

Sonographic Imaging for Guiding Botulinum Toxin Injections in Limb Muscles

Preliminary note

This short review on the use of sonography to guide botulinum toxin injections is written from the perspective of a neuropaediatrician. Children are very sensitive to pain, rarely cooperative and don't like any procedures that require them holding still for a length of time. Sonography was always therefore very popular in paediatrics, and consequently, it seemed the obvious choice to utilise this technique for muscle identification and injection control. It is important to understand the paediatric background because an experienced neurologist who specialises on adult patients is used to applying electromyography (EMG) and muscle stimulation with usually excellent results, and thus would not feel any need for introducing a new technique. Nevertheless, even for adult patients, sonographic imaging offers a completely different approach (eg. visual vs. acoustic control) and it has the potential to evolve into a procedure that may equal the current gold-standard.

This article focuses on the treatment of spastic movement disorders, although many principles are also applicable to other indications such as focal or cervical dystonia.

Introduction

Botulinum toxins (Btx) are used to treat spastic muscles in children with cerebral palsy, and in adults, eg. following stroke. A prerequisite for successful therapy is the anatomically correct administration of the substance into the muscle belly.

Orientation on anatomical landmarks and muscle palpation alone provide inadequate guidance for reliable needle placement. Thus, 63% of injections were incorrectly placed when trained neurologists attempted to target arm muscles without electromyographic assistance.¹ Chin and colleagues experienced similarly high failure rates in children with cerebral palsy. Needle placement by palpation alone failed the targeted muscles in between 22% (gastrocnemius muscle) and 88% (tibialis posterior muscle, flexor carpi radialis muscle) of cases.² Therefore, correct needle placement, especially in small and deep-seated muscles, is a challenging task even for the experienced user and requires assisted control techniques.

Electromyography and electrical muscle stimulation can

provide effective and valuable assistance.³ However, these methods are of limited use in children because the procedure is painful, time consuming, and requires the patient's cooperation. As an alternative, imaging techniques were introduced, especially to guide injections into deep seated muscles. Among the various possibilities, the ultrasound guided injection technique is by far the most convenient one. It has been introduced primarily for use in children.⁴ This review will cover the technical requirements, benefits and problems of this technique with specific reference to guided injections in Btx treatment.

The Technique of Sonographic Guidance

Technical requirements

Ultrasonography is well established as a reliable and reproducible imaging method in muscle anatomy.⁵ The necessary equipment comprises a standard ultrasound system with 7.5 MHz linear transducer. This provides sufficient resolution for superficial muscles but is also able to depict deep-seated muscles. A 'small parts' setting or any other preprogrammed setting of the system is sufficient.

Imaging of muscles

The transverse viewing mode is arranged such that the medial part of the limb is seen on the left, the lateral part on the right side of the monitor screen. The musculature appears poorly echogenic, while the perimysia and fascicular tissue between the muscle bellies is echogenic.

Three principles of muscle identification proved useful.

1. Recognising the characteristic pattern of individual muscles

The transverse sonogram corresponds to transverse anatomic sections. Each individual muscle has a characteristic contour line. An example is shown in Figure 1. These muscle specific patterns allow prompt (within a few seconds) identification of individual muscles.

2. Imaging of neighboring structures

Visualisation of neighbouring bones and vessels helps



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Figure 1 a, b: Sonogram of flexor carpi radialis muscle (fcr) and neighbouring muscles in a five years old girl (a) and a 29 year old man (b) with same adjustment of the ultrasound system to allow comparison of muscle dimension. Fcr shows up as a characteristic bulge to the right, which caps the pronator teres muscle. This characteristic appearance is reproducible in every patient so that the identification of fcr in daily routine results from its pattern recognition. Abbrev.: r=radius, u=ulna, pt=pronator teres, fcr=flexor carpi radialis, fds=flexor digitorum superficialis, fdp=flexor digitorum profundus, br=brachioradialis muscle. Ultrasound system: Philips® Sonoline 5500 with 11-3L linear transducer.

