COMPRESSION NEUROPATHY IN THE UPPER EXTREMITY
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THE BIG THREE
Median nerve
- Carpal Tunnel
- Anterior Interosseous Syndrome
- Pronator Syndrome
Radial Nerve
Radial Tunnel Syndrome
Posterior Interosseous Nerve Syndrome
Wartenberg's Syndrome
Ulnar Nerve
Cubital Tunnel
Ulnar Tunnel (Guyon’s Canal)

BASIC SCIENCE
• Compression of a peripheral nerve leads to a series of histopathologic changes
• Initially, decrease in epineural blood flow and axonal transport
• Axonal transport inhibited at 30mmHg
• Increased or sustained compression leads to increased endoneurial pressure, epineurial edema occurs, and complete axonal block results
BASIC SCIENCE

- Increased intraneural pressure is a result of disproportion between volume of nerve and the space thru which it passes.
- Degree of axonal injury proportional to duration and magnitude of compression.
  - 30 mmHg = Paresthesias
  - 50-60 mmHg = Complete sensory/motor block

Epidemiology

- Risk factors: Female, pregnancy, diabetes, hypothyroidism, RA
- Other factors: Middle age, gout, infection, ETOH, obesity, mucopolysaccharidosis, mucolipidosis
- Role of occupational and repetitive activities remains controversial.
- Tobacco use probably not associated

PHYSICAL EXAM

- Motor: Muscle strength grade 1 - 5
  - Mild compression = no measurable dysfunction
  - Moderate compression = muscle weakness
  - Severe compression = denervation and muscle wasting
PHYSICAL EXAM

- Sensory: threshold testing, innervation density testing
- Threshold tests a single nerve fiber. Useful in evaluation of subtle changes. Semmes-Weinstein monofilaments and vibrometry
- Innervation density tests evaluate overlapping sensory receptors. Static and moving 2-PD. Abnormal >5mm. Only in severe stages.

ELECTRICAL TESTING

- NCS and EMG - Gold standard for diagnosing most nerve compression syndromes

ELECTRICAL TESTING

- NCS Sensory nerve - Latency = time from stimulation to initial deflection recorded. Conduction velocity = divide length of tested nerve segment by latency.
**ELECTRICAL TESTING**

- **EMG** - Used to study activity of individual muscle fibers and motor units. Helpful in differentiating between primary nerve and muscle dysfunction, and partial or complete nerve dysfunction.
- Denervated muscles produce fibrillations about 3-5 weeks after nerve injury.

**DOUBLE CRUSH SYNDROME**

- Entrapment at one level can be associated with symptoms at a different level.
- Endoneurial edema alters axonal transport of nutrients distally. This disruption in neuronal transport lowers the threshold for compression symptoms at a different site on the same nerve.

**MEDIAN NERVE**

- Carpal tunnel syndrome
- Pronator syndrome
- Anterior interosseous nerve syndrome
CARPAL TUNNEL SYNDROME

- Median nerve compression at the wrist
- Most common compression neuropathy
- U.S. - >$1 billion annual medical costs
- >200,000 surgeries annually

CARPAL CANAL ANATOMY

- Scaphoid tubercle & trapezium > radially
- Hook of hamate & pisiform > ulnarily
- Transverse carpal ligament > "roof"
- Nine flexor tendons
- Median nerve

CARPAL CANAL ANATOMY

- Normal canal pressure 2.5mmHg (at rest with wrist neutral, and fingers extended)
- Can rise to 30mmHg with wrist flexion
- Average resting pressure in CTS 30mmHg, up to 90mmHg with wrist flexion. Up to 110mmHg in extension.
MEDIAL NERVE ANATOMY

MEDIAN NERVE ANATOMY

- Motor branch - variable, but most often extraligamentous
- Palmar branch - usually pierces antebrachial fascia to lie superficial to TCL (also variable)

