TBI and Spasticity

Angie Davis, PT, MHS, NCS; Dan Gladmon, PT, MPT; Michael A. Dimyan, MD

University of Maryland Rehabilitation and Orthopedics Institute
Learning Objectives

After completing this session, you will be able to:

• Define spasticity and describe its underlying pathophysiology

• Analyze both positive and negative effects of spasticity on function in patients with neurologic disorders

• Describe salient outcomes measures used to assess spasticity

• Discuss medical interventions utilized in the management of spasticity

• Identify evidence-based therapeutic interventions employed in spasticity management, including serial casting
Spasticity Defined

Lance 1980

“One component of the upper motor neuron syndrome which is characterized by a velocity dependent increase in the tonic stretch reflexes.”
Spasticity and the ICF Model

Body Function and Structure *Impairments*

Health Conditions

Activities *Limitations*

Participation *Restrictions*

Environmental Factors

Personal Factors
## Upper Motor Neuron Syndrome

<table>
<thead>
<tr>
<th>Positive Signs (excessive normal resting state)</th>
<th>Negative Signs (less than normal resting state)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spasticity</td>
<td>Lack of strength</td>
</tr>
<tr>
<td>Rigidity</td>
<td>Lack of motor control</td>
</tr>
<tr>
<td>Hyperreflexia</td>
<td>Lack of coordination</td>
</tr>
<tr>
<td>Primitive reflexes</td>
<td></td>
</tr>
<tr>
<td>Clonus</td>
<td></td>
</tr>
</tbody>
</table>
Pathophysiology of Spasticity

- Not fully understood
- Imbalance of inhibitory and excitatory inputs resulting in over-activity of the alpha motor neuron
- Hyperactive stretch reflex arc
- Lack of supraspinal inhibition
Prevalence of Spasticity

Spasticity could be present in our patients with upper motor neuron injury or disorder, including patients with:

- Traumatic or acquired brain injury
- CVA
- Multiple sclerosis
- Spinal cord injury
- Cerebral palsy
Spasticity and Brain Injury

- Approximately 50% of patients with acquired or traumatic brain injury develop spasticity

- This is more difficult to study in this population due to wide range of injury from mild TBI/concussion to severe TBI

- Patterns of spasticity development widely variable
Importance of Spasticity

- Lower levels of functional outcomes
- Decreased health related quality of life
- Higher cost of care – increased economic burden
- Increased burden of care on caregivers
- More likely to require institutionalized care
What does spasticity look like?

• Stereotypical patterns of presentation

• Patients present individually
  • Full stereotypical pattern
  • Partial patterns
  • Outside of pattern
Lower Extremity Flexor Pattern

www.Medscape.com via Google image search
Lower Extremity Extensor Pattern

1. Crosswords911.com via Google image search
2. www.pediatric-orthopedics.com via Google image search
Claw Hand Pattern

1. www.enviaaesthetic.org via Google image search
2. Pixgood.com via Google image search
How does spasticity act in function?

Anna: Patient post TBI
There are positive and negative effects of spasticity… we must find the balance.
Negative Effects of Spasticity

Contracture
Abnormal posturing
Deformity
Degenerative joint changes
Pain

Decubitus ulcers
Restricted volitional movement
Restricted motor return
Impaired mobility
Impaired ADLs
<table>
<thead>
<tr>
<th>Positive Effects of Spasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substitute for decreased strength</td>
</tr>
<tr>
<td>Allows increased mobility</td>
</tr>
</tbody>
</table>
Examination of Spasticity
Examination

- Initial observation
- Patient report
  - Penn Spasm Frequency Scale
- Passive motion testing
  - Modified Ashworth Scale (MAS)
  - Tardieu Scale
- Assessment of function
# Penn Spasm Frequency Scale

<table>
<thead>
<tr>
<th>Spasm Frequency</th>
<th>Spasm Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = no spasm</td>
<td>1 = mild</td>
</tr>
<tr>
<td>1 = mild spasms induced by stimulation</td>
<td>2 = moderate</td>
</tr>
<tr>
<td>2 = infrequent full spasms occurring &lt; once per hour</td>
<td>3 = severe</td>
</tr>
<tr>
<td>3 = spasms occurring &gt; once per hour</td>
<td></td>
</tr>
<tr>
<td>4 = spasms occurring &gt; 10 times per hour</td>
<td></td>
</tr>
</tbody>
</table>
Penn Spasm Frequency Scale

Psychometrics

Self report measure

ICF: body structure and function

Population studied: chronic SCI

Reliability: test-retest excellent
ICC = 0.91

Recommendations: SCI Edge – reasonable to use, but limited study in target group for acute, subacute and chronic SCI and CVA