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Presentation: Vials of 500 units of *Clostridium botulinum* type A toxin-haemagglutinin complex. **Indications:** The treatment of focal spasticity, including: arm symptoms associated with focal spasticity in conjunction with physiotherapy in adults; and dynamic equinus foot deformity due to spasticity in ambulant paediatric cerebral palsy patients, 2 years of age or older. Spasmodic torticollis, blepharospasm and hemifacial spasm in adults. **Administration:** Dysport should only be injected by specialists who have had administration training. Blepharospasm and hemifacial spasm, reconstitute 500 units in 2.5ml normal saline. Spasmodic torticollis and focal spasticity, reconstitute in 1ml. **The units of Dysport are specific to the preparation and are not interchangeable with other preparations of botulinum toxin.** **Posology:** The dose should be lowered for patients with low muscle mass or in whom the suggested dose may result in excessive weakness. See SPC for recommendations. **Arm spasticity:** The recommended dose is 1,000 units in total, distributed among the most active arm muscles; biceps brachii (300-400 units); flexor digitorum profundus (150 units); flexor digitorum superficialis (150-250 units); flexor carpi ulnaris (150 units); flexor carpi radialis (150 units). Sites of injection should be guided by standard EMG locations, although actual sites will be determined by palpation. All muscles should be injected at one site, except for the biceps which should be injected at two sites. **Paediatric cerebral palsy:** Starting dose is 20 units/kg body weight given intramuscularly as a divided dose between calf muscles. Subsequently the dose may be titrated between 10 and 30 units/kg body weight, depending on response. If only one calf is affected, the dose should be halved. The maximum dose administered must not exceed 1,000 units/patient. Injections may be repeated approximately every 16 weeks or as required to maintain response, but not more frequently than every 12 weeks. **Spasmodic torticollis:** The

initial recommended dose is 500 units given intramuscularly as a divided dose to the two or three most active neck muscles, which will likely include splenius capitis and sternomastoid. The split amongst muscles will vary according to the type of torticollis diagnosed. Doses within the range 250-1,000 units are recommended. Injections should be repeated approximately every 12 weeks or as required to prevent recurrence of symptoms. **Blepharospasm and hemifacial spasm:** The initial recommended dose is 120 units per affected eye; injections are given subcutaneously, medially and laterally into the junction between the preseptal and orbital parts of both the upper and lower orbicularis oculi muscles of each eye. Injections should be repeated approximately every 12 weeks or as required to prevent recurrence of symptoms. Subsequently the dose may be reduced to 80 units per eye and then to 60 units by omitting the medial lower lid injection. **Contraindications:** Dysport is contraindicated in individuals with known hypersensitivity to any component of Dysport. **Warnings and precautions:** Dysport should be administered with caution to patients with existing swallowing or breathing difficulties or with subclinical or clinical evidence of marked defective neuromuscular transmission. Careful consideration should be given to the use of Dysport in patients with a history of allergic reaction to a product containing botulinum toxin type A or in patients with prolonged bleeding times, infection or inflammation at the proposed injection site. Dysport contains a small amount of human albumin. The risk of transmission of viral infection cannot be excluded with absolute certainty following the use of human blood products. Antibody formation to botulinum toxin has been noted rarely in patients receiving Dysport. **Interactions:** Drugs affecting neuromuscular transmission, eg. aminoglycoside antibiotics, should be used with caution. **Pregnancy and lactation:** Safety in this patient group has not been demonstrated. Dysport should not be used unless clearly necessary. **Side effects:**

Side effects may occur due to deep or misplaced injections of Dysport temporarily paralysing other nearby muscle groups. In general, adverse events reported in clinical trials included: *common:* generalised weakness, fatigue, flu-like syndrome, pain/bruising at injection site; *uncommon:* itching; *rare:* neuralgic amyotrophy, skin rashes. **Arm spasticity:** *common:* dysphagia, arm muscle weakness, accidental injury/falls. **Paediatric cerebral palsy:** *common:* diarrhoea, vomiting, leg muscle weakness, urinary incontinence, abnormal gait, accidental injury due to falling. **Spasmodic torticollis:** *very common:* dysphagia; *common:* dysphonia, neck muscle weakness; *uncommon:* headache, diplopia, blurred vision, dry mouth; *rare:* respiratory disorders. **Blepharospasm and hemifacial spasm:** *very common:* ptosis; *common:* facial muscle weakness, diplopia, dry eyes, tearing, eyelid oedema; *uncommon:* facial nerve paresis; *rare:* entropion, ophthalmoplegia. **Overdose:** Respiratory support may be required where excessive doses cause paralysis of respiratory muscles. There is no specific antidote; antitoxin should not be expected to be beneficial and general supportive care is advised. **Pharmaceutical precautions:** Unopened vials must be maintained at temperatures between 2°C and 8°C. Reconstituted Dysport may be stored in a refrigerator (2-8°C) for up to 8 hours prior to use. Dysport should not be frozen. **NHS Cost:** £329.48 per pack of two 500 unit vials. **POM:** PL 6958/0005. **MA Holder:** Ipsen Ltd, 190 Bath Road, Slough, Berkshire, SL1 3XE. **Date of preparation of PL:** October 2004. 2701. Dysport® is a registered trademark. **Date of preparation:** October 2004. 2708.



