Ultrasound Guided Nerve Hydrodissection

Nerve Hydrodissection Topics
- Definition & background
- Why hydrodissect a nerve?
- Nerve anatomy
- Hydrodissection safety
- Injection principles
- Injectate solutions
- Hydrodissection examples
- Literature review

Hydrodissection Definition
- Use of a pressurized fine stream (jet) of liquid to create tissue planes or to divide certain soft tissues less traumatically than ordinary sharp dissection.
  - i.e. Needle/syringe rather than a scalpel
- Relatively new procedure made possible by musculoskeletal ultrasound

Nerve Hydrodissection vs. Perineural Injection
- Nerve hydrodissection:
  - Inject between a nerve and surrounding tissue to separate tissue away from or off of the nerve
  - Higher volume injectate usually needed
- Perineural injection:
  - Not creating a tissue plane per se
  - Usually small injectate volume

Evolution of Nerve Block Procedures
- Paresthesia Technique
- Nerve Stimulation
- Ultrasound-guidance:
  - Perineural → Hydrodissection

Nerve Hydrodissection Topics
- Definition & background
- Why hydrodissect a nerve?
- Nerve anatomy
- Hydrodissection safety
- Injection principles
- Injectate solutions
- Hydrodissection examples
- Literature review
Why hydrodissect a nerve?

- As part of a pre-procedural nerve block
- Separate a potential soft tissue adhesion or obstruction from the nerve that could be causing an entrapment.
  - Nerve entrapment syndrome
  - Myofascial pain syndrome rather than trigger point injections

Recognizing Nerve Entrapment

- Nerve swelling just proximal to entrapment site +/- just distal to site ("dumbbell sign")
  - Why swelling?
    - Compensatory growth of new axons & Segmental remyelination → thickening of perineurum & endoneurium → overall nerve thickening
    - Restriction of axoplasmic flow
  - Fascicle enlargement

Nerve Hydrodissection Topics

- Definition & background
- Why hydrodissect a nerve?
- Nerve anatomy
- Hydrodissection safety
- Injection principles
- Injectate solutions
- Hydrodissection examples
- Literature review

Nerve Anatomy

- Bundles/fascicles of axons & dendrites
  - Endoneurium - around individual processes
  - Perineurium - around fascicles; individual nerve fibers with their endoneurium
  - Epineurium - outermost covering around entire peripheral nerve

Nerve Hydrodissection Topics

- Definition & background
- Why hydrodissect a nerve?
- Nerve anatomy
- Hydrodissection safety
- Injection principles
- Injectate solutions
- Hydrodissection examples
- Literature review
Avoid Nerve Expansion

- Nerve expansion consistent with intraneural injection—i.e.: either in perineurium (aka perineural) space or intrafascicular
- But nerve expansion does not equate to definite nerve injury
  - Perineural space injection: injury very unlikely
  - Intrafascicular injection: injury possible

Injury Mechanism: Axon damage from needle penetration?

- Perineurium: tough, resistant tissue, therefore unlikely to be easily penetrated especially by a blunt short-bevel needle
- May explain why penetration of epineurium does not always result in neural damage—i.e. penetrate epineurium but not necessarily perineurium

Injury Mechanism: Pressure

- Injection pressure study canine sciatic nerves
  - Perineural (i.e. inject outside the nerve proper): low pressure (<5 psi)—neurologic function returned to normal <24 hours
  - Intraneural:
    - Intermediate pressure (5-12) 12/20 injections—neurologic function returned to normal <24 hours: probably in perineural space
    - High pressure (20-38 psi) 8/20 injections—persistent neurologic deficits: probably intrafascicular
  
- Injury Prevention?: Pressure Monitoring
  - B-smart pressure monitor: measures injection pressure
  - Might help to prevent nerve injury during injection since high injection pressures as can occur with intraneural injections might predict neurologic injury

Injury Mechanism: Needle Type

- Rabbit sciatic nerve study
  - Needles
    - 14-degree (long) bevel
    - 45-degree (short) bevel
  - Short bevel pushed aside nerve fascicles rather than pierced the perineurium; therefore, short bevel needles less frequently produced fascicular damage vs. long bevel needles that impaled nerves.

