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Point/Counterpoint

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Should Ultrasound Be Used Routinely to Guide Botulinum Toxin Injections for Spasticity?

CASE SCENARIO

You are the head physiatrist in a multispecialty group of 150 physicians, including 10 physiatrists. Four of these physiatrists practice primarily neurologic rehabilitation with at least 50% of their volume in upper and lower extremity botulinum toxin injections for spasticity management. The musculoskeletal physicians have used ultrasound (US) liberally for the past few years in their practice. They purchased and paid for 2 machines, both of which are being used constantly without currently available time. Two of the neurologic rehabilitation members have approached you regarding the purchase of a third US machine to be used exclusively for botulinum toxin injections. Because the overhead expense of the machine would be spread out among all 4 neurologic rehabilitation physicians, the remaining 2 are objecting strongly because of the expense and time required, subsequently decreasing productivity. All 4 agree that it would be odd to have 2 physicians using US guidance routinely and 2 not. They agree everyone needs to do the same thing. The cost of the US machine is estimated at $50,000. As the CEO of the practice has become obsessed with expense cutting, you know this will be a difficult fight to garner approval. When you meet with the CEO, would you make a strong argument to pursue the purchase and routine use of US in injecting botulinum toxin? Supporting the routine use of US guidance for botulinum toxin injection in spasticity management is John McGuire, MD, and arguing against is Kelly Heath, MD.

John McGuire, MD, Responds

A picture is worth a thousand words. This old adage could not be truer than when considering the benefits of adding US to chemodenervation with botulinum neurotoxin (BoNT). US is a powerful imaging tool that can provide injection guidance and diagnosis in the management of motor impairments after upper motor lesions. Enhanced visualization of a targeted muscle and adjacent structures with the use of US can improve treatment outcomes, reduce patient complications, and expand practice options. Before jumping to the conclusion that the cost of and learning curve for US outweighs the benefits, the clinic must consider the cost of not using US when performing BoNT injections.

Several consensus groups have endorsed BoNT as a first-line treatment for focal spasticity and dystonia [1,2], but poor localization of appropriate muscles is a potential cause for lack of effectiveness after the injections. Anatomic localization, electromyography (EMG), electrical stimulation (ES), and US guidance are the most commonly used injection techniques [3]. In a recent publication, Walker et al [4] eloquently reviewed the advantages and disadvantages of each injection technique for BoNT injections. Identifying anatomic landmarks and muscle palpation are important first steps in clinical evaluation; however, when surface anatomy alone is used, BoNT injections are less effective than when EMG, ES, or US is used. Because spasticity can cause torsional postural limb changes that disrupt the normal anatomic muscle orientation [5], EMG guidance can improve the accuracy of muscle identification and confirm muscle over activity.

When performing BoNT injections in patients with upper motor lesions, it is often difficult to isolate voluntary individual muscle movements. This limits, for example, the usefulness of EMG when trying to identify individual finger fascicles for the flexor digitorum superficialis (FDS) or flexor digitorum profundus (FDP) injection [6]. ES may assist in isolating certain muscles, but this technique often is tolerated poorly by the patient and does not assure the injected BoNT stays within

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the muscle fascicle [7]. Although US can visualize the target muscle and adjacent structures, it does not indicate of the degree of abnormal muscle firing patterns. Because each technique has limitations, a more effective strategy for muscle localization is needed for chemodenervation with BoNT.

Each of these injection techniques is more effective than anatomical localization, but more studies are needed to show which is superior at producing the best clinical outcomes for each clinical condition [4]. Given the complexity of the motor dysfunction after an upper motor neuron lesion, relying on only 1 injection technique likely limits the potential for optimal outcomes. For example, a golfer would never rely on 1 club to make every shot and a carpenter would not be able to use 1 tool for every job. To optimize clinical outcomes with chemodenervation, the clinician should have access to each localization technique for injections. Certain muscles and conditions will favor ES, EMG, US, or a combination [7].

