Peripheral Neuropathies (GENERAL)  

Last updated: December 19, 2020

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**CLASSIFICATIONS**

N.B. *diabetes can cause any type / category of neuropathy!!!*

A. **Axonal neuropathies** (e.g. lead, dopamine, tick bite, porphyria, diphtheria, some cases of Guillain-Barré syndrome, anti-GM antibodies = motor axonal neuropathy associated with multiple conduction blocks).

B. **Demyelinating neuropathies** (e.g. dorsal root ganglionitis, leprosy, HIV, chronic vit.B12 intoxication or deficiency, arsenic, thallium, hypothyroidism).

C. **Autoimmune** neuropathies (e.g. pure autonomic failure, pure adrenergic neuropathy, amyloidosis).

D. **Mixed** neuropathies

A. **Axonal neuropathies**

B. **Demyelinating neuropathies:**

1. Inflammatory neuropathies
2. Neuropathies associated with paraproteinemia
3. Inherited disorders of myelin
4. Many neuropathies have admixture of both axonal degeneration and demyelination.

N.B. **clinically axonal and demyelinating neuropathies may be identical; differentiated only by nerve conduction studies & EMG.** See below >> and p. D220++

**POLYNEUROPATHY**

**MONONEUROPATHY**

**MONONEUROPATHY MULTIPLEX**

**Neuropathy** = inflammatory disorder (infection or autoimmunity).

**Acute** (days): Guillain-Barré syndrome, porphyria, diphtheria, toxins.

**Subacute** (weeks): most toxins, nutritional neuropathies, carcinomatous neuropathies, uremic neuropathy.

**Chronic** (months + years): many neuropathies (e.g. diabetic).

**Very chronic** (childhood onset): heritable neuropathies.

**ETIOLOGY**

1. **Trauma** - most common cause of mononeuropathy.
2. **Toxic & metabolic** disorders - usually affect many nerves (mononeuropathy multiplex, polyneuropathy):  
   1. diabetes
   2. alcohol
   3. amyloid - small fibers suffer first!
   4. uremia
   5. porphyria
   6. heavy metals, industrial solvents
   7. diphtheria toxin
   8. group B vitamin deficiency
   9. drugs (amiodarone, nitrofurantoin, isoniazid, vincastrine; are common offenders)

3. **Inflammatory/immunologic** - Guillain-Barré, postimmunization, collagenoses.

4. **Direct infection** - e.g. leprosy, CMV (esp. in HIV patients).

5. **Hereditary** disorders - course protracted over several years!

6. **Ischemia** (occlusion of vasa nervorum).

7. **Malignancy**:
   a. direct tumor invasion / compression
   b. monoclonal gammopathy (e.g. monoclonal IgM against myelin-associated glycoprotein)
   c. amyloid deposition
   d. nutritional deficiencies
   e. paraneoplastic syndrome.

8. **Radiation** (e.g. plexopathy after ≥ 1 yr latent period).

**PATHOPHYSIOLOGY, PATHOLOGY**

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<th>NEUROPATHIES MULTIPLEX</th>
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<td>Neuropathy</td>
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PERIPHERAL NEUROPATHIES (GENERAL)

Pathologic Reactions of Neurons (wallerian degeneration, chromatolysis, etc) → see p. A5

1. Diseases that affect primarily Schwann cell → segmental demyelination.
2. Diseases that affect primarily axon → wallerian degeneration.
3. Diseases that affect primarily neuron body → distal degeneration (s. distal axonopathy, “dying back”).

SEGMENTAL DEMYELINATION

- no primary abnormality of axon.
- process affects some Schwann cells and their corresponding internodes while sparing others (SEGMENTAL pattern).
- disintegrating myelin is engulfed initially by Schwann cells and later by macrophages.
- axon and myocytes remain intact!

Remyelination

- denuded axon provides stimulus for remyelination.
- population of cells within endoneurium has capacity to replace injured Schwann cells.
- newly formed myelinated internodes are shorter than normal (several are required to bridge demyelinated region); new myelin sheath is also thin in proportion to axon diameter.