REMEMBER

- Women > Men
- Age > 45-50
- Smoking — No
- Occupation — No
ETIOLOGY OF CTS

• Anatomic abnormalities
• Associated medical conditions
• Inflammatory factors
• Fluid imbalances
• Trauma
• Position

ANATOMIC ABNORMALITIES

• Congenital anomalies
  • Persistent median artery
  • Proximal lumbrical muscles
  • Distal sublimus muscles

ASSOCIATED MEDICAL CONDITIONS

• DJD Thyroid disease (hypothyroidism)
• Diabetes
• Pregnancy
INFLAMMATORY FACTORS

- Rheumatoid arthritis
- Gout
- Infection

FLUID BALANCE ABNORMALITIES

- Pregnancy
- Hemodialysis - (high correlation between the side of dialysis access, and side affected with CTS)

TRAUMATIC FACTORS

- Distal radius fractures
- Carpal dislocations
- Hematoma
**POSITIONAL FACTORS**

• BOTH FULL EXTENSION AND FULL FLEXION DECREASE THE SIZE OF THE CANAL, INCREASING THE PRESSURE IN THE CARPAL CANAL.

**CLINICAL PRESENTATION**

• Numbness, tingling, and pain - radial 3 1/2 digits. Weakness & clumsiness of grip.
• Pain may radiate proximally into forearm, arm, and shoulder
• Frequently awakens pt from sleep (positional)
• Worse with activities - gripping, writing, driving

**CLINICAL STAGING**

• Early (mild) CTS intermittent paresthesias, night sx
  wrist flexion may elicit sx
• Intermediate (moderate) CTS
  - more frequent paresthesias, worse with use
  Feeling of numbness, clumsiness
  - +/- weakness
• Advanced (severe) CTS
  constant impaired sensibility, severe pain
  Thenar atrophy, pinch/opposition weakness
PHYSICAL EXAM

- Decreased sensation to moving light touch
- Positive provocative tests
- Weakness of thenar muscles (OP, APB, FPB-sup. head)
- Thenar muscle wasting - late finding

PROVOCATIVE TESTS

- Tinel's
- Phalen's
- Reverse Phalen's
- Durkin's ~Sp 90%, Se 87%

NCV / EMG

- NCV
  - Distal sensory latency >3.5ms
  - Motor latency >4.2ms
  - Conduction velocity <52m/s
- EMG
  - Fibrillations, positive sharp waves, decreased amplitude of action potentials
- False negative
  - 8-25%
  - Yes, NCV/EMG negative CTS does exist!
TREATMENT

• Non-surgical - static night splints, orals, and steroid injections

Non- Op Treatment

• Night splints
  Effective – wrist in neutral position
  Not too tight!

• Steroid injections
  80% transient relief – days to months
  Only 20% get long-term relief (1 year)
  Most successful in pts with mild symptoms

Non-OP Treatment

• Oral therapies
  Vitamin B6 - no evidence to support use
  NSAIDs - no benefit
  Gabapentin - no benefit
  Corticosteroids - maybe short term
  Alpha lipoic acid - maybe short term
SURGICAL OPTIONS
• Considered for patients with persistent or progressive symptoms, despite non-operative treatment.
• Transient improvement following cortisone injection - good prognostic indicator for surgery.
• Motor denervation on EMG
• Thenar weakness/atrophy

SURGICAL OPTIONS
• Classic open release
• Mini open release
• Endoscopic release

SURGICAL OPTIONS
• Risks and long term outcomes equivalent regardless of technique - surgeons pref.
• Arguably less initial post op pain, and possibly earlier return to work with endoscopic procedure
• Most common cause for failure - incomplete release TCL
SURGICAL OPTIONS

• Unnecessary to perform:
  - internal neurolysis
  - tenosynovectomy
  - antebrachial fascia release
  - concomitant release of Guyon’s canal

POST OP CARE

• Splints – not necessary
• Hand therapy – not necessary
• Antibiotics – not necessary (pre or post-op)
• Return to work – controversial
  - depends on kind of work (Duh…)
  - 2-3 wks for mini-open. Probably sooner with endo (multiple studies)

