ULNAR NERVE

Course of ulnar nerve (UN): (Dumitru pp 876-880)
Roots: (Grant p 476)
  C8: From between the C7 and T1 vertebra
  T1: From between the T1 & T2 vertebra. Posteriorly the T1 root is below the first rib, where the rib meets the vertebra. Anteriorly the T1 root is above the first rib, between the first rib inferiorly & the clavicle superiorly. (Potential site of compression at apex of lung)

Lower trunk: Formed by the C8 & T1 roots, after the roots pass between the anterior and middle scalene muscles, between the edge of the first rib inferiorly & clavicle superiorly (Potential site of entrapment between the anterior and middle scalene muscles [both insert into first rib] )

Anterior division of lower trunk: Begins after the lower trunk has crossed the first rib

Medial cord: Formed from the anterior division of the lower trunk in the axilla (Hollinshead p 226)

Ulnar nerve (UN) begins at lower border of pec minor near corocoid process

Descends arm medial to:
  Distal axillary artery &
  Brachial artery (The axillary artery becomes the brachial artery at the distal teres major)

With above arteries, the ulnar nerve located anterior to the intermuscular septum. The intermuscular septum passes between the humerus & the fascia surrounding the triceps muscle (epimysium) separating the arm into anterior and posterior compartments. Lies, and is covered and tightly bound to the medial head of triceps by arcade of Struthers (present in about 70% of individuals, Dumitru p876-9)

Passes through the intermuscular septum (Potential site of entrapment), into posterior compartment of the arm, at distal end of the insertion of the corocobrachialis. At this point septum is called the internal brachial ligament.

In 0.7% to 2.7% of individuals, the ulnar nerve passes under (Potential site of entrapment), a fibrous structure (ligament of Struthers) from an aberrant spur at the distal humerus to the medial epicondyle, located about 3-6 cm proximal to the medial epicondyle (Dumitru pp 861-2 & Dawson p 98).

Passes within the postcondylar (retroepicondylar) groove (Potential site of entrapment), posterior to the medial epicondyle and medial to olecranon (at a line drawn between the medial epicondyle and the olecranon). 18 % sublux (Campbell 1991 p 735)

Passes between the tendonous fibrous arch of the two heads of the flexor carpi ulnaris (FCU) (Potential site of entrapment). This arch is preferably called the humeroulnar arcade rather than the cubital tunnel. The arcade is located 0.3 to 2cm from the retrocondylar groove

Exits from the deep surface of the FCU at the the deep flexor pronator aponeurosis (DFPA) (Potential site of entrapment). The exit of the ulnar nerve from the deep aspect of the FCU is from 2.8cm to 6.9cm from the retrocondylar groove (Campbell 1991 p 734)

Passes down the forearm between the FCU and flexor digitorum profundus

Proximal to the wrist the ulnar nerve gives off:
  Palmar cutaneous branch arises from UN prox to dorsal cutaneous; supplies the ulnar palmar hand
Passes, with the ulnar artery, into hand between the pisiform and hook of the hamate superficial to the transverse carpal ligament (piso-hamate ligament) and beneath the thin volar carpal ligament and the palmaris brevis. The space between the transverse carpal ligament and the thin volar carpal ligament and the palmaris brevis is called Guyons canal (Potential site of entrapment). (Dumitru p 877-9)

At level of Guyon canal ulnar splits into deep & superficial branches (Potential site of entrapments). Muscles that should be tested to localize lesions related to ulnar nerve symptoms (Dumitru 877-9) (MMT):
1. Weakness of ext dig longus (EDL) & ext carpi uln (ECU) places lesion at root or lower trunk level
2. Weakness of superficialis & median profundus places lesion at least at medial cord level
3. Ulnar nerve:
   a. None in arm (8% of cadavers, FCU supplied proximal to tip of medial epicondyle Campbell 1989p 965)
   b. FCU usually supplied just distal to medial epicondyle
   c. Flexor digitorum profundus supplied distal to FCU
   d. Superficial branch usually supplies the palmaris brevis; 25% branch to
   e. Deep branch first usually (50%) supplies the abductor digiti minimi (ADM) (25% branch to ADM arises from UN prior to split into deep & superficial branch; 25% branch to ADM arises from between deep & superficial branch) and the flexor digiti minimi and then passes around the hook of the hamate to supply the remaining ulnar innervated hand muscles

