SHORT COMMUNICATION

IS THE OUTCOME OF DIAGNOSTIC NERVE BLOCK RELATED TO SPASTIC MUSCLE ECHO INTENSITY? A RETROSPECTIVE OBSERVATIONAL STUDY ON PATIENTS WITH SPASTIC EQUINOVARUS FOOT

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Objective: To investigate the relationship between spastic calf muscles echo intensity and the outcome of tibial nerve motor branches selective block in patients with spastic equinovarus foot.

Design: Retrospective observational study.

Patients: Forty-eight patients with spastic equinovarus foot.

Methods: Each patient was given selective diagnostic nerve block (lidocaine 2% perineural injection) of the tibial nerve motor branches. All patients were evaluated before and after block. Outcomes were: spastic calf muscles echo intensity measured with the Heckmatt scale; affected ankle dorsiflexion passive range of motion; calf muscles spasticity measured with the modified Ashworth scale and the Tardieu scale (grade and angle).

Results: Regarding the outcome of tibial nerve selective diagnostic block (difference between pre- and post-block condition), Spearman’s correlation showed a significant inverse association of the spastic calf muscles echo intensity with the affected ankle dorsiflexion passive range of motion (ρ = 0.045; ρ = 0.00–0.269), modified Ashworth scale score (ρ = 0.014; ρ = 0.327), Tardieu grade (ρ = 0.008; ρ = 0.352) and Tardieu angle (ρ = 0.043; ρ = 0.306).

Conclusion: These findings support the hypothesis that patients with spastic equinovarus foot with higher spastic calf muscles echo intensity have a poor response to selective nerve block of the tibial nerve motor branches.

Key words: muscle hypertonia; muscle spasticity; nerve block; rehabilitation; ultrasonography.

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Lay Abstract

This study reviewed data from 48 patients with spastic equinovarus foot in order to investigate the relationship between spastic calf muscles echo intensity (which indicates the degree of muscular fibrosis) and the outcome of tibial nerve motor branches diagnostic block (which temporarily relieves focal muscle overactivity). Outcome was the response to nerve block as to passive motility of the affected ankle and overactivity of the calf muscles. All patients were evaluated before and after the nerve block. A significant inverse association was found for the outcome of selective diagnostic nerve block of the tibial nerve motor branches with their respectively supplied spastic calf muscles (i.e. gastrocnemius medialis and lateralis, soleus and tibialis posterior) echo intensity. These results support the hypothesis that the degree of spastic muscle fibrosis may reduce the response to selective diagnostic nerve block in patients with spastic equinovarus foot.

Spastic paresis is a main feature of upper motor neurone syndrome (UMNS) (1). Equinovarus foot is one of its most common patterns, which may be due to a combination of calf muscles overactivity, Achilles tendon/muscle shortening, weakness of ankle dorsiflexors muscles and imbalance between peroneal and tibialis anterior muscles (2, 3). According to its composite pathophysiology, spastic equinovarus foot requires interdisciplinary management (3, 4). In line with the guidance from the Mont-Godinne interdisciplinary group, diagnostic nerve block (DNB) of the tibial nerve and its motor nerve branches plays a key role in determining the most appropriate management of spastic equinovarus foot (3). This is because selective tibial nerve DNB allows differentiation of spastic muscle overactivity from contracture, also determining the respective role of different muscles in patterns of spastic paresis, and testing the strength of antagonist muscles (3).

Soft tissue contracture is a main disabling feature in patients with spastic paresis, which may occur over time, including degenerative changes at the myotendinous junction, muscle atrophy and loss of sarcomeres,
accumulation of intramuscular connective tissue and increased fat content (5). Echo intensity is a parameter commonly used for grading pathological changes of the muscle due to fatty infiltration and fibrosis (6). Increased spastic gastrocnemius muscle echo intensity has been shown to correlate with a reduced response to botulinum toxin type A (BoNT-A) injection in chronic stroke patients with spastic equinus (7). Furthermore, the increased echo intensity has been found to be associated with reduced muscle thickness, posterior pennation angle, and compound muscle action potential amplitude (8).

