

Muscle Release in the Management of Spasticity in Spinal Cord Injury

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Summary

Muscle spasticity and contractures in the spinal cord injured are a big problem interfering with rehabilitation, leading to inconveniences and complications in these patients. Management is based on pharmacotherapy, physiotherapy and surgeries. The authors are against central neurosurgery except on rare occasions. They have been practicing peripheral surgeries chiefly on muscles and tendons with satisfactory results in selected cases. The guidelines and procedures are presented.

Key words: Spasticity; Contractures; Myototomy (muscle release); Spinal cord injury.

Spasticity and contractures of the muscular system below the level of spinal cord injury (SCI) are one of the most incapacitating complications of the cord injury (Yarkony *et al.*, 1985). They stand as a formidable obstacle to the rehabilitation of SCI victims, cause a lot of pain, inconvenience ending by contractures and other complications, viz. joint ankylosis, dislocation and subluxation, oedema of the extremities, pressure ulcers, vascular compromise both arterial and venous, falls with subsequent fracture, even pathological fractures, difficulty in positioning and seating of the patients. For these reasons spasticity and contractures should be treated and above all be prevented. Pharmacotherapy (Woolsey, 1981; Pedersen; Duncan *et al.*, 1976; Shears and Nance, 1985) and physical therapy (Guttmann, 1953) should always be given the chance before surgery is considered, particularly in incomplete cases in which spasticity may be of value in supporting the patient especially when there is paraplegia in extension. Neurosurgical interventions, e.g. rhizotomy (Foerster, 1908, 1911; Freeman and Heimburger, 1947, 1948; Gonsette and Andre-Balisaux, 1963; Kerr, 1966; Laitinen *et al.*, 1983; Munro, 1945, 1948; Sindou *et al.*, 1987; Lehmann, 1936), cordotomy (Hyndman, 1943), cordectomy (McLaughlin *et al.*, 1986), myelotomy (Bischof, 1951; Fogel *et al.*, 1985; Weber, 1955), neurotomy, griseotomy (Padovani *et al.*, 1982) and epidural stimulation (Bajd *et al.*, 1985; Campos *et al.*, 1987; Dimitrijevic *et al.*, 1986; Richardson and McLone; Maiman *et al.*, 1987; Romana *et al.*, 1985), etc. (Pourpre, 1960; Schurmann, 1953) are major surgeries and carry morbidity. Besides, their results

are not permanent. Epidural spinal cord stimulation has lately been advocated but long term results are not well documented. Chemical block of the reflex arc by intrathecal alcohol, phenol with or without the use of contrast medium (Comarr, 1960; Dogliotti, 1933; Gringras, 1948; Kelly and Gautier-Smith, 1959; Lacombe *et al.*, 1966; Liversedge and Maher, 1960; Maher, 1955; Nathan, 1959, 1965; Scott *et al.*, 1985; Sheldon and Bors, 1948), peripheral nerve block (Khalili and Betts, 1967; Khalili *et al.*, 1964) and motor point block (Muller *et al.*, 1987; Halpern and Meelhuysen, 1966) have been practiced. Intrathecal baclofen (Muller *et al.*, 1987; Penn and Kroin, 1985) has recently been tried. It has therefore been our policy in the Long Beach Veterans Administration Spinal Cord Center, to practice peripheral surgeries whereby spasticity can be controlled without resorting to major neurosurgeries (Comarr, 1960). Before tendon surgery is planned it is important to apply the following criteria:

1. All triggering factors should be treated, viz. pressure sores, osteomyelitis, high urine residual, genitourinary infections, stones, epididymitis, phimosis, etc., gastrointestinal problems, e.g. ulcers, gall stones, distension, faecal impaction, haemorrhoids, perianal infections and fissures, etc. Other causes should be looked for, e.g. ingrowing toenails, paronychia, hidden fractures, fever, anaemia, malnutrition, drug addiction, heavy smoking, etc. Psychological stresses should be considered (Hohmann, 1954) (Table I).
2. Have all conservative measures been exhausted and failed either partially or totally? That means the use of pharmacotherapy and all physical therapy modalities.
3. Before surgery is considered a thorough neurological evaluation is essential, especially for any preserved motor power, any chances of motor recovery and the effect of surgery on the antagonistic muscles. In older patients a syrinx can be manifested by increasing spasticity usually with increasing pain and if suspicious it should be ruled out by appropriate investigations.
4. The status of the joints for contracture of the capsules, displacement and periarticular ossification should be studied.
5. Careful planning as to which muscle or group of muscles is to be tackled by surgery and what procedure will be performed. One has to ascertain which muscle or muscle group is predominant in the heightened reflex activity. All these criteria are needed to choose the right type of surgery at the right time, neither too early nor too late.

