Mini Review

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The rationale of operative treatment for spasticity of the upper limb

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Petros Mikalef, Dominic Power
Birmingham Hand Centre, England

Correspondence: Petros Mikalef, Birmingham Hand Centre, England, Email pmikalef2000@gmail.com

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Spasticity is one of the clinical signs of Upper Motor Neuron Syndrome. The cause of the syndrome can be Cerebral Palsy, Stroke, Traumatic Brain Injury, Multiple Sclerosis or other lesions. Spasticity clinically manifests as an increased resistance offered by muscles to passive stretching (lengthening) and is often associated with other commonly observed phenomena like clasp-knife phenomenon, increased tendon reflexes, clonus and flexor and extensor spasms.[1]

Non-operative treatments are usually considered as the first line of treatment for patients with Spasticity. These include oral medication, physiotherapy, splinting, chemodenervation, or, most likely, an individualised combination of some or all of these treatment modalities.[2] Any non-operative treatment modality is considered to be reversible,[3] so it gives the treating healthcare professional the advantage to stop or modify it if the result is suboptimal.

Operative treatment of Spasticity is indicated when the patient's function is impaired, when it causes significant pain to the patient, when it makes caring for the patient troublesome, or when it may lead to irreversible deformities of the skeletal system.[4] It is understandable that operative treatment is irreversible and the results of this treatment are permanent for the patient.[3] Operative treatment is expected to decrease, eliminate or redirect muscle forces, mobilize stiff joints, restore balance to joints or stabilize joints, but it is not expected to restore volitional control to muscles or increase muscle force generation.[5]

Patients with Spasticity that involves the Upper Limb can be either functional or non-functional.[6] Thorough and detailed preoperative assessment is essential through a multidisciplinary setting where all health professionals who are treating the patient are involved.[6,7] In the functional patient the aim of any treatment modality is usually to improve function by restoring the balance between agonists and antagonists. In the non-functional patient the treatment usually aims to improve hygiene, sometimes improve pain, and to facilitate dressing and nursing. An important part of the decision making is preop assessment with the use of nerve blocks or Botulinum toxin. Botulinum toxin and nerve blocks can give a result which is very similar to the result after surgery. This can give the patient, the carers and the members of his/her family the opportunity to see the condition of the limb after surgery.[8]

It is important to understand that timing of treatment can be extremely important. In the paediatric patient there doesn't seem to be a consensus for the optimal age for surgical intervention. The age of 6years in the appropriate patient seems to be favored by Tonkin[9] when Seruya et al.[10] reports that surgery remains an option for the older patient. In post stroke spasticity and post Traumatic Brain Injury Spasticity early surgical intervention has the advantage the joints of the involved Upper Limb are still supple and the duration of disability is shorter, but on the other side the neurologic condition might still be dynamic and unpredictable and also medical comorbidities and the initial injury are relatively recent. Later intervention has the advantage of having a patient with a more stable condition but the disability is present for a longer time which can have an effect on the patient, while the patients might have already developed stiffness[5] since uncontrolled spasticity can lead to permanent contracture in the muscles and soft tissues.[7] So depending on the timing from the initial accident and the clinical picture, the treatment options can be significantly different.

Surgery for the treatment of Spasticity of the Upper Limb can involve the Spine, the peripheral nerves, Muscles, tendons or joints. Lin et al. published a series of 13 patients who had selective posterior rhizotomy of the C8 root for the treatment of spasticity of the hand. The outcome was graded excellent in 2 patients, good in 3 patients and 8 patients had recurrence of spasticity of the hand.[11] The article concluded that the long term results of the technique seem to be poor so it looks that this technique needs to be improved further. Surgical intervention for spasticity at the level of the peripheral nerve seems to have attracted quite some attention. The first ever described procedure for spasticity at the level of the peripheral nerve was described in 1887 by Lorenz[12] and was a neurotomy of the obturator nerve. The idea was revisited and used in the upper limb by Stoffel who published his techniques and results in 1913.[13] Although the results described in the paper were promising and quite a few technical details are still valid, it required long procedures through big incisions. Since this was before the era of antibiotics his results were complicated with postoperative infections, so the idea was abandoned.[14] It was revisited for the Upper Limb by Bruneelli and Brunelli[14] who presented their technique in 1983. The adoption phenomenon was described to justify the recurrence of spasticity on the operated muscles.