In order to understand the clinical presentation of people with spastic equinovarus foot in more depth and to better define treatment goals, it would be useful to determine the role played by the development of changes in the spastic calf muscles on the outcome of DNB. However, to the best of our knowledge, no previous study has investigated this issue, despite the importance of selective tibial nerve DNB in the management of spastic equinovarus foot. Thus, the main aim of this study was to investigate the relationship between spastic calf muscles echo intensity and the outcome of tibial nerve motor branches selective DNB in patients with spastic equinovarus foot.

**METHODS**

This single-centre retrospective (chart review), observational study analysed data from 48 patients with spastic paresis due to UMNS with equinovarus foot, who had undergone selective DNB of the tibial nerve motor branches at the Neurorehabilitation Unit of the University Hospital of Verona, Italy, from January 2019 to December 2020.

Inclusion criteria were: age >18 years; spastic equinovarus foot consequent to UMNS with equinovarus foot, who had undergone selective DNB of the tibial nerve motor branches at the Neurorehabilitation Unit of the University Hospital of Verona, Italy, from January 2019 to December 2020.

**Ultrasonographic evaluation procedures**

As usual in our clinical practice, before DNB all patients performed real-time B-mode ultrasonography by means of a MyLab 70 XVision system (Esaote, Genoa, Italy) interfaced with a linear probe (scanning frequency 13 MHz), which was positioned perpendicular to the affected calf surface in order to scan it up and down using the “elevator technique” (7, 11). The highest degree of echo intensity was chosen for each muscle (i.e. GM, GL, soleus and TP). The probe was placed gently over the skin using water-soluble transmission gel in order to avoid pressure alterations of the muscle tissue. The spastic calf muscles echo intensity found at these points was graded on the Heckmatt scale (grade 1 = normal; grade 2 = increase in muscle echo intensity; grade 3 = marked increase in muscle echo intensity; grade 4 = very high muscle echo intensity) (6). The same experienced operator performed all the ultrasonographic evaluations.

**Clinical evaluation procedures**

According to our routine practice, all patients were clinically evaluated before and after DNB. During evaluations patients remained in the supine position with their knees extended. The affected ankle dorsiflexion passive range of motion (PROM) was mea-
Diagnostic nerve block and muscle echo intensity

RESULTS

Demographic and clinical features of patients are reported in Tables I and II.

Regarding the relationship between the Heckmatt grade and calf muscles spasticity at baseline (before DNB condition), Spearman’s correlation showed a significant inverse association of the spastic calf muscles echo intensity with the MAS score (ρ = 0.044; p = 0.033; ρ = −0.327) and the TS angle (ρ = 0.033; ρ = −0.362).

Regarding the outcome of tibial nerve selective DNB (difference between post- and pre-block condition), Spearman’s correlation showed a significant inverse association of the spastic calf muscles echo intensity with the affected ankle dorsiflexion PROM (ρ = 0.045; ρ = −0.269), MAS score (ρ = 0.014; ρ = −0.327), TS grade (ρ = 0.008; ρ = −0.352) and TS angle (ρ = 0.043; ρ = −0.306).

DISCUSSION

This observational study based on a chart review aimed to retrospectively investigate whether the clinical outcome of DNB might be related to the development of changes in muscles of patients with spastic paresis. The results showed that patients with spastic equinovarus due to UMNS with higher spastic calf muscle echo intensity (i.e. GM, GL, soleus and TP) had a reduced response to the tibial nerve selective DNB.

