

Forced Use as a Potential Cause of Gastrocnemius Tears During Neurologic Rehabilitation: A Report of 2 Cases

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ABSTRACT. Fisher SR, Wiggs LL, Ivanhoe CB. Forced use as a potential cause of gastrocnemius tears during neurologic rehabilitation: a report of 2 cases. *Arch Phys Med Rehabil* 2007;88:386-8.

Broadly defined, forced-use therapy uses specific techniques designed to engage the patient with brain injury in activities that disallow overcompensation with the noninvolved or less involved body segments while forcing the use of the more involved segments. Some applications may involve placing the patient's hemiparetic extremity in a closed-chain weight-bearing activity with therapist support. We describe 2 cases of gastrocnemius muscle tears that occurred during inpatient neurologic rehabilitation that may be attributed to forced use of the hemiplegic lower extremity. Each presented with signs and symptoms indicative of deep vein thrombosis of the calf but was later confirmed with magnetic resonance imaging to be muscle tears. Some closed-chain, forced-use activities may be ill advised in the early stages of rehabilitation or if force generation of the muscle is inadequate to provide a protective response to overstretching. Gastroc-soleus tears should also be considered in the differential diagnosis of unilateral or even bilateral lower-extremity swelling and pain in neurologically impaired patients who are undergoing forced-use therapy.

Key Words: Case report; Leg; Muscles; Rehabilitation; Stroke.

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FORCED USE THERAPY IS A technique used by therapists working with people who have had an injury to the central nervous system, most often brain injury resulting in hemiparesis. The patient is engaged in activities that disallow overcompensation with the noninvolved or less involved body segments while forcing use of the more involved segments.^{1,2} Therapists may create situations in the closed chain in which the less involved side is placed at a disadvantage for use as the primary base of support in relation to the body mass. The intent is to set up conditions in which the client is forced to use skeletal muscle control in the more involved extremities.³ In addition, there is emphasis on open chain (non-weight bearing) movements of the less involved extremities.³ These activities can be quite demanding. For the lower extremity, patients are frequently assisted into positions that encourage full-body weight bearing on the hemiparetic leg. Tools such as ladders, steps, or stools may be used in the therapy session to further

encourage complete weight bearing on the affected extremity (fig 1).

Adverse events associated with forced-use paradigms for neurologic rehabilitation are absent in the literature. Concerns regarding worsening hemiplegic shoulder pain may influence upper-extremity treatment intensity, but equivalent restraints for the lower extremity do not exist for most patients. We describe 2 cases of gastrocnemius muscle tears that occurred during inpatient neurologic rehabilitation that may be attributed to forced use of the hemiplegic lower extremity. Both cases also received motor point blocks to the plantarflexor muscle group, and 1 underwent serial casting before the muscle tears; both presented after the injury with calf pain and swelling, which initially suggested deep vein thrombosis (DVT).

CASE DESCRIPTIONS

Case 1

A previously active 19-year-old man suffered a left cerebrovascular accident. The initial computed tomography scan showed an ischemic left middle cerebral stroke with increased intracranial pressure and midline shift requiring emergent craniotomy. A hypercoagulable workup and transesophageal echocardiogram bubble study were negative. The luteinizing hormone and follicle-stimulating hormone were decreased consistent with an exogenous anabolic steroid use.

The patient was transferred to a comprehensive inpatient brain injury rehabilitation program approximately 2 weeks after onset. On admission, he presented with right flaccid hemiplegia and expressive greater than receptive aphasia. The patient was transferred back to the acute-care hospital approximately 1 week later secondary to complications related to the craniotomy. During this acute-care stay, the patient developed a lower-extremity DVT of the posterior tibial vein of the calf and right pulmonary embolism. Once stabilized, the patient was readmitted back to our facility on coumadin for comprehensive inpatient rehabilitation.

The motor examination at this time revealed continued paresis of the left upper extremity with some improvement in left lower-extremity volitional movement. The patient was very motivated and participated daily in physical, occupational, and speech therapies for 10 weeks. Increased muscle tone and clonus of the plantarflexors that interfered with gait developed, and the patient received neurolytic phenol injections to the right plantarflexors before discharge to the home of his parents. He was immediately transitioned to a day hospital program where he continued comprehensive rehabilitation. Daily physical therapy (PT) included activities that encourage maintenance of body mass over the affected leg. The progression of activities advanced to the use of raised surfaces such as stepping up to and down from the first rung of a ladder with the involved lower extremity. Throughout the hospital course, the patient's mobility status progressed from overall moderate/maximal assist for most transfers and gait to modified independence. Distal, right upper-extremity and lower-extremity paresis persisted, and the patient was fitted with a custom right ankle-foot orthosis (AFO) before discharge from day hospital.