Cutaneous supply (Sensory Exam):
1. Medial brachial cutaneous supplies skin over medial arm
2. Medial antebrachial cutaneous supplies skin over medial aspect of forearm
3. Palmar cutaneous supplies skin over hypothenar muscles
4. Dorsal cutaneous supplies the dorsal ulnar skin over the back of the hand, the dorsum of the little finger to the base of the fingernail and the ulnar half of the ring finger to the middle phalanx
5. Superficial branch supplies: the palmar aspect of the little finger; ulnar half of the middle and distal phalanges of the ring finger (dorsal and palmar): and the dorsal tip of the little finger

Potential sites of involvement in the differential diagnosis of ulnar compression/entrapment
1. Proximal to elbow
   a. Roots: Apex of lung
   b. Plexus
      Between middle and anterior scalenes
      Between clavicle & first rib
   c. Intermuscular septum: Arcade of Struthers
   d. Ligament of Struthers
2. Elbow/Forearm
   a. Postcondylar groove = retroepicondylar groove
   b. Cubital tunnel (humeroulnar arcade)
   c. Deep flexor pronator aponeurosis where the ulnar nerve exits from the deep surface of FCU
3. Wrist (Modified from Shea 1969 by Oh 1993)
   Type I. Proximal Guyon canal (motor & sensory)
   Type II. Distal Guyon canal (motor including ADM; no sensory involvement)
   Type III. Hook of hamate (motor exclusive of ADM; no sensory involvement)
   Type IV. Within palmaris brevis (sensory only)

Clinical signs
C8 Root:
Decrease motor power (among other muscles):
Radial: ECU; EDL  
Median: FDS; FDP; FPL; APB  
Ulnar: FCU; FDP; ADM; Interossei; AddP  
If posterior root involved: Decreased sensation ulnar fingers and forearm

T1 Root:  
Horners  
Decrease motor power  
Median: FDS; FDP; FPL; APB  
Ulnar: FCU; FDP; ADM; Interossei; AddP  
If posterior root involved: Decreased sensation ulnar elbow and arm

Plexus:  
Lower trunk  
Decrease motor power  
Radial: ECU; EDL  
Median: FDS; FDP; FPL; APB  
Ulnar: FCU; FDP; ADM; Interossei; AddP  
Decreased sensation medial arm & forearm & ulnar aspect of hand & little & half of ring fingers

Medial Cord  
Decrease motor power  
Median: FDS; FDP; FPL; APB  
Ulnar: FCU; FDP; ADM; Interossei; AddP  
Decreased sensation medial arm & forearm & ulnar aspect of hand & little & half of ring fingers

Ulnar nerve  
Arm between axilla & epicondyle at intermuscular septum or Ligament of Struthers  
Decrease motor power: FCU; FDP; ADM; Interossei; AddP  
Decreased sensation ulnar aspect of hand & little & half of ring fingers  
Elbow/forearm at: retrocondylar groove, humeroulnar arcade & deep flexor pronator aponeurosis  
Decrease motor power: FDP (sometimes); ADM; Interossei; AddP  
Decreased sensation ulnar aspect of hand & little & half of ring fingers  
Wrist:  
Guyons canal (motor & sensory)  
Decrease motor power: ADM; Interossei; AddP  
Decreased sensation palmar ulnar half of ring finger and little finger  
Within palmaris brevis (sensory): Decreased sensation palmar ulnar half of ring finger, little finger  
Hook of hamate (motor): Decrease motor power: Interossei; AddP

Conduction studies in evaluating differential diagnosis of ulnar neuropathy  
Proximal to elbow  
Roots:  
Motor  
Abnormal amplitude if sufficient axon loss and done early  
Normal CV  
Sensory: Conduction studies only of value if the patient has decreased sensation. Then if amplitudes are normal the lesion must be proximal to the dorsal root ganglion.

Plexus  
Abnormal (If axonal death of fastest conducting axons)  
Distal sensory latency
Dorsal ulnar cutaneous
Medial antebrachial cutaneous
Estimated F wave based on motor conduction from elbow to wrist
(No faith in root stimulation)
Normal (if no axonal death of fastest conducting axons)
Sensory conduction across elbow
Motor conduction across elbow
Motor conduction from axilla to above elbow
Mixed conduction from above elbow to axilla

Arcade of Struthers (AS) & medial intramuscular septum (IMS)
Abnormal (If axonal death of fastest conducting axons)
Distal sensory latency
Dorsal ulnar cutaneous
Motor conduction from axilla to above elbow (distal to AS & IMS)
Mixed conduction from above elbow to axilla
Estimated F wave based on motor conduction velocity from elbow to wrist
Normal (if no axonal death of fastest conducting axons)
Sensory conduction across elbow
Motor conduction across elbow
Medial antebrachial cutaneous

Elbow/Forearm
Postcondylar (retroepicondylar) groove
Abnormal
Distal sensory latency
Dorsal ulnar cutaneous
Sensory conduction across elbow
Motor conduction across elbow
Mixed conduction from below elbow to axilla
Normal medial antebrachial cutaneous