In our series the most common indications for tendon surgery are as follows.

Lower extremity

1. Hip flexion, hip adduction.
2. Knee flexion contracture, knee extension contracture.
3. Ankle: equinovarus deformity.
4. Toes: flexion contracture, occasionally hallux extension.

Table I Triggering factors to rule out

Skin	Pressure sores
	Skin infections
	Wounds
	Ingrowing toenails
	Paronychia
Muscles	Active heterotopic ossification
	Abscess: i.m. injection
Bones	Osteomyelitis
	Fractures
Joints	Arthritis
GU	UTI
	Stones
	Perirenal infection
	Balanitis
	Epididymitis
GI	Dyssynergia
	Gastritis
	Peptic ulcer
	Gas distension
	Faecal impaction
	Megacolon
	Haemorrhoids
	Anal fissure
	Perianal infections
	Gall stones
Pancreatitis	
General	Anaemia
	Malnutrition
	Heavy smoking
	Caffeinism
	Drug addiction
	Psychological stress

1. *The hip*

For hip flexion contractures, release of the iliopsoas is the most important procedure. This can be approached in the following ways:

1. Iliopsoas myotomy by the retroperitoneal approach (Michaelis' technique) (Michaelis, 1964).
2. Iliopsoas tenotomy through a thigh approach (Bleck and Holstein, 1963; Keats, 1967). Other flexors may be divided: Rectus femoris, Sartorius.

For hip adductor spasm, obturator neurectomy, preferably by the suprapubic extraperitoneal approach (Michaelis, 1964; Keats, 1967) or by the inguinal approach when combined with adductor tenotomies. Through this latter approach a combined iliopsoas and adductor tenotomy can be performed.

2. *The knee*

For the flexed knee, the flexion deformity of the knee may simply be due to a hamstring contracture or may be secondary to flexion deformity of the hip,

occasionally to a spastic equinus deformity of the ankle or to overactivity of the spastic gastrocnemius and also prolonged sitting with the knees flexed. Careful evaluation is therefore necessary before the operation is planned and this should be directed towards the primary cause of knee contracture. In many cases, correction of the hip deformity (flexion and/or adduction) automatically corrects the knee deformity. Also Achilles tenotomy or lengthening or gastrocnemius lengthening may correct the knee deformity. That is why in some cases of hamstring tenotomies, the results to the knee are not satisfactory. The muscles to be divided are the gracilis, semitendinosus, semimembranosus and biceps femoris. Comarr has recommended on occasions additional neurectomy of the tibial and peroneal nerves. Tendon lengthening may be considered on these muscles if any functional element is preserved, also tendon transfer.

3. *The ankles*

The most common deformity of the ankle is that of equinus, and this may be combined with a varus or valgus deformity. The triceps surae (gastrocnemius and soleus) act on the knee, ankle and subtaloid joint thus when contracted will be accompanied by knee flexion, varus or valgus deformity. Misplacement of the os calcis and talus results in chronic cases which account for tendon surgery failures. That is why surgery should not be too long delayed. The procedures that are usually adopted are: Achilles tenotomy, Achilles tendon lengthening by Z-plasty or by gastrocnemius release at the junction of the muscle belly with the tendon (tongue-in-groove procedure of Baker) especially when some function is expected. Others combine gastrocnemius denervation (Stoffle's) with the tenotomy or tendon lengthening.

In many cases we have noticed that the release of tension of the triceps surae corrected ankle deformity, reduced the spasticity in the whole leg and even in the contralateral limb. For ambulating patients tendon lengthening is the procedure of choice since tenotomy alone weakens the stability of the ankle. For persistent varus deformity after Achilles tendon lengthening open tenotomy of the tibialis posterior may be attempted. In unilateral severely spastic equinovarus deformity a transfer of the tendon of the tibialis anterior into the sheath of the extensor digitorum communis after section of the latter and removal of a wedge of bone on the lateral side of the foot will correct that deformity. In bilateral cases correction can be achieved by tibialis anterior transfer to the tendon of extensor digitorum communis without bone wedge removal. For pes equinovalgus the peronei are transferred to the sheath of the extensor digitorum communis. For talipes calcaneus it is recommended to do shortening of the Achilles either alone or with a transfer of the flexor hallucis longus or digitorum longus to the tendocalcaneus and occasionally to the os calcis separately.

