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Topical Anesthesia: A Possible Treatment Method for Spasticity

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ABSTRACT. Sabbahi MA, De Luca CJ, Powers WR: Topical anaesthesia; a possible treatment method for spasticity. Arch Phys Med Rehabil 62:310-314, 1981.

• Topical anesthesia was applied to the skin of the leg and thigh of a hemiparesis patient resulting from embolic infarction in the middle cerebral artery. After application of the anesthesia, the angular displacement of the ankle and knee joints measured during a full gait cycle showed a substantial shift towards normal. This response indicated a reduction in muscle spasticity which was confirmed by clinical tests. Neurophysiologic studies performed on the patient suggested that the reduction in muscular hypertonicity was mediated by reduced cutaneous inputs on the α - γ motoneuron interaction. This conjecture is supported by studies of other investigators performed on animals as well as humans.

A recently completed study performed in our laboratory has demonstrated that desensitization of skin receptors significantly alters the discharge characteristics of the motoneuron pool in normal individuals.[8,9] Encouraged by these results, we have begun to investigate the use of topical anesthesia as a means of reducing muscle hypertonicity in spastic patients.

This approach has been tried on 5 patients: 2 patients with stroke from cerebrovascular accidents, 1 head injury patient with right hemiparesis, and 2 with multiple sclerosis and consequent muscular hypertonicity in both lower limbs. In all cases a substantial increase in the range of joint mobility was noticed after the skin area of the affected limbs was desensitized. The increased joint mobility enabled the patients to perform movements they were previously unable to accomplish.

This report presents the details of the investigation performed on one patient whom we were able to study in detail.

Patient Background. The study was performed on a 34-year-old man with a left pure motor hemiparesis secondary to embolic infarction in the middle cerebral artery. Onset had occurred almost 9 months prior to our investigation. The patient reported sudden complete weakness in the left side of the body. Previous medical history revealed a left Bell palsy 2 years earlier that responded to steroid therapy. There was a positive history of concussion and head trauma with-

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out loss of consciousness within 3 years of this investigation. There was no history of hypertension.

On admission, neurologic examination revealed dysarthria and left central facial paralysis. Sensitivity to pin, touch, cold and warm stimuli was normal. Motor examination revealed normal bulk with flaccidity and a variable degree of weakness in the left upper and lower limb muscles. Tendon reflexes in the upper and lower limbs were hyperactive, with a positive Babinski sign on the left. Electroencephalograms and brain scan were within normal limits. Carotid arteriography showed no evidence of any vasculitis. However, some decreased perfusion was noted in the distal segment of the left middle cerebral artery over the precentral area.

Physical therapy resulted in significant improvement in the strength of upper and lower limb muscles. The lower limb developed a moderate degree of spasticity in the extensor muscle groups (extension synergy). However, with the limb raised, hypertonicity also increased in the flexor muscle groups (flexion synergy). The patient had developed an inverted foot with significant weakness in eversion, dorsi and plantar flexion. The gait had a characteristic hemiplegic pattern and a cane was necessary for stability. He was unable to fully extend the knee while standing as a result of muscular hypertonicity in the hamstrings muscles. Also, the patient was unable to lift his foot off the ground during the swing phase.

Four months after the onset of treatment, the chief complaints of the patient were the gait abnormalities, the muscle spasticity, and muscular weakness in the left lower limb. His physical therapy program had ceased to provide further improvements.

METHODS

When the patient first came to our laboratory, a gait study was performed using the method of Antonsson.[1] The angular displacements of the knee joint (flexion-extension, external rotation-internal rotation) and of the ankle joint (dorsiflexion-plantar flexion, eversion-inversion) were measured by the Selspot system of Selcom AB. This system uses cameras containing lateral-photo-effect diodes which are sensitive to infrared light to monitor the position of the image of infrared sources located on the patient. Two cameras were used for detecting the position of the limb segments in both lower limbs. The angular displacements were obtained by measuring the relative displacements of the thigh with respect to the leg, and the leg with respect to the foot. Topical anesthesia (20% Benzocaine) was sprayed for 15 seconds to all skin areas of the affected left leg below the knee joint. Prior to anesthesia, control gait measurements were taken while the patient walked with and without the cane. Then the topical anesthesia was applied to all skin areas on the left thigh and gait measurements were taken again. The time when all gait measurements were taken is shown in table 1.