Rehabmeasures.org

Clinical Pearls

Nice tool for describing patient perspective of spasticity

Especially helpful when MAS scores low to track spasm

Be mindful of subjectivity of the scale
### Modified Ashworth Scale (MAS)
*(Bohannon and Smith 1987)*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No increase in muscle tone</td>
</tr>
<tr>
<td>1</td>
<td>Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at end of ROM</td>
</tr>
<tr>
<td>1+</td>
<td>Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (&lt; half) of the ROM</td>
</tr>
<tr>
<td>2</td>
<td>More marked increase in muscle tone through most of the ROM, but affected part easily moved</td>
</tr>
<tr>
<td>3</td>
<td>Considerable increase in muscle tone, passive movement difficult</td>
</tr>
<tr>
<td>4</td>
<td>Affected part is rigid in flexion or extension</td>
</tr>
</tbody>
</table>
Modified Ashworth Scale (MAS)

**Psychometrics**

ICF: body structure and function

Population studied: adults & children with lesions of the CNS

Reliability: varies by muscle group, population and acuity of patient, from poor to excellent, ICC = 0.36-0.83

**Clinical Pearls**

Training is required to improve reliability

Technique for testing must be standardized to improve inter and intrarater reliability

Annual competencies are recommended

Recommendations: SCI Edge reasonable to use; StrokEdge recommended; MS Edge unable to recommend; TBI Edge recommended

Rehabmeasures.org
Assessment of Function

Observe and assess the effect of spasticity in the upper and lower extremity in functional tasks

- Bed mobility
- Transitional movements – transfers with varied demands
- Sitting
- Standing
- Gait
- Wheelchair positioning and mobility
- Vary speeds of task
- Add dual task/distraction
Management of Spasticity
Goals of Spasticity Management

- Minimize changes in the viscoelastic properties of connective tissue and muscle
- Alter neural patterns of spasticity and/or spasms
- Decrease and/or manage pain
- Maintain hygiene and skin integrity
- Promote neuroplasticity
- Improve or maintain function
Medical Management

**Systemic**
- Baclofen
- Tizanidine
- Dantrolene
- Cyclobenzaprine
- Metaxalone
- Carisoprodol
- Methocarbamol
- Benzodiazepines
- Gabapentin

**Injected**
- Botulinum Toxin
- Phenol
Therapeutic Intervention
Therapeutic Interventions

- Weightbearing
- Active Movement
- Passive Movement and Stretching
- Constraint-induced movement therapy
- Positioning – splinting, serial casting
Benefits/Evidence

Promotes antigravity muscle activation in trunk and lower extremities

Maintains or improves joint and soft tissue flexibility

Modulates neural component of spasticity through prolonged stretch and altered sensory input

Decreases lower extremity spasms

Positive psychological effect

Images: google.com; bioness.com
Active Movement: Progressive Resistive Exercise

Benefits/Evidence

Increased strength and function without increased tone or pain
Enhances motor learning in paretic limbs
Reverse disuse weakness in chronic illness/injury
Strengthen antagonist muscle to those which are spastic
Strengthen spastic muscles
Active Movement: Aerobic Exercise
Cycling, Running, Walking, Swimming

Benefits/Evidence
Increased muscle strength
Increased endurance
Improved AROM
Enhanced motor learning
Decreased spasticity

Images: google.com
Active Movement: Functional Task Practice

Benefits/Evidence
Promotes neuroplasticity

Trains functional movement for learning

Incorporates weightbearing and exercise with same noted benefits

Images: google.com
Benefits/Evidence

- Produces functional movement
- May improve motor return, avoiding abnormal patterns
- Repeated movement may reinforce neuroplasticity
- May assist in skill acquisition

Combined with Botulinum Toxin Injection

- Decreased scores on MAS
- Increased ROM at the ankle
- Improved gait mechanics
- Increased gait speed on 10MWT

Decreased cost and burden of care
Decreased secondary effects of spasticity

Images: Bioness.com
Active Movement: Treadmill Training

Benefits/Evidence
Decreases spasticity
Allows early training of postural and stepping reactions
Facilitate motor learning of gait cycle, increased motor recovery
Increased gait speed
Increased balance
Increased stepping with step activity monitor
Increased QOL
Increased gait tolerance
Increased muscle activation on EMG
Decreased spasticity ankle plantarflexors
Active Movement/Passive Movement: Robotics

Benefits/Evidence (Active)
Provides assisted ROM to joints
Reduces spasticity

Benefits/Evidence (Passive)
Reduces spasticity in the upper extremity
Addresses mechanical factors of spasticity
Increased afferent stimulation to motor cortex for motor relearning

