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Long Term Results of Microsurgical Dorsal Root Entry Zonotomy for Upper Extremity Spasticity

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Objective : The purpose of the present study is to assess the long-term results of microsurgical dorsal root entry zonotomy (MDT) for the treatment of medically intractable upper-extremity spasticity.

Methods : The records of nine adult patients who underwent MDT by one operating neurosurgeon from March 1999 to June 2004 were retrospectively reviewed by another investigator who had no role in the management of these patients. In all patients, MDT was performed on all roots of the upper limb (from C5 to T1) for spasticity of the upper extremity. The degree of spasticity was measured by the Modified Ashworth Scale (grade 0-4). Severity of the pain level was determined using the Numeric Rating Scale (NRS, score 0-10). Also, patient satisfaction of the post-operative outcome was assessed.

Results : Comparing the preoperative and postoperative spasticity using the Modified Ashworth Scale, we observed improvement in all patients, particularly in five of the nine patients (55.6%) who improved by three grades over an average of 66.4 months (range, 40-96). Regarding patient satisfaction, seven patients (77.8%) had affirmative results. None of the patients experienced severe, life-threatening, postoperative complications. We observed a decrease in the intensity of painful spasms to less than three scores as measured by NRS in all four patients with associated pain.

Conclusion : This study shows that MDT provides significant, long-term reduction of harmful spasticity and associated pain in the upper limbs.

KEY WORDS : Muscle spasticity · Upper extremity · Spinal cord · DREZ operation · Long-term effect.

INTRODUCTION

Spasticity is one of the most common sequelae of neurologic disease. In most patients, spasticity is useful in compensating for lost motor strength. Nevertheless, in a significant number of patients, it may become excessive and harmful, leading to further functional losses. When uncontrolled by other forms of physiotherapy and drug treatment, spasticity can benefit from functional neurosurgical procedures[17].

One intervention is the microsurgical dorsal root entry zonotomy (MDT)[15,16,18]. It consists of cutting only the ventral portion at the entry zone, including the area extending up to the superficial layers of the posterior gray matter. This technique was developed especially for treating neurogenic pain secondary to a brachial plexus avulsion[11,15], but it now has many indications in the treatment of severe spasticity[7].

The purpose of the present study is to assess the long term results of MDT for the treatment of medically intractable upper extremity spasticity.

MATERIALS AND METHODS

The records of nine adult patients who underwent MDT by one operating neurosurgeon from March 1999 to June 2004 were retrospectively reviewed by another investigator who had no role in the management of these patients.

All were selected for this study based on the presence of severe, disabling spasticity that affected the upper limb(s). The spasticity was resistant to high dosage of multiple medications and also to intensive physiotherapy, traction, and immobilization. The causes of the spasticity included cerebral palsy (5), cerebrovascular accidents (2), and traumatic brain injury (2). Of the nine patients, four patients had intractable pain (Table 1).

In all patients, MDT was performed on all roots of the upper limb (from C5 to T1) for

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spasticity of the upper extremity. Under general anesthesia, the patient was placed in the prone position. A hemilaminectomy, generally from C4 to T1 with preservation of the spinous processes, allowed sufficient exposure to the posterolateral aspect of the spinal cord segments of the upper limb. The incision was made at the junction of the ventrolateral region of the rootlet entry zone in the posterolateral sulcus. The incision was 2.5 mm deep in Lissauer's tract and obliquely oriented at 45° down to the apex of the dorsal horn (recognizable under the microscope by its gray-brown color).

The global assessment of the patient was performed by a rehabilitation physician who was not involved in the operation. The degree of spasticity was measured using the Modified Ashworth Scale (grade 0-4) preoperatively, six months postoperatively, and at the last long-term follow-up. Severity of the pain level was determined using the Numeric Rating Scale (NRS, score 0-10). Also, patient satisfaction of the post-operative outcome was assessed at the final follow-ups. As "excellent" if there was consistently greater than 75% satisfaction, "good" if there was 51 to 75% satisfaction, "fair" if there was 26 to 50% satisfaction, and poor if there was less than 25% satisfaction.