When no function is expected from the targeted muscle a full division of the nerve that supplies the spastic muscle can be performed. This has been described for the elbow flexors, when Garland et al (1980) described their results on musculocutaneous neurectomy.[15] In a similar way neurotomy of the motor branch of the ulnar nerve can be performed to treat spasticity of the intrinsics[16] and neurotomy of the recurrent branch of the median nerve has been proved to be useful as an adjunct of surgical treatment of the nonfunctional hand and prevention of an intrinsic Thumb in Palm Deformity.[17] When the Upper Limb is functional and the result of the procedure is expected to be improved function, the nerve supply to the targeted muscle needs to be reduced in order to reduce hypertonia but also maintain volitional control over the muscle. There is no consensus in the literature as to which is the best

technique to achieve reduction of hypertonia. Intervention at the level of the nerve trunk.[18,19,20] have been described as well as interventions at the level of the terminal motor branches.[21,22,23] Stoffel's publication highlighted the importance of detailed knowledge of the anatomy and the variations of nerve supply.[13] Further cadaveric detailed anatomic studies of the terminal branches of the musculocutaneous[24] the median nerve[25] and the ulnar nerve[26] in cadavers has helped considerably in optimising surgical techniques and incisions when selective neurectomy is used to treat hypertonia in a functional Upper Limb. Selective Peripheral Neurectomy has been used for the treatment of neurectomy in various levels of the Upper Limb with a variety of results. Maarrawi et al.[19] reported neurectomies in various levels in 31 patients with a recurrence rate of 15.6%(5 patients, 2 of which required repeated surgery). Leclercq and Gras[21] reported results of hyperselective neurectomies which took place in 20 patients – 63 muscles. These included shoulder muscles, elbow flexors, forearm pronator and wrist flexors. There was one complete failure reported that was due to a technical problem, and no recurrences of spasticity.

Tendon lengthenings have been used for a long time in the treatment of Spasticity of the limbs and is used in the functional Upper Limb. It looks that tendon lengthening weakens the operated muscle and this is one of the reasons why the function is harmonised (also by achieving approximately normal joint excursion and thus the antagonists often exert a stronger force after lengthening of a spastic agonist in such a way that changes in activity of these muscles are noticed).[27] Tendon lengthenings can either be fractional lengthenings which means that the tendon is transected in various points at the level where the tendon overlaps with the muscle or z-lengthenings which is the classic way of lengthening where a vertical incision is made in the middle of the tendon and the blade is turned 90 degrees on the one half of the tendon on one direction, distally or proximally and the contralateral half is sectioned on the other direction by the blade which is turned 90 degrees.[28] Both techniques have been used in various levels on the joints of the Upper Limb, in the shoulder[29] the elbow flexors,[30] wrist flexors,[30] finger flexors[31] even fractional lengthening of the intrinsics have been published.[32] Fractional lengthenings are taking place within the aponeurosis or muscle, in the muscle tendon junction so they are stable without postoperative immobilization, whereas z-lengthenings require immobilization for 4weeks to avoid excessive lengthening or recurrence of contracture.[28]

Proximal releases can also be used for operative treatment of Upper Limb Spasticity. The technique consists of sectioning the proximal insertion of a muscle or muscle group at the aponeurotic fascia.[28] It has been used for the brachioradialis muscle, either combined with lengthenings of biceps and brachialis, when function is expected postoperatively, or with releases of these muscles in the non-functional Upper Limb, and for the thenar muscles occasionally combined with the first dorsal interosseous muscle.[30] Elevation of all the forearm muscles from the bones and interosseous membrane has been described and is known as flexor slide. It is used to reduce hypertonia mainly in the non-functional hand and results in a rather floppy hand.[30]