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Fig 1. The subject is forced to recruit skeletal muscle force on the involved side by maintaining body mass over the affected extremity. The less involved lower extremity is placed at a disadvantage for supporting body weight. The therapist provides assistance at the hip and knee to encourage full weight bearing on the affected extremity.

The patient presented for an outpatient PT evaluation the same day after discharge from the day hospital program. At this time, he complained of right calf pain, which his mother stated had worsened over the past couple of days. The physical therapist observed tenderness to palpation, increase in temperature of the right popliteal fossa and upper calf, and mild swelling of the midcalf. The therapist advised notification of the physician. Considering the patient's history, he was taken to the local emergency department for workup of possible DVT. A Doppler study was negative, but the emergency department physician referred him to an orthopedic surgeon who ordered a magnetic resonance image (MRI) of the calf.

T1- and T2-weighted MRIs of the right calf revealed hyperintense signaling within the medial head of the gastrocnemius over an area measuring 10cm in length and 3cm in width. There was some disruption of muscle fibers apparent, suggesting a muscle tear as opposed to a simple muscle strain. There were minor signal changes within the lateral head representing a minimal strain. The patient was allowed weight bearing as tolerated by the orthopedic surgeon. Outpatient PT was adapted to accommodate his comfort levels. Activities that would have been emphasized to encourage weight bearing on the affected extremity had to be reduced, but he remained ambulatory, although his right stance time during gait was markedly reduced.

Case 2

A previously healthy 19-year-old woman suffered a left intracranial hemorrhage secondary to arteriovenous malformation (AVM) with resultant right hemiparesis. The patient was managed with embolization of the AVM and transferred to our comprehensive inpatient brain injury rehabilitation program approximately 2 weeks later. She was motivated and participated daily in physical, occupational, and speech therapies.

PT included forced-use exercises that encouraged maintenance of body mass over the affected leg, again such as stepping up onto the first rung of a ladder or step with the right lower extremity. Neurolytic phenol injections to the right plantarflexors were administered after the development of increased muscle tone that interfered with gait (1 month after admission to the rehabilitation unit). A course of serial casting was initiated after the injections to increase dorsiflexion range of the ankle. The patient was discharged to an outpatient community re-entry program for people with brain injuries 11 days after neurolytic injections.

During evaluation for the community re-entry program, she complained of severe right calf and popliteal fossa pain that was prohibiting her from walking. (Ambulation before this was with a left forearm crutch and right AFO requiring supervision only.) The calf and popliteal fossa were warm and tender to palpation. Swelling was evident as well with a midcalf circumferential measurement of 39.4cm on the right compared with 35.6cm on the left. The patient was sent to the emergency department to rule out DVT. Her Doppler study was negative, but the emergency department physician did not totally rule out DVT. The patient was non-weight bearing at this time and did not participate in PT. A second Doppler study 3 days later was also negative. Her physician cleared her for weight bearing as tolerated 4 days after the last Doppler study.

The patient continued to have pain in the calf and popliteal fossa, which was worse with weight bearing. A right anterior drawer test was equivocal, and the therapist recommended referral to an orthopedic surgeon for possible anterior cruciate ligament (ACL) injury and gastroc-soleus tear. (The patient had a history of right ACL repair 2 years before but no ongoing symptoms related to the right knee before the AVM.) At this time, the patient stated that she had felt a pull in her calf while performing forced use weight-bearing activities while an inpatient just before discharge. The orthopedic surgeon ordered an MRI with contrast of the knee and calf, which revealed intact but surgically repaired ACL and 3 ovoid areas of increased intensity in the gastrocnemius. This was interpreted as gastrocnemius muscle tears. The patient was cleared by the orthopedic surgeon for weight bearing as tolerated and for pain-free stretching of the gastrocnemius. By this point, she had lost range in her ankle and was lacking 25° of dorsiflexion passively. The patient was unable to tolerate weight bearing for gait as her primary means of mobility until approximately 1.5 months after the most likely time of injury.