Table 1: Time (in minutes) When Gait Measurements Were Taken

	Before Anesthesia	Anesthesia to Leg		Leg and Thigh	
	Control	Trial 1	Trial 2	Trial 1	Trial 2
With Cane	0	16	32	45	62
Without Cane	0	25	35	50	67

In addition to gait studies, the range of the free joints movements of the affected lower limb was assessed by goniometric measurements of the passive movement of the hip, knee and ankle joints before and after the anesthesia was applied to the skin. This was used as an indication of the degree of muscular hypertonia. The maximal H-reflex of the subject was measured by stimulating the posterior tibial nerve with 1 msec constant-current pulses every 5 seconds, and recording the EMG signal from the surface of the soleus muscle (unpublished data). The Achilles tendon reflex was measured by striking the tendon with an electrically operated solenoid plunger which delivered a constant-force stimulus every 10 seconds. The tendon and H-reflexes were measured before and after anesthesia was applied to the skin of the lower limb. Each measurement was obtained by averaging at least 10 consecutive responses.

RESULTS

Examples of the angular displacement of the ankle and knee joints for 1 gait cycle before and after the anesthesia was applied may be seen in figures 1 and 2. In these figures the 0° value is the reference point

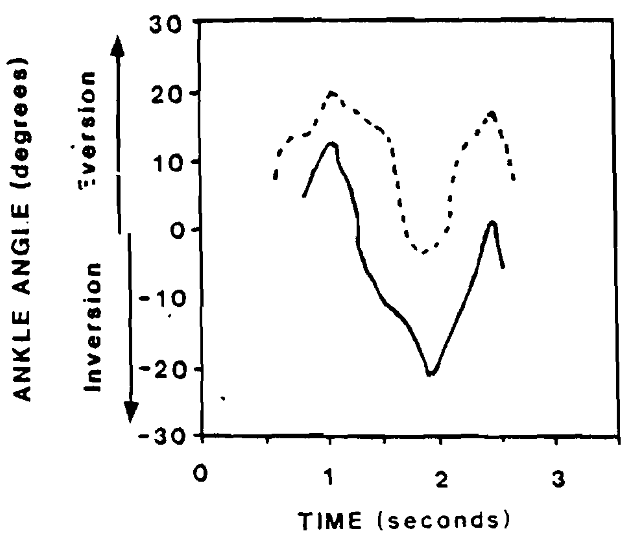

Fig 1 — Angular displacement of the ankle joint before (solid line) and 16 minutes after (dash line) application of topical anesthesia to the skin of the leg. Note the movement shift toward normal eversion.

measured with the patient standing before starting the experimental procedure. The negative sign indicates a movement towards inversion or plantar flexion of the ankle joint; for the knee joint it indicates movement towards flexion or internal rotation of the thigh. The positive sign indicates movements in the opposing directions. The maximal excursions of all the angular measurements are displayed in table 2.

Two apparent observations may be made from table 2. First, when the anesthesia was applied to the leg area and the patient walked with the cane, there was an increase in the range of motion of dorsiflexion and eversion of the ankle, as well as a decrese in the range of motion of inversion of the ankle. These were all improvements towards normal. Second, a motion shift towards increased internal rotation of the knee was noted in all the trials. When the anesthesia was also applied to the thigh area, a motion shift towards extension of the knee was observed. All these motion shifts were improvements towards normal. The effect of the anesthesia diminished gradually over a period of 3 to 4 hours. The results are diagrammatically displayed in table 3.

