1 Upper Extremity Compression Neuropathies
   • Bernard F. Hearon, M.D.
   • Clinical Assistant Professor, Department of Surgery
   • University of Kansas School of Medicine – Wichita
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2 www.drhearon.com
   education > residents’ file
   outline
   review questions
   references
3 Evidence-Based Practice
   Five Step Process
   • Ask a specific clinical question
   • Find best evidence to provide answer
   • Critically appraise the evidence usefulness
   • Integrate clinical expertise & patient values
   • Evaluate the outcomes
4 Levels of Evidence
   • 1 – Randomized, clinical trials w/clear results
   • 2 – Randomized trial w/uncertain results
   • 3 – Case-controlled studies
   • 4 – Case series w/o controls
   • 5 – Expert opinion w/o critical appraisal
5 Topic Outline
   • Introduction / Basics
   • Median Nerve Entrapment
   • Ulnar Nerve Entrapment
   • Radial Nerve Entrapment
6 Neuron Morphology
   • Neuron is functional unit
   • Cell body contains nucleus
   • Motor (anterior horn of cord)
   • Sensory (dorsal root ganglion)
   • Axon propagates action potentials (APs)
   • Myelin insulates the axons
7 Myelin Speeds Action Potentials
8 Pathophysiology of Nerve Compression
   • Increased external pressure
   • Decreased microvascular blood flow
   • Blood-nerve homeostasis disrupted
   • Perineural edema, inflammation, fibrosis
   • Localized, then diffuse demyelination
   • Axonal injury, Wallerian degeneration
9 Nerve Conduction Study (NCS)
- Electrophysiologic evaluation of nerve
- Electrical gradients from nerve depolarization
- Sensory nerve action potential (SNAP)
- Compound motor action potential (CMAP)

10 Nerve Conduction Study – Limitations
- Evaluates only large myelinated axons
- Unmyelinated axons are first affected
- May have normal latency w/disease
- May also have false positive result
- Study quality is examiner dependent

11 Electromyography (EMG)
- Evaluates muscle activity as action potentials
- Voluntary activity measured as MUPs
- Fibrillations are earliest sign of denervation
- High amp, long duration MUPs > neuro pathology

12 Carpal Tunnel Syndrome – Risk Factors
- Obesity
- Hypothyroidism
- Diabetes (14–30%)
- Pregnancy (50%)
- Renal disease
- Inflammatory arthritis
- Mucopolysaccharidoses
- Gender (3:1, women: men)
- Advanced age (> 50 yrs)
- Genetic factors

13 CTS – Pathogenesis
- Idiopathic
- Structural
- Systemic

14 CTS and Occupation
- Work compensable issue is controversial
- Increased incidence CTS w/certain occupations
- Positional, mechanical & repetitive stress
- Hand–held vibrating tools are causative
- Keyboarding is not causative
- Trend is to declare work an aggravating factor

15 CTS: Study of Carpal Canal Pressures
Gelberman et al., JBJS 1981, 63–A: 380–3
- Intracarpal canal pressures by wick catheter
- 15 patient w/CTS; 12 control subjects
- Wrist in neutral: 32 mmHg vs. 2.5 in controls
- VF: 94 vs. 31 mmHg; DF: 110 vs. 30 mmHg
• Canal pressure reduced w/CTR

16 CTS is Clinical Diagnosis
• Median nerve compression in carpal tunnel
• Median paresthesia aggravated by grasping
• Nocturnal paresthesia, morning numbness
• Symptoms relieved by shaking the hand
• Grip weakness, fatigue (thenar intrinsics)

17 Physical Findings in CTS
• Sensory tests (Semmes–Weinstein, 2 PD)
• Provocative tests (Phalen’s, Tinel’s, Durkan’s)
• Motor tests (FPB strength, thenar atrophy)

18 EMG/NCS is Confirmatory Test
• Quantifies disease severity
• Serves as a preop baseline
• In early CTS, study is normal
• Distal sensory latency > 3.5 ms
• Distal motor latency > 4.5 ms
• Fibrillation potentials, abn MUPs

19 Nonsurgical Treatment
• Night splinting, wrist in neutral
• Oral NSAIDs
• Corticosteroid injections
• Ultrasound

20 EBM: Nonsurgical Treatment of CTS
• Splinting better than no treatment (3 months)
• Oral steroids helped up to 8 weeks
• Steroid injection may help 6 months and has prognostic significance
• Ultrasound may be beneficial

