

Spasticity in post-stroke patients: incidence and therapeutical approach

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Abstract

Stroke is a leading cause of serious long-term disability: about one third of patients developing spasticity of the affected limbs. Spasticity is characterized by a velocity-dependent increase in resistance to passive movement, and is one of the “positive signs” of upper motor neuron syndrome. Spasticity induces pain, ankylosis, tendon retraction, increasing motor deficit, which may limit the efficacy of rehabilitation methods. Spasticity is also correlated with activity limitations, and reduces quality of life of patients and caregivers. Assessment of post-stroke spasticity requires first clinical examination; scales as Ashworth Modified scale and Tardieu Modified scale are useful quantitative tools. Treatment of spasticity is often challenging for the rehabilitation team, requiring a multidisciplinary approach. Therapeutic interventions include physical therapy, occupational therapy, use of assistive devices, pharmacological treatment and injectable treatment. Botulinum toxin injections in spastic upper and lower limb muscles have significant effect in reducing muscle tone and improving passive function in affected limbs, and should also be considered for improvement of active function.

Key words: *spasticity, stroke, rehabilitation, botulinum toxin,*

Introduction

Stroke is a debilitating disease. According to the Heart Disease and Stroke Statistics - 2018 Update [1], stroke prevalence increases with advancing age in both males and females, affecting 2.7% of persons in the United States. Stroke is a leading cause of serious long-term disability: about half of stroke survivors remain with some degree of physical or cognitive impairment, and 3% of males and 2% of females in general population reporting post-stroke disability, females often having greater disability [1].

More than two thirds of stroke survivors receive rehabilitation services after hospitalization. In data from 2011, 19% of Medicare patients were discharged to inpatient rehabilitation facilities, 25% were discharged to skilled nursing facilities, and 12% received home health care [2].

Spasticity was first described by Lance, as a state of increased muscle tone with exaggerated reflexes characterized by a velocity-dependent increase in resistance to passive movement [3]. It is a “positive sign”, component of the upper motor neuron syndrome, together with extensor or flexor spasms, spastic dystonia, clonus, spastic co-contraction, and exaggerated deep tendon reflexes. All these abnormal features will lead to abnormal limb positioning.

The prevalence of spasticity in stroke patients in any limb is in the range of 25% to 43% in the first year

after stroke [4]. On the basis of its time course, post-stroke spasticity could be divided in acute (less than one month after stroke), sub-acute (between one month and six months after stroke onset), and chronic (occurring more than six months) [5]. Early spasticity appears in 4 to 27% of patients during the first 6 weeks after stroke onset [6]. In the first 3 months, the incidence of upper limb spasticity is 33% and increases with time [7].

Patients with strokes located in the basal ganglia and internal capsule had the highest spasticity incidence [7].

Spasticity distribution primarily affects the elbow (79% of patients), the wrist (66%) and the ankle (66%) [8]. Most common pattern of upper limb post-stroke spasticity is internal rotation and adduction of the shoulder coupled with flexion at the elbow, the wrist and the fingers. In the lower limbs, adduction and extension of the knee with equinovarus foot is the most observed pattern [9], [10].

Predictors of spasticity development are severe proximal and distal limb weakness early after stroke, low Barthel Index, sensory deficit, lesion volume, stroke location and associated diseases [6]. Early identification of these factors is essential for treatment decision, which will minimise long-term complications and will provide better motor and functional outcomes in stroke patients [6].

Patients with acute and subacute stroke with severe motor and sensorimotor deficits required close monitoring by stroke and rehabilitation physicians and by other members of the rehabilitation team, in order to detect spasticity.

Spasticity could induce pain, ankylosis, tendon retraction, and increase muscle weakness in patients, which may limit the efficacy of rehabilitation methods [11]. Spasticity is correlated with activity limitations of daily function, and reduces quality of life of patients and caregivers [4].

Spasticity is induced by the dissociation or disintegration of motor responses from sensory input, leading to hyperexcitability of the segmental central nervous system [12].

Assessment of post-stroke spasticity requires first clinical evaluation: inspection of limb posture, examination of passive and active joint range of motion, voluntary muscle contraction in affected limb, deep tendon reflexes and sensory examination. Scales are developed and validated to assess the degree and angle of muscle contraction [5]. The two most commonly used scales are Modified Ashworth Scale and Modified Tardieu Scale [11].

