Sonoelastography contribution in cerebral palsy spasticity treatment assessment, preliminary report: A systematic review of the literature apropos of seven patients

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Abstract

This paper aims to present our experience of 7 cases of spastic children, using sonoelastography in assessing the muscle spasticity: the relaxed muscle structures appear mostly soft (green-yellow-red), while contracted or degenerated muscle fibers appear hard (blue). Using sonoelastographic findings we established the proper place for injecting the botulinum toxin (20 U/kg Dysport) into the affected muscle. The result was a precise, guided injection, with positive, therapeutic results. It is important consider several factors that can influence the evolution of the case: gray scale ultrasound appearance of the muscle, the patient age, the dosage and the fractionation of toxin.

Keywords: Spasticity, botulinum toxin, sonoelastography

Introduction

Botulinum toxin is a neurotoxin produced by Clostridium botulinum, a gram-positive anaerobic bacterium. Clinical applications are based on its effect on the neuro-muscular junction, producing neuromuscular paralysis. The use of botulinum toxin for medical purposes is mentioned in the late ‘80s. Initial experiments were conducted on animals and in the late ‘90s the first applications in humans were made. Currently known applications are spastic muscle pathology, in dermatology, in dystonic torticollis, injections in the submandibular and parotid glands, and even applications in neurogenic bladder pathology.

Known products approved for clinical use are: Onabotulinumtoxin A (Botox), Abobotulinumtoxin A
The applications, including the therapy for spastic muscles, implied injecting the toxin in the targeted muscle groups. Until a few years ago, the injections were made only by clinical palpation or by using muscle stimulation or by using electromyography (EMG). In recent years, ultrasound techniques were introduced to help guide the injection.

In 2005, Chin et al [2] published a study which showed the accuracy of tracing the target muscle with no guidance. They performed 1,372 separate injections for upper and lower limb spasticity in 226 cases of children with cerebral palsy. The accuracy of manual needle placement when compared to electrical stimulation was satisfactory only for gastro-soleus (>75%); it was not satisfactory for hip adductors (67%), medial hamstrings (46%), tibialis posterior (11%), biceps brachii (62%), and for forearm and hand muscles (13% to 35%).

Due to the need for a higher accuracy in needle placement in all muscles, ultrasonography (US) became the method most frequently used in guiding the injections. The average time needed to identify and inject the targeted muscle ranged from 5 s in superficial muscles, such as the gastrocnemius muscle, to 30 s in deep-seated muscles [3].

The use of muscle stimulation and of EMG may produce local pain and increase the stress level. In pediatric patients the use of minimally invasive techniques is required and sedation and analgesia is often needed. In these cases EMG potentials recorded from the targeted muscles are low. Also, due to the contraction of the neighboring muscle, EMG might not always identify the right pathological muscle group. All these reasons recommend the use of ultrasound techniques [4].

Sonoelastography is an ultrasound technique that allows the assessment of tissue elasticity. Its application in the musculoskeletal field includes the evaluation of the muscle contraction status. On sonoelastographic images a relaxed muscle structure will appear mostly soft (green-yellow-red), while contracted or degenerated muscle fiber will appear hard (blue) [5,6]. Sonoelastographic images obtained were analysed using a dedicated software with the purpose of obtaining objective and quantifiable data, useful in establishing an exact imaging diagnosis and in monitoring this disease. The decision where to administer the Dysport was made according to the US findings.

The distance to the pathologic muscle, perpendicular to the skin was measured using points marked on the surface of the skin at the end of US examination.

Case 1:
Five year old boy with cerebral palsy with spasticity predominantly affecting the lower limb muscles. Clinical and US assessment was performed in calf and thigh bilaterally previous injection (fig 1, fig 2). Evident improvement seen on ultrasound images was confirmed by the parents and by the clinical examination.
Sonoelastography contribution in cerebral palsy spasticity treatment assessment

**Fig 1.** a) Left thigh and b) right thigh before injection (gray scale US and sonoelastography). Hard aspect (contracted) of the medial gastrocnemius muscle.

**Fig 2.** a) Left thigh and b) right thigh 6 months after from injection (gray scale US and sonoelastography). Gastrocnemius muscle looks softer (less contracted).

**Fig 3.** a) Right pronator teres muscle before injection (gray scale US and sonoelastography) predominantly contracted; b) right pronator teres muscle 4 weeks after injection. The aspect is softer, less contracted

**Fig 4.** Right abductor policis muscle a) before injection – contracted aspect of the muscle; b) 4 weeks after injection. The aspect is softer, less contracted
Case 2
Seven year old boy. Cerebral palsy predominantly affecting the upper limb muscles. Clinical and ultrasound evaluation was performed on the arm and forearm, bilaterally (fig 3, fig 4). Ultrasound appearance was confirmed also by clinical examination.

