

DIFFERENTIAL DIAGNOSIS FOR SPASTICITY

- **The clinical impact of upper motor neuron (UMN) syndrome on patients is broad. UMN syndrome limits functional capacity by reducing mobility and limb usage and leads to, contractures, osteoporosis, neurogenic bladder and bowel, decubiti, cardiovascular problems, thrombophlebitis, respiratory infections, physical dependence, and social isolation¹**
 - **Motor disorder associated with central nervous system (CNS) injury or disease²**
 - **Clinical phenomena associated with UMN syndrome include muscle overactivity, muscle weakness, and reduced soft-tissue plasticity³**
 - These symptoms contribute to limb immobility, which may lead to muscle contracture and joint range of motion (ROM) limitations, further restricting limb movement
 - These symptoms interfere with the patient's independence, mobility, and ability to perform daily activities
 - It is important to identify functional impairment and differential muscular anatomy associated with common patterns of limb deformities for treatment planning and to determine treatment goals
 - Understanding the extent to which muscle overactivity, weakness, and soft-tissue changes contribute to each fixed limb posture also helps the physician to develop an integrated treatment strategy
- **Possible causes of spasticity**
 - **Traumatic brain or spinal cord injury²**
 - Can result in dysfunction in corticospinal tract and other descending pathways involved in voluntary motor activity
 - Immediate consequences may include paralysis and muscle immobilization, with symptoms such as weakness, stiffness or rigidity, decreased manual dexterity, slowed movement, and fatigue
 - Delayed consequences due to compensatory rearrangement of spinal neuronal circuits to allow function below level of injury
 - This loss of inhibitory impulses from higher centers in the CNS allows excessive activity of some spinal cord neurons and excessive muscle activity
 - Spasticity and excessive muscle activity eventually contribute to contracture
 - Symptoms that may accompany spasticity include involuntary muscle spasms, clonus, scissoring of legs, and joint contractures
 - **Stroke**
 - Major cause of serious long-term disability in survivors
 - Spasticity manifests as increased muscle tone, abnormal posture, hyperactive reflexes²
 - **Cerebral palsy (CP)**
 - Most common cause of spasticity in children
 - Congenital or acquired chronic disorder that impairs control of movement²
 - Symptoms include involuntary muscle spasm, weakness, and difficulty with fine motor tasks, maintaining balance, and walking²
 - Spasticity related to CP results from improper development of or damage to motor areas of the brain²
 - **Multiple sclerosis (MS)**
 - An autoimmune process that attacks the myelin sheath on nerves in the CNS²
 - Symptoms of MS include paresthesias, weakness, ataxia, tremor, fatigue, and spasticity²
 - Spasticity is a major cause of disability for patients with MS
- **Possible upper limb symptoms to observe and quantitate**
 - **Upper limb spasticity associated with the following deformities²**
 - Upper limb measures of function include
 - Barthel index⁴
 - Performance of standardized tasks such as the modified Frenchay Scale⁵
 - The Nine-Hole Peg test and Rivermead Motor Assessment⁴
 - Dressing⁴
 - The most common pattern of spasticity in the upper limb involves flexion of the fingers, wrist, and elbow and adduction with internal rotation at the shoulder; wrist or elbow extension are less common⁴
 - Spasticity involving wrist and finger muscles²
 - Range-of-motion assessment: flexor tone of wrist and fingers; ratings on modified Ashworth Scale (muscle tone intensity) over specific intervals (eg, 2, 4, and 6 weeks)²
 - Loss of selective control of individual movements¹ is one of the last motor control capabilities to recover after a UMN lesion
 - Loss of dexterity, ie, loss of use of hand¹
 - Ability to fractionate finger movements
 - Sustained manual stretching of the UMN muscle can result in resistance of a sustained or tonic nature throughout the period of muscle stretch; reflex-induced electromyographic activity will persist in sustained manner throughout the period of stretch and will not cease until the stretch is reversed¹
 - Dystonia is a persistent posture observed in the absence of phasic stretch (ie, not involving spasticity)¹
 - **Clenched fist**
 - Very common deformity, often associated with thumb-in-palm deformity⁴
 - Patient unable to perform (or has limited hand opening during) reaching to grasp an object¹
 - Symptoms include pain caused by fingernails digging into palmar skin, nail bed infections,¹ pain with attempt to pry fingers open to gain palmar access