Needle Injury:
Needle Orientation Relative to Nerve
- Degree of injury with long-beveled needles varied with bevel orientation
  - Injuries caused by needle bevels perpendicular to the nerve fibers were more severe than those caused by bevels aligned parallel

Nerve Injury Risk Factors
- Risk factors for nerve injury
  - Obesity
  - Diabetes
  - Anticoagulants


Safety of Nerve Hydrodissection
- No studies have evaluated safety of nerve hydrodissection
- Infer from data on safety of
  - Perineural injections
  - Regional anesthesia

- Peripheral nerve injury: rare complication of regional anesthesia
  - Retrospective studies: 0.5-1%
  - Prospective study: 10-15%
  - Most transient & subclinical
- Nerve stimulation techniques do NOT prevent intraneural injections

Nerve Hydrodissection Topics
- Definition & background
- Why hydrodissect a nerve?
- Nerve anatomy
- Hydrodissection safety
- Injection principles
- Injectate solutions
- Hydrodissection examples
- Literature review

Basic Injection Principles Pertinent to Nerve Hydrodissection
- Where do you do the procedure?
  - Blocking a nerve vs. fixing an entrapment
- Consider using bone as a backboard if possible: serves as an additional marker for needle tip localization
- How do you distribute the injectate relative to the nerve?
  - Halo the nerve
  - Don’t expand the nerve
Nerve Entrapment Syndromes: Nerve block vs. Fixing the Entrapment

- Nerve block: Blocking nerve helps with diagnosis of the entrapment but does not necessarily treat the entrapment. For example, block lateral femoral cutaneous nerve in subcutaneous triangle between TFL & the sartorius muscles.

- Hydrodissection: Separate nerve from tissue causing the entrapment potentially directly treats entrapment. For example, hydrodissect lateral femoral cutaneous nerve just medial to ASIS & deep to inguinal ligament.

Basic Injection Principles Pertinent to Nerve Hydrodissection

- Where do you do the procedure?
  - Blocking a nerve vs. fixing an entrapment

- Consider using bone as a backboard if possible: serves as an additional marker for needle tip localization.

- How do you distribute the injectate relative to the nerve?
  - Halo the nerve
  - Don’t expand the nerve

Hydrodissection Injection Tips

- Guard against nerve expansion

Intercostal Nerve Block Video

Basic Injection Principles Pertinent to Nerve Hydrodissection

- Where do you do the procedure?
  - Blocking a nerve vs. fixing an entrapment

- Consider using bone as a backboard if possible: serves as an additional marker for needle tip localization.

- How do you distribute the injectate relative to the nerve?
  - Halo the nerve
  - Don’t expand the nerve

Halo the Nerve

- Technique:
  - Get needle opening as close to epineurium as possible
  - Bevel opening to face epineurium
  - Use fluid to hydrodissect tissue away from nerve
  - Push needle forward as inject to counteract back pressure from injectate upon needle
Hydrodissection Injectate Solutions

- D5W:
  - Exact mechanism unclear but theory that it affects small polymodal nerve fibers associated with neuropathic pain (i.e., might act at the level of sensory nerve fibers)
  - Weak anesthetic properties
  - No data for nerve hydrodissection
  - Superior to Lidocaine for trigger point injections
    - Kim MY. J Korean Acad Rehab Med 1997

- Dexamethasone:
  - No data on nerve hydrodissection
  - Perineural dexamethasone added to local anesthesia for brachial plexus block improves pain but delays block onset and motor blockade recovery.

Entrapment Syndromes: Where can nerves get entrapped?

- Between muscle (intramuscular)
- Within muscle (intramuscular)
- Adjacent to a blood vessel (perivascular)
  - Artery
  - Vein
- Under a ligament
- Within a tissue plane due to traction
- Within a tissue plane where tendons cross
- Within paratenon and/or tendinopathic tendon
- Within a fascial opening
- Within a tunnel between muscle and bone
- Within a fibro-osseous tunnel
- Up against a bone
- Next to a sesamoid bone
- Within its own myelin sheath
Nerve Entrapment Syndromes:
**Intermuscular Entrapment**
- e.g., Musculocutaneous nerve between biceps & coracobrachialis muscles