Cubital tunnel (Humeroulnar arcade {HUA})
Abnormal
Distal sensory latency
Dorsal ulnar cutaneous
Sensory conduction across humeroulnar arcade
Motor conduction across humeroulnar arcade
Mixed conduction across the HUA from below elbow to axilla
Normal medial antebrachial cutaneous
Normal
Sensory conduction across elbow
Motor conduction across elbow
Mixed conduction from below elbow to axilla
Medial antebrachial cutaneous

Deep flexor pronator aponeurosis (DFPA)
Abnormal
Distal sensory latency
Dorsal ulnar cutaneous
Sensory conduction from below humeroulnar arcade to wrist
Motor conduction across from below humeroulnar arcade to wrist
Mixed conduction across the HUA from below elbow to axilla
Normal medial antebrachial cutaneous

Normal
Sensory conduction across retroepicondylar groove
Motor conduction across retroepicondylar groove
Mixed conduction from below retroepicondylar groove to axilla
Medial antebrachial cutaneous

Wrist:
Guyons canal (motor & sensory)
Abnormal:
Distal sensory latency
Distal motor latency
Normal: Dorsal ulnar cutaneous

Within palmaris brevis (sensory):
Abnormal: Distal sensory latency
Normal:
Dorsal ulnar cutaneous
Motor conduction

Hook of hamate (motor):
Abnormal:
Distal latency to first dorsal
(I have no faith in latency with recording over the first dorsal because of volume conduction from all other interossei and the addusator pollicis)
Normal:
Distal sensory latency to little finger
Distal motor latency to abductor digiti minimi

Needle EMG:
Abnormal in same muscles as anticipated clinical weakness.
With ulnar neuropathies FCU usually normal because (Campbell 1989 p 966-7)
Fascicles that innervate FCU are deep
Most distal muscles as the 1st dorsal are more likely abnormal

Ulnar
Stimulation (motor & sensory) with elbow bent 70 to 90 degrees (AAEM p409, Dawson p 145)
Wrist just lateral or medial to the FCU; 8cm proximal to G1
Elbow:
Distal: 3cm distal to retrocondylar groove
Proximal: > 10cm proximal to distal stim point but be sure not to stimulate median nerve
Axilla: Kimura 1989 pg. 114 ( ≥54m/s)

Motor
Recording electrodes
G1 over middle of ADM
G2 over tendon of ADM
Response usually 2 humps because all the ulnar hand muscles contribute to the CMAP
Values:
Distal:
Latency <3.6 (Bushbacher 1999 p. S11), 3.3ms (@ 34⁰ Falco 1992 & @ 32 degrees Olney 1985)
Amplitude greater than 2.8mV(Kimura 1989 p 114); & ≥ 5mV (Olney 1985 p 17)
Side to side difference:
  Latency: 0.6ms (Bushbacher 1999 pg. S12); 0.8ms (Kimura 1989 pg 114)
  Amplitude: 97th percentile- 25%; 100th percentile 39% (Bushbacher 1999 pg. S12)
Conduction velocity (C.V.)
  50m/s below elbow to wrist (Kimura 1989 pg 114)
  ≥ 50 m/s across elbow (AAEM 1999 p 410 & ≥ 53 Kimura 1989 pg. 114)
  ≤ 10m/s difference between below & above elbow C.V. (AAEM 1999 p 410)
  ≥ 54 m/s axilla to above elbow (Kimura 1989 pg. 114)
Amplitude:drop across elbow: ≤ 20% (AAEM 1999 p 410); ≤ 25% (Dawson p 146)

Inching from 6 cm above medial epicondyle to 8 cm below medial epicondyle
  ≤ .4ms between two successive 1 cm segments (Campbell 1992 p 1053)
  ≤ .63 ms between two successive 2 cm segments (Kanakamedala 1988)

Sensory
  Recording
    G1 at PIP crease
    G2 as far distal without ring falling off finger
    Spread fingers to prevent volume conduction from ring interossei
  Values:
    Distal:
      Peak latency ≤ 3.5ms ( amp ≥ 10uV Nesathurai Arch Phys Med Rehabil 1999; 80:756)
      (Bushbacher 1999 p S65: latency ≤ 4.1)
    Side to side difference: Bushbacher 1999 p S65: peak latency ≤ 0.5ms & peak to peak drop in amp: 97th percentile= 64%; 100th percentile = 74%
    Conduction velocity above elbow -wrist ≥ 50m/s (Melvin 1950 Table 2, ≥ 53 Kimura 1989p114)