Sequential episodes of demyelination - remyelination

- accumulation of tiers of Schwann cell processes (on transverse section appear as concentric layers of Schwann cell cytoplasm and redundant basement membrane that surround thinly myelinated axon - onion bulb structure); superficial cutaneous nerves may be thickened and visibly enlarged.
- in time, many chronic demyelinating neuropathies give way to secondary axonal injury.

Electron micrograph showing onion-bulb formation (hypoglycemic neuropathy). Myelinated fiber in center is surrounded by concentrically arranged Schwann cell cytoplasmic processes. Collagen is longitudinally oriented between these processes.

MEMBRANE POTENTIAL

Normal motor units

Segmental demyelination

Neurotrophs

Meyelin

Axon

Myocytes

Peripheral neuropathy. A myelin stain that discloses loss of total bulk of myelin and fragmentation of the remnant myelin.
**AXONAL DEGENERATION**

- primary destruction of axon (with secondary myelin disintegration)
  a) focal event (e.g. trauma or ischemia); distal axon may undergo wallerian degeneration.
  b) generalized abnormality - affecting neuron cell body (neuroropathy) or its axon (axonopathy);
  most distal part of axon is affected first, and axonal degeneration ascends proximally.

  - in slowly evolving neuropathies, evidence of myelin breakdown is scant because only few fibers are degenerating at any given time.
  - myocytes within affected motor unit undergo denervation atrophy.

**CLINICAL FEATURES**

Clinical manifestations of PNS lesion depend on:

1. **ANATOMICAL SITE** (root + terminal distribution)
   - anatomic localization of SENSORY SYMPTOMS - see p. S22
   - anatomic localization of MOTOR SYMPTOMS - see p. Mov3

2. **RADICULOPATHY** – segmental distribution (dermatome, myotome, sclerotome).
3. **PLEXOPATHY** – distribution of >1 peripheral/spinal nerve.
4. **MONONEUROPATHY** – distribution of 1 peripheral nerve.
5. **MONONEUROPATHY MULTIPLE** – distribution of ≥2 major named nerves in ≥2 limbs

**SYMPTOMS**

- Neurogenic pain
- Sensation (small fiber)
- Visceral motor (autonomic)

**PHENOMENA**

- result from interruption of normal impulse flow:

  **SOMATOMOTOR** system
  - weakness, paralysis (→ atrophy in chronic cases).
  - see p. Mov3

  **VISEROMOTOR** system (affected in small fiber neuropathies)
  1. Atony of visceral walls (peristalsis)
  2. Vasomotor paralysis (vasodilation)
  3. Anhidrosis

  4. Trophic changes (hair loss, skin thinning, nail dystrophy, etc) - more common when sensory or mixed nerve is injured (vs. motor nerve).

**SENSORY** system (all sensory modalities may be impaired; however, one modality may predominate)

- N.B. skin ulceration, poor healing, tissue resorption, neurogenic dysaesthesia, dysesthesia, allodynia.

**PHENOMENA**

- result from excessor nerve impulse flow:

  **VISEROMOTOR** system
  - fasciculations (more common in LMN and root lesions).
  - see p. Mov3

  **SOMATOMOTOR** system
  - hyperhidrosis, vasomotor reaction (episodic hypertension), diarrhea, tachycardia or bradycardia.

  **SENSORY** system
1. Paresthesias, hyperesthesia, dysesthesia.
2. Pain & hyperpathia (after incomplete interruption of nerve).

Peripheral Neuropathies (general)

PN1

1. Small-fiber neuropathies of diabetes
2. Axonal degenerations (particularly alcoholic and uremic)
3. Nerve infarction
4. Metal intoxications
5. Some drugs (e.g., gold, vincristine)
6. Fabry’s disease

Cranial nerves may also be involved (e.g., Guillain-Barre syndrome, Lyme disease, diabetes mellitus, diplopia).

Palpation of nerve trunk is frequently forgotten part of neurologic examination:
1. Focal or diffuse thickening
2. Presence of neurofibroma
3. Point tenderness
4. Tinel’s phenomenon (tapping along course of nerve trunk → tingling sensation in nerve territory)
5. Pain elicited by stretching of nerve trunk.