21 Difficult to Avoid Nerve During Carpal Tunnel Injection
• Ulnar to palmaris longus, needle pierced median nerve in 4/15 specimens and was 1.34mm from median nerve
• Ulnar to FCR, needle pierced median nerve in 1/15 specimens but was 1.74mm from palmar cutaneous branch

22 Methods of Carpal Tunnel Release
• Open CTR
• Mini–open CTR
• Endoscopic CTR

23 EBM: Endoscopic Versus Open Carpal Tunnel Release
• ECTR better for earlier RTW, grip strength
• ECTR higher risk neurapraxia, revision surgery
• No difference in risk of major nerve injury
• No clinical difference in long–term outcome

24 Open Carpal Tunnel Release – Technique
• Regional or local anesthesia
• Loupe magnification (2.5x – 4.5x)
• Incision 3 cm mid-palm in line w/radial ring
• Divide entire TCL under direct vision
• Inspect for anomalies
• Deflate tourniquet, hemostasis, closure, splint

25 Not Required
• Release Guyon’s canal
• Step-cut lengthening TCL
• Flexor tenosynovectomy
• External epineurotomy
• Internal neurolysis
• Preserve subcutaneous nerves

26 Median Nerve Variations
• Multiple divisions (persistent median artery)
• Motor branch variants (extra-, sub-, trans-, or intra-ligamentous)
• Associated with aberrant muscles / tendons (palmaris profundus, reverse palmaris longus)
• Neural loops (median to ulnar cross-over innervation or anastomosis)

27 Postoperative Protocol
• Immediate digital motion
• Wrist motion in 2–3 days
• Sutures out at 14 days
• Doctor–patient therapy
• Full activity 6–8 weeks

28 CTS – Treatment Complications
• Nerve injection
• Hypertrophic / painful scar
• Incomplete decompression
• Hematoma
• Artery, nerve, tendon injury
• Perineural scar
• Bowstringing flexors
• Persistent / recurrent symptoms
• Complex Regional Pain Syndrome

29 Recalcitrant CTS
• Persistent symptoms
• Recurrent symptoms
• New symptoms

30 Revision CTR
• Longer incision
• Repeat TCL release
• Dissect from normal to abnormal
• Epineurotomy (external, internal)
• Neuroma turn back
• Protect nerve from new scar (hypothenar fat flap)
31 Median Nerve Compression in the Forearm
- Pronator Syndrome (sensory, distinguish from CTS)
- Anterior Interosseous Nerve Syndrome (primarily motor, distinguish from Parsonage–Turner or FPL rupture)

32 Pronator Syndrome
- Clinical diagnosis
- Compression test at pronator teres
- Resisted forearm pronation is provocative
- Decreased senation at thenar eminence
- Electrodiagnostics are not helpful
- XR may show supracondylar process

33 Five Potential Points of Median Nerve Compression
- Ligament of Struthers
- Bicipital Aponeurosis
- Lacertus Fibrosis
- Pronator Teres
- Proximal FDS Arch

34 AIN Syndrome
- Weakness index FDP, FPL, PQ
- Difficulty writing, clumsiness
- If associated with pain, observe
- If tumor or trauma, decompress
- Unable to make “OK” sign
- EMG/NCS is confirmatory

35 Possible Anatomic Causes
- Deep head PT
- FDS arch
- Gantzer’s accessory FPL
- Variant muscles
- Aberrant vessels

36 Pronator or AIN Syndrome – Conservative Treatment
- Activity modification
- NSAIDs
- Corticosteroid injection
- Minimum 3–month trial
- Highly effective

37 Surgical Decompression
- Surgeon at patient’s head
- Release all compression points
- Bloodless dissection
- Light, compressive dressing
- Early elbow & wrist motion
- Activity modification 4–6 weeks

38 Cubital Tunnel Anatomy
• Medial epicondyle
• Olecranon
• Floor – elbow, UCL
• Roof – retinaculum

39 Osborne’s Ligament – O’Driscoll’s Classification
• Type 0 – Absent
• Type 1A – Tight in full elbow flexion
• Type 1B – Tight in 90–120 deg arc
• Type 2 – anconeus epitrochlearis