Muscle hypertonia of the affected lower limb demonstrated a substantial and consistent reduction beginning 10 minutes after the application of the topical anesthesia. Passive range of movement of the hip flexion increased by 15°, knee flexion increased by 20°, knee extension increased by 15°, and ankle dorsiflexion increased by 20°. Similarly, active foot dorsiflexion increased by 10°, and active foot eversion by 10° after the application of topical anesthesia. Before the application of the anesthesia the patient gen-

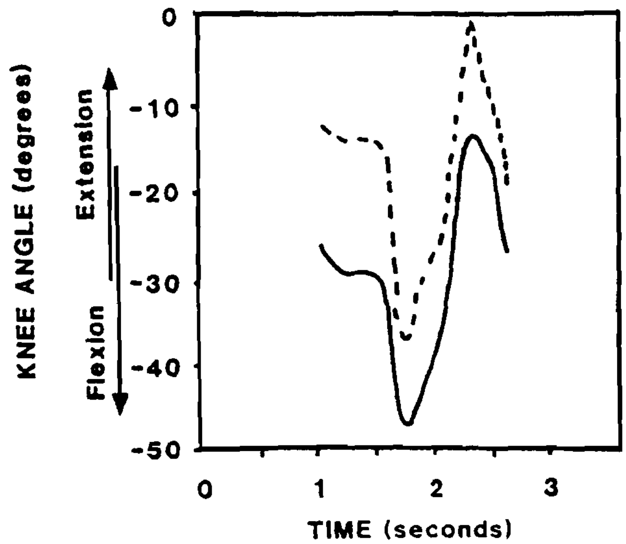

Fig 2 — Angular displacement of the knee joint before (solid line) and after (dash line) application of topical anesthesia. Measurements were taken after the anesthesia had been applied to the skin surface of the thigh (13 minutes) and leg (45 minutes). Note the movement shift toward normal extension.

Table 2: Maximal Angular Displacements (in degrees) of Ankle and Knee Joints During a Full Gait Cycle

		Before Anesthesia	Anesthesia to Leg		Anesthesia to Leg and Thigh	
		Control	Trial 1	Trial 2	Trial 1	Trial 2
With Cane	Ankle					
	Dorsiflexion	18	54	27	18	27
	Plantar Flexion	2	− 2	− 2	− 7	−10
	Inversion	−21	2	−12	−20	−22
	Eversion	13	22	13	10	8
	Knee					
	Flexion	−48	−48	−34	−37	−37
	Extension	−13	−12	−10	0	− 6
	External rotation	12	−13	2	− 8	− 2
	Internal rotation	−18	−66	−34	−36	−45
Without Cane	Ankle					
	Dorsiflexion	26	28	32	26	31
	Plantar Flexion	− 2	− 3	0	0	− 5
	Inversion	−22	−12	−20	−17	−22
	Eversion	13	15	17	15	15
	Knee					
	Flexion	−50	−40	−49	−33	−38
	Extension	−26	−12	−15	−12	− 6
	External rotation	14	2	3	−10	0
	Internal rotation	−21	−30	−39	−37	−41

*The 0° value is the reference point measured with the patient standing before starting the experimental procedure. The negative sign indicates a movement towards inversion or plantar flexion of the ankle joint; for the knee joint it indicates movement towards flexion or internal rotation of the thigh. The positive sign indicates movements in the opposing direction.

Table 3: Changes in Movement Direction and Range.

		Anesthesia to			
		Leg		Leg and Thigh	
		Trial 1	Trial 2	Trial 1	Trial 2
With Cane	Ankle Dorsiflexion Plantar flexion	* ↑	* ↑	*	*
	Inversion Eversion	* ↓	* ↓	----	----
	Knee Flexion Extension	----	----	↓	↓
	External rotation Internal rotation	* ↓	↓	↓	↓
Without Cane	Ankle Dorsiflexion Plantar flexion	----	----	----	----
	Inversion Eversion	----	----	----	----
	Knee Flexion Extension	↓	----	↓	↓
	External rotation Internal rotation	↓	↓	↓	↓

*The arrows point towards the direction of the shift of movement, and the asterisks indicate substantial changes (greater than 10°) in the range of movement.

erally displayed clawing of the foot with flexion of the interphalangeal joint accompanied by hyperextension of the metatarsophalangeal joints. This was clearly noticed during dorsiflexion of the foot and was a prominent problem during walking. However, after the topical anesthesia was applied to the leg area, normal extension of the metatarsophalangeal and interphalangeal joints with a substantial increase in active foot dorsiflexion was noticed by the investigators and the patient.