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to accurately determine the injection site in muscles whose perimysia are too thin for proper imaging. An example is shown in Figure 2.

- 3. **Passive movements, visible as concurrent oscillations**
Especially in the upper limb, movement of target muscles through passive movement of the corresponding part of the body may help to resolve any difficulties with correct anatomic allocation. Already passive movements of very small amplitudes are visible as concurrent oscillations of the intramuscular echo. In this way, even individual fascicles of the superficial and profound finger flexors can be clearly identified.

Sonography guided injection

The needle is inserted closely aligned to the middle of the broad side of the transducer (Figure 3). As the needle penetrates the skin, its path through the tissue to the target site for injection is continually monitored on the screen. Slight movements of the needle along its longitudinal axis can help to obtain a satisfactory image. Upon injection, the solution spreads out in the muscle, usually as an echogenic cloud, sometimes with echo-obliteration (Figure 4). The injected solution is still visible for approximately 3 minutes after injection of the full dose is completed.



Figure 2: Sonogram of tibialis posterior muscle, situated in the valley formed by tibia and membrana interossea. Abbrev.: t=tibia, f=fibula, s=soleus muscle, tp=tibialis posterior muscle, mi=membrana interossea.

Significance of Sonographic Imaging to Guide Btx Injections

The current experience after thousands of injections suggests that sonography allows an anatomically precise injection of Btx. Table 1 summarises the characteristics compared to EMG and muscle stimulation.

Most importantly, sonography guided injection is visually controlled. By seeing the whole process, the operator gains a better understanding of the individual anatomy. This enables a more differential target selection and helps to further improve the injection technique. One example is shown in Figure 5.

Although so far no comparative studies have been

	Passive EMG	Active muscle stimulation	Sonography
Accuracy of needle placement	0	+	+
Time required for muscle identification	-	0	+
Availability of technical equipment	0	0	+
Pain and distress caused by procedure	-	-	+
Dependency on expert knowledge	-	-	0
Necessary number of stabs	-	-	+
Control of injection depth	0	+	+
Differentiation of neighbouring (co-contracting) muscles	-	0	+
Differentiation of muscle tissue from surrounding structures (eg vessels, nerve, bone)	-	-	+
Independency on patient cooperation	-	+	+
Possibility to ascertain correct placement after finishing the injection	-	-	+
Possibility to document the injection	-	-	+
Disturbance through analgesedation*	-	+	+
Identification of proximity to motor-endplates	+	+	-
Identification of muscular hyperactivity	+	0	-
Identification of muscle dimension	0	0	+
Identification of muscle fibrosis	0	0	+
Potential for further development	-	-	+

*Analgesedation = combined analgesia + sedation with rectal pethidine + midazolam



Figure 3 left: Positioning of the transducer and the injection needle to inject the iliopsoas muscle, distal injection site (please refer also to Figure 5).

