Chemodenervation Using Ultrasound Guidance

Michael C. Munin, M.D.
Professor
Department of Physical Medicine and Rehabilitation
University of Pittsburgh School of Medicine
Outline for Discussion

• Why Learn About Ultrasound Localization?
• Machine Settings: Basic controls to understand
• Transducer Pearls
• Injection Techniques
• Case Examples
• Outcome Studies
Why Use Ultrasound (US) in Chemodenervation?

• Botulinum toxins (BTX) yield dose dependent decrease in spasticity and strength
• For endocytosis of BTX, must be intramuscular and (ideally) near motor end plates
• Studies have shown treatment with BTX does not always increase upper-limb motor function after stroke
  – BotULS Multi-center trial *Stroke* 2011
Why Use Ultrasound (US) in Chemodenervation?

• If botulinum toxin injections improve function, why have clinical trials not shown this consistently?
• Inappropriate outcome measures
• Inappropriate patient selection
• Inappropriate BTX injection protocol especially localization
Limitations Without Ultrasound

• EMG needle accuracy in cadavers using surface landmark localization and blind needle placement can be unreliable.

  Haig 2003 Archives PMR

• Difficulty using surface landmarks based on normals or cadavers when full ROM not possible due to contracture.

• 3-dimensional structure may be distorted or obscured from severe muscle atrophy and fibrotic tissue replacing muscle.
Limitations Without Ultrasound

- Goal of injection: Keep injectate in fascial planes for endocytosis of toxin
- While toxin may be transported in retrograde fashion via neurons, keeping injectate within targeted muscle gives best opportunity to maximize outcome
- In forearm, toxin may spread causing difficulty with selected injections i.e. FDS of digit 3 and 4 only
- US can ensure that injectate stays within correct fascial borders and does not penetrate neurovascular structures
US Advantages vs. EMG/Nerve Stim

• With EMG guidance:
  ☐ Active motor unit potentials or insertional activity
  ☐ Don’t know where generator is coming from
  ☐ Surprising how far injectate can spread

• With Nerve Stimulation:
  ☐ May be stimulating nerve branch before target muscle so injectate deposited in another muscle
  ☐ Even if stimulating within target muscle, no idea on depth or where the injectate spreads out
  ☐ Painful with multiple needle sticks; hard to find target
Machine Settings: Basic Controls to Understand
US Machine Settings: **Gain**

- Compensates for attenuation (a reduction in sound amplitude) as waves travel deep into body
- Intensity of returning signals amplified so that displayed image is brighter and more visible on the screen
- Gain makes entire image brighter or muted
- Gain = Brightness
US Machine Settings: Depth

- Right side of screen shows scanning depth in cm
- For superficial structures, use highest magnification (Low scanning depth ≈2cm, ↑Frequency 10 to 18Mhz)
- For deeper structures, less magnification (Higher scanning depth ≈5cm, ↓Frequency 5 to 8Mhz)
- Depth = Magnification
US Settings: Focal Zone

• Regardless of depth, focal zone tells machine to highlight a certain region

• Modern machines provide electronic focusing (Focusing = Focal Zone)

• For example, if total scanning depth is 3cm, may want to highlight structures at 1.5cm

• It is important to place the Focal Zone at or slightly below level of target structure of interest
Compounding

- Most machines have feature built-in. Older machines may not have this feature.
- http://www.usra.ca/
US Settings: Doppler

- Can be standard Doppler or Power Doppler
- Very useful to identify blood vessels while injecting
- Power Doppler more sensitive to differentiate vascular structures
- Std Doppler indicates flow direction, but not required in chemodenervation
Transducer

• Key piece of equipment for US procedures
• Frequency—10 MHz to 13 MHz best for most chemodenervation
• Design—Some are easy to hold during injections. Look at different manufacturers for personal preference
• Sterility—For chemodenervation absolute sterile conditions are not required but...
Transducer Pearls

• I wipe skin with alcohol and use sterile US gel packs
• US gel is bacteriostatic; others use non-sterile gel
• For our clinics where US is used on multiple consecutive patients, transducer cover is recommended
• I use cheap non-sterile condoms as barrier to blood that can easily smear across transducer
• Important: Place non-sterile gel inside condom to get an image!
• Special cleaners are suggested to wipe the transducer between patients
Transducer Alignment

• Alignment refers to sliding transducer to follow course of target
• Needle can approach target in 2 directions
• Parallel= longitudinal= in plane
• Perpendicular= axial= out of plane
• Must understand these concepts in chemodenervation!
In Plane Approach

