Ultrasound-Guided Musculoskeletal Injection Procedures

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Topics

• General Principles of ultrasound-guided injections
  – Types of musculoskeletal interventional procedures
  – Injection terminology
  – Office set-up
  – Materials for ultrasound injections
  – Aseptic technique
  – Injection tips
  – Injection training
Types of Musculoskeletal Ultrasound Interventional Procedures

- Aspiration
- Injections
  - Local anesthetic diagnostic injection
  - Corticosteroid injection
  - Viscosupplementation
  - PRP and other biologics
  - Botulinum toxin
  - Gadolinium injections prior to MRI
  - Trigger point injection
  - Prolotherapy
- Barbotage (needle lavage)
- Nerve block
- Hydrodissection
- Percutaneous needle tenotomy (PNT)
- EMG/NCS guidance
- Foreign body extraction
- Biopsies
Body Regions

- Occipital region
- Cervical region
- Shoulder
- Elbow
- Forearm
- Wrist
- Hand
- Hip region
- Knee
- Lower leg
- Ankle
- Foot
- Spine
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Probe and Needle Terminology

- **Probe position relative to anatomic structure**
  - Longitudinal (Long Axis)
  - Transverse (Short axis)

- **Needle position relative to probe**
  - In-Plane: needle parallel to probe’s long-axis
  - Out-of Plane: needle perpendicular to probe’s long-axis
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Injection Room Set-Up

- Screen directly across from physician
- Height-adjustable power table and/or exam stool
- Lighting
  - Room light off
  - Background lighting
    - X-ray view box
    - Supplemental focal light source if needed
- Comfort
  - Patient: Supine, prone or side-lying: decreased vasovagal risk
  - Physician
Mobile Ultrasound Injection Cart

- Cart stocked with injection supplies
  - Shelf
    - Clamp
    - Sharpie
  - Draws:
    - Medications
    - Needles
    - Syringes
    - Extension tubing
    - Sterile gel
    - Chloraprep
    - Gauze
    - Band-Aids
- 3 probes with 1 button probe switching
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• Ideally have a range of needle lengths available

• Estimating Length
  – Measure
  – Can use local anesthetic injection needle (eg 25-gauge 1 ½” needle) to help estimate length of subsequent aspiration/injection needle

• Err on side of slightly longer needle if in doubt

• Longer the needle, more likely need a larger gauge to maintain needle control
  – Long needles can be flimsy*
• Ideally have a range of needle gauges available
  – Injection procedure
    • > 25 gauge for injections
      – Corticosteroid
      – Viscosupplementation
    • 30 gauge OK for local anesthetic injections or non-particulate corticosteroid
  – Aspiration procedure
    • Use large gauge (18 and sometimes 16 gauge) for some fluid collections, eg
      – Ganglion cyst
    • Better to err on side of a larger gauge
    • Be prepared to dilute out the aspirate if necessary
• Larger gauge needles more painful- consider skin wheel local anesthetic with small gauge needle 1st for some patients/body regions
Needles: Type

- Hypodermic vs. Spinal
  - Some longer needles only available as spinal needles
  - Sometimes need spinal needle: cut on an angle, therefore steering & tip more visible esp. if bevel up
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Aseptic technique

- Antiseptic solution
  - Disinfect skin: Chloraprep vs. Betadine
  - Disinfect probe
    - PDI wipe
    - Chloraprep
  - Sterile gel
  - Chloraprep bullet @ needle entry site
- Non-sterile gloves
  - Do NOT touch needle
  - Do NOT touch sterilized skin site
- Do NOT drag probe from non-aseptic → Aseptic region
- Optional
  - Sterile gloves: required if need to touch needle
  - Probe covers
  - Tegaderm
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Injection Tips: General

- Sonopalpation
- Needle steering & bevels
- Needle bending
- Needle visualization
- Syringe exchange
- Out-of-plane injections
Sonopalpation (Edge Technique)

- Palpate using edge of transducer & elicit feedback from patient regarding pain sensitive structure(s)
- Helps to focus ultrasound exam & select injection target
  - Can be very helpful for certain injections: eg lateral hip
Steering Needles
Needle Steering: Bevel

- Needle will move opposite to bevel (side of opening @ needle tip)
- Bevel & notch in same direction
- Mark hub of spinal needle with sharpie to help identify bevel side during procedure as plastic notch can be tough to see when stylet removed
Needle Visualization Tips & Tricks
Needle Visualization: In-Plane vs. Out-of-Plane

- **In-Plane view:**
  - Can be tougher to see full length of a long needle because of bending

- **Out-of Plane view**
  - Only see needle tip: can be very tough to see
  - Once see tip, DO NOT advance further since can no longer judge depth of needle insertion as needle shaft looks similar along its length
Out-of-plane: needle tip vs shaft
Why can it be difficult to see needle?