US provides a finer lens for isolating spastic muscles, which will enhance the accuracy of BoNT injections. Chiou-Tan et al [5] used US to illustrate the torsional muscle orientation changes of commonly injected spastic forearm muscles. With pronation of the forearm, the pronator teres and flexor carpi radialis rotate medially, causing the standard surface landmark [8] for the pronator teres to lay over the brachialis muscle and biceps tendon and the flexor carpi radialis surface landmark [8] to lay over the pronator teres and median nerve.

Unfortunately, anatomy textbooks are illustrated in the anatomic position and do not account for muscle orientation changes typically seen in spastic extremities. US can visualize this spastic muscle orientation whereas EMG or ES cannot. Henzel et al [6] demonstrated how US can be used to isolate nonspastic individual forearm muscles and suggested US may need to be combined with EMG in spastic muscles because of the increased echointensty. In a randomized controlled trial, Santamato et al [8] demonstrated improved outcomes of wrist and finger spasticity injections using US guidance versus anatomical landmarks. With training, using US the physician can more quickly and easily identify the individual fascicles of the flexor digitorum superficialis and FDP and other muscles, such as the scalenes, pronator quadratus, piriformis, posterior tibialis, flexor digitorum longus, and extensor hallicus longus [3,9]. The ability to visualize the muscle will reduce the number of needle sticks needed to isolate the muscle. Fewer injections will reduce discomfort with each procedure and improve compliance with follow-up injections.

Another potential reason for lack of effectiveness for BoNT injections is misidentification of the most spastic or overactive muscles. Understanding which muscles are most "problematic" can be challenging. Bedside evaluation in which passive stretch is used, such as the Ashworth or Tardieu scale, does not reveal which muscles are contributing to the abnormal muscle patterns. Dynamic EMG can reveal overactive motor unit activity and assist with dose titration; however, it does not provide information on muscle diameter, degree of contracture, or anatomic variation.

US can be viewed as a diagnostic tool and also facilitate injection planning. Noninvasive US visualization of potential targeted muscles can be an important "first look" of the anatomy to assess muscle bulk, architecture, anatomic variation, and vulnerable structures [3,7]. US has been shown to be a useful tool in the diagnosis of a variety of neuromuscular disorders [10]. Specifically, Yang et al [11] reported increased pennation angle and muscle thickness in spastic compared with normal muscle and the changes correlated with Ashworth scale. Melchiorre et al [12] found that spastic muscle tends to be more echointense and this characteristic appears somewhat reversible with chemodenervation. Also, Picelli et al [13] demonstrated reduced response to BoNT in the more echo intense gastrocnemius muscle. BoNT can cause lingering muscle atrophy that can potentially be monitored with US as a measure for duration of drug effect [14]. More research is needed to understand how US changes can be used to adjust dosing and timing for BoNT injections. Also, no single method of evaluation can give a complete picture of spastic muscle pattern. The combination of US, dynamic EMG, and bedside evaluation will give the most complete picture of which muscles are contributing to the problematic spastic condition.

US also can provide visualization of anatomic variations. For example, the Gantzer muscle is an accessory head of the flexor pollicis longus (FPL) originating from the FDP and attaches medially to the medial epicondyle of the humerus or coronoid process of the ulna. In a recent meta-analysis by Roy et al [15], pooled data from 24 cadaver studies reported the prevalence of accessory head of the FPL at 44.2%. The inability to identify these muscle variations can limit the effectiveness of the BoNT injections.

For example, we were referred a 40-year-old plumber with a dystonic FPL. We initially used a combination of EMG and ES to guide the BoNT injections to the FPL in distal third of the lateral forearm [8]. After the first 3 injections, there was little-to-no improvement, even with increased doses on follow-up visits. Moreover, increased doses lead to weakness of the FDP of the index finger. Subsequently, using US visualization, we were able to identify a prominent Gantzer muscle of the FPL extending to the proximal medial foreman. After US-guided injections, and with a reduced dose of BoNT, we were able to effectively treat the dystonic FPL without adjacent muscle weakness. Spread of toxin beyond the target muscle to adjacent muscles or distant