COMPLICATIONS CTR

• Incomplete division of TCL
• Damage to PCBMN
• CRPS (RSD)
• Hypertrophic painful scar
• Hematoma
• Bowstringing
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REVISION CTR

• 50% experience some relief
• Adjunctive procedures
  - hypothenar fat pad flap
  - radial forearm fascial flap
  - radial artery perforator based flap

ANTERIOR INTEROSSEOUS NERVE SYNDROME

• AIN primarily a motor nerve
• Branches from median nerve 4 - 6 cm distal to elbow
• Passes between 2 heads of PT
• Supplies radial half of FDP (index & long), FPL, and PQ

AREAS OF COMPRESSION

• Multiple sites have been implicated
• Deep head of PT
• Origin of FDS – fibrous arch
• Edge of lacertus fibrosis
• Enlarged bicipital tendon bursa
• Accessory head of FPL (Gantzer’s muscle)
CLINICAL PRESENTATION

- Complains of ill defined forearm pain
- Inability to flex IP joint of thumb and DIP of index finger
- EMG/NCS helpful
- R/O Parsonage-Turner syndrome (bilateral)
- Weak forearm pronation

AINS

- Incomplete syndrome
  - common
  - isolated paralysis FPL and/or FDP 2
- Atypical presentations
  - AIN innervates entire FDP muscle
  - Ulnar nerve innervates FDP 2-5
  - Martin-Gruber (15% of limbs) (50% from AIN to ulnar nerve) may have some intrinsic muscle palsy

AINS - ddx

- Differential diagnosis
  - attritional rupture FPL or FDP (check tenodesis)
  - Brachial plexus neuropathy
  - Cervical spine etiology
- EMG/NCV
  - helps with localization
  - rules out other diagnoses
- Most common etiology --- Idiopathic
TREATMENT

Complete spontaneous recovery is common may take 6 - 12 months
• Consider surgery if no motor recovery after 3-6 months of observation.
• Surgical release of all potential sites of compression.
• Penetrating trauma – surgery
• Traction injury - observation

PRONATOR SYNDROME

• Potential sites of compression:
  • Lacertus fibrosus
  • Liagament of Struthers
  • Origin of FDS – fibrous arch
  • Pronator muscle

CLINICAL PRESENTATION

• Numbness and tingling as with CTS
• Numbness may extend to the palm in the PC branch distribution
• Pain can radiate into the volar forearm
• Night pain not typical complaint
PHYSICAL EXAM

- Palpate for supracondylar process of distal humerus, proximal to medial epicondyle
- Check for Tinel's over proximal volar forearm (+/- finding)
- May have some motor weakness
- Provocative maneuvers for each potential site of compression

PROVOCATIVE TESTS

- Lacertus fibrosus-
  resisted elbow flexion forearm supinated
- Pronator teres-
  resisted pronation elbow extended
- FDS- resisted flexion long finger PIP

EMG/NCS

- Generally misleading. Usually normal.
- Fibrillation potentials and positive sharp waves in pronator and FDS may aid in dx
- XRAY: Look for supra-condylar process on anterior-medial humerus
TREATMENT

• Activity modification - specifically those involving repetitive flexion/pronation
• Surgical release of all potential sites of compression yields good results.
  - Ligament of Struthers (if present)
  - Lacertus fibrosis
  - Fascia superficial head of pronator
  - Fascial arch of proximal FDS
• Literature reports 90% satisfactory results

RADIAL NERVE

• BRACHIAL COMPRESSION SYNDROME
• POSTERIOR INTEROSSEOUS NERVE SYNDROME
• RADIAL TUNNEL SYNDROME
• SENSORY RADIAL NERVE COMPRESSION

BRACHIAL COMPRESSION

• Compression at the arm, due to: humerus fx, tourniquet palsey, prolonged postural compression.
• Lateral intermuscular septum. As radial nerve passes from posterior to anterior compartment of the arm.
• Usually spontaneous recovery. If not by 3-4 months, neurolysis, nerve grafting, tendon transfers.
• Explore nerve in open humerus fx at time of ORF
PIN SYNDROME

• PIN supplies: supinator, ECRB, EDC, ECU, EDM, APL, EPB, EIP, and EPL
• 5 sites of potential compression: fibrous bands at ant. radial head, radial recurrent vessels (Leash of Henry), fibrous edge of ECRB, proximal edge of supinator (Arcade of Frohse- most common site), distal edge of supinator.