RESULTS

The average patient age was 36.4 years (range, 18-63). Six (66.7%) of the nine patients were male (Table 1). The mean follow-up duration was 66.4 months (range, 40-96).

Comparing the preoperative spasticity and six-month postoperative spasticity (using the Modified Ashworth Scale, Table 2), we observed improvement in all patients, most notably in six of nine patients (66.7%) who improved by three grades. In the long-term follow-up study, one patient had improved by two grades, but two patients had deteriorated by a grade. Finally, five patients (55.6%) improved by three grades, and six patients (66.7%) improved to the level of less than grade 2 on the Modified Ashworth Scale. We observed decreased painful spasms in all four patients to less than three scores, measured by NRS (Table 3).

Regarding patient satisfaction, seven patients (77.8%) had affirmative results on the long-term follow-up visit. Three patients categorized the results as "excellent", and four patients as "good".

Three of nine patients (33.3%) remained distal spasticity of the wrist and fingers. Because of wrist flexion-pronation with finger flexion, they underwent additional selective peripheral neurotomy (SPN) on median and ulnar nerve. There was one postoperative complication noted (transient ataxia). None of the patients experienced severe, postoperative complications (Table 3).

DISCUSSION

Spasticity can be defined as a condition in which there is a velocity-dependent increase in the resistance of the

Table 1. Clinical data of the patients with upper limb spasticity

Patient Number	Age	Sex	Etiology	Preop Pain (NRS)	Preop Spasticity (A/S)
1	63	F	CVA	7	4
2	23	M	CP	No	3
3	22	M	CP	5	4
4	39	M	TBI	6	4
5	31	M	CP	No	3
6	18	F	CP	No	4
7	59	F	CVA	7	4
8	26	M	CP	No	3
9	47	M	TBI	No	4

NRS : numeric rating scale, A/S : Ashworth scale, F : female, M : male, CVA : cerebrovascular accident, CP : cerebral palsy, TBI : traumatic brain injury

Table 2. The modified Ashworth scale

	The modified Ashworth scale
0	No increase in tone
1	Slight increase in muscle tone, manifested by a catch and release or minimal resistance through the remainder (less than half) of the ROM when the affected part(s) is moved in flexion or extension
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

ROM : range of motion

Table 3. Long term outcome after microsurgical dorsal root entry zonotomy for the patients with upper limb spasticity

Patient Number	F/U (ms)	Pain Level (NRS)			Spasticity (A/S)			P/S	Add.SPN	Cx
		Preop	PO6m	Last	Preop	PO6m	Last			
1	96	7	2	0	4	1	1	E	No	No
2	93	No	–	–	3	2	0	G	Yes	No
3	85	5	1	1	4	1	1	E	No	No
4	69	6	3	2	4	2	2	F	Yes	Transient.Ataxia
5	62	No	–	–	3	0	1	G	No	No
6	56	No	–	–	4	1	2	G	No	No
7	53	7	3	4	4	2	2	F	Yes	No
8	44	No	–	–	3	0	0	E	No	No
9	40	No	–	–	4	1	1	G	No	No

F/U : follow up, NRS : Numeric rating scale, A/S : Ashworth scale, P/S : patient satisfaction, Add.SPN : additional selective peripheral neurotomy, Cx : complication, E : excellent, G : good, F : fair muscle group to passive stretching, with a "clasp-knife" -type component associated with hyperactive tendon reflexes[6]. Spasticity affects both children and adults and arises from a number of neurological disorders, including cerebral palsy, multiple sclerosis, cerebrovascular accidents, spinal cord injury, and head trauma.

Most proposed mechanisms of spasticity include the loss of several types of inhibition. The loss of inhibition of the motor neuron pool at the segmental spinal level is an accepted view, but the exact types of inhibition lost are not clearly defined and may vary in different patient populations[19].

Considering the indication for neurosurgery in patients with spasticity, we have to carefully define the goals of the patients, i.e. increase comfort, decrease pain, improve function and autonomy, and prevent orthopedic disorders. Surgery is not without its consequences, and the surgical procedure must be highly selective in order to diminish the excessive hypertonia without suppressing useful muscle tone and limb function. As such, the selection of the type of surgery is very important.