Hypertrophic nerves (Schwann cell proliferation and collagen deposition as result of repeated episodes of demyelination-remyelination or deposition of amyloid or polysaccharides):
1. Demyelinating form of Charcot-Marie-Tooth disease (type I)
2. Degaine-Sottas neuropathy
3. Refsum disease
4. Neurolitmitis
5. Lepros neuritis
6. Amyloidosis
7. Chronic demyelinating polyneuritis
8. Sarcoid

Diagnosis

Electrophysiology • key test in all neuropathies!
1. Sensory evoked potentials – for lesions at and proximal to dorsal root ganglion. see p. D25 >>
   a) conventional (surface) – for large nerve fibers (motor, touch, proprioception).
   b) Microelectrode – for small nerve fibers (pain, temperature, autonomic).
3. EMG see p. D20 >>
   a) Conventional (surface) – for large nerve fibers (motor, touch, proprioception).
   b) Microneurography – for small nerve fibers (pain, temperature, autonomic).

Axon-loss lesions – amplitude reduction; EMG shows denervation.
Remyelination lesions – conduction slowing; normal EMG.
Uniform (vs. differential) conduction slowing per se does not seem to have clinical correlate!

Neuroimaging
MRI or CT myelography – for radiculopathy (compression of nerve root by disc or bony spur).
MRI – for plexopathy (infiltrating mass).

Other
1. CBC (e.g., megaloblasts of vitamin B12 deficiency, stippled RBCs of lead poisoning).
2. Nerve biopsy – special indications. see p. D32 >>
3. CSF protein ↑ – in demyelinating neuropathies.
5. Urine (e.g., porphobilinogen & δ-ALA↑ in acute intermittent porphyria).

Treatment

In many instances there is no specific treatment for particular type of neuropathy!
1. Eliminate cause – remove toxins, treat systemic illnesses, vitamin supplements, etc.
2. Symptomatic therapy (e.g., amelioration of pain, bed–feet hygiene).
Avoid chronic compression on diseased nerves!
3. Rehabilitation measures should commence immediately:
   1) Massage & passive range-of-motion exercises for paralyzed muscles
   2) re-educative exercises for weak muscles.
   Patients should not attempt to walk before muscle testing indicates they are ready!
   3) Electrical stimulation for preventing permanent weakness (unproven value).
Treatment of PAINFUL neuropathies

- Pain can be most distressing part of disease!
- Neuropathic pains often do not respond well to conventional analgesics!
- Mild symptoms:
  1. soaking extremities in cool water (≈ 15°C) for 20 min late in evening + ASPIRIN 600-900 mg.
  2. CAPSICUM cream (0.025-0.075%) applied sparingly 3-4 x day.

- More severe symptoms - anti-convulsants (PEMONIYA, CARBAMAZEPINE), antidepressants (AMITRIPTYLINE, MALEOL TYLE, TENS).

FOOD SUPPLEMENTS for reversing neuropathies (esp. diabetic and HIV-related):

1. Acetyl-L-carnitine (500-1000 mg, three times per day); note that higher end of this is probably better, success in reversing neuropathy caused by antiretroviral drugs occurs with doses of 1500 mg twice daily (3000 mg total daily dose);

2. Alpha-lipoic acid (200-400 mg, 3 times per day);

3. B6 (50-100 mg/day in form of pyridoxal 5-phosphate, or combination of pyridoxine hydrochloride with pyridoxal-5-phosphate would probably be appropriate starting dose, although higher dosages, of perhaps 100 mg, three times per day, might be required for treatment of some neuropathies);

4. Vit. B12 (1000 mcg of B-12, 3-7 times per week; oral forms can work for some but for those with absorption problems nasal gel or subcutaneous (intramuscular injection may be required);

5. Vit. B6 (in form of Benfotamine, 400-600 mg daily [taken as four 150 mg capsules spread throughout the day]) appears to be most effective dosage for neuropathy for diabetics; it has not been studied for HIV-associated neuropathy and it’s not clear if it would be useful for this; available online at www.benfothamine.net; information and lengthy list of abstracts of studies showing its benefit are available at www.benfothamine.org);

6. Biotin (5-20 mg/day may be necessary; note that this is usually found in “mcg” strengths in which case this dose would be 5000 mcg to 20,000 mcg daily;