 - Results in chronic difficulty accessing the palm for washing and drying, which can lead to skin maceration and development of malodor^{1,4}
 - With respect to active function, grasp, manipulation, and release of objects from the hand depend on finger and thumb control; the loss of the hand even as a gross assist makes daily living activities difficult¹
 - Chronically flexed fingers likely develop muscle, skin, and joint contractures¹
 - Muscles exhibiting overactivity in the clenched fist may include

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- Flexor digitorum superficialis (FDS; index, long, ring, little)
 - Resistance to passive stretch of the FDS can be assessed by holding wrist in neutral position or relatively extended, holding the metacarpophalangeal (MCP) joint in neutral position or relatively extended, and stretching the proximal interphalangeal (PIP) joint at different rates¹
 - Flexes PIP joints of index, middle, ring, and little fingers; may contribute to wrist flexion³
- Flexor digitorum profundus (FDP; index, long, ring, little)
 - Flexes distal interphalangeal (DIP) joints of index, middle, ring, and little fingers; may contribute to wrist flexion³
 - Resistance to passive stretch of the FDP is estimated similarly as for the FDS, but the examiner attempts to hold the PIP joint in a neutral or relatively extended position while stretching the DIP joint¹
- Isolated finger flexion deformity can result from cocontraction or dystonic overactivity in FDP or FDS muscle fascicles of that finger alone
 - The flexed index finger interferes with picking up objects with the radial side of the hand¹
 - Chemodenervation to index finger musculature alone is effective in relieving clinical dysfunction¹
- Chemodenervation and orthopedic lengthening are useful for treating clenched fist deformity¹
- Use of phenol in the depths of the forearm is not optimal¹ because of possible leaking into nearby sensory nerve branches, which could cause dysesthesia
- Chemodenervation with botulinum neurotoxin A is excellent for treating the small muscles of the hand, which are readily accessible for injection and require only small amounts of toxin for treatment to be effective¹
- **Thumb-in-palm deformity¹**
 - Thumb is pulled into the palm and is unable to extend during the reach phase of reaching to grasp an object
 - Thumb position restricts hand opening during hand grip and does not serve well as opposition post for the fingers
 - Often accompanied by clenched fingers
 - Symptoms include disfiguring appearance of a thumb poking out between clenched long and ring fingers or buried in the palm underneath flexed fingers and pain from long thumbnail digging into index finger skin
 - Prevents activation of the most common types of grasp patterns, including “three-jaw chuck,” lateral grasp (“key” pinch), and tip pinch
 - Muscles that may exhibit overactivity include
 - Flexor pollicis longus (FPL)
 - Flexes distal phalanx of thumb³
 - Flexor pollicis brevis
 - Flexes MCP joint of thumb³
 - Adductor pollicis
 - Adducts thumb in plane perpendicular to palm³
 - First dorsal interosseous
 - Abducts and flexes the index finger, which narrows the web space¹
 - Because FPL crosses the wrist joint anterior to its axis of rotation, the wrist angle should be identified and controlled during examination of passive stretching of the FPL¹
 - It is preferable to test intrinsic of the thumb with the wrist flexed to minimize the contribution of the extrinsic FPL¹
 - Skin contracture in the web space may contribute to the narrowing of the hand during reaching¹
 - These muscles are amenable to chemodenervation and orthopedic lengthening¹
 - Orthopedic lengthening is especially useful for patients with contractures or in younger patients, who have recovered a reasonable degree of motor control as determined by dynamic electromyography (EMG) studies but are left with severe muscle and soft-tissue contractures including skin and joint contractures¹
 - Abduct digit from axial line and act with lumbricals to flex MCP joints and extend interphalangeal joints³
- **Flexed wrist**
 - Sometimes presents with radial or ulnar deviation¹
 - Often associated with a clenched fist deformity¹
 - Symptoms include uncomfortable or painful passive stretching of wrist flexors, carpal tunnel syndrome if compression of the medial nerve occurs, disfiguring appearance¹
 - Results in awkward hand placement during reaching, impairs positioning of objects held by the hand before their manipulation or release, and weakens grip strength¹
 - May interfere with use of gloves or donning a coat¹
 - Need to assess whether patient has any active wrist extension¹
 - Muscles that might include overactivity in the flexed wrist include