More recently, we have seen the development of totally conservative operations that can increase the inhibitory mechanisms and decrease reflex hyperactivity at the spinal cord level. Chronic cerebellar stimulation techniques were developed by Cooper[2] for cerebral palsy. Cervical spinal cord stimulation was developed for spinal spasticity by Cook and Weinstein[1] and for cerebral palsy by Waltz et al.[20]. Chronic neurostimulation has very few indications at the present time. The main conservative technique is now intrathecal baclofen infusion with implantable pumps, proposed by Penn and Kroin[12].

Historically, neurosurgical procedures started with neuro-ablative techniques by Foerster and Lorenz[7]. The objective was to decrease the excitatory inputs and the spinal motor neuron hyperexcitability. Dorsal rhizotomy is the oldest standard surgical technique for treating spasticity, but it has been modified and improved by many neurosurgeons, especially by Gros et al.[4]. He developed the functional and selective posterior rhizotomy for pediatric cerebral palsy.

Modern approach is dorsal root entry zone (DREZ) lesioning. Sindou et al.[16] and Nashold and Ostdahl[10] refined these procedures even further. The technique of DREZ consists of lesioning only the ventral portion at the entry zone, including a large area up to the superficial layers of the posterior gray matter. It must be performed under general anesthesia, with an initial, short lasting, non-depolarizing muscle block.

The goal of the DREZ procedure is to destroy Rexed layers 1, 2, and 5, as well as the medial portion of the tract of Lissauer[21]. It is important to spare the lateral portion of Lissauer's tract, which has been recognized to possess an inhibitory inter-segmental function that modulates dorsal horn pain[15]. MDT based on microsurgical incisions and bipolar coagulations was introduced by Sindou in 1979, and since that time, several authors have extended the technique to other lesion modalities, such as thermocoagulation, laser light and ultrasounds[3,8].

Sindou et al.[18] reported a series of 16 hemiplegic patients suffering from harmful spasticity in the upper limb and treated with selective posterior rhizotomy (SPR) in the DREZ. In this study, the excess of spasticity was slightly diminished (two cases), markedly reduced (nine cases), or totally abolished (five cases), making possible an improvement in voluntary movements in eight patients and at least a good passive mobilization in seven additional cases. Our study showed that 55.6% improved by three grades, and overall 66.7% improved to the desirable level of less than grade 2 on the Modified Ashworth Scale.

The indication for peripheral neurotomy itself is focal spasticity, localized to a muscular group innervated by a single or few peripheral nerves. Also, in situations of multifocal spasticity, it is possible to perform combined neurotomies, or to combine peripheral neurotomy with other ablative procedures (DREZ operation) at the spinal level and with complementary orthopedic surgery (tenotomy, articular surgery)[7]. In our study, three patients needed additional neurotomies for their residual distal wrist and finger spasticity.

MDT was originally developed for the treatment of neurogenic pain, particularly for those cases secondary to a brachial plexus avulsion[7]. The patients with severe spasticity associated with intractable pain are theoretically good candidates for MDT. In this report, all four patients with pain have experienced less pain in the setting of MDT.

Complications after the procedure have been reported to include loss of bowel, bladder, or sexual function, sensory loss, dysaesthesias, and weakness of the lower extremities[14]. One serious complication of early DREZ surgery is muscular weakness. Post-DREZ motor deficits are due to the involvement of the spinocerebellar tract, which lies near the dorsal root entry zone[9]. However, these symptoms tend to subside within a few weeks after surgery[5,11]. It was recently demonstrated that intraoperative monitoring could limit thermal effects of thermocoagulation on the long tract[13]. In our study, one case involved the complication of transient ataxia, but this largely recovered within a few months.

CONCLUSION

This study shows that MDT provides a significant, long-term reduction of harmful spasticity and associated pain in the upper limbs. However, there were two cases of worsening spasticity on long-term follow-ups. For maximized, consistent long-term results, sophisticated rehabilitation and physical treatment might be necessary. Selective peripheral neurotomy can be helpful for residual distal spasticity in post-MDT patients.

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