Spastic paresis is due to lesions of the central nervous system involving corticospinal pathways and consists of 2 main disorders: a muscle disorder (called “spastic myopathy”, which refers to a combination of muscle shortening and loss of extensibility) and a neurological disorder (comprising spastic dystonia, spastic co-contraction, spasticity and stretch-sensitive paresis) (1). Neural blockade with anaesthetics (e.g. lidocaine 2% or bupivacaine 0.5%) is a diagnostic tool to obtain a transient suppression of muscle overactivity (i.e. the neurological disorder of spastic paresis) as a consequence of drug action on Ia fibres (which mediates the myotatic reflex) and alpha motor fibres (which mediates voluntary contraction) (3, 13). In particular, the effect of anaesthetics is based on the block of depolarization by acting on the voltage-gated sodium channel, which determines a lack of calcium ions entry at the neuromuscular junction and, consequently, the

Table I. Demographic features of patients

<table>
<thead>
<tr>
<th>Characteristics</th>
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<tbody>
<tr>
<td>Age (years), mean (SD)</td>
<td>52.3 (16.9)</td>
</tr>
<tr>
<td>Sex (n), male/female</td>
<td>31/17</td>
</tr>
<tr>
<td>Aetiology of spastic equinovarus foot (n)</td>
<td>22</td>
</tr>
<tr>
<td>Stroke</td>
<td>22</td>
</tr>
<tr>
<td>Multiple sclerosis</td>
<td>9</td>
</tr>
<tr>
<td>Brain injury</td>
<td>7</td>
</tr>
<tr>
<td>Spinal cord injury</td>
<td>6</td>
</tr>
<tr>
<td>Chiari malformation type 1</td>
<td>2</td>
</tr>
<tr>
<td>Hereditary spastic paraparesis</td>
<td>2</td>
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<tr>
<td>Tibial nerve motor branches DNB (n)</td>
<td>34</td>
</tr>
<tr>
<td>Gastrocnemius medialis</td>
<td>8</td>
</tr>
<tr>
<td>Gastrocnemius lateralis</td>
<td>7</td>
</tr>
<tr>
<td>Soleus</td>
<td>34</td>
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<tr>
<td>Tibialis posterior</td>
<td>15</td>
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SD: standard deviation; n, number; DNB: diagnostic nerve block.

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impossibility of triggering the acetylcholine release process. Therefore, the effect of DNB is due to its action on the contractile component of muscles.

Selective DNB of the tibial nerve motor branches may be considered mandatory to evaluate and define the management of patients with spastic paresis with equinovarus foot (3). A relevant change in clinical pattern after DNB indicates muscle overactivity as the “main problem” (13, 14). On the other hand, the development of spastic myopathy may lead to the progressive loss of response to myorelaxant procedure/treatments, such as selective DNB or BoNT-A injection (4, 7).

Spastic myopathy is mainly due to atrophy (i.e. loss of muscle mass), loss of sarcomeres (i.e. muscle shortening) and accumulation of connective tissue and fat (5). Ultrasonography may be used to detect some of its features by evaluating muscle thickness and cross-sectional area, fascicle length, pennation angle, muscle echo intensity and elasticity (15). In particular, the increase in intramuscular connective tissue and fat content has been reported to increase reflections of the ultrasound beam, resulting in an increased echo intensity of spastic muscles (6, 7, 16).

The findings of a significant inverse association between spastic calf muscles echo intensity and the outcome of tibial nerve selective DNB in UMNS patients are in line with previous ones about chronic stroke patients showing a reduced response to BoNT-A injection of spastic gastrocnemius muscle with higher echo intensity (7). From this perspective, one may argue that ultrasonography (and in particular the evaluation of muscle echo intensity by means of the Heckmatt scale) might differentiate spastic myopathy from the neurological components of spastic paresis. Considering its retrospective design, this study cannot draw definitive conclusions about this issue. However, in our view, to differentiate muscle and neurological disorders, the clinical evaluation of spastic paresis should include not only the ultrasound features of spastic myopathy (e.g. reduced muscle thickness and cross-sectional area; increased muscle echo intensity; reduced pennation angle; shortened fascicle length; reduced muscle elasticity), but also the DNB evaluation and its outcome. This is because spastic paresis comprises deeply related muscular and nervous components, which influence and potentiate each other over time. Hence, recording ultrasound parameters should be useful to follow-up the patient over time, starting from the first assessment (e.g. before DNB and or BoNT-A injection). On the other hand, for example, indications about surgical procedures (e.g. tendon lengthening) should be based on clinical, ultrasound and DNB evaluation.