DISCUSSION

In both cases, the patients were young, highly motivated people engaged in intensive neurologic rehabilitation who participated in similar forced-use activities of treatment. They each developed increased muscle tone in plantarflexor muscle groups and had motor point blocks with phenol. One patient underwent a brief course of serial casting after the motor point blocks. Although we cannot definitively identify the exact time and cause of the gastrocnemius muscle tears in these 2 cases, considering the time course of events, it is highly likely they occurred during neurologic rehabilitation just before their pre-

sentation at our outpatient clinic. It is our belief that they occurred through the application of commonly used, specific forced-use exercises. It is also possible that some combination of forced use, the condition of post neurolytic injections, and serial casting to increase dorsiflexion range may increase susceptibility to muscle-strain injuries in neurologic patients. One patient specifically recalled the forced-use exercise that she believes caused the injury. The other patient had significant aphasia and could not communicate a specific event. He performed the same type of weight-bearing activities with a different therapist immediately before discharge from the rehabilitation day hospital, however. His mother reported that nothing done at home likely contributed to the muscle tear. The patient wore an articulated AFO during all walking outside of therapy as well. His suggested prior history of exogenous anabolic steroid use could have played a role in predisposing the muscle to tearing during heavy use.^{4,5} However, this was never verified and even if so would have been discontinued months earlier.

Reports of muscle tears in the neurologic rehabilitation population are very rare.^{6,7} Although muscle tears typically occur as a result from direct trauma, contusion, or indirect stretch injury,⁸ strain thresholds exist for both passive and active injury and most often take place as the result of excessive stretch while the muscle is being activated.⁹ These circumstances would have occurred during forced-use activities involving full weight bearing on the forefoot of the involved lower limb while standing at the edge of a step or rung of a ladder. Normally, the hindfoot would not be allowed to be unsupported when the involved extremity is in a raised position. Still, it is not clear whether the muscle tears occurred as a result of passive hyper-dorsiflexion or through muscle activation during weight bearing in a non-hyperstretched position. Although muscle tears are not associated with neurolytic procedures,¹⁰⁻¹² motor point blocks with phenol have been shown to cause muscle necrosis in animal models.¹³ When correlated with the clinical presentations and the likelihood that the radiologists interpreting the studies were aware of the patients' neurologic and motor point injection history, it is highly unlikely that the findings here represent pure necrosis without tear. It is possible that the reduced muscular activity that occurs after phenol injections diminishes the already impaired natural defense mechanism against overstretching, a decreased gain of the stretch reflex. The gastrocnemius is also particularly susceptible to injury even with intact protective stretch reflexes. It crosses multiple joints and has complex architecture, both conditions known to increase susceptibility to strain injury.⁸

It is widely accepted that recovery after stroke is in part dependent on treatment intensity, with more pronounced effects with higher treatment intensity.¹⁴ Forced-use methods are recognized as valuable treatment tools for therapists working with individuals with a brain injury.¹⁵ Closed-chain, weight-bearing techniques, including those used in these cases, are taught in schools and continuing education courses to physical and occupational therapists as treatment alternatives for appropriate neurologically involved patients. Yet, the literature is notably sparse regarding the acute or long-term effects on the joints and soft tissues of patients encouraged to weight bear, via any imposed method, through a neurologically weakened extremity. In the efforts to provide intense levels of stimulation using forced-use therapy, perhaps a minimal criterion of voluntary muscle activity should be considered before engaging in some closed-chain, weight-bearing exercise. To our knowledge, these minimal criteria have not been established or put forth in the rehabilitation literature. For the lower extremity, we recommend that the patient with hemiparesis be able to perform a supported heel raise on the affected extremity before

engaging in forced-use activities that may allow forefoot weight bearing over an unsupported heel or even moderate dorsiflexion. Future research should be directed toward establishing appropriate criteria and guidelines for the safe application of forced-use therapies that involve closed-chain, weight-bearing exercise. There is also a need for investigations into the acute and long-term effects of weight bearing through a neurologically weakened extremity on the joints and soft tissues of that extremity.

CONCLUSIONS

Gastroc-soleus tears should be considered in the differential diagnosis of unilateral or even bilateral lower-extremity swellings in patients undergoing neurologic rehabilitation. Forced use exercises for the hemiparetic lower extremity may place weakened muscles, especially those that cross multiple joints, at increased risk for strain injuries. It is possible that some combination of commonly utilized forced use exercises, motor point blocks, and serial casting contributed to the muscle tears seen in these 2 cases. In regard to the lower extremity, we recommend that the patient with hemiparesis be able to perform a supported heel raise on the affected extremity before engaging in forced use activities that may allow forefoot weight bearing over an unsupported heel or dorsiflexed ankle.

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