40 Ulnar Nerve at Elbow is Susceptible to Neuropathy
• Anatomy is unlike radial and median nerves
• Superficial – vulnerable to mechanical stress
• Posterior – traction increases w/elbow flexion
• Treatment must address anatomic factors

41 Changes in Ulnar Nerve Pressure & Cubital Tunnel Area with Elbow Flexion
Gelberman et al., JBJS 1998, 80A: 492–501
• Cadaveric study measuring pressures, area
• Cross-sectional area cubital tunnel decreased
• Intraneural pressure increased > extraneural
• Traction causes increase intraneural pressure

42 Five Potential Points of Ulnar Nerve Compression
• Arcade of Struthers
• Medial IM septum
• Medial epicondyle
• Cubital tunnel
• Osborne’s fascia

43 CuTS – Etiology
• Idiopathic
• Intrinsic anomalies
• Occupational
• Trauma
• Post-traumatic deformities
• Elbow osteoarthritis
• Ganglia, tumors, RA
• Post-operative
• Heterotopic ossification
• Elbow UCL instability

44 CuTS is Clinical Diagnosis
• Paresthesia in ulnar distribution
• Elbow flexion is provocative
• Achiness medial elbow / forearm
• Paresthesia progresses to constant
• Loss of pinch & dexterity
Clinical Findings in CuTS
- Ulnar n. subluxation w/elbow flexion
- Tinel’s sign is overly sensitive
- Passive elbow flexion test
- Elbow flexion w/digital pressure
- Prolonged static 2–PD
- Intrinsic muscle weakness, atrophy

McGowan Grading Scale
- Grade I – Mild symptoms, intermittent paresthesia, no motor changes
- Grade II – Persistent paresthesia, mild intrinsic weakness, atrophy
- Grade III – Persistent sensory symptoms, marked intrinsic weakness, atrophy

EMG / NCS is Confirmatory
- > 50 m/sec is normal; < 50 m/sec, abnormal
- 15–25% reduction in velocity is diagnostic
- 40–50 m/sec range, often observe, serial exam
- < 40 m/sec, often require operative treatment
- Positive EMG indicates severe entrapment

CuTS – Differential Diagnosis
- Cervical disc disease
- Syringomyelia
- Thoracic outlet syndrome
- Pancoast’s tumor
- Double crush syndrome
- Guillain–Barre syndrome
- Amyotrophic lateral sclerosis

CuTS Non–Operative Rx
- Avoid provocative position, activity
- Pressure-absorbing elbow pad
- Figure-of-eight towel at night
- Night splint w/elbow flexed 60 deg
- 50% improve if CuTS is mild

Operative Indications
- Intermittent ulnar paresthesia, 6 months
- Constant ulnar paresthesia
- Symptomatic ulnar nerve subluxation
- Demonstrable ulnar motor weakness
- Prolonged static 2–PD, ulnar distribution
- Positive EMG / NCS

Ulnar Nerve Decompression – Techniques
- Simple in situ decompression
- Arthroscopic–assisted decompression
- Medial epicondylectomy (King & Morgan)
- Subcutaneous transposition (Curtis)
- Submuscular transposition (Learmonth)
• Intramuscular transposition (Adson)
• Transmuscular transposition (Dellon)

52 Intraneural Ulnar Nerve Pressure Related to Technique for Cubital Tunnel Decompression
Dellon et al., JHS 1994, 19A: 923–30
• 50 fresh human cadavers
• Pressures measured at different nerve locations and in varying degrees elbow flexion
• All surgical techniques elevated pressure except anterior transmuscular transposition
• True for all sites in all positions of elbow flexion

53 Extraneural & Intraneural Arterial Anatomy of Ulnar Nerve at Elbow
Yamaguchi et al., JSES 1999, 8: 17–21
• 22 fresh human cadaveric arms
• Consistent extra- & intraneural blood supply
• Superior & inferior ulnar collateral arteries & posterior ulnar recurrent artery
• Dense intraneural collaterals at cubital tunnel

54 Anterior transmuscular transposition of the ulnar nerve in lateral decubitus position for cubital tunnel syndrome

55 Lateral Decubitus
• General anesthesia
• Bean bag stabilization
• Padded arm support
• Sterile tourniquet
• 2.5 x loupes
• Surgeon standing