Conduction to electrode over first dorsal (I do not perform this conduction)
  Recording electrodes (Olney 1985)
    G1 over middle of 1 st dorsal where the amplitude is maximal
    G2 over second metacarpalphalangeal joint (MCP)
  Values:
    Latency: <4.4ms @ 32⁰ latency variable from 20 to 70 yrs of age (Olney 1985 p17)
    ≤ 2ms more than latency to ADM
    Amplitude ≥ 6 mV (Olney 1985 p 17)

Medial antebrachial cutaneous (MABC)
  Stimulation: 5 cm proximal to halfway point between bicipital tendon & medial epicondyle. Use 0.1 ms pulse and hold cathode lightly on skin
  Recording:
    Use bar
    G1: 8 cm from the halfway point between the bicipital tendon & medial epicondyle on a line drawn from cathode to pisiform
  Onset latency: < 2.7 ms
  Peak to peak amplitude: ≥ 8 uV (Ma 1983 pg 146)

Dorsal ulnar cutaneous (DUC)
  Stimulation:
    Between flexor carpi ulnaris and ulna
    Cathode 8 cm proximal to G1 with 0.1ms pulse duration
  Recording:
Bar recording
G2 at base of “V” between the 4th & 5th metacarpal phalangeal joints
G1 proximal to G2 between 4th & 5th metacarpals
Latency to negative peak < 2.6 ms;
Amplitude: (onset to peak) $\geq 8uV$ (Jabre’s method from Oh p 201) & compare to uninvolved side
< 6uV peak to peak and interside ratio $> 1.66$ (Seror 2002)
Use when consideration is: Where is ulnar lesion wrist or elbow?)
1. if DUC normal & conventional distal ulnar cutaneous is abnormal this confirms ulnar lesion at wrist
2. if DUC is abnormal then the ulnar lesion is at the elbow

F wave (Modified from Mayo Course Handout)
Stimulation
Pulse duration: Use same as for motor conduction studies
Pulse frequency: no more frequent than 1 per 2 sec (Fisher 1992)
Cathode placed same as for motor conduction studies
Recording
G1, G2 & ground electrodes positioned same as for motor conduction studies
Sensivity (Gain)
M wave: 1mV to 10mV per vertical division
F wave: 0.2mV to 0.5mV per vertical division
Sweep speed
Uppers: 5ms per horizontal division
Lowers: 10 ms per horizontal division
Response
Fastest latency of 10 responses (Fisher 1992)
Abnormal side-to-side difference stimulating & recording distally:
$> 2ms$ (Dumitru p195)
$> 3ms$ Mayo course
Absolute
Stimulation site: Wrist 8cm from G1
Record: ADM or APB
Measurements (Weber & Piero 1978 p467)
Arm: 30 deg abd
Measure forearm CV from elbow to wrist
Add 5msec to normogram (see next page) for upper limit of normal:

F wave
(Mayo Course Handout)
Stimulation site: 8cm from G1
Record: APB or ADM
Distance: From Sternoclavicular joint to cathode stimulation point at wrist

F wave latency should be no more than 3msec longer than estimated F wave (F est)
$F_{est} = 2 \times \text{distance to wrist stimulation site from sternoclavicular joint (mm)} + DL(\text{ms})$
\text{conduction velocity (mm/ms)}$
\text{i.e. Abnormal upper extremity F wave using hand muscles with wrist stimulation:}$

$\geq 2 \times \text{distance to wrist stimulation site from sternoclavicular joint (mm)} + DL(\text{ms}) + 3\text{ms}$
\text{conduction velocity (mm/ms)}$

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Melvin JL, Harris DH, Johnson EW. Sensory and motor conduction velocities in the ulnar and median nerves. Arch Phys Med Rehabil 1966; 47: 511-9


ULNAR NERVE CONTINUED

LIGAMENT OF STRUTHERS
About 3 - 6 cm proximal to retrocondylar groove

HUMEROULNAR ARCADE
About 0.3 to 2 cm distal to retrocondylar groove

DORSAL CUTANEOUS
About 5 cm to 10 cm proximal to pisiform

RETROCONDYLAR GROOVE

SUPERFICIAL BRANCH

PI SIFORM

DORSAL CUTANEOUS
APONEUROSIS
2.8 cm to 6.9 cm distal to retrocondylar groove

HUMEROULNAR ARCADE
About 0.3 to 2 cm distal to retrocondylar groove

DEEP FLEXOR PRONATOR
APONEUROSIS
2.8 cm to 6.9 cm distal to retrocondylar groove

DEEP BRANCH

HOOK OF HAMATE

PALMAR CUTANEOUS

ADM