- Narrow widths: ultrasound beam & needle
  - Ultrasound beam: approximately 1 mm @ focal zone of high-frequency transducers
    - Even thinner for matrix probes
  - Needle: 22g = 0.7 mm
    - cf. Credit card 0.76 mm thickness: analogous to trying to line up 2 credit cards
Visualization Tips

• Some Solutions:
  – Bevel up: Insert with bevel up: 3 vs. 1 reflective surfaces
  – Center of probe: Make every effort to place needle under exact center of probe & keep under center as advance*
    • Eye/hand dominance
Visualization Tip: Eye Dominance

- Identify an object on the wall to use as a target.
- Use your hands to make a small triangle & look through them with both eyes open at an object on the wall.
- Close your LEFT eye.
  - If the target is still there then you are right eye dominant.
  - If it disappears then you are left eye dominant.
Injection Tip: 

Eye Dominance & Hand Dominance

• Optimally position your head & arm so as to line up dominant eye with dominant hand
  
  - Easier: Eye dominance SAME SIDE as hand dominance side: Pin elbow to your side & line up eye parallel to injection side forearm
  
  - More difficult: Eye dominance side OPPOSITE TO hand dominance side: Put elbow in front of side of your abdomen, move head to side to line up eye parallel to injection side forearm
Where to look: Ultrasound screen or at Needle/Probe? Rule:

• Look @ needle-probe 1st
  – Insert needle under probe bevel up & keep looking until needle enters under probe
    • Keep thumb holding probe out of way of visual field so that can see needle under probe center

• Do NOT be mesmerized by the ultrasound screen (ie look also at needle relative to probe)!
Why can’t see needle even though under center of probe?

- Needle most visible for in-plane injections when needle and probe are parallel & becomes increasingly less visible as angle changes especially beyond 30°
Needle Visualization: In Plane
Keeping Probe & Needle Parallel

• Probe pressure
  – Can use back pressure on probe in lieu of or in addition to gel standoff
  – Back pressure ≠ “death grip” on probe per se
    • Fatigue
    • Can worsen visualization
**Probe Pressure**

- **Back Pressure**: desirable since improves (decreases) angle between probe and needle – (makes them more parallel).

- **Uniform Pressure**: undesirable since worsens (increases) angle between probe & needle (makes them less parallel) by pushing needle downwards as well.
Needle Visualization: In Plane - Gel Standoff

- Helps with needle visualization by orienting needle & probe more parallel
- Often combined with back pressure on the probe
Why can I no longer see the needle? Hooking Needle

- Tendency to hook needle away from dominant hand, especially if dominant eye is opposite dominant hand
  - Left-handers hook to the right
  - Right-handers hook to the left
- Always be aware of this tendency & avoid it
Injection Tip: Tuck Elbow In

Helps with driving the needle straight (i.e. prevents hooking needle)
Why does the needle blend in?

- Amount of ultrasound beam reflection proportional to acoustic impedance differences.
- Lack of uniform contrast between needle & surrounding echogenic tissue.
  - Tissue- heterogeneous mix of different acoustic impedances: connective tissue, fat, fluid, muscle, etc.
    - cf. Gel phantom training models: easier since uniform echogenicity
- Needle visualization tips:
  - Inject local anesthetic through needle to create contrast around needle tip (hydrolocation)
  - Change instrument parameters to enhance contrast differences
  - Doppler to detect needle motion
Needle Visualization Tip

- Injecting fluid ("hydrolocation") can help to visualize needle tip for either In-Plane or Out-of-Plane injections especially if patient slightly dehydrated (causes hyperechoic tissue)
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Needle Visualization: Needle Enhancement Software

• “Advanced Needle Visualization Software”
  – Image process settings: ↑ needle contrast vs. background structures
  – Can be helpful to an extent for some procedures if steep angle & tough to keep probe & needle II
  – Set steepness so that needle is __ to green line
  – Adjust probe position so that needle stays perpendicular to turquoise line
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Needle Visualization Tip

• Doppler
  – Move stylet within needle to create motion: more precise localization vs. moving entire needle since less tissue motion transmission beyond needle tip
  • cf. “chicken pecking” = move needle in quick small bursts & look for tissue motion
Doppler: Avoiding Blood Vessels

- Helps to avoid inadvertent vascular penetration
- Especially important is some body regions
  - IA hip
  - Subcoracoid region
Doppler: Avoiding Blood Vessels

- Is this approach the best choice?
  - I.e. needle approach from side opposite to artery?
  - Answer: **Wrong choice** since too easy for needle to inadvertently travel too far towards artery, especially if perform syringe exchange. Instead approach over the blood vessel- (i.e. starting from same side as vessel) would have been better, since needle tip will travel away from vessel. (If must approach towards a structure that wish to avoid, use extension tubing to make syringe exchange & use ultrasound visualization throughout procedure.)
Out-Of-Plane Injections

- 2 techniques for placing needle to a target at a certain depth
  - 45° angle estimate
    - Place needle same distance away from probe as target depth & insert needle at 45° angle
    - **Easiest to use 45° technique since**
      - depth = distance from probe center
      - Pythagorean theorem needle length
  - Walk down technique

DANGER

Critical structure
- Vessel
- Nerve
- Pleura
Out-of-plane 45° angle estimate
Out of Plane Injection: Walk Down Technique