Musculocutaneous Nerve Hydrodissection Video

Entrapment Syndromes:
Where can nerves get entrapped?
- Between muscle (intermuscular)
- Within muscle (intramuscular)
- Adjacent to a blood vessel (perivascular)
  - Artery
  - Vein
- Under a ligament
- Within a tissue plane due to traction
- Within a tissue plane where tendons cross
- Within paratenon and/or tendinopathic tendon
- Within a fascial opening
- Within a tunnel between muscle and bone
- Within a fibro-osseous tunnel
- Up against a bone
- Next to a sesamoid bone
- Within its own myelin sheath

Entrapment Syndromes:
Where can nerves get entrapped?
- Within muscles (intramuscular)
  - e.g., After penetrating trauma
  - e.g., After muscle tear injury
    - Macrotear from acute injury
    - Microtears from repetitive strain injuries

Entrapment Syndromes:
Where can nerves get entrapped?
- Within muscles (intramuscular)
  - Traumatic: penetrating trauma to anterior thigh

Nerve hydrodissection video anterior thigh

- Femoral nerve
- Pelvic fracture affecting nerve
- Numbness or weakness

- 1 Muscle Tears
- 2 Muscle Tears in Muscles

- An injury like this results in small tears of the muscle fibers
- Repeatedly using a muscle results in small tears of the muscle fibers
- The body repairs the torn ends, but tears continue
- This body, across the myelin sheath, of all fibers
- The same site of a frequent injury
- The same site of a frequent injury
**Entrapment Syndromes:**
Where can nerves get entrapped?

- Between muscle (intermuscular)
- Within muscle (intramuscular)
- Adjacent to a blood vessel (perivascular)
  - Artery
  - Vein
- Under a ligament
- Within a tissue plane due to traction
- Within a tissue plane where tendons cross
- Within paratenon and/or tendinopathic tendon
- Within a fascial opening
- Within a tunnel between muscle and bone
- Within a fibro-osseous tunnel
- Up against a bone
- Next to a sesamoid bone
- Within its own myelin sheath
- Nerves in general lie adjacent to blood vessels
  - Under some circumstances, blood vessels (even in the absence of arterial or venous aneurysms can cause nerve compression)
    - e.g. Radial nerve compression by Leash of Henry

---

**Entrapment Syndromes:**

| Needle path |

**Leash of Henry Hydrodissection Video**

**Saphenous Nerve Hydrodissection Video**

**Entrapment Syndromes:**
Where can nerves get entrapped?

- Within tissue plane where tendons cross
- Saphenous nerve proper & infrapatellar branch susceptible to traction within subsartorial plane deep to sartorius muscle where gracilis tendon crosses underneath
  - Cf. Not @ Hunter’s canal

- Within paratenon and/or tendinopathic tendon
- Within a fascial opening
- Within a tunnel between muscle and bone
- Within a fibro-osseous tunnel
- Up against a bone
- Next to a sesamoid bone
- Within its own myelin sheath
Entrapment Syndromes: Where can nerves get entrapped?

- Between muscle (intermuscular)
- Within muscle (intramuscular)
- Adjacent to a blood vessel (perivascular)
  - Artery
  - Vein
- Under a ligament
- Within a tissue plane due to traction
- Within a tissue plane where tendons cross
- Within paratenon and/or tendinopathic tendon
- Within a fascial opening
- Within a tunnel between muscle and bone
- Within a fibro-osseous tunnel
- Up against a bone
- Next to a sesamoid bone
- Within its own myelin sheath

Entrapment Syndromes: Where can nerves get entrapped?

- Entrapment of neonerves within paratenon and/or tendinopathic portion of tendon?
- High volume hydrodissection with tendon scraping

Nerve Entrapment at Fascial Openings

- Nerves can become entrapped where they travel through fascial openings
  - eg Superficial peroneal nerve at crural fascia
  - eg Abdominal wall cutaneous nerve entrapment (ACNES)
  - eg Radial nerve at arcade of Frohse

Arcade of Frohse Hydrodissection Video
Entrapment Syndromes: Where can nerves get entrapped?

