Ultrasound of Upper Extremity Entrapment Neuropathies

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Normal Peripheral Nerve
• Ultrasound appearance:
  – Hypoechoic nerve fascicles
  – Hyperechoic connective tissue
• Transverse:
  – Honeycomb appearance


Volar Wrist: median nerve

Nerve Compression

- Experimental model (rat, sciatic nv):
  - Compression causes ischemia
  - First pathologic change: edema
    • Correlated with severity of axonal injury
  - Mild compression: demyelination
  - Severe compression: axonal damage

Powell, Laboratory Investigation 1986; 55:91

Nerve Entrapment

- US findings:
  - Nerve enlargement proximal to entrapment
    • Best appreciated transverse to nerve
  - Abnormally hypoechoic
    • Especially the connective tissue layers
  - Variable enlargement or flattening at entrapment site

Nerve Entrapment Syndromes

- Median:
  - Carpal tunnel syndrome
  - Pronator teres syndrome
- Ulnar:
  - Ulnar tunnel syndrome
  - Cubital tunnel syndrome

Volar Wrist

From Netter’s Atlas of Human Anatomy

Carpal Tunnel Syndrome:

- Proximal median nerve swelling
  - Area: circumferential trace
  - Normal: < 9 mm²
  - Borderline: 9 – 12 mm²
  - Abnormal: > 12 mm²
    • 12.8 mm² = moderate (83% sens, 95% spec)
    • 14.0 mm² = severe (77% sens, 100% spec)

Klauser AS et al. Sem Musculoskel Rad 2010; 14:487
Ooi et al. Skeletal Radiol 2014; 43:1387

Median Nerve: how to measure

- Short axis
- Toggle transducer: defined borders
- Site of maximal enlargement
- Circumferential trace
- Inner border of hyperechoic epineurium
Carpal Tunnel Syndrome

- Compare areas:
  - Proximal: pronator quadratus
  - Distal: carpal tunnel
- $\geq 2 \text{mm}^2$ = carpal tunnel syndrome
- 99% sensitivity
- 100% specificity

Klauser AS. Radiology 2009; 250:171

Carpal Tunnel Syndrome: US

- Close correlation between US and electrophysiological studies, reflects severity of disease\(^1\)
- Median nerve area = sensitivity to nerve conduction studies\(^2\)
- Nerve area decreases after surgery\(^3\)

\(^1\)Bayrak IK, Muscle Nerve 2007; 35:344
\(^2\)Nakamichi K, Muscle Nerve 2002; 26:798
\(^3\)Abicalaf CA, Clin Radiol 2007; 62:891.
Postoperative Carpal Tunnel

- Discontinuous or thickened transverse carpal ligament
- Anterior displacement of transverse carpal ligament
- Median nerve size:
  - May decrease
  - Does not correlate with success

1Lee CH et al. Ann Plast Surg 2005; 54:143
3Naranjo A et al. Scand J Rheum 2010; 39:49

Failed Carpal Tunnel Release

- Thickened transverse carpal ligament (white arrows)
- Persistent median nerve enlargement (yellow arrows)

Bifid Median Nerve + CTS

- Carpal tunnel syndrome
  - Increase in cross-sectional area of ≥ 4 mm
  - Intraneural hypervascularity: 95% accuracy in diagnosis of CTS

1Klauser et al. Radiology 2011; 259; 808
2Mallouhi et al. AJR 2006; 186:1240

Bifid Median Nerve with Aberrant Ulnar Trunk and Carpal Tunnel Syndrome

Persistent Median Artery

- Incidence: 10 – 20%: most with bifid median nerve

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Gassner EM et al. JUM 2002; 21:455c
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Pronator Teres Syndrome

- Median nerve compression between humeral and ulnar heads
- Trauma, congenital, pronator teres hypertrophy
- Rare
- Forearm pain, numbness, weakness


Volar Wrist

Guyon’s canal: normal

Axial T1w Transverse

Guyon’s canal: normal

Sagittal T1w Longitudinal
Guyon’s Canal:
- Ulnar tunnel syndrome
  - Ulnar nerve compression
  - Accessory Abductor Digiti Minimi
    - Variant: up to 24% of wrists
  - Hypothenar hammer syndrome
    - Trauma
    - Ulnar artery thrombosis + distal emboli

1AJR 1999; 172:1397
2J Vasc Surg 1987; 5:838

Accessory Abductor Digiti Minimi:
- Normal variant: 24%
- Origin: palmaris longus, flexor retinaculum, fascia
- Insertion: abductor digiti minimi
- Superficial to ulnar nerve
  - Nerve compression
  - Uncommonly interposed

Hypothenar Hammer Syndrome
- Ulnar artery thrombosis
  - Level of hamate hook
- Distal emboli
- Post-traumatic

Ulnar Nerve: cyclist wrist
- Sensory branch impingement between hook of hamate and bicycle handlebar

