Injection Techniques for Botulinum Toxin Using Electromyography and Electrical Stimulation

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Introduction

Developing proficiency with the injection of botulinum toxin (BTX) requires significant time commitment and skill development on the part of the injector. In a busy clinical practice, any technique that can improve the efficiency and efficacy of such a treatment is valuable. Electromyographic guidance (EMG) and electrical stimulation (ES) are two such techniques used to improve the effectiveness of treatment with BTX.

Increasing data supports the use of botulinum toxin type A injection as a therapeutic intervention in the management of spasticity. 1-4,9-11 Fortunately, the avid binding of botulinum toxin (BTX) to presynaptic neuron terminals and the diffusion characteristics of BTX allow relative ease of administration. However, for many clinical applications, efficacy may be improved, and adverse effects reduced, by more precise targeting of the muscles to be injected. Electromyographic guidance is commonly used to confirm appropriate localization of the injection needle in specific muscles immediately before injection. Equipment options and technical aspects of EMG and ES are discussed, including some adjunctive imaging methods for injecting difficult-to-localize muscles. ©1997 John Wiley & Sons, Inc.

Abstract: Increasing data supports the use of botulinum toxin injection as a therapeutic intervention in the management of spasticity. The avid binding of botulinum toxin (BTX) to presynaptic neuron terminals and the diffusion characteristics of the medication allow relative ease of administration. For many clinical applications, efficacy may be improved, and adverse effects reduced, by more precise targeting of the muscles to be injected. Electromyographic guidance (EMG) is commonly used to confirm appropriate targeting of the injection needle in specific muscles immediately before injection. Electrical stimulation (ES) may be more useful in patients who are unresponsive or sedated. Equipment options and technical aspects of EMG and ES are discussed, including some adjunctive imaging methods for injecting difficult-to-localize muscles. 

Table 1 lists the muscles most commonly targeted using EMG and ES in patients with spasticity. At the present time, our understanding of the role of electrophysiologic guidance is in the early stages of development. What follows is a practical approach for the busy clinician based upon early experience.

Electromyography

EMG may be used to assess muscle activity in patients with dystonia and spasticity. 5,6 It may also be used as a localization technique to aid the injector with drug placement (e.g., botulinum toxin, phenol, or local anesthetic). A discussion of EMG for diagnosis of spasticity is beyond the scope of this article. Attention will be directed towards localization methods.

EMG for localization of target muscles can be quite straightforward. The objective is to record motor unit potentials that are in close proximity to the needle tip, and confirm placement in the target tissue. Table 1 lists the muscles most commonly targeted using EMG and ES in patients with spasticity. At the present time, our understanding of the role of electrophysiologic guidance is in the early stages of development. What follows is a practical approach for the busy clinician based upon early experience.

Electrode placement in a muscle can be confirmed by the presence of full-sized, bi- or triphasic MUPs with fast rise times. Such MUPs have the acoustic property of a “crisp” sound. If low amplitude, poorly defined units are seen (or low amplitude
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"muffled" units are heard), the needle can be repositioned in order to achieve optimal placement. Occasionally, the “sea shell” sound is encountered which may reflect miniature end plate potentials of the neuromuscular junction.

However, crisp MUPs do not necessarily signify correct placement of the needle in a target muscle, only proximity of the tip to a contracting fascicle. Confirmation of placement in a target muscle must be accomplished by either active contraction or passive movement. This can be difficult in patients with patterns of mass synergies (i.e., in spasticity following a stroke) or in young children. The steps outlined below represent a typical sequence for BTX injection of an awake, cooperative patient.

Select the target muscle based on clinical assessment

- Palpate the local anatomy for the belly and tendon of the target muscle
- Palpate the local anatomy for the belly and tendon of the non-target muscles
- Perform passive range of motion (ROM) of target muscle/tendon/joint unit
- Perform ROM of non-target muscle/tendon/joint units
- Have the patient perform voluntary activation of target muscle/tendon/joint unit
- Have the patient perform voluntary activation of non-target muscle/tendon/joint units

At this point, insert the Teflon®-coated, hollow EMG needle into the target muscle and turn on the EMG device. Table 2 lists the equipment most commonly used for injections.

If MUP activity is present, have the patient attempt to relax with gentle stretching, encouragement, or other techniques. Once MUP activity is relatively quiet, begin assessment of tip location with passive and active maneuvers. The primary objective is, of course, to obtain crisp MUPs corresponding only with activity in the target muscle/tendon/joint unit. These steps aid this process:

- Move the target joint through passive ROM and monitor EMG for MUP activation (these may reflect spasm triggered by the movement, or insertion potentials)
- Move the non-target joint through passive ROM and monitor EMG for MUP activation (these should be absent or minimal in non-target areas)
- Have the patient activate the target muscle and monitor EMG for MUP activation
- Have the patient activate non-target muscles and monitor EMG for MUP activation (these should be absent or minimal in non-target areas)

The steps outlined above can be quite effective in isolating small, deep muscles such as individual fascicles of the finger flexors. For instance, one can use this technique to demonstrate flexor carpi ulnaris activity.