Tenotomies have also been used to reduce hypertonia. Tenotomies of the pectoralis major, latissimus dorsi, teres major and subscapularis[33] have been described in the shoulder, as well as tenotomies of the central slip for swan neck deformity[32] and division of the brachialis[34] or the palmaris longus.[30]

Tendon Transfers have been described when the paretic or paralysed muscles require augmentation. They are usually performed to improve forearm supination, wrist extension, thumb extension-abduction and/or finger extension. In addition to the already known indications for the use of a muscle as donor, in spasticity the muscle that is used for the transfer is often spastic to some degree but needs to have phasic control which means that the patient should be able to recruit it and relax to release.[6] Transfer of the Flexor Carpi Ulnaris to Extensor Carpi Radialis Brevis seems to be the most commonly used tendon transfer. The technique and the results have been studied in extent and the results have been published in the literature.[35,36] Other tendon transfers that have been published in the literature are pronator teres rerouting for forearm pronation deformity in pediatric patients with spastic hemiparesis[37,38] brachialis to extensor carpi radialis brevis tendon transfer to restore wrist extension, brachialis to extensor digitorum communis tendon transfer to restore finger extension, brachialis rerouting supinatoplasty,[39] re-routing of Brachioradialis to restore supination,[40] redirecting of the Extensor Policis Longus to augment the extensor abduction position of the thumb in thumb in palm deformity.[41] In the non-functional Upper Limb flexor digitorum superficialis to the flexor digitorum profundus tendon transfer is performed when the goal is to improve passive function in patients with clenched fist deformity.[42,43]

There are a few tenodesis that have also been described. Wrist Extensor tenodesis is performed in order to prevent flexion, but still allow extension, by attaching the Extensor Carpi Radialis Longus, the extensor Carpi Radialis Brevis and the Extensor Carpi Ulnaris to the distal radius with the wrist in 20 degrees of extension.[30] The biceps suspension procedure is performed to reduce the inferior subluxation of the humerus and improve shoulder pain. During the procedure the tendon of the long head of the biceps is dissected distally, free of muscle, then the distal end is passed through a tunnel in the humerous and sutured to the proximal part of the tendon.[44] The joints can also be stabilised with an arthrodesis. In Spasticity of the Upper Limb arthrodesis of the wrist has been used extensively when there is flexion deformity of the wrist.[45] In quite a few occasions proximal row carpectomy is required to bring the wrist in the desired position.[46] The Metacarpophalangeal joint of the thumb can also be stabilised by an arthrodesis.[47]

Careful preoperative assessment is very important to make a plan for operative treatment. The aim is to improve the function of the Upper Limb, and this is achieved mainly by trying to restore the balance of agonists and antagonists. Surgery in multiple levels can be required and it is generally preferred to perform these operating procedures in one sitting when possible. Although there are different treatment options when the ultimate aim is to reduce hypertonia, it is still not clear if a method of treatment is better than another. There is no evidence that neurectomies have better or poorer results than tendon lengthenings or if one tendon transfer has better functional results than another one that is performed for the same clinical reason. Every patient needs an individualised treatment plan depending on his overall clinical picture, so it is difficult to have patients with similar characteristics to be able to compare results. There is a definite need for further research to improve the surgical techniques that are currently in use in the Upper Limb. Parot and Leclercq[25] studied the median nerve branching in cadavers and concluded that the flexor digitorum superficialis is not suitable for hyperselective neurectomy. Further research is needed to guide the decision towards a technique when there is no limitation arising from the anatomy.

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Conflict of interest

Author declares that there is no conflict of interest.

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