 - Flexor carpi radialis^{1,4}
 - Flexion of wrist with radial deviation³
 - Palmaris longus¹
 - Tightens palmar fascia, flexes wrist³
 - Flexor carpi ulnaris^{1,4}
 - Flexion of wrist with ulnar deviation³
 - Extensor carpi ulnaris¹
 - FDP³
 - Flexes distal phalanges³
 - FDS
 - Flexes PIP joints of index, middle, ring, and little fingers; may contribute to wrist flexion³
- **Flexed elbow**
 - Muscles involved include
 - Brachioradialis⁴
 - Flexes forearm³

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- Biceps brachii⁴
 - Forearm flexion and supination³
 - May flex arm at shoulder³
- Brachialis⁴
 - Flexes forearm³
- Pronator teres³
 - Pronates and flexes forearm (at elbow)³
- ✦ **Flexed elbow with the arm and elbow held close to the chest**
 - Persistent elbow flexion during sitting, standing, and especially walking¹
 - Prolonged elbow flexion posturing is frequently associated with contracture¹
 - Patients complain that their elbows “ride up” when they stand to transfer or walk and complain of stiffness¹
 - Disfiguring appearance of the flexed elbow; elbows get hooked on doorframes, furniture, and even people (eg, when shopping in a crowded mall)¹
 - Physical examination typically shows a flexed resting position of the elbow¹
 - Muscles that contribute to flexed elbow deformity include biceps, brachialis, and brachioradialis¹
 - Measure muscle tone of the elbow, wrist flexors, and finger flexors using modified Ashworth Scale⁶
 - Biceps
 - Flexor carpi radialis
 - Flexor carpi ulnaris
 - FDP
 - FDS
- ✦ **Pronated forearm**
 - Typically pronated fully, often with flexed-elbow in the physical examination¹
 - Typically reveals a pronated resting position of the forearm¹
 - Muscles that might exhibit overactivity in the pronated forearm include³
 - Pronator teres
 - Pronates and flexes forearm (at elbow)
 - Pronator quadratus
 - Pronates forearm; deep fibers bind radius and ulna together
- ✦ **Functionally limited arm after stroke⁷**
 - Spasticity may interfere with self-care tasks, which negatively affects the overall quality of life
 - Establish degree of possible functional improvement of upper extremity in patients after stroke
 - In this study, patients ranged in age from 21 to 72 years, and each had experienced a stroke 3 months to 3 years before study entry
 - Tone score was required to be ≥ 2 in at least one group of muscles using the modified Ashworth Scale
 - Causes of the stroke included ischemia, intracerebral hemorrhage, and subarachnoid hemorrhage
- ✦ **Adducted, internally rotated, flexion-restricted shoulder^{3,4}**
 - Muscles involved may include
 - Pectoralis major
 - Adducts and medially rotates humerus, draws scapula anteriorly and inferiorly³
 - When acting alone, the clavicular head flexes humerus, and the sternocostal head extends it³
 - Teres major
 - Adducts and medially rotates arm³
 - Latissimus dorsi
 - Extends, adducts, and medially rotates humerus³
 - Raises body toward arms during climbing³
 - Subscapularis³
 - Medially rotates arm and adducts it
 - Helps to hold humeral head in glenoid cavity of scapula
 - Long head of triceps (triceps brachii)³
 - Extends shoulder
 - Long head steadies the head of abducted humerus chief extensor of forearm
- ✦ **Intrinsic plus hand³**
 - Muscles involved may include
 - Interossei lumbriales (dorsal and palmar)
- **Possible lower limb symptoms to observe and quantitate**
 - ✦ **Equinovarus foot^{1,4}**
 - Foot and ankle turn down and in; toe-curling or toe-clawing may be present¹
 - Skin breakdown over the fifth metatarsal may develop if the lateral border of the foot is often compressed against the mattress, bed rail, footrest, or floor^{1,8}
 - Weight bearing over the lateral border of the foot in the region of the fifth metatarsal head can cause pain¹
 - Severe deformity makes donning and wearing shoes difficult or impossible¹
 - Loading of body weight when walking can be painful and unstable; equinovarus produces instability of the whole body^{1,8}
 - Knee swing during preswing is limited, and an early swing foot drag might develop¹
 - Muscles that may contribute include



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- Medial gastrocnemius
 - Powerful plantar flexor of ankle³
 - Minor knee flexor³
 - Question as to the relevance of its ability to invert foot (anatomists say yes; physiologists have not seen this movement when stimulating the muscle)⁹
 - Lateral gastrocnemius³
 - Powerful plantar flexor of ankle
 - Soleus³
 - Plantar flexes foot
 - Tibialis anterior³
 - Dorsiflexes and inverts the foot
 - Tibialis posterior³
 - Inverts and plantar flexes the foot
 - Long toe flexors³
 - Flexor digitorum longus³
 - Flexes the lesser toes
 - Flexor digitorum brevis³