Ulnar Nerve: anatomy
- Behind medial epicondyte of humerus:
  - Cubital tunnel retinaculum or Osborne fascia
- Distal to epicondyte:
  - True cubital tunnel
  - Between ulnar and humeral heads: flexor carpi ulnaris
  - Under arcuate ligament

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- Median:
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  - Ulnar tunnel syndrome
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Cubital Tunnel Syndrome:

- Ulnar nerve entrapment at elbow
- 2nd most common upper extremity entrapment neuropathy
- Etiologies:
  - Trauma, valgus deformity,
  - Nerve subluxation, cyst, arthritis

Technique: cubital tunnel

Ulnar Nerve: cubital tunnel syndrome

- Hypoechoic and enlarged
  - > 9 mm² area\(^1\)
  - Ratio greater than 2.8 compared to proximal\(^2\)
- Mild hypoechoogenicity alone: may be normal
- Causes:
  - Idiopathic, overuse, joint process
  - Anconeus epitrochlearis: compression
- Normal variant accessory muscle

\(^1\)Thoirs K et al. J Ultrasound Med 2008; 27:737
\(^2\)Yoon JS et al. Muscle Nerve 2008; 38:1231

Ulnar Nerve Dislocation

- Occurs in elbow flexion
- Reduces in extension
- Nerve irritation, predisposes to injury
- Found in 20% asymptomatic volunteers

Okamoto, J Hand Surg 2000; 25B:85
Technique: ulnar nerve subluxation

Isolated Ulnar Nerve Dislocation

Ulnar Nerve Dislocation

Ulnar Nerve Transposition

Snapping Triceps Syndrome
- Ulnar nerve and medial triceps dislocate over apex of medial epicondyle
- Ulnar nerve and medial triceps remain in contact with each other
- Palpable snap felt through transducer

Radiology 2001; 220:601

Snapping Triceps Syndrome: dynamic imaging

Transverse
Nerve Entrapment Syndromes

- Radial:
  - Posterior interosseous nerve syndrome
  - Wartenberg syndrome
  - Superficial sensory branch radial nerve
- Suprascapular: paralabral cyst

Radial Nerve: deep branch

- Supinator syndrome:
  - Motor deficits (wrist, finger extension)
  - Abnormal electrodiagnostic studies
  - Nerve enlargement: entrapment
- Radial tunnel syndrome:
  - Pain, no motor deficits, normal EMG
  - Muscle denervation on MRI
  - No nerve enlargement

Ferdinand BD et al. Radiology 2006; 240:161

Radial tunnel

- Radial nerve: deep branch
  - Originates from radial nerve between brachioradialis and brachialis
  - Passes between deep and superficial layers of supinator muscle
  - Exits as posterior interosseous nerve

Jacobson JA. et al. Sem Musculoskel Rad 2010; 14:473

Radial Nerve: deep branch

- As it enters into supinator under Arcade of Frohse
- Normally flattens in AP dimension: 50%
- Cross-sectional area does not change

**Supinator Syndrome**

- Idiopathic
- Rheumatoid Arthritis
  
  [Image: Supinator and Synovitis]

  Courtesy of V. Flores, MD, Texas

**Radial Nerve Impingement: Bicipitoradial Bursa**

- Short Axis: Radial Nerve

**Radial Nerve Compression: Saturday Night Palsy**

- Long Axis: Humerus
- Short Axis: Humerus

**Nerve Transection**

- Hypoechoic and retracted nerve ends if complete
- Neuroma formation:
  - Disorganized and tangled nerve end
  - Normal response to nerve transection
- After amputation:
  - US important to determine if symptomatic

  J Clin Ultrasound 1997; 25:85

**Radial Nerve Transection: Humerus fracture**

- Longitudinal
- Transverse

[Image: Longitudinal and Transverse Views]
**Nerve Entrapment Syndromes**

- **Radial:**
  - Posterior interosseous nerve syndrome
  - Wartenberg syndrome
    - Superficial sensory branch radial nerve
  - Suprascapular: paralabral cyst

**Wartenberg Syndrome:**

- Superficial branch of radial nerve
  - Sensory branch
  - Crosses over distal radius and first wrist compartment
  - Entrapment
  - Injury: direct trauma, iatrogenic
Nerve Entrapment Syndromes

- Radial:
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Labral Cyst:

- Most associated with labral tear
- Suprascapular notch:
  - Supraspinatus and infraspinatus atrophy
- Spinoglenoid notch:
  - Infraspinatus atrophy
- US guided aspiration

Labral Cyst: infraspinatus atrophy

Labral cyst

- Usually with labral tear
- Aspiration
  - Axial plane
  - Lateral to medial

Pitfall: suprascapular vein dilation

Take Home Points

- Each nerve has select locations
- Fibro-osseous canals
- Common locations for entrapment
- Image entire limb regardless
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