For severe inversion, if Achilles lengthening does not correct it, then the tendon of the tibialis posterior is rerouted anteriorly to the medial malleolus.

For valgus deformity with pes equinus, the tendo Achilles is lengthened and the peronei are translocated anterior to the lateral malleolus thus acting as dorsiflexors.

For the varus deformity, the tendon of the tibialis posterior is divided, it may

be transferred subcutaneously anterior to the ankle and fixed to the cuboid or lateral cuneiform bone.

4. *The toes*

For spastic toes, tenotomies of the flexors or extensors with or without capsulotomies, sometimes basal phalangectomy or amputations have to be done.

Upper extremity

For the upper extremities the most common contracture deformity is that of elbow flexor. Repeated splintage may be of help but we resorted to biceps brachii tenotomy or lengthening or brachialis myotomy.

The aim of surgery on the muscles and tendons is to allow a spastic muscle to retract and find a new length at rest resulting in correction of the contracture and reduction of the afferent inflow from the muscle to the isolated spinal cord. Tendon lengthening and/or transfer are of great value in patients who have some function preserved such as walking or standing or in whom it is believed to be possible. Tenotomies and myotomies do not necessarily lead to loss of function of the muscle involved. Osseous contact may be re-established by a scar and the muscle may be able to contract, if functioning, again. It is a common observation in our patients to find reunion of the cut Achilles tendon by a bridge of scar necessitating repeated surgery. Our experience consists of surgeries on the tendons mostly by tenotomies in 120 patients comprising 307 procedures as seen in Table II.

Table II Procedures carried out

Achilles tenotomy	114
Achilles tendon, lengthen	3
Adductor tenotomy and myotomy	34
Obturator neurectomy/neurotomy	13
Elbow tenotomy and fasciotomy	12
Hip flexor tenotomy and fasciotomy	41
Flexor hallucis longus tenotomy	1
Extensor hallucis longus tenotomy	2
Flexor tenotomy, knee	48
Tenotomy toes	
Extensor—6, flexor—21	27
Finger tenotomies	
Flexor—1, extensor thumb—1	2
Foot, flexor tenotomy and plantar fasciotomy, tibialis posterior tenotomy	4
Femoral neurotomy	2
Patellectomy with quadriceps tenotomy	3
Total surgeries	307

In the last 14 years there were approximately 120 patients who required tendon surgery for spasticity in a total population of approximately 3000, accounting for approximately 4%. The ages ranged between 21 and 74 with an average of 43 years. Duration of spinal cord injury ranged from 1 to 45 years, average 22 years.

Level of injury was from C3 to L1, most common C5–C6. Anaesthesia was mostly i.v. sedation except in restless patients with jerky extremities and incomplete lesions when the patients were put under general anaesthesia or spinal, particularly for iliopsoas tenotomies. There was no morbidity nor any mortality. Wound sepsis was rarely encountered since we used closed suction drainage for more major myotomies, viz. the iliopsoas and adductor group. The results of the iliopsoas myotomies were encouraging except in patients who had joint problems; capsular contraction, subluxation and dislocation. The latter we now exclude from myotomies. In the flexed knees the results were satisfactory. Those with capsular contracture of the knee had capsulotomy and/or ligamentous section. Subluxation of the knee was an obstacle to correction of the deformity. Skin shortening was similarly an obstacle and in some cases Z-plasty with or without skin grafting was done but we did not force the extension due to possible popliteal vascular compromise. Skin expansion by an expander may be tried. In the ankle tendon lengthening and tenotomies resulted in correction of the equinus deformity and to some extent the varus deformity. However, with Achilles tenotomies if physical therapy does not start as early as possible, recurrences do occur and in some cases re-operation was indicated. Other deformities of the foot were handled by tenotomies and tendon transplants as indicated above. For ankle or foot deformities we did not attempt bone surgeries because of the risk of infection in this patient population.

Conclusions

Spasticity in spinal man, especially in those with complete lesions can be most incapacitating and should be treated. A choice of one or more lines of treatment depends on the lesion and its manifestations. Conservative treatment should always be tried first, viz. pharmacological and physical therapy after eliminating all source of lowering the threshold of spinal reflex activity. Destructive procedures, e.g. rhizotomy and myelotomy as well as spinal alcohol or phenol block, should be kept as a last resort. Peripheral surgeries, viz. neurotomies, neurectomies, tendon lengthening and transfers, tenotomies and capsulotomies should be tried before embarking on major surgery. Our results on such patients have been satisfactory, based on over 300 procedures performed in the Long Beach Veterans Administration Spinal Cord Injury Center.

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