 - Flexes the lesser toes
 - Extensor hallucis longus³
 - Extends the great toe, dorsiflexes ankle, and can invert foot
 - Flexor hallucis longus³
 - Flexes the great toe, plantar flexes the foot, and can invert foot
 - Other muscles³
 - Peroneus longus
 - Extends foot and plantar flexes ankle
 - Helps to support the transverse arch of foot
- ROM is examined with the knee extended and the knee flexed¹
 - Inspection of standing or walking with shoes off often reveals the inverting pull of tibialis anterior¹
 - Activity of tibialis posterior and other muscles that can invert the foot can be identified in laboratory gait studies using intramuscular wire electrodes¹
 - Diagnostic tibial nerve block with lidocaine can be used to distinguish muscle overactivity from calf muscle contracture and help differentiate muscle involvement¹
 - Blocks or chemodenervation and serial casting are used to stretch a tight heel cord conservatively
 - If toe-curling is present, chemodenervation and orthopedic interventions can be helpful
 - Persistent hyperextension of the great toe can be seen in isolation as well as with some degree of equinovarus
 - Chemodenervation of the overactive extensor hallucis longus, tibialis posterior or anterior, and gastrocnemius and/or soleus effectively provides relief¹
 - Spastic equinus (abnormal gait)²
 - Assess gait velocity, cadence, and stride length
- **Flexed hip**
- Patient presents with a sustained hip flexion that interferes with positioning and gait¹
 - Chronic flexion posturing leads to flexion contracture¹
 - Hip flexor spasms are a common complaint of patients with spinal cord lesions¹
 - Patients with overactivity of the hip flexors bilaterally walk with a crouched gait pattern; this often leads to compensatory knee flexion to maintain balance¹
 - Often the thigh is adducted as well¹
 - The Thomas test can demonstrate hip flexion contracture¹
 - Muscles that are involved in an excessively flexed hip include³
 - Iliopsoas
 - Flexes the torso and thigh with respect to each other
 - Rectus femoris
 - Flexes the hip and extends the knee
 - Pectineus
 - Adducts the thigh and flexes the hip joint
 - Adductor longus
 - Adducts and flexes the thigh and helps to laterally rotate the hip joint
 - Adductor brevis
 - Adducts and flexes the thigh and helps to laterally rotate the thigh
 - Gluteus maximus
 - Acts as the major extensor of the hip joint
 - Dynamic EMG may help to identify muscle overactivity in the above listed muscles, as well as weakness of hip extensors and lumbar paraspinals¹
 - Chemodenervation, neurolysis, and orthopedic intervention are useful¹
- **Nonflexing hip**
- Patient is unable to advance the limb due to lack of hip flexion. May interfere with limb clearance when stepping
 - Limb is functionally longer; toe drag in early swing can cause tripping and falling
 - Muscles involved include (in order of descending overactivity)

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- Gluteus maximus
- Hamstrings
- Paraspinals
- Muscles involved include (in order of descending underactivity)
 - Iliopsoas
 - Rectus femoris
- Gait analysis, including kinematics and dynamic EMG, can help to identify the distribution of muscles with overactivity and underactivity
- Neurolysis or chemodenervation of the hip extensors in combination with hip flexor strengthening is desirable
- A contralateral shoe lift may also be of help
- **Adducted thigh**
 - Patient presents with unilateral or bilateral scissoring thighs, which greatly impedes daily living and affects balance¹
 - Relative leg length discrepancy might be associated with an adductor contracture or severe spasticity¹
 - With passive abduction of the thigh, the pelvis as a whole moves, the anterior superior iliac spine on the same side moves upward, and the pelvis appears to be oblique (ie, not parallel to the bed)¹
 - Presence or absence of contracture may be revealed with a local anesthetic block to the obturator nerve¹
 - Muscles involved include (in order of descending overactivity)^{1,4}
 - Adductor magnus
 - Adductor longus and brevis
 - Gracilis
 - Pectineus
 - Iliopsoas
 - Gait analysis, including kinematics and dynamic EMG, can help to identify the distribution of muscles with overactivity and underactivity, as well as the degree of adduction present¹
 - Neurolysis of the obturator nerve might be more efficient than chemodenervation if many muscles are involved in producing adduction deformity¹
 - Orthopedic interventions, including transaction of the anterior branch of the obturator nerve (for dynamic deformity) and proximal release of the adductors (for static contracture), are other possible treatments¹
- **Adducted hip³**
 - Involved muscles may include