- Sequentially “walk down needle” to target
  - Put target under center of probe: can use paperclip to help line up target & center of probe
  - 1 needle entry site close to center of probe
  - Pull needle back slightly & sequentially raise needle angle as aim needle tip down to target
Out-of-plane walk down technique
Out-of-Plane Injection: Probe Perpendicular to Needle- Probe Tilt

Example below illustrates that without probe tilt, ultrasound beam did NOT detect needle tip because needle tip did not reach under probe, whereas when tilted probe, the ultrasound beam now intersected needle tip
Probe tilt can make a big difference

In-Plane:
Tile to orient probe **parallel** to needle

Out-of-Plane:
Tilt probe away- orient **perpendicular** to needle

In-plane and Out-of-Plane sometimes combined- especially tendon sheath injections*
Out-of-Plane Injection: Redirecting a Needle Sideways

- Small sideward movements (eg 1-2 mm) require very large redirect angles
  - Leverage point is so distal that must re-angle the needle shaft a lot to get the tip to move a little*
Out-of-Plane Injection: Redirecting a Needle Sideways
Redirecting Out-Of-Plane Example: Percutaneous needle tenotomy

- Must use both in-plane & out-of-plane views to visualize needle to make sure are performing tenotomy to entire tendon width
  - Probe width very small vs. tendon width
Visualizing Needle & Target

- Steer the needle to the probe (unless needle tip can’t be seen & in close proximity to important structures- e.g. nerve, blood vessel, pleura, viscera)
- Don’t move probe to needle
  - Ideally, probe stays in same place other than minor rocking or tilting
- Don’t move both needle & probe or will lose best site of target
Injection Tips: Specific Injection Types

- Bursae
- Aspiration
- Hydrodissection
Injection Accuracy

Tips: Bursae

• Fluid-filled bursae much easier*

• Collapsed bursae
  – Minimal to no initial fluid accumulation as inject
    • If local accumulation of injectate, then NOT in bursa
    • Might observe injectate flow along bursa as inject*

• Examples
  • “Dry knee” being injected via suprapatellar bursa approach
  • Typical subacromial bursa
Fluid Aspiration Tips

- Look at fluid 1st to determine if
  - Simple: Anechoic - likely very thin
  - Complex: Hypoechoic or mixed echogenicity - likely a bit thicker
- Do not confuse fluid with
  - Synovitis: gray & + CPD
  - Cartilage: non compressible & conforms to surface of underlying bone
- Err on side of large enough gauge needle if not anechoic
- Use longitudinal & transverse views to choose best portion to aspirate
- Rule out clogged needle tip especially if flow ceases
- Consider diluting out aspirate with saline
- Compress structure to help with flow
  - Probe
  - Other hand
  - Assistant
Manual compression can assist fluid aspiration
Hydrodissection

• Use of injected fluid to separate tissues planes in order to achieve a therapeutic effect- examples

  – Nerves entrapment/compression: “liquid neurolysis” = surgical breaking up of perineural adhesions*
    • Retinacular tissue: median nerve at carpal tunnel
    • Otherwise normal connective tissue: ulnar neuropathy at elbow
    • Ligaments: inguinal ligament in meralgia paresthetica
    • Cutaneous nerve fibers within scars
  – Tendons
  – Scars
    • Tissue tethered down s/p trauma
  – Muscle s/p trauma

• Must advance needle as inject since injectate tends to push needle away
Identifying the Pain Generator: Use of needle tip to replicate pain

- Gently use needle tip to more precisely identify the pain generator*
  - Patient ideally should report reproduction of their “typical pain” as needle tip probes structure
  - Especially useful in certain body regions—eg tendon insertions of short hip external rotators at posterior inferior hip
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Injection Training: Gel Phantoms

• Phantom training is potentially helpful but potential for false sense ease of injections due to stark contrast between needle and uniform gel background vs. needle and heterogeneous living tissue.

• Tissue’s multiple acoustic interfaces causes refraction (scatter) & attenuation of returning echoes → further reduction in needle visibility
Injection Training: Animal Parts

- Pork shoulders
- Turkey legs
- Pigs feet
Injection Training: Cadavers*

- Unembalmed preferred
- The “fresher” the cadaver, the better
Other Injection Training Options:

- Fellowship training
- “Personal Trainer”
  - Bring in a trainer to guide you through actual injections on your patients
Injection Training: Using Fluoroscopy to Help Learn Ultrasound Injections

• Examples
  – Intraarticular hip
  – Piriformis
  – Sacroiliac joint

• Use the ultrasound rather than fluoro injection approach to do the procedure, then inject Omnipaque to confirm accuracy
Ankle-Foot Region Injection Examples
Intra-articular Ankle PRP
Sinus Tarsi
Subtalar Joint
Tibialis Posterior Tendon PRP
Tibial Nerve Block
Tibial Nerve Block
FDL-FHL-Med Plantar Nv Intersection Syndrome
Knot of Henry HDN
Calcaneal Nerve HDN