, and central pain syndromes in spinal cord injury (SCI) (Formica, Verger, et al., 2005).
1) Maximum dose of 3600 mg divided into three- or four-times daily dosing.
2) Better for neuropathic pain than spasticity
3) Side effects of dizziness and drowsiness

d. Dantrolene (Dantrium®): A hydantoin derivative whose primary pharmacologic effect is to reduce calcium flux across the sarcoplasmic reticulum of skeletal muscle. This action uncouples motor nerve excitation and skeletal muscle contraction (Ellis & Carpenter, 1974; Ward, Chaffman, & Sorkin, 1986; A. Tilton, J. Vargus-Adams, M. Delgado, 2010).
1) Maximum dose of 400 mg divided into three- and four-times daily dosing.
2) Peak blood concentration in 3 to 6 hours
3) Side effects of liver toxicity (1%), drowsiness, nausea, diarrhea, dizziness

e. Diazepam (Valium®): A long-acting benzodiazepine that enhances $GABA_A$ receptor current, which increases the opening frequency of the ionophore complex (Study & Barker, 1981). It decreases polysynaptic reflexes and has muscle relaxant, sedation, and antispasticity effects (Pederson, 1974; J. Dhaliwal, A. Rosani, A. Saadabadi, 2023).
1) Maximum dose of 60 mg a day in divided dosing
2) Side effects of intellectual impairment decreased motor coordination, psychological addiction, and abuse potential.

f. Muscle relaxants: Centrally acting muscle relaxants, which are not indicated for treatment of spasticity:
1) Cyclobenzaprine (Flexeril®) - Max dose 30 mg a day. Usually used at night, at a dose of 10 Mg. May help with pain, as it has similar molecular, tricyclic structure, like amitriptyline.
2) Carisoprodol (Soma®) - has an addictive potential. Schedule IV medication; average dose is 350 mg four times a day. Its active metabolite is meprobamate, and acts at multiple CNS sites to decrease anxiety and cause sedation.

g. Cryoheptadine (Periactin®)- an antagonist at the 5-HT2, histamine H1, L-calcium channels and muscarinic cholinergic receptors. Has been used off label for spasticity secondary to SCI (Lanig, 2018)
1) 2-4 mg PO q8hr initially; not to exceed 24 mg/day
2) Side effects of drowsiness, dizziness, nausea, diarrhea, increased appetite Advanced age is associated with reduced clearance and greater risk of confusion, dry mouth, constipation, and other anticholinergic effects and toxicity

h. Cannabinoids- Tetrahydrocannabinol (THC) mediates activity by stimulating presynaptic CB_1 receptors to reduce glutamate release which is thought to control spasticity (S. Nielsen, B. Murnion, G. Campbell, et al 2019)

1) Recommendations and effectivity vary in the literature in terms of decreasing spasticity. (J. Hansen, S. Gustavsen, H. Roshanisefat, et al 2023). There are few and small studies of route and dosing. Oral THC (dronabinol, Marinot™) 15-20mg daily (U. Hagenback, S. Luz, et al 2007); THC-CBD oromucosal spray up to 12 sprays daily (U. Zettl, P. Rommer, P. Hipp and R. Patejdl 2016)