**Table 1. Common Muscle Targets Using Electromyography and Electrical Stimulation**

| Forearm flexors (e.g., flexor digitorum profundus, flexor digitorum sublimis, flexor carpi radialis, pronator) |
| Wrist and digit extensors (e.g., extensor digitorum communis, extensor carpi radialis) |
| Thumb adductors, opponens, flexor pollicis longus |
| Interossei and lumbricales |
| Hip flexors |
| Posterior tibialis |
| Extensor hallucis longus |

<table>
<thead>
<tr>
<th><strong>KEY POINTS</strong></th>
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<td>• MUP activity should be absent during passive range of motion of the target, and voluntary activation of non-target muscles</td>
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independent of flexor digitorum profundus with passive and active flexion/extension of wrist and fingers. These steps are equally useful for large, deep muscles such as the tibialis posterior.

For patients unable to cooperate in or intolerant of these procedures, short-acting sedation may be given by an anesthesiologist in an appropriate outpatient setting. In this situation, the injector is restricted to the passive ROM technique, as the patient would be unable to voluntarily activate muscles while sedated. In such a situation, electrical stimulation may be a more appropriate tool.

The main problem associated with EMG is distinguishing MUPs from target vs. compensatory muscle activity elicited during the exam. This distinction is best made through use of the passive and active ROM activities as outlined above. In patients with spastic dystonia, however, co-contraction of agonists and antagonists may confound the assessment. Which muscle to inject is a clinical decision.

Electrical Stimulation

Electrical stimulation may be used to activate an entire muscle via large nerve stimulation, or to activate small fascicles within the muscle belly. The former technique is referred to as motor nerve stimulation, the latter as motor point stimulation. The latter most likely reflects stimulation of small motor nerve branches within the belly of the muscle. Motor nerve stimulation is used primarily for phenol neurolysis rather than BTX injection, as the nerve may be somewhat remote from the belly of the muscle. Motor point stimulation is useful for BTX administration, in that needle placement is, in theory, within a region of a high density of neuromuscular junctions (the "motor point zone"). Such placement would presumably put the BTX as close to the binding area as feasible. Whether this affords maximal effect at reduced doses remains an intriguing but unproven hypothesis in humans. Compelling data from animal studies has been published \(^2\) and human studies are underway.

A variety of stimulators may be employed. Most high quality EMG/NCV units come equipped with a stimulator for nerve conduction velocity (NCV) studies. A reference lead with surface electrode is plugged in, and the surface electrode tip is positioned above the muscle/tendon junction. The lead from the injection needle is plugged into the stimulator. Alternatively, a portable battery-powered stimulator may be purchased or manufactured. The advantages of the latter include cost, portability, and ease of use.

The basic technique for ES is similar to that for EMG. After the initial palpation and passive ROM steps, the Teflon®-coated, hollow EMG needle is inserted into the target muscle. Stimulation is initiated at an intensity sufficient to produce a visible contraction or fascicle twitch. Initial intensity is often in

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**KEY POINTS**

- Co-contraction of agonists and antagonists may confound the assessment
- Motor point stimulation attempts to place the needle within a region of high neuromuscular junction density. Such placement presumably puts the BTX as close to the binding area as feasible

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### Table 2. Equipment Requirements

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<th>Item</th>
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<tbody>
<tr>
<td>Teflon®-coated, hollow EMG needle</td>
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<tr>
<td>Reference lead with surface electrode</td>
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<tr>
<td>EMG machine (standard or portable)</td>
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<tr>
<td>ES (in EMG machine or as a portable unit)</td>
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<tr>
<td>Alcohol skin cleanser</td>
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<tr>
<td>Syringe</td>
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<tr>
<td>Preservative-free 0.9% saline</td>
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<tr>
<td>Botulinum toxin</td>
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**Table 2.**
the 1-3 milliampere (mA) range. The primary objective at this point is to reposition the tip with successive reductions in stimulus intensity such that maximum twitch is produced from the minimum stimulus. The final target stimulus intensity is typically 0.025-0.5 mA.

**Adjunctive Measures**

Several other techniques may be used in conjunction with EMG and ES to allow access to otherwise inaccessible muscles. For example, fluoroscopy may be used to guide the EMG needle to the target muscle. CT and ultrasound guidance have also been employed effectively in patients with spasticity.

**Future Research**

There are a number of important questions that remain to be answered regarding the role of electrophysiology in BTX injections. We would like very much to know whether EMG or ES localization provides the greater efficiency, i.e., the maximum effect with the lowest dose of toxin. Minimizing toxin exposure is important for patients requiring injections at multiple sites (e.g., spastic quadriparesis following traumatic brain injury); for reducing the development of antibody-mediated nonresponsiveness, and for cost control. Some work with animal models on BTX injection using various techniques has been published.

Further study is also needed to determine which response parameters are most altered when EMG or ES is employed. For example, localization with ES may alter extrafusal fibers disproportionately. Finally, the many issues of good clinical trial design must be addressed. Double-blind studies comparing EMG, ES, and palpation techniques should include equivalent subjects, not an easy task given the clinical variability in spasticity patients.

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**KEY POINTS**

- Stimulation is initiated at an intensity sufficient to produce a visible contraction or fascicle twitch
- The tip is repositioned and the stimulus reduced until the maximum twitch is achieved with the minimum stimulus
- Fluoroscopy and ultrasound guidance may aid in tip placement, as well
Bibliography