Case 3
Seven year old girl. Cerebral palsy with predominant spasticity of the lower limb muscles. First injection was administered after clinical palpation of the muscle group indicated by a previous US exam. The failure in clinical response imposed a new injection, this time with US control (marking points on the patient’s skin and indicating the depth of the pathological muscle) (fig 4, fig 5).

This case is a good example of repeating the toxin administration if there is no favorable response, before considering that the case as resistant to the therapy. The incorrect administration of the toxin could be another reason for this failure.

Case 4-6
These 3 patients (age 3, 4, and 7 years) had limb palsy. After US guided toxin administration all presented favorable overall evolution.

Case 7
Ten year old boy with cerebral palsy predominant to the lower limb muscles. No improvement was obtained after toxin administration.

Results and Discussion
The use of Botulinum toxin in pediatric patients requires a complex evaluation: orthopedic, neurological and imaging. One of the reasons of therapeutic failures may be an incomplete evaluation of the case. This suggests the need of teamwork: neurologist-radiologist-orthopedist-physical therapist and that standardized tests are needed to monitor the evolution of cases.

The cases presented in this paper show related features regarding the location of muscle groups that were suitable for the injection of botulinum toxin, including upper and/or lower limbs. In our opinion an unsatisfactory therapeutic result after Botulinum toxin injection would be expected if the muscles had structural alterations with the appearance of fibrosis (gray scale US); if the toxin was administrated in other structures than those indicated by the ultrasound examination; in cases of patients older than 7 years; if the treatment was not followed by a proper physical therapy;
Improvement of protocols for clinical and ultrasound examination could lower the rate of treatment failure. It is also necessary to administer a sufficient dose of toxin to achieve the expected effect and the injection should be followed by a proper physiotherapy. Dosage should be individualized to each patient and suitably fractionated for targeted muscle groups. It should also be considered as an option to inject the muscle in several different points. We appreciated that the use of US had an important contribution in the easiness of a precise tracking of the muscle groups, being the easiest technique in pediatric patients.

Schroeder et al [7] concluded that in most aspects ultrasound is superior to EMG (table I). Sonoelastography improves the findings of grayscale US in assessing the degree of muscle contraction, especially in the cases with less information then the ones offered by EMG.

Superior therapeutic results seem to be obtained by combining two-dimensional ultrasound with sonoelastography to mark the exact injection site or making the approach ultrasound guided, as it can be seen in the 3-rd presented case.

Larger studies are needed to confirm the substantial contribution of sonoelastography, but also to discover new aspects that would improve the therapeutic decision. For a better evaluation of muscle contraction status we need more experience with the benefits of sonoelastography in the musculoskeletal pathology.

Table I. Differences between EMG, muscle stimulation and US in guiding the toxine injection [7].

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<th>EMG</th>
<th>Muscle stimulation</th>
<th>US</th>
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<tbody>
<tr>
<td>Identification accuracy</td>
<td>o</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Time for identify the muscle group</td>
<td>–</td>
<td>o</td>
<td>+</td>
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<tr>
<td>Availability of technical equipment</td>
<td>o</td>
<td>o</td>
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<tr>
<td>Pain and stress caused by the method</td>
<td>–</td>
<td>–</td>
<td>+</td>
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<tr>
<td>Dependency on expert experience</td>
<td>–</td>
<td>–</td>
<td>o</td>
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<tr>
<td>Necessary number of stabs</td>
<td>–</td>
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<td>+</td>
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<tr>
<td>Depth injection control</td>
<td>o</td>
<td>o</td>
<td>+</td>
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<tr>
<td>Differentiation of adjacent muscle groups (also contracted)</td>
<td>o</td>
<td>o</td>
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<td>Differentiation of the muscle from surrounding tissues</td>
<td>–</td>
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<td>Dependence on patient cooperation</td>
<td>–</td>
<td>+</td>
<td>+</td>
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<td>The possibility to confirm the correct placement after injection</td>
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<td>The possibility of injection documentation</td>
<td>–</td>
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<td>+</td>
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<td>Issues related to sedation–analgesia association</td>
<td>–</td>
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<td>Control of neuro–muscular junction proximity</td>
<td>+</td>
<td>+</td>
<td>–</td>
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<tr>
<td>Control of muscular hyperactivity</td>
<td>+</td>
<td>o</td>
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<tr>
<td>Control of muscle dimension</td>
<td>o</td>
<td>o</td>
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<td>Control of muscle fibrosis</td>
<td>o</td>
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<td>Potential for future technology development and research</td>
<td>o</td>
<td>–</td>
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- : unfavourable; +: advantageous; o: acceptable

References