7. Folic acid (1600 mcg, 3 times per day);

8. Niacin (25-50 mg, 3 times per day);

9. Choline (400-800 mg of choline citrate or 1000-3000 mg of phosphatidylcholine, 3 times per day);

10. Gamma linolenic acid (GLA) (240 mg, 2-3 times per day; least expensive source is usually borage oil);

11. Inositol (500-2000 mg of myo-inositol, three times per day);

12. Lecithin (one tablespoon, two or three times daily);

13. Magnesium (500-600 mg/day with one meal per day may be useful; best to take magnesium separately from calcium as they compete for absorption);

PROGNOSIS

- axon injury: nearer injury to CNS, lower probability of regeneration of completely severed nerve (esp. cranial nerves); recovery is slow! see p. A5 >>
- Neuronomus may form!
- Recovery may fail to occur at all!
- myelin injury: recovery is complete within few days or weeks.

POLYNEUROPATHY

- diffuse lesions of peripheral nerves:

- Clinical Features

  Mostly metabolic / toxic causes (esp. diabetes mellitus, alcoholism, uremia).
  60% patients have diabetes mellitus or inherited neuropathy!
  - most are caused by primary axonal degeneration - involves ends of long nerve fibers first; with time, degenerative process involves more proximal regions of long fibers, and shorter fibers are affected (distal axonal degeneration or “dying back”);
  - primary demyelination: likes to manifest as polyradiculoneuropathy.
  - must be SURACUTE (evolve over weeks) or CHRONIC (evolve over months to years), or ACUTE neuropathies (evolve over days) - relatively uncommon:

  Acute Axonal Neuropathy:
  1) poikilothermic neuropathy
  2) massive intoxications (e.g. arsenic)

  Acute Demyelinating Polyneuropathy:
  1) Guillain-Barré syndrome
  2) buckthorn berry intoxication
  3) diphtheritic polyneuropathy.

CLINICAL FEATURES

- symmetric legs > arms
- extensors > flexors
- distal → proceeds centripetally in graded manner

  *nerve fibers are affected according to length (without regard to root or nerve trunk distribution).

  a) primarily sensory (diabetes, AIDS, paraneparectic)
  b) primarily motor (inflammatory demyelinating neuropathies, hereditary motor sensory neuropathy, polyrpithy)
  c) mixed (most often type)

First symptoms tend to be paresthesias (tonguing, burning, etc.)

- in hands or feet or tips of toes (or in general distribution over soles).

- symmetric and graded distally (occasionally dysesthesias appear in one foot shortly before other or are more pronounced in one foot).

If symptoms first appear in individual digital nerves (involve only half of digit at time, and then gradually spread and coalesce) – it is sign of mononeuropathy multiplex.

- if polyneuropathy remains mild, no objective motor or sensory signs may be detectable.

In some instances, process begins with feet weakness (without sensory symptoms).

- With progression:

  1) sensory loss moves centripetally in graded “Stocking” fashion;

- see p. 520 >>

- see p. S20 >>
Peripheral Neuropathies (general)

1) sensory involvement
   - pansensory loss over both feet (feet have "wooden" feeling - "I feel as though I'm walking on stumps").
   - by time sensory disturbance has reached upper shin, dysesthesias are usually noticed in tips of fingers.
   - when sensory disturbance reaches lower abdomen (tsa apex will extend rostrally toward sternum).
   - in profound sensory loss, repeated traumatic injury* → painless ulcers on digits, Charcot's joints.
   - scalp crown may be affected (may spread radially into CN5 and C2 distribution).
   - in profound sensory loss → repeated traumatic injury* → painless ulcers on digits, Charcot's joints.
   - when sensory disturbance reaches elbows and mid-thighs, tent-shaped area occurs on lower abdomen (its apex will extend rostrally toward sternum). (avoidable by proper care!)

2) proprioceptive loss → gait unsteadiness, ataxia (out of proportion to muscle weakness).

3) spontaneous pain is often considerable (worse at night); light stimuli to hypesthetic areas, once perceived, may be extremely uncomfortable (hyperpathia).

4) motor deficit is also graded, distal, and symmetric:
   - loss of reflexes: ankle jerk → knee jerk → arm reflexes.
   - motor component begins as weakness and atrophy in intrinsic feet muscles →→→ quadriplegia, impaired ventilation, sphincteric dysfunction.
   - atrophy of extensor digitorum brevis is often first helpful clue - weakness of toe dorsiflexion

5) autonomic nervous system may be additionally involved (postural hypotension), anhidrosis!, nocturnal diarrhea, urinary and fecal incontinence, impotence, smooth and shiny skin, pitted or ridged nails, osteoporosis, etc.