• Entire needle length visible including tip
• Deep structures and nerve blocks are best for this technique
• Beam Steer feature brightens entire needle length
• If many surrounding structures in path, not best approach
• Useful for pronator teres and forearm extensors, anterior thigh muscles, calf muscles and phenol injections
In Plane Approach

© 2012 Michael C. Munin
In Plane Injection to Pronator Teres

© 2012 Michael C. Munin
Out of Plane Approach

• Surrounding structures best seen in this view
• Important to slide transducer along shaft of needle to identify needle tip
• Do not see entire needle length
• Needle tip and shaft in cross section appear as hyperechoic white dot or shadow on the screen

© 2012 Michael C. Munin
Out of Plane Approach

© 2012 Michael C. Munin
Out of Plane Flexor Carpi Radialis

© 2012 Michael C. Munin
Tilting Transducer

• Helpful in out of plane view
• If tip goes past or in front of transducer, tilting will aim beam at tip
• Helps resolve anisotropy (a change in nerve echogenicity with the angle of incidence)
Orientation of US and Patient

- For chemodenervation transducer is perpendicular to injected limb
- Screen should be oriented as you are looking at patient
- EXAMPLE: If injecting left forearm, US screen should be in front of injector and behind the arm
- Injector sees ulnar left screen and radial right screen
- For parallel positions, it is customary to have cephalad (superior) left of screen and caudad (distal) to right
Orientation of US and Patient

© 2012 Michael C. Munin
Ergonomics During Injections

BAD

GOOD

© 2012 Michael C. Munin
Top 10 List for US in Chemodenervation

1. Orient patient and US properly
2. Scan area to identify target structures and anatomy
3. Pick injection path that does not cross another muscle
4. Look for familiar patterns
   -- Pronator teres/FCR -- FDS2 & 3 to median nerve
Top 10 List for US in Chemodenervation

5. May use passive movement to confirm muscle
6. Determine in plane or out of plane approach
7. Review approach to ensure nerve or vasculature clear of path. Power doppler?
8. Slowly advance gently pertubating skin to view needle movement
9. Confirm tip is within target muscle
10. See ‘blush’ and keep injectate within target muscle
US Injection Pearls

- Know how muscle looks different than nerve, gland and vessels
- Realize that with spasticity, extracellular matrix increases
- Myofibrils have less cross sectional area and more fibrous tissue; these changes can make muscle look brighter
- Muscles can be injected in multiple locations given their length and width
- Goal is to inject directly without crossing other muscles
CASE EXAMPLES USING US FOR CHEMODENERVATION
44 yo F Spastic Dystonia 3\textsuperscript{rd}, 4\textsuperscript{th} PIP
25 yo F MS, ankle injury with spastic inversion. Targeting Med Gastroc
49 yo F Cervical Dystonia
Outcome Studies for US Chemodenervation

• No definitive trials in literature
• Studies limited by small patient numbers, lack injection technique consistency and application of different rating scales
• Good recent review—

  Accurate targeting of botulinum toxin injections:
  How to and why

  Lim 2011  Parkinsonism and Related Disorders
Outcome Studies for US Chemodenervation

Botulinum Toxin A Injection into Calf Muscles for Treatment of Spastic Equinus in Cerebral Palsy: A Controlled Trial Comparing Sonography and Electric Stimulation-Guided Injection Techniques

Kwon AJPMR 2010  N=30 children

• Sonography-guided group significantly better with Physician's Rating Scale (gait pattern and hindfoot position; maximum foot/floor contact during stance)
• MAS and Tardieu not different with techniques
Outcome Studies for US Chemodenervation

Comparison of Surface and Ultrasound Localization to Identify Forearm Flexor Muscles for Botulinum Toxin Injections

Henzel PMR 2010   N=18

• Compared surface localization using FB landmarks to US
• Goal was to obtain optimal injection site
• Significant proximodistal differences in FPL and Pro Teres location; FCR trended toward significance
• For lateral coordinates, significant differences in FDS3 and FCR location. FDS2 and FDS4 trended significant
Outcome Studies for US Chemodenervation

Elimination of dysphagia using ultrasound guidance for botulinum toxin injections in cervical dystonia

- Submitted for publication Muscle and Nerve
- 5 patients with EMG only guidance
- 34.7% rate of dysphagia over 98 injection sessions
- 0% rate of dysphagia over 27 sessions with US plus EMG
- SCM thin; US keeps injectate within fascia
Take Home Points

• US has a role in chemodenervation procedures
• Understand in plane vs. out of plane technique
• Proper orientation of patient to US machine
• Pattern recognition to find target and optimal injection site while avoiding neurovascular structures
• Keep injectate within fascial borders
Questions?  Thank you!