The **Modified Ashworth Scale (MAS)** measures the level of resistance to passive movement [13]. Its quotations are (after Bohannon):

- 0 = No increase in muscle tone
- 1 = Slight increase in muscle tone, manifested by a catch or by minimal resistance at the end of the range of motion (ROM) when the affected part(s) is (are) 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, but affected part(s) easily moved
- 3 = Considerable increase in muscle tone, passive movement difficult
- 4 = Affected part(s) rigid in flexion or extension

The **Modified Tardieu Scale (MTS)** measures the velocity of passive joint movement and the angle of contraction [14], [15]. Its items are:

X: Quality of movement mobilization

0 = No resistance throughout the course of the passive movement

1 = Slight resistance throughout the course of passive movement, no clear catch at a precise angle

2 = Clear catch at a precise angle, interrupting the passive movement, followed by release

3 = Fatigable clonus with less than 10 seconds when maintaining the pressure and appearing at the precise angle

4 = Unfatigable clonus with more than 10 seconds when maintaining the pressure and appearing at a precise angle

5 = Joint is fixed

V: Measurements take place at three different velocities

V1 – as slow as possible

V2 - Speed of limb segment falling under gravity

V3 - As fast as possible

Y: Angle of catching (muscle reaction)

Classification of spasticity depends on the scores obtained on Ashworth scale: mild spasticity is considered at 1 point, moderate at 2 points and severe if the Ashworth score is 3 [16]. .

Other functional parameters that needs to be tested in spastic post-stroke patients are active upper limb function (scales – Action Research Arm Test, Modified Frenchay Scale)[17] and the Disability Assessment Scale, which assesses hygiene, dressing, limb position and pain [18].

Treatment of spasticity is often challenging for the rehabilitation team, requiring a multidisciplinary approach. Therapeutic interventions include physical therapy, occupational therapy, use of assistive devices, pharmacological treatment, and in selected cases surgical treatment.

Role of physical therapy in ameliorating spasticity is well known. Evidences support a positive effect of muscle stretching and muscle reinforcement on spasticity [19]. Muscle stretching can be apply by moving the joint manually or by mechanical devices; includes active stretching, passive stretching, prolonged positioning, isotonic and isokinetic stretching. The goal is to increase the extensibility of soft tissues, normalize muscle tone and to reduce contracture-related pain. Muscle strengthening could be obtained by muscle training and biofeedback procedures [19]. The efficacy of physical agents is also reported: shock wave therapy, ultrasound therapy, cryotherapy, thermotherapy, hydrotherapy and vibratory stimulation have been used in post-stroke spasticity. However, only vibration treatment applied to spastic muscle groups might be considered, but did not have long-term effects, according to current Guidelines for adult stroke rehabilitation and recovery [4].

Electrical stimulation used TENS (Transcutaneous Electrical Nerve Stimulation) – with controversial effect and NMES (NeuroMuscular Electrical Stimulation), which may be reasonable to improve spasticity temporarily (in combination to other non-pharmacological therapies), but is ineffective in improving functional hand use [4], [11],[19].

Role of assistive devices is also controversial in post-stroke spasticity. Splints or orthoses, which can be placed and left for several hours, were used to obtain reductions in spasticity and pain, improvement of function, and prevention of contracture and deformity [11]. The use of resting hand splints is not effective for preventing muscle contracture of paretic upper limb early after stroke and also in reducing wrist and finger spasticity [4]. Casting immobilizes the limb in a stretch position, inducing prolonged muscle stretching. Short duration ankle casting may be used to facilitate reduction of plantarflexor spasticity (but after botulinum toxin treatment), but . taping has no effect in these situations [4].

Oral antispastic agents aim to reduce muscle tone, acting on the CNS (central nervous system) or directly on the muscle. Traditional muscle relaxants should be introduced when the patient suffers from motor disability due to spasticity, but have a controversial efficacy [11]. They have a limited effect on reducing general spasticity and dystonia, but they have dose-limiting side effects (weakness, tiredness and sedation) [4], [17]. Agents frequently used are : baclofen (5–20 mg 3–4 times daily), clonazepam (0.5–1.0 mg once daily – at bedtime), diazepam (5–20 mg 3 times daily), gabapentin (240–360 mg daily), tizanidine (4–36 mg daily) and dantrolene (25–100 mg 4 times daily) [11]

Phenol or alcohol injections are no more used because of severe local adverse reactions [11]. Intrathecal baclofen therapy (pump) is effective in reducing generalized spasticity in stroke patients which do not respond well to other interventions or experienced severe adverse effects from other treatments [4].

Injection of botulinum toxin (BoT) in spastic muscles have shown efficacy in reducing spasticity. Improvements were attributable to the lowered resistance to muscle stretch during passive movements. Mechanism of action of BoT on spastic muscle involved reduction in spastic co-contraction (inappropriate antagonistic co-activation during volitional command on an agonist), decreasing of

spastic dystonia, stretch facilitation and lengthening of the injected muscle [20].