The H-reflex increased in amplitude after the application of the topical anesthesia. This facilitation increased with time reaching a value of 29% after 30 minutes; and then decreased gradually. The Achilles tendon reflex demonstrated no significant change with topical anesthesia. The H-reflex facilitation and unaffected Achilles tendon reflex response has also been observed on 58 normal subjects participating in a detailed study recently completed in our laboratory.[8,9]

DISCUSSION

All the tests directed at measuring the mobility of the knee and ankle joints indicated that topical anesthesia applied to the skin of the affected lower limb resulted in an increase in the range of movement of the joints. The increased joint mobility was towards normal. This suggests a decrease in muscular hypertonicity and possibly improved functional motor control in the affected limb of the hemiplegic patient.

The increase in the amplitude of the H-reflex indicates that the application of topical anesthesia on the skin has a demonstrable effect on the motoneuron discharge. Beyond the observations made on this patient, a previous study in our laboratory[8,9] has shown that the effect is significant ($p<0.01$). Furthermore, similar results, elicited via different stimuli of skin receptors, have been reported by other investigators.[3,4,6]

The behavior of the H and Achilles tendon reflexes provides a possible explanation for the decreased muscular hypertonicity. The H-reflex may be considered to be a measure of the α-motoneuron excitability, while the Achilles tendon reflex may be considered to be a measure of both α and γ-motoneurons excitabilities.[7] Therefore, it appears that the decreased excitation of the skin receptors, induced by topical anesthesia, causes an increase in the α-montoneuron excitability; whereas, the lack of change in the Achilles tendon reflex implies a concurrent reduction in the excitability of the γ-motoneurons (implying a decrease in the sensitivity of the muscle spindles to phasic stretch), resulting in reduced hypertonicity of the muscle(s).

It appears probable that the excitabilities of the α and γ-motoneurons counteract each other in order to maintain the gain of the monosynaptic reflex at a near constant level. This conjecture is in agreement with similar observations reported by other investigators.[11] This explanation is also supported by the fact the hemiplegics appear to have an increased γ-bias[2,5,10] in conjunction with their increased spasticity. Hence, a reduction in the γ-motoneuron excitability is consistent with more normal motor control.

Follow-up Treatment. The patient was placed on the same physical therapy program that he had prior to this investigation. This was almost 9 months after the onset of the stroke. By that time the patient was gaining no further improvement with physical therapy. The program consisted of routine treatments, including isolated movement training, bicycle exercise, walking training on a treadmill, and proprioceptive neuromuscular facilitation techniques. But before each treatment session, topical anesthesia was applied to the skin of the leg and thigh. The procedure was repeated for a total of 13 sessions (twice a week for 6½ weeks).

The patient stated that his affected lower limb was "much looser" after application of the topical anesthesia, and that he could better control the speed, direction and magnitude of his movements. The effect of the anesthesia lasted approximately 4 hours, and during this time substantial progression towards a normal gait pattern was noticed. At the end of the treatment sessions, the patient was able to walk without the assistance of a cane.

CONCLUSION

The application of topical anesthesia to the skin of the affected limb of a spastic hemiplegic patient results in increased joint mobility and more normal gait pattern. This improved motor performance appears to be mediated by the reduction of cutaneous inputs which conceivably alter the α - γ motoneurons excitabilities. The direct effect is temporary, lasting less than 4 hours. However, during this time the patient can execute movements and perform exercises which he previously could not do. It appears that this augmented exercise-capability has a lasting effect in providing improved and more normal motor performance. These intriguing results could provide a basis for a novel approach which may help in the rehabilitation of spastic patients.

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