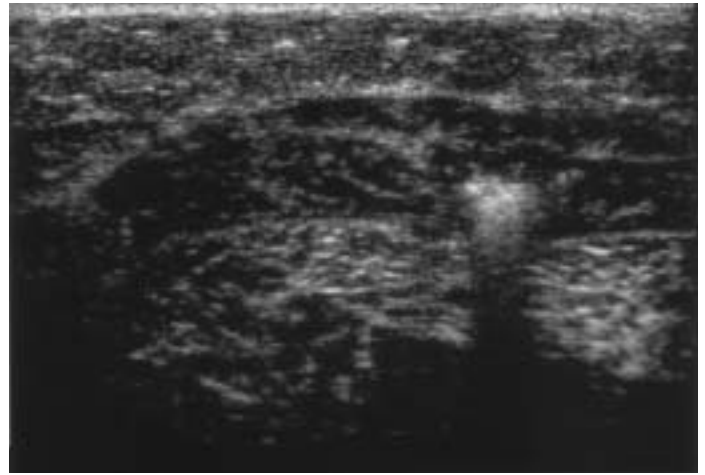


Figure 4 right: Intramuscular cloud-like echogenic appearance immediately after injection of botulinum toxin solution in gastrocnemius muscle, lateral head.

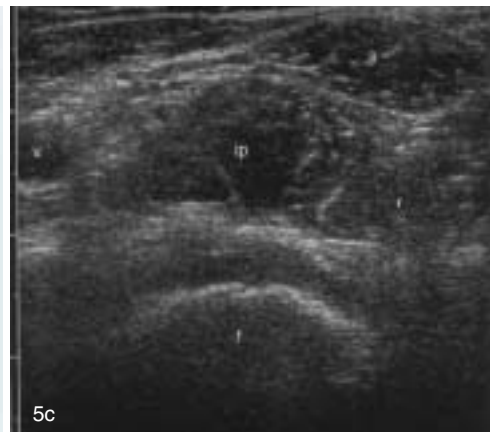
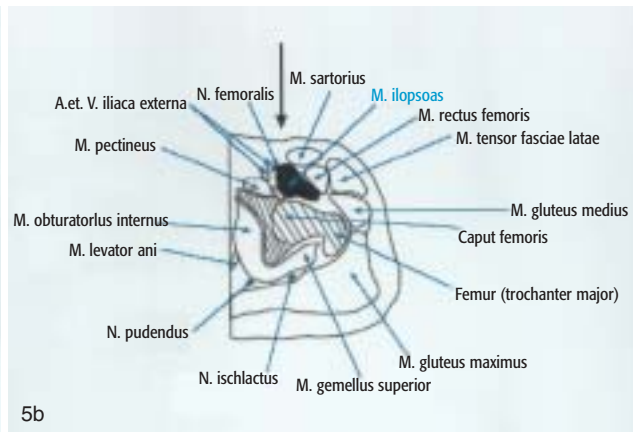
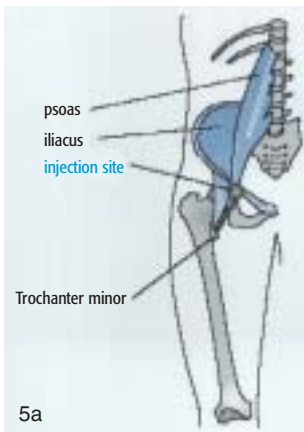


Figure 5 a, b, c: (a) Illustration of distal injection site for the iliopsoas muscle, (b) cross-sectional view (at the level of the inguinal ligament, arrow indicating the position of the transducer), and (c) corresponding sonogram. Due to the distal position of the injection site, there is no need to inject through the muscular abdominal wall and peritoneum. General anesthesia, used to ensure a completely relaxed abdominal wall, is therefore unnecessary. In contrast to the conventional proximal approach, distal sonography-guided injection only requires analgesedation, as recommended for any muscle injection in a paediatric setting.^{8,9} Abbrev.: ip=iliopsoas muscle, f=femoral head, s=sartorius muscle, r=rectus muscle, v=vena iliaca.

done, we expect that sonography can identify muscles with similar accuracy as that obtained with muscle stimulation.

Sonography cannot measure muscular hyperactivity when the clinical situation is uncertain. Furthermore, it is not possible to detect motor end-plate regions, which may have some implications in the treatment of large muscles.⁶ On the other hand, the sonogram provides information about muscle size and fibrosis, factors that can be important in decision making.

To summarise, in children sonography has overcome some restrictions of the EMG/muscle stimulation technique and is regarded as a further step in increasing the accuracy and quality of Btx injections.⁷ Especially in patients who do not cooperate, it may be very helpful in the identification of small muscles, such as single fascicles of finger flexors in spasticity and in focal dystonia.

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