Current guidelines recommend botulinum toxin for reducing muscle tone and improving passive function in adults with spasticity; BoT should also be considered for improvement of active function.

BoT is the most potent neurotoxin; it is produced by *Clostridium botulinum*, and induces a blockade of neuromuscular transmission, with a paralytic effect on muscles. BoT is available in 2 serotypes: A and B. There are 4 commercial approved preparations: onabotulinumtoxinA (Botox), abobotulinumtoxinA (Dysport), incobotulinumtoxinA (Xeomin) and rima botulinumtoxinB (Myobloc). There are important pharmacological differences between BoT preparations, including latency, duration and intensity of the effect [21].

The effects of botulinum toxin injections are generally dose dependent, are realized within 3 to 7 days following injection, and last approximately 2 to 4 months [22].

Doses used in treatment are variable, ranging from 75 to a maximum of 500 units of onabotulinumtoxin and 500 to 1500 units of abobotulinumtoxinA [17]. Generally all doses of botulinum toxin resulted in reduction in muscle tone; however, increasingly higher doses were associated with greater muscle weakening [22].

For upper limb post-stroke spasticity, 2010 American Academy of Neurology guidelines [21] stated that aboBoT-A (Botox), onaBoT-A (Dysport) and incoBoT-A (Xeomin) were safe and demonstrated significant reductions in upper limb muscle tone (measured by the MAS) and improvements in passive arm function.

In spastic lower limb, the most disabling problem is spastic equinovarus foot, frequent complication following stroke, caused by increased tone in a pattern that includes spasticity of the gastrocnemius and tibialis posterior muscles [22]. Injections with aboBoT-A (Botox) and onaBoT-A (Dysport) in the gastrocnemius and soleus muscles are safe and effective for the reduction of lower limb spasticity [4], [21].

However, data are inadequate to support the efficacy of BoT in improvement of active function of spastic upper limb or lower limb [21]. There is no evidence to sustain an effect of BoT injections on functional upper limb use, although it improves upper limb positioning for daily activities (dressing, hygiene) [4].

Another study showed that BoT injections in spastic upper limb have also a small, but significant effect on improving daily activities, as measured by Disability Assessment Scale (DAS), a measure of self-reported disability [4].

For active lower limb function, BoT injections in the ankle plantarflexor and invertor muscles reduce spasticity, indirectly improving gait speed [4]. BoT injections in rectus femoris muscle will also improve knee extension during walking [4].

The maximal effect of the BoT treatment was observed at 4 weeks after injection, and the improvement in MAS scores were sustained up to 12 weeks [17].

Timing of BoT injections was also assessed. There are evidences supporting early administration of abobotulinumtoxinA in the first 2 to 12 weeks after stroke. This will not only improve spasticity (as measured by MAS), but the improvement lasts longer, increasing significantly the time until re-injection, compared with placebo. The hypothesis is that early BoT injections could induce a delay in symptomatic spasticity development, and suggest a prolonged effect of BoT if administrated early [23]. Despite beneficial effect of BoT injections in decreasing spasticity, there are concerns about the relatively high cost of treatment and about the smaller or absent effect on active function [22]. For this reason, some studies focused on the impact of reducing spasticity by BoT treatment on functional disability and quality of life. BoT treatment improves impression of functional disability assessed by the Global Assessment Scale (which consider also patient's perspective), at 4 and 6 weeks after treatment [17], but the effect did not last after week 12.

Botulinum toxin injections have also demonstrated significant greater global benefit, but no significant difference in quality of life (QOL) of stroke patients. In a study performed by McCrory et al, which used 2 injections of BoT in the distal spastic upper limb at 12 weeks interval, no significant benefit in improving quality of life was demonstrated using the AQoL (Assessment of Quality of Life) scale [24].

The possible explanation for lack of effect of BoT treatment on patient's quality of life is that BoT treatment should not be seen as a treatment in isolation, but as part of a more comprehensive treatment strategy that also involves physiotherapy,

bracing, balneotherapy with the use of natural therapeutic factors and pharmacotherapy [25].

Surgical treatment of spasticity is mainly used for severe cases or for the effects induced by spasticity that become functional impairments (e.g. irreducible equinus) [11].

In conclusion, spasticity is a disabling post-stroke condition, which requires treatment. The evident diagnosis is followed by challenging management strategies. Spasticity treatment needs a multidisciplinary approach, in which botulinum toxin focal injections have a central role, targeting increase in muscle tone; other treatment modalities, such as oral pharmacological agents, rehabilitative interventions and pain management, aimed to improve functional disability of the patients.

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