- N.B. variations are common → diversity of clinical syndromes.

Major fluctuations (over weeks or months) in course raise two possibilities:
   a) relapsing form of neuropathy (esp. chronic inflammatory demyelinating type, porphyria).
   b) repeated toxic exposures (e.g. lead, alcohol).

Exceptions to distal distribution (i.e. predominantly proximal distribution):
1) lead neuropathy (tends to affect upper extremities first, esp. radial nerve)
2) Guillain-Barré syndrome
3) familial amyloidosis type 2
4) adult-onset Tangier disease
5) porphyria (occasionally).

Temperature-related distribution – leprosy.

Differentiating from ischemic paralysis - paralysis of extremity due to occlusion of large arteries: anesthesia extends in glove-like distribution; hand is held extended and fingers are slightly flexed; fibrous consistency of tissues, absence of peripheral pulsations.

Peripheral Neuropathies - Metabolic, Toxic and Nutritional

**Etiology**
- Diabetic
- Alcoholic
- Uremic
- Drug-related (isoniazid, Dapsone, Warfarin, Hydralazine, Other medications)

**Clinical manifestations**
- Graduated glove-and-stocking anesthesia
- Impaired vibration sense
- Paresis, ophthalmoplegia, diplopia
- Loss of ankle jerk

**MONONEUROPATHY**
- disorder of single nerve.
- most commonly due to local cause:
MONONEUROPATHY MULTIPLEX (MM)

- simultaneous or sequential focal involvement of ≥ 2 major named nerves in ≥ 2 limbs (i.e. nerves from individual noncontiguous nerve roots).

  * most commonly due to generalized diseases
  1) ≥ 50% cases are due to demyelination - multifocal demyelinating neuropathy (part of chronic acquired demyelinating neuropathy).
  2) vasculitis of vasa nervorum (polymyositis nodosa??, RA!!, SLE!, Sjögren syndrome, Wegener granulomatosis, progressive systemic sclerosis, Churg-Strauss allergic granulomatosis, hypersensitivity angiitis→ – may cause acute MM!)
  3) compression by sarcoidosis
  4) metabolic diseases (diabetes, amyloidosis)
  5) infections ( Lyme disease, HIV, leprosy).

  * disease progression involves additional nerves (neurologic deficits: patchy and multifocal → confluent and symmetric*):

  * patients may present with distal symmetric neuropathy - attention to pattern of early symptoms is important!

Radiculopathy

1. Disk herniation - commonest cause!
   - most common radiculopathies affect C5-6 roots and L3-S2 roots, since those are roots most often compressed by herniated discs. see p. 507/12
   - Compression by osteophyte/almost* spine degeneration aka spondylolisthesis (second commonest cause), osteoarthritis of spine or sacroiliac joint.

   *normal anatomic changes should only be considered pathological if they are etiologically related to specific clinical syndrome.

2. Compression / irritation by abscess.
3. Compression / invasion by tumor.
4. Leptomeningitis, meningeal granulomatosis (meningeal sheath follows roots).
5. Trauma, root avulsions (e.g. stretching accidents in cervical region).
6. Compression by cyst (synovial, meningeal).
8. Herpes zoster.

Clinical Features

Paresthesias

   - pain is poorly localizing (radicular pain may follow dermatomal pattern but more typically is deep and aching and only roughly corresponds to involved dermatome).
   - pain is radiating (e.g. back or neck pain radiating into extremity – sciatica, etc).
   - pain is precipitated by:
     1) moving spine
     2) Valsalva maneuver (transmits pressure to nerve root through subarachnoid space).
     3) root stretching maneuvers (e.g. straight leg rising).
     4) root compression maneuvers (e.g. Spurling’s test).
   - pain is relieved by eliminating root stretch (e.g. arm abduction).

2. Dermatomal sensory loss of all modalities (numbness is more localizing than pain!).

Anterograde pain (root pain) → myotonic muscle weakness & tendon reflexes; rarely fasciculations; eventually, atrophy.