Images: marylandva.gov; allinahealth.org
Passive Movement: Stretching

Benefits/Evidence
Maintain or increase joint mobility
Low load, long duration stretch is most effective
Focus on spastic muscles
Constraint-Induced Movement Therapy

Benefits/Evidence
When combined with Botulinum toxin injection:

- Decreased spasticity on MAS
- Increased motor control on Fugl-Meyer, Motor Activity Log and Wolf Motor Function test
- Increased coordination

Application
Started 1 week post injection
CIMT with mitt for 6 hours per day,
5 days per week for 2 weeks per protocol
Positioning: Casting and Splinting

Benefits/Evidence
Decrease motor neuron excitability (neural component)
Reduce tensile stress of soft tissues (non-neural component)
Increased flexibility
Decreased ankle plantarflexion contracture due to spasticity
Restored biomechanics
Improved gait scores
Improved function
Definitions: Serial Casting

Stoeckmann 2001

“The application and removal of a series of casts, with the result of progressively increased range of motion with each casting with the purpose of correction of deformity, lengthened contractures, and reduced spasticity.”
Rationale: Serial Casting

- Muscle shortening is reversible
- Prolonged stretch inhibits spasticity
- Controls sensory input to the limb
- Increases patient’s visual and tactile attention to the limb
- Both number and length of sarcomeres are increased, thereby affecting length–tension relationship
Indications: Serial Casting

- Increased spasticity
- Range of motion loss
- Loss of function in affected limb
Considerations: Serial Casting

- **Contraindications**
  - Open wounds
  - Unhealed fracture/external fixator
  - Acute inflammation
  - Uncontrolled hypertension
  - Recent episode of autonomic dysreflexia

- **Precautions**
  - Fluctuating edema
  - Poor skin integrity
  - Reduced sensation
  - Cognitive impairment
  - Agitation

- **Other Considerations**
  - Medical stability
  - Functional use
  - Pain
  - HO
  - Subluxation
  - Timing
  - Bi-valve
Evidence: Serial Casting

Best Practice in Serial Casting

• Botulinum toxin injections and casting is better than botulinum toxin alone for improved ankle ROM

• Timing of casting with botulinum toxin injection: 2-4 weeks

• Goals of ankle serial casting: 10 degrees ankle DF in subtalar neutral with knee extended for ambulatory patients; 0 degrees for non-ambulatory patients

• Serial cast change interval: < 5 days best to decrease complication and discontinuation rates
Serial Cast Application
These videos and discussion is intended as an introduction to serial casting.

This is a potentially low volume, high risk procedure that requires further training, practice, observation and competency.
Serial Casting Supplies

- Stockinette
- Tongue depressors (2)
- Foam padding
- Cotton roll padding
- Fiberglass
- Bucket
- Lotion (if leaving on only)
- Cast saw
- Cast splitter
- Bandage scissors
Serial Casting: Supine Positioning

- Patient supine
- Bolster under knees
- Knee flexed
- Support ankle in dorsiflexion with subtalar neutral
Serial Casting: Prone Positioning

- Patient prone
- Knee flexed
- Support ankle in dorsiflexion with subtalar neutral
Apply Stockinette

- Stockinette should extend to the knee beyond toes
- Tongue depressors along 1st and 5th metatarsals and extend out beyond toes
Add Foam Padding

- Proximal end of cast – 2 finger widths below fibular head
- Distal end of cast - past toes, around tongue depressors
- Over medial and lateral malleoli
- Along tibia
- Over any additional bony prominences
Apply Cotton Roll Padding

- Work distal to proximal
- Overlap by half
- Avoid wrinkles
- 2 layers of padding
Cotton Roll Padding Application
Completed

Cotton Roll Padding Application
Fiberglass Application
Completed Fiberglass Application

- During application:
  - Work distal to proximal
  - Overlap by half
  - Apply 2 layers of fiberglass
  - Do not pull material tightly as you wrap
  - Ensure 2 fingers can fit around proximal end of cast
  - Ensure all toes are visible, but included within the cast
Draw Medial Cut Line for Removal

- Ensure cut line is anterior to the malleolus
Draw Lateral Cut Line for Removal

- Ensure cut line is anterior to the malleolus
Cast Removal
Completed Medial Cut
Completed Lateral Cut
Cast Splitter
Bi-Valved Short Leg Cast

- Remove all padding and stockinette
Bi-Valve Padding Supplies

- Large roll adhesive padding for top and bottom halves of cast
- Edging roll for covering edges of top and bottom halves of cast
Completed Bi-Valved Short Leg Cast
Open
Completed Bi-Valved Short Leg Cast
Closed

- Secure with Ace wraps or strapping
- Ensure proper fit with patient
- Instruct in appropriate wearing schedule
Any Questions?
Thank you for your attention.