In addition, the current observations further confirm the relationship previously observed between spastic calf muscles echo intensity and some outcome measures used to evaluate the features of spastic equinus/equinovarus foot (i.e. ankle PROM, MAS and TS) (7, 8). From a clinical point of view, the TS has been reported to differentiate spasticity from contracture, whereas the MAS grades the resistance to rapid passive movement without differentiating stretch reflex hyperactivity from non-reflex biomechanical changes in spastic muscles (12). From this perspective, the similar results obtained by this study as to the MAS and the TS might seem quite unexpected, particularly with regard to the TS performed at V3 (maximum speed stretch to evaluate muscle overactivity), which evaluates not only the resistance to passive movement, but also clonus and its duration (12). Based on previous findings, this is probably because the reduced extensibility of spastic fibrotic muscles in a shortened position may produce a more ready transmission of any pulling force to the muscle spindles, thus enhancing stretch reflexes (7).

This study has several limitations. First, the design of the study was retrospective. In our view, the findings should be considered preparatory for larger, future, prospective studies on the same field. Furthermore, due to the retrospective design, the patients were not standardized and we did not provide information about the ankle dorsiflexion active range of motion because the database was incomplete with respect to

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**Table II. Clinical features of spastic equinovarus foot**

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<thead>
<tr>
<th>Before tibial nerve selective DNB</th>
<th>After tibial nerve selective DNB</th>
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<tr>
<td><strong>Spastic muscles echo intensity (Heckmatt grade)</strong></td>
<td>2.0 (2.0; 3.0)</td>
</tr>
<tr>
<td><strong>Ankle dorsiflexion PROM (degrees)</strong></td>
<td>3.0 (3.0; 4.0)</td>
</tr>
<tr>
<td><strong>Calf muscles spasticity (MAS score)</strong></td>
<td>16.1 (6.5)</td>
</tr>
<tr>
<td><strong>Calf muscles spasticity (TS grade)</strong></td>
<td>5.7 (7.4)</td>
</tr>
<tr>
<td><strong>Calf muscle spasticity (TS angle)</strong></td>
<td>5.8 (8.3)</td>
</tr>
</tbody>
</table>

DNB: diagnostic nerve block; PROM: passive range of motion; MAS: modified Ashworth scale; TS: Tardieu scale; SD: standard deviation; IQR: interquartile range.
this outcome. Similarly, the current study did not collect data about the non-affected limbs. Secondly, no neurophysiological (e.g. electromyography) evaluation was performed to assess spastic muscles condition/activity before and after DNB. Thirdly, to assess the spastic muscle echo intensity we used the Heckmatt scale (6) and not its modified version (16). This was because the validation of the modified Heckmatt scale was published after the current study data collection. Unfortunately, we are unable to update our evaluation in light of the current literature because in our database we usually record only the Heckmatt grade and do not store the ultrasound images of each patient. Fourthly, we considered some different aetiologies of UMNS, which might have played a role in spastic muscle structure (17). Fifthly, no other evaluation of muscle tissue (e.g. MRI muscle composition analysis) was considered.

In conclusion, the results of this study about the relationship between spastic calf muscle intensity and the outcome of tibialis nerve motor branches selective DNB might be useful for clinicians during the management of spastic equinovarus, in order to guide the choice of which spastic muscles to block by DNB, and to improve understanding of its outcome.

The authors have no conflicts of interest to declare.

REFERENCES