"weakness" may be due to sustained effort (breakaway weakness) associated with radioculopathy.

Tendinitis

muscles are innervated by more than one spinal root! (tendon reflexes (segmental hyporeflexia) are affected by either anterior or posterior spinal root.

muscles are innervated by more than one spinal root! (actual motor innervation is multisegmental)

difficult to differentiate C4 from C5 or C5 from C6 root injury (C5 may depress either biceps or triceps reflex).

differentiating C4 from C5 is easier (C4 reduces biceps jerk, whereas C5 reduces triceps).

differentiation of L2 from S1 is most readily made by watching patient walk on heels and toes; ankle jerk may be affected by either lesion (more often by S1).

POtography

N.B. signs may not be as distinct in actual practice as table implies!

1root function normally varies somewhat from patient to patient; 2overlap in function between roots is common; 3distribution of symptoms and signs often occupies only part of associated root territory.
### Root and Muscle Weakness

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<th>Muscle Weakness</th>
<th>Pain</th>
<th>Reflex</th>
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<td>C5</td>
<td>Triceps, levator scapulae, strap muscles, sternocleidomastoid, diaphragm</td>
<td>Neck</td>
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<td>C6</td>
<td>Triceps, rhomboids, levator scapulae, diaphragm</td>
<td>Supraclavicular, subscapular, and posterior auricular regions</td>
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<tr>
<td>C6</td>
<td>Triceps, rhomboids, levator scapulae, diaphragm</td>
<td>Infraspinatus and posterior auricular regions</td>
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<tr>
<td>C7</td>
<td>Deltoïd – shoulder abduction (15-90°)</td>
<td>Lateral shoulder (deltoïd area)</td>
<td>Pectoralis, Biceps (C5,6)</td>
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<td>Clavicular head of the pectoralis major</td>
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<td>Supraspinatus – shoulder abduction (0-15°)</td>
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<td>Infraspinatus – humerus external rotation</td>
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<td>Biceps (C5,6)</td>
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<td>Brachialis, brachioradialis – elbow flexion</td>
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<td>C8</td>
<td>Biceps (C7,8)</td>
<td>Posterior shoulder</td>
<td>Biceps (C7,8)</td>
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<td>Brachioradialis (C5-6) – elbow flexion in semi-pronation</td>
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<td>Pronator teres (C5-8) – pronation</td>
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<td>Supinator</td>
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<td>Extensor carpi radialis (C5-7) – radial wrist extension</td>
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<td>Flexor carpi radialis</td>
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<td>C7</td>
<td>Flexors (C6,7) – elbow extension</td>
<td>Posterolateral arm and forearm</td>
<td>Triceps (C6,7)</td>
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<td>Pronator teres (C6-7) – pronation</td>
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<td>Extensors carpi ulnaris (C6-7) – wrist extension</td>
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<td>Extensor digitorum (C6-7) – finger extension</td>
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<td>Flexor carpi radialis</td>
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<td>Abductor pollicis longus, extensor pollicis brevis and longus, extensor indicis</td>
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<td>C8</td>
<td>Flexor pollicis longus – thumb flexion</td>
<td>Interscapular</td>
<td>Finger flexors (C7,8-10)</td>
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<td>Flexor digitorum superficialis &amp; profundus – finger flexion</td>
<td>4-5 fingers</td>
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<td>Interossei manus (C8)</td>
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<td>Interspinalis manus</td>
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</table>

### Most common mimickers of C5 radiculopathy:
1. Rotator cuff tear – also gives shoulder abduction weakness but starts from 0 degrees and is not associated with weakness of other C5 innervated muscles (C5 radiculopathy is not associated with painful shoulder movement or significant tenderness). Check Neer and Hawkins’ tests for impingement. (See p. Exam5)
2. Supraacromial nerve entrapment – not associated with weakness of other C5 innervated muscles (such as the deltoid, biceps, and pectoralis major).

### Most common mimickers of C6 (C6-7 radiculopathies):
- Carpinal tunnel syndrome - associated with nocturnal dysesthesias, and the hypoesthesia is present distally, over the palm side of the hand and over the first three to three and one half digits. This can be weakness and atrophy of the thenar and first two lumbricals muscles, which are innervated by C6 and T1. Phalen’s test may be positive, and Tinel’s sign may be present.
- Posterior interosseous nerve compression - not associated with sensory findings, does not affect the triceps, pronator teres, and flexor carpi radialis.