ETIOLOGY

• Repetitive forearm motion
  -Monteggia fx/dislocation
  -radial head fx-dislocation
  -blunt trauma
  -masses -lipomas, ganglion cysts,
    -idiopathic.

CLINICAL PRESENTATION

• Motor nerve, therefore no sensory complaints
• Difficulty with extension of MP joints of digits and IP joint of thumb (IP joints of fingers intact thru interosseous muscle innervation by ulnar nerve)
• Wrist extension with radial deviation, due to loss of ECU function. ECRL functions due to innervation proximally.
• DDX: RA tendon rupture or lead poisening
TREATMENT

• Activity modification and splinting first.
• Surgical treatment (after 12 weeks), involves release of involved structures.
• Patients continue to improve for up to 18 months after surgery

RADIAL TUNNEL SYNDROME

• Primarily a pain syndrome, NOT associated with motor or sensory deficits.
• Similar sites of compression to PIN syndrome. Most common site - Arcade of Frohse.

CLINICAL PRESENTATION

• Deep aching pain in the dorsal-radial forearm, in the radial neck region.
• Pain radiates from lateral elbow to dorsal wrist
• Tenderness to palpation of mobile wad over supinator arch.
• Pain with resisted supination - wrist in ext.
• Pain with passive pronation - wrist in flex.
• Night pain
Diagnostic tests

• EMG/NCT typically normal.
• Injection of local anesthetic radial tunnel region- pain relief and wrist drop = diagnostic.

TREATMENT

• Treatment similar to PIN syndrome.
• Conservative first
• Surgery if all else fails

RADIAL SENSORY NERVE COMPRESSION

• AKA: Wartenberg’s Syndrome, Cheiralgia Paresthetica
• Scissor like action of BR and ECRl tendons with pronation compress the nerve.
CLINICAL PRESENTATION

- Paresthesias in dorsal-radial aspect of hand.
- Ill defined pain in radial forearm and wrist.
- Repetitive wrist flexion and ulnar deviation may exacerbate the sxns.
- Tinel's over nerve
- Pain with forced pronation
- Diagnostic nerve block relieves pain.
- DDx: DeQuervain's

ETIOLOGY

- Direct blow
- Handcuffs
- Tight cast
- Tight watch band
- Ex.Fix. pins

TREATMENT

- Splinting and NSAIDs
- Steroid injection – 70% successful
- Avoiding offending activities
- Surgery rare. Involves neurolysis, and release of fascia between BR and ECRL. 80-85% reported success
ULNAR NERVE

- Cubital tunnel syndrome - elbow
  most common site of ulnar nerve compression
- Ulnar tunnel syndrome - wrist
  Guyon’s canal

CUBITAL TUNNEL SYNDROME

- Two most common sites of compression at the elbow:
  - Medial epicondylar groove
  - Two heads of FCU

CLINICAL PRESENTATION

- Numbness and tingling ulnar 2 digits
- Medial elbow pain, night pain, sx worse with elbow flexion
- Wartenberg’s sign - abducted small finger due to weakness of 3rd palmar interosseous m.
- Clawing of ulnar two digits - late finding
- Interosseous wasting - late finding
CLINICAL PRESENTATION

• Froment’s sign - weakness in thumb adduction with compensatory FPL flexion during pinch
• EMG/NCT - Slowing across the elbow and low amplitude sensory and motor action potentials
• Look for subluxation

TREATMENT

• NSAIDs (?) and night extension splints at 45 degrees and neutral rotation
• Surgical options:
  • In situ decompression
  • Medial epicondylectomy
  • Anterior transposition

