OBJECTIVE:
To investigate the accuracy of intramuscular needle placement by electrical stimulation guidance for botulinum toxin injections.

BACKGROUND:
The intramuscular injection of botulinum toxin (BoNT) in targeted muscles has emerged as a treatment of choice for the management of spasticity as well as for numerous other conditions. BoNT is a neurotoxin complex derived from the bacteria clostridium botulinum. It prevents the release of acetylcholine at neuromuscular junctions, which in turn results in weakness of the injected muscle. One important factor influencing the treatment outcome is the accuracy in delivering the toxin to the target muscle. The needle must be positioned within the targeted muscle in or near motor end plate zones or motor points. Although accurate injection of the toxin into the desired muscle is crucial for obtaining the best possible clinical result, standardization of the localization technique is lacking. The European Consensus 2009 on the use of botulinum toxin for children with cerebral palsy emphasized the need for accurate localization techniques. They recommended neurophysiological localization (EMG, electrical stimulation) amended by sonography to allow precise identification of any target muscle (Heinen et al. 2010).

The most common BoNT injection guidance techniques in patients with hypertonia include: (1) muscle injection by anatomical knowledge only (AKO) (21) motor and plate localization by electrical stimulation (ES) guidance, and (3) visualization of target muscles by ultrasound guidance (US). Although injection guidance by AKO is the most common technique, its accuracy has been questioned, especially for deep and small muscles (Chin et al. 2005; Yang et al. 2009).

ES guidance increases the accuracy of placement compared to AKO placement by using muscle activation. The potential advantage of ES is that it does not only ensure that the injecting needle is in the target muscle, but that the needle is in close proximity to motor endplates and/or motor points (Children 2010). Electrical stimulation is easy to perform, does not require formal training, and does not prolong the procedure significantly. However, it does require experience/practice in electrophysiological techniques as well as familiarity with the relevant anatomical landmarks. One major disadvantage is that it does require the patient to have sedation or mask anesthesia, since electrostimulation requires the patient to be relaxed so muscle twitch can be observed. Ultrasound helps to identify muscles by showing boundaries of individual muscles, each with characteristic landmarks, and by concurrent oscillations of the intramuscular echo produced by passive movement or tenden stretch. Ultrasound visualizes bones, blood vessels, and nerves and differentiates between the target muscle and neighboring structures (Fietzek et al. 2010). Ultrasound guidance is non-invasive, precise, and real-time. It demands very little time, is painless, and does not expose subjects to radiation. It allows visually guided injection into the center of every targeted muscle belly. Ultrasound guidance is recommended in multiple botulinum toxin studies (Berweck et al. 2002; Berweck & Lokiec 2004; Mork et al. 2010; Huchhoff et al. 2003) and test reporting of injection sites are easily identified. However, ultrasound requires extensive training of personnel and the cost of the equipment is often prohibitive. Although small laptop devices are available for mobile use, most sonography devices in the hospital setting are large and cumbersome. Patient factors can also present challenges with sonography. The injection of deep-seated muscles in larger extremities, especially those in obese patients, cannot be performed with the same visual acuity as in superficially seated muscles. The least accurate rate was 91% for the lateral head of the gastrocnemius.

MATERIALS/METHODS:
Real-time US was performed using the Sonosite S-nerve Portable US machine with a linear transducer (scanning frequency, 13-6 MHz) (see figure 1). Electric stimulation guidance was used with the Digitist II Neuro Technology machine (see figure 2). A low current one per second repetitive electrical stimulation pulse was delivered using a 1.5 inch (37mm) 27 gauge disposable insulated hypodermic needle electrode with Luer Lock Hub.

STUDY PARTICIPANTS/SITTING:
This was a convenience sample of 16 children (20 females) with hypertonia of different etiologies, mean age of 7 ± 4.27 years. Subjects were recruited from the PI’s patients scheduled for intramuscular BoNT injections under anesthesia in day surgery at a tertiary care facility. This study was approved by the UT Southwestern IRB and consent was obtained from each subject’s legally authorized representative and assent when appropriate for subjects ten years or older.

RESULTS:
A total of 490 BoNT injections were given. Twelve different lower limb muscles were included in the study with an overall accuracy rate of 98% (478/490). The accuracy rate in the most frequently injected muscles was: 98% (112/114) in the soleus muscle, 97% (66/68) medial head of gastrocnemius, 91% (50/55) in the lateral head of the gastrocnemius, 97% (132/135) in the medial hamstrings, 100% (70/70) in the hip adductors, and 100% (19/19) in posterior tibialis. The accuracy rate for the six least frequently injected muscles, iliacus (n=2), lateral hamstrings (n=7), flexor digitorum longus (n=4), flexor digitorum brevis (n=3), peroneus brevis (n=5) and peroneus longus (n=8), was 100% (29/29).

CONCLUSIONS/SIGNIFICANCE:
• ES guidance for BoNT injections in the lower extremities in children with hypertonia had an excellent overall accuracy rate of 98%.
• The least accurate rate was 91% for the lateral head of the gastrocnemius.
• ES is easy to perform as long as the patient is relaxed.
• ES accuracy estimates the use of a low stimulation current (1-3mA).
• ES is easy to use, does not require formal training and does not prolong the procedure significantly.

REFERENCES:
Fietzek et al. 2010). Ultrasound helps to identify muscles by showing boundaries of individual muscles, each with characteristic landmarks, and by concurrent oscillations of the intramuscular echo produced by passive movement or tenden stretch. Ultrasound visualizes bones, blood vessels, and nerves and differentiates between the target muscle and neighboring structures (Fietzek et al. 2010). Ultrasound guidance is non-invasive, precise, and real-time. It demands very little time, is painless, and does not expose subjects to radiation. It allows visually guided injection into the center of every targeted muscle belly. Ultrasound guidance is recommended in multiple botulinum toxin studies (Berweck et al. 2002; Berweck & Lokiec 2004; Mork et al. 2010; Huchhoff et al. 2003) and test reporting of injection sites are easily identified. However, ultrasound requires extensive training of personnel and the cost of the equipment is often prohibitive. Although small laptop devices are available for mobile use, most sonography devices in the hospital setting are large and cumbersome. Patient factors can also present challenges with sonography. The injection of deep-seated muscles in larger extremities, especially those in obese patients, cannot be performed with the same visual acuity as in superficially seated muscles. Misaligned extremities demand the use of alternative strategies and expert spatial and anatomical knowledge. Chronic spasticity is associated with substantial atrophy of muscle bulk and significant increases of muscle echogenicity, thus rendering the detection of contour lines more difficult (Fietzek et al. 2010). Finally, ultrasound cannot reliably localize endplate zones (Schorroder et al. 2016). Despite these challenges, US is preferred by many clinicians and is often for more accurate.

Currently at our facility, ES is the current standard of care for BoNT injection guidance. Ultrasound guidance for toxin injections is only used for difficult/critical injection site locations, most often for non-intramuscular injections (i.e. salivary gland injections).

Figure 1
Figure 2
Figure 3a. Needle tip within the muscles.
Figure 3b. Needle tip touching the fascia.
Figure 3c. Needle tip outside the muscles.