 - Gracilis
 - Flexes and medially rotates leg and adducts thigh
 - Iliopsoas
 - Flex the torso and thigh with respect to each other
 - Semitendinosus (medial hamstrings)
 - Extends the thigh and flexes the knee
 - Rotates the tibia medially, especially with flexed knee
- **Stiff knee**
 - Typically presents as a gait deviation with the knee remaining extended through most of the gait cycle¹
 - As the limb becomes functionally longer, toe drag in early swing can cause tripping and falling¹
 - Dynamic EMG may demonstrate activity in ≥ 1 head of the quadriceps or in the various hamstrings¹
 - Muscles that are involved include
 - Rectus femoris¹
 - Extends the knee and flexes the thigh³
 - Vastus intermedius¹
 - Extends the knee³
 - Vastus medialis¹
 - Extends the knee and draws the patella medially³
 - Vastus lateralis
 - Extends the knee and draws the patella laterally³
 - Gluteus maximus¹
 - Major extensor of hip joint³
 - Hamstrings³
 - Medial hamstrings (semitendinosus) extend the thigh, flex the knee, and rotate the tibia medially, especially when the knee is flexed
 - Lidocaine motor point blocks to identified selected muscles may reveal whether “weakening” strategies can help to reduce stiff knee gait¹
 - Chemodenervation or neurolytic agents can be used if the diagnostic blocks are successful¹
 - The rectus femoris is the main target for orthopedic intervention to correct stiff knee gait¹
- **Flexed knee**
 - Knee remains flexed throughout the swing and stance phases of gait¹
 - Stretching of overactive hamstrings can be painful and not well tolerated¹
 - Knee flexion deformity interferes with sitting, wheelchair positioning, and transfers; the trunk extends due to the overactive hamstrings, causing patients to slide forward in their wheelchairs¹
 - Results in short step lengths¹
 - Passive and active ROM is determined with physical examination¹
 - Overactive muscles that may contribute include



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- Medial hamstrings
 - (Semimembranosus) Extend the thigh, flex the knee, and rotate the tibia medially, especially when the knee is flexed³
- Lateral hamstrings^{1,3}
 - (Semimembranosus) Extend the thigh, flex the knee, and rotate the tibia medially, especially when the knee is flexed³
- Other muscles include³
 - Rectus femoris
 - Vastus lateralis
 - Vastus medialis
 - Vastus intermedius
 - Gastrocnemius
 - Quadriceps
- Chronicity of this deformity often causes contracture¹
- When the dynamic block is active, chemodenervation of targeted hamstrings during the period of motor recovery may reverse static deformity¹
- Orthopedic lengthening may help the hamstrings¹
- Neurolysis with phenol is a less efficient technique for hamstrings because of the many motor branches and need for multiple injections¹
- **Valgus foot³**
 - Muscles involved may include
 - Gastrocnemius
 - Powerful plantar flexor of ankle
 - Soleus
 - Powerful plantar flexor of ankle
 - Peroneus longus
 - Everts foot and plantar flexes ankle
 - Helps to support the transverse arch of the foot
 - Peroneus brevis
 - Everts foot and plantar flexes ankle
 - Extensor digitorum longus
 - Extends toes 2 to 5 and everts ankle
 - Tibialis posterior
 - Dorsiflexor of ankle and invertor of foot
 - Tibialis anterior
 - Dorsiflexor of ankle and invertor of foot
- **Hyperextended big toe^{3,4}**
 - Muscles involved include
 - Extensor hallucis longus
 - Extends great toe, dorsiflexes and inverts ankle
 - Foot and ankle turn up and in. Skin breakdown over the tip of the toe may develop if toed box of the shoe is not high enough
 - Irritation of the skin and nail on the hyperextended big toe can cause pain
 - Severe deformity makes donning and wearing shoes difficult or impossible and unstable; equinovarus produces instability of the whole body
- **Assessment**
 - Suputtitada and Sunwanwela used the following to assess upper limb⁶
 - Degree of tone using the modified Ashworth Scale
 - Dexterity using the Action Research Arm test
 - Activities of daily living using the Barthel index
 - Pain assessment with Visual Analogue Pain Scale
 - Disability assessment in 4 areas² rated on a 4-point scale ranging from no disability to mild to moderate to severe disability
 - Personal hygiene
 - Dressing
 - Pain
 - Limb position
- **Spasticity-associated pain¹⁰**
 - Spasticity may manifest as painful flexor, extensor, or adductor spasms
 - Pain due to upper and/or lower limb spasticity can manifest in addition to other symptoms or can be the primary complaint
 - Pain can be associated with involuntary muscle spasms
 - In a study involving 60 patients with spasticity-related pain, 48% had spasticity caused by a stroke

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