56 Advantages of Lateral Decubitus
• Familiar position
• Front door to elbow
• Frees first assistant
• Avoids MABC
• Best view ulnar nerve
• Allows open CTR

57 Postoperative Protocol
• Drain removed 3 days postop
• Neoprene compression sleeve
• Early active elbow ROM
• No elbow stiffness
• OT for strengthening 4–6 weeks
• Full activity at 2–3 months

58 Operative Findings in Reoperations for Cubital Tunnel Syndrome
Mackinnon & Novak; Hand 2007; 2: 137–43
Retrospective study 100 pts (1995–2001)
New ulnar nerve symptoms (55%)
New pain in MABC distribution (55%)
Ulnar nerve distal kinking at FCU (57%)
MABC neuromas (73%)
Medial IM Septum – 39%
Flexor–Pronator Bands – 30%
Ulnar Nerve at Medial Epicondyle – 50%

Mackinnon’s Lessons Learned
- All techniques may be successful
- Meticulous execution more important than technique
- If transpose, leave nerve in straight line, no kinks
- If decompress, nerve must be stable, no subluxation
- With all techniques, avoid traumatizing MABC nerve

My procedure of choice for primary or recurrent ulnar nerve entrapment (or subluxation) at the elbow is transmucular transposition

EBM: Three Level I Studies Suggest No Outcome Difference Between Simple Decompression and Transposition
- Three randomized, controlled clinical trials
- Nabhan (2005): No difference SD vs SQT
- Gervasio (2005): No difference SD vs SMT
- Biggs (2006): No difference SD vs SMT
- Chung now does SD as procedure of choice due to simplicity, potential faster recovery

Problems with Simple Decompression
- 33% of my cases of ulnar neuropathy at the elbow are due to nerve subluxation
- Requires intraoperative assessment of nerve subluxation after decompression (not always easy or straightforward)
- Anterior transposition requires much more operative time than simple decompression
- Simple decompressions with nerve initially stable may progress to subluxation over time

Simple decompression of the ulnar nerve at the elbow may result in late ulnar nerve subluxation requiring operative treatment

Ulnar Tunnel Syndrome – Causes
- Ganglia (triquetrohamate joint)
- Anomalous muscles
- Ulnar artery thrombosis
- Pseudoaneurysms
- Fractures hook of hamate
- Ulnar nerve subluxation
65 Guyon’s Canal Decompression
- Volar carpal ligament
- Pisohamate ligament
- Fibrous arch hypothenars
- Hook of hamate

66 Radial Tunnel Syndrome
- Controversial diagnosis
- Lateral proximal forearm pain
- Distinguish from lateral epicondylosis
- ECRB tendinous origin implicated
- Electrodiagnostics not helpful
- Injection may confirm diagnosis

67 PIN Syndrome
- Motor deficit (no sensory loss)
- Weakness wrist & digital extension
- Wrist radial deviation on extension
- Positive compression test at supinator
- Causes: Trauma, inflammation, mass, entrapment, iatrogenic

68 Five Potential Points of Radial Nerve Compression
- Fascia anterior to radiocapitellar joint
- Leash of Henry (radial recurrent branches)
- Fibrous origin or leading edge of ECRB
- Arcade of Froshe (leading edge supinator)
- Trailing edge of supinator

69 Nonsurgical Treatment
- Activity modification
- Stretching
- NSAIDs
- Corticosteroid injection
- 3 months observation

70 PIN Decompression – Approaches
- Transmuscular (BR-splitting)
- BR–ECRL (Mackinnon)
- Posterior (Thompson)
- Anterior (modified Henry)

71 Anterior Approach
- Surgeon sits in axilla
- Find SRN beneath BR and dissect proximally
- Find PIN and release all compression points
- Arcade of Froshe (leading edge supinator)
- Compression dressing, early motion
- Activity modification 4–6 weeks

72 Wartenberg’s Syndrome
- Cheiralgia paresthetica
- Direct compression SRN
- Between BR and ECRL
- SRN compressed in pronation
- Distinguish from deQuervain’s
- Differentiate from LABC

73 Radial Sensory Nerve Release
- Divide forearm fascia
- Window BR tendon
- Release SRN proximal & distal

74 www.drhearon.com
- education > residents’ file
- outline
- review questions
- references