2) SE: dizziness, nausea, headache, dizziness, increased fall risk

3. Injections (Nance, Satkunam, & Ethas, 2011; Anwar, 2019; Picelli, 2018)
   a. Botulinum toxins (I. Otero-Luis, A. Martinez-Rodrigo, et al 2024):
      1) Neurotoxins that are the biologic product of the action of an anaerobic bacterium, *Clostridium botulinum.* These toxins are one of the world's most deadly poisons. They are extremely potent neuromuscular blocking agents when injected into the area of a motor point.
      2) Botulinum toxins have seven identified serotypes, A through G. The botulinum toxin serotypes A and B are currently available in clinical practice. Serotype A is marketed as Botox, Dysport, Xeomin and BTXA, whereas botulinum toxin B is marketed as Myobloc and NeuroBloc. Serotypes C through G are not available, clinically.
      3) Chemical denervation occurs when the intramuscular injection of the toxin prevents fusion of the acetylcholine-filled vesicles with the synaptic cleft, preventing the release of acetylcholine and therefor muscle activity.
      4) Accomplished in a clinical setting by a physician about every three months to help with the management of spastic muscles.
      5) Adjunct therapies after botulinum toxin administration can be used to improve botulinum toxin effect. Adhesive taping to provide a progressive stretch of hypertonic muscles can improve outcomes. Casting reduces excitatory input and helps prevent changes in muscle length and reduces contractures.
      6) Side effects are rare and botulinum toxin is safe. There are rare allergic reactions. Distant spread of the toxin can occur hours to weeks after injection and can cause swallowing and breathing difficulties. Rarely patients can develop antibodies to the toxins.
   b. Phenol or alcohol:
      1) Phenol denatures the protein of nerve fibers, and in low concentrations has the property of a reversible local anesthetic.
      2) Alcohol is thought to have a dehydration effect on nerve tissue, resulting in sclerosis of nerve fibers and the myelin sheath.
      3) Both agents can be injected at motor points identified by electrical stimulation or ultrasound, or directly into or onto nerves and thus be used for motor point blocks and nerve blocks.
      4) Potential complications include pain, dysesthesias that can last from weeks to months, arrhythmias, variable duration and magnitude of effect, and incomplete irreversibility.
4. Implants
   a. Intrathecal Baclofen Pump (S. Cho, 2023):
      1) Directly control spasticity with fewer systemic side effects than oral baclofen.

2) Beneficial for lower extremity spasticity that does not respond effectively to more conservative measures such as oral medications or injections.
3) Patients must undergo an intrathecal baclofen pump (ITB) test trial prior to implantation to confirm that intrathecal baclofen helps their spasticity.
4) ITB pump has a wide variety of dosing and concentration. It can be dosed with continuous infusion and/or bolus dosing.
5) Adverse effects include headache, drowsiness or worsening balance. Withdrawal of baclofen can result in worsening spasticity, seizures or even death.

B. Restrictions
1. If the patient is managing their spasticity well—in ways such as stretching routinely, taking an appropriate dose of oral anti-spasticity medication, staying warm; and has had no change in bladder or bowel function; and there is no new source of pain (including new onset of a pressure sore, new bed or new wheelchair that does not fit well)—then the patient may have developed a new medical condition that is causing increased spasticity. Refer this patient to a local medical doctor for further workup and assessment. Consider the possibility that the patient may have developed a secondary complication of spinal cord injury, such as a deep vein thrombosis (DVT), fracture, gastric ulcer, heterotopic ossification or syringomyelia.
2. Spasticity can be helpful, and patients use the presence of minimal or moderate spasticity for stability and to accomplish functional tasks, such as standing, transfers or getting their legs into bed.

C. Major outcomes
1. Well managed spasticity that does not impair function or safety.
2. Minimum side effects from treatment management strategy
3. Ability to use the treatment strategy for the long term without undue risks, side effects or cost.

III. Prevention and Education

A. Assess the patient's use of basic management techniques before increasing the dose of medication or using injections.
1. Create a stretching schedule of spastic muscle groups and encourage routine stretching.
2. Minimize painful input to the spinal cord, including:
a. Bladder distention – avoid by using a catheter schedule to lessen the risk of bladder infection or stones.
b. Bowel distention – avoid by using an effective bowel program.
c. Tight fitting shoes or clothes
d. Proper wheelchair position.

B. Use the smallest dose of spasticity medication that is effective.

C. Be aware of changes in ambient temperature as colder weather can increase spasticity and tone.

D. Use Valium and Soma judiciously and be aware of the addictive potential and street value of both these medications.

This guideline was developed to improve health care access in Arkansas and to aid health care providers in making decisions about appropriate patient care. The needs of the individual patient, resources available, and limitations unique to the institution or type of practice may warrant variations.

Guideline Developers

Guideline developed by Thomas S. Kiser, MD, in collaboration with the TRIUMPH team led by Thomas S. Kiser, MD, Rani H Lindberg, MD, and Merna S. Griess, DO.

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