SURGICAL OPTIONS

• Over the past 15 years, 438 articles

OUTCOME DATA:

- In situ: 86%
- Endo IS: 89%
- Med. Epi.: 89%
- A.T. subcut: 75%
- Intra muscular: 85%
- Sub muscular: 87%
IMPORTANT STUDY

- Meta-analysis of 4 retrospective clinical trials
- NO difference in clinical outcomes and motor conduction velocity, when in situ decompression and anterior transposition compared

BOTTOM LINE

- NO STATISTICALLY SUPERIOR TECHNIQUE
- Decision based on:
  - Surgeon preference
  - +/- subluxing nerve
  - S/P prior elbow surgery
  - Trauma
  - Etiology: DJD, RA, tumor, metabolic neuropathy

COMPLICATIONS

- Elbow flexion contracture
- Medial epicondylitis
- Neuroma (MABCN)
- Elbow instability
- Failed decompression
  - inadequate initial release
  - kinked nerve
  - consider other sites of compression
REVISION SURGERY
• Indications for re-operation
  - pain
  - progressive post op motor/sensory loss
  - Unchanged neurologic deficit +/- pain

REVISION SURGERY
• Submuscular transposition recommended
• Poor results associated with previous submuscular transposition
  Age >50
  EMG evidence of denervation
  ETOH/diabetes
  CRPS (RSD)

ULNAR TUNNEL SYNDROME
• Entrapment at the wrist, at Guyon’s canal
• Zone I - proximal to bifurcation
• Zone II - from deep motor branch to just past fibrous arch of hypothenar muscles
• Zone III - involves only superficial sensory branch
**CLINICAL PRESENTATION**

- No sensory deficit on dorsal aspect of hand (in contrast to cubital tunnel syndrome)
- Symptoms vary according to Zone of compression (Gelberman 1985)
  - Zone I - sensory symptoms and motor weakness
  - Zone II - only motor symptoms
  - Zone III - only sensory symptoms

**Etiology**

- Ganglion cysts - most common cause
  - Zone I - 86%
  - Zone II - 88%
- Repetitive trauma - bicycles, walkers
- Other - lipomas, ulnar artery thrombosis, hook of hamate fx, pisiform dislocation, inflammatory arthritis, congenital/fibrous bands

**DIAGNOSTIC TESTS**

- EMG/NCT - valuable in confirming diagnosis
- Xrays – carpal tunnel view
- MRI useful if xrays don’t confirm fx or if ganglion present
TREATMENT

• Padded gloves, splints
• NSAIDs +/-
• Avoiding provocative activities
• Surgical decompression of Guyon’s canal +/- release of hypothenar muscle origin
• Removal of space occupying lesions

OTHERS

• Lateral antebrachial cutaneous n. compression
• Thoracic outlet syndrome
• Suprascapular nerve compression
• Musculotaneous nerve compression
• Long thoracic nerve entrapment
• Spinal accessory nerve entrapment
• Axillary nerve entrapment (quadrilateral space)

REVIEW QUESTIONS
In Wartenberg’s syndrome, the RSN is felt to be compressed between which two tendons?

A. Brachioradialis and ECRL
B. Pronator teres and ECRL
C. APL and ECRL
D. Brachioradialis and ECRB
E. Abductor pollicis longus and extensor pollicis brevis

A. Brachioradialis and ECRL

The evidence in the literature suggests that AIN syndrome is best treated with:

A. Early surgical decompression
B. Immediate excision of the affected segment and nerve grafting
C. Observation
D. Early tendon transfers
E. ROM and strengthening therapy
C. Observation

A pt. has weakness in flexion of thumb IPJ and DIPJ of digits 2 & 3. There is no sensory deficit. Pathology is in which nerve?

A. MABC
B. LABC
C. Posterior interosseous
D. Anterior interosseous
E. Musculocutaneous

D. Anterior interosseous
THANK YOU!