- Between muscle (intermuscular)
- Within muscle (intramuscular)
- Adjacent to a blood vessel (perivascular)
  - Artery
  - Vein
- Under a ligament
- Within a tissue plane due to traction
- Within a tissue plane where tendons cross
- Within paratenon and/or tendinopathic tendon
- Within a fascial opening
- Within a tunnel between muscle and bone
- Within a fibro-osseous tunnel
- Up against a bone
- Next to a sesamoid bone
- Within its own myelin sheath

Peroneal Nerve Fibular Tunnel Hydrodissection

- Within tunnel between muscle and bone
  - eg Fibular tunnel

Cluneal Nerve Hydrodissection Video

- Fibro-osseous tunnel: i.e. nerve running within a tunnel consisting of a bony floor and a fibrous tissue roof
  - eg Cluneal nerve (medial branch superior cluneal)
Entrapment Syndromes: Where can nerves get entrapped?

- Between muscle (intermuscular)
- Within muscle (intramuscular)
- Adjacent to a blood vessel (perivascular)
  - Artery
  - Vein
- Under a ligament
- Within a tissue plane due to traction
- Within a tissue plane where tendons cross
- Within paratenon and/or tendinopathic tendon
- Within a fascial opening
- Within a tunnel between muscle and bone
- Within a fibro-osseous tunnel
- Up against a bone
- Next to a sesamoid bone
- Within its own myelin sheath

Dorsal Scapular Nerve Hydrodissection Video

- Dorsal scapular nerve as crosses over thoracic rib cage, especially in a kyphotic or kyphoscoliotic patient

Fabella: Anatomy

- Fabella: Sesamoid within lateral gastroc tendon
  - Rarely in medial head gastroc
  - 10-30% incidence, 61% bilateral
  - Can be confused with
    - IA loose body
    - Fracture
    - Osteophyte
    - Connected to fibula via fabella-fibular ligament
    - Common peroneal nerve passes superficial or immediately lateral to fabella (94%)
      - Lateral subluxation of fabella risk factor for nerve compression

Peroneal nerve hydrodissection from fabella video
Entrapment Syndromes: Where can nerves get entrapped?

- Between muscle (intermuscular)
- Within muscle (intramuscular)
- Adjacent to a blood vessel (perivascular)
  - Artery
  - Vein
- Under a ligament
- Within a tissue plane due to traction
- Within a tissue plane where tendons cross
- Within paratenon and/or tendinopathic tendon
- Within a fascial opening
- Within a tunnel between muscle and bone
- Within a fibro-osseous tunnel
- Up against a bone
- Next to a sesamoid bone
- Within its own myelin sheath
- Within its own myelin sheath after nerve injury and remyelination
  - Eg Stretch injury

Quadrilateral Space Hydrodissection Video

Nerve Hydrodissection Topics

- Definition & background
- Why hydrodissect a nerve?
- Nerve anatomy
- Hydrodissection safety
- Injection principles
- Injectate solutions
- Hydrodissection examples
- Literature review

Hydrodissection Literature

- No high-level studies to determine the need effectiveness of hydrodissection or to establish its safety.
- Low-level studies demonstrate some effectiveness & safety, but further research necessary

Hydrodissection Literature: Carpal tunnel syndrome

- DeLea et al.: ultrasound-guided median nerve hydrodissection prospective study:
  - Pain & vasomotor changes significantly reduced and no adverse outcomes but no control group
Hydrodissection Literature: Carpal tunnel syndrome

Lee et al. Randomized study of CTS corticosteroid injections: in-plane ultrasound injection, out-of-plane and landmark-based injections.

Ultrasound groups: hydrodissection to “peel the nerve off the overlying flexor retinaculum.”

Statistically improved pain and functional scores in-plane vs. out-of-plane and landmark groups.

Hydrodissection Literature: Ulnar Neuropathy

• Pilot study (n=10): cubital tunnel syndrome improvement in pain, decreased cross-sectional area, and improved electrophysiological measurements with no neurological injuries. (Choi)

Hydrodissection Literature: Meralgia Paresthetica

• Prospective study (n=20): perineural hydrodissection nerve was floated away from adjacent structures:
  - 16/20 statistical improvement in pain & function
  - 4/20 received another injection
  - After 2 months, all symptoms disappeared completely (Tagliafico).

• Similar results case study chronic meralgia paresthetica. Using a similar in-plane injection, the patient remained symptom free at 18-month follow-up (Mulvaney).

Hydrodissection Literature: Saphenous Nerve

Retrospective study (n=16) chronic medial knee pain after TKR, infrapatellar branch of saphenous nerve: hydrodissection technique followed by a corticosteroid injection: 75% improved their VAS pain score to < 3 to 4 from baseline of 8.