### Most common mimicker of C7 (C6-7 radiculopathies):
- Carpal tunnel syndrome - associated with nocturnal dysesthesias, and the hypoesthesia is present distally, over the palm side of the hand and over the first three to three and one half digits. This can be weakness and atrophy of the thenar and first two lumbricals muscles, which are innervated by C6 and T1. Phalen’s test may be positive, and Tinel’s sign may be present.

### Most common mimickers of C8 radiculopathy:
1. Anterior intersosseus nerve entrapment - no sensory loss, pain over the proximal forearm, positive “pinch sign” (weakness of flexion at the interphalangeal thumb joint and at the distal interphalangeal joint of the index).
2. Ulnar entrapment at the elbow - tenderness along the medial aspect of the elbow; positive Tinel’s sign, no weakness of the pronator quadratus and flexor digitorum superficialis and of the first two flexor digitorum profundus muscles (innervated by the median nerve), sensory change does not extend proximal to the wrist.

### T4
- Intertoe flexion – finger abduction
- Lumbricals 1-2
- Abductor digiti minimi – 5th finger abduction
- Adductor pollicis, abductor pollicis brevis, opponens pollicis, flexor pollicis brevis
- Horner’s syndrome may be present

### L1
- Quadriceps (L1-5) – knee extension
- Gastrocnemius (L1-5) – hip flexion
- Adductor magnus (L2-3) – hip adduction
- Tibialis anterior (L4-5) – foot dorsiflexion
- Gastrocnemius (L1-5) – foot dorsiflexion
- Hamstring jerk?
- Tibialis posterior test walking on heels
- Test for straight-leg raising*

### L2
- Gastrocnemius (L3-5) – h. flexion
- Soleus (L3-5) – h. flexion
- Small, inner, low insertion
- Intertoe adduction
- Peroneus (L3-5) – foot eversion
- Tibialis anterior (L4-5) – foot dorsiflexion
- Test for straight-leg raising*

### S1
- Ankle jerk (S1)
- Test walking on toes
- Low, posterior, inner, high insertion
- Small, outer, low insertion
- Fleshy (S1-3) – toe flexion

### S2+*+
- Buttock muscles
- Bulbocavernous
- “Butt’s eye” around anus, genitalia
- Anal (S3-4) – bulbocavernous
IDIOPATHIC

- characteristic pain on opposite leg elevation (crossed Lasègue sign) may be even stronger evidence of root compression.
- pain may also be elicited by having patient walk on heels; some patients avoid full weight bearing on heel of involved side (stand with knee flexed and heel off floor).

**often bilateral**, because sacral fibers are situated medially in cauda equina - liable to midline compression.

<table>
<thead>
<tr>
<th>Reflex</th>
<th>Roots</th>
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<tbody>
<tr>
<td>Ankle</td>
<td>S3</td>
</tr>
<tr>
<td>Knee</td>
<td>L5,6</td>
</tr>
<tr>
<td>Biceps</td>
<td>C5,6</td>
</tr>
<tr>
<td>Triceps</td>
<td>C7,8</td>
</tr>
</tbody>
</table>

“going from ankle to triceps, roots are numbered consecutively from 1 to 8”.

Quickest screening for radiculopathy: knee-jerk (L4) - great toe dorsiflexion (L5) - ankle-jerk (S1).

**Diagnosis**

**Neuroimaging:**

1) plain X-rays – sagittal balance, instability on dynamic studies.
2) CT
3) MRI
4) myelography

**EMG & evoked potentials** - localize level + determine severity of root lesions.

**Nerve conduction velocities** – normal (vs. in peripheral neuropathies), but spontaneous activity (positive waves, fibrillations) and decreased motor recruitment occur in muscles innervated by injured roots.

CSF – seek for etiology

**Differential**

Cervical:

1) upper extremity nerve entrapment (compressive neuropathy)
2) primary shoulder disease
3) brachial plexus disorders
4) peripheral neuropathies

**Treatment**

Symptomatic relief - muscle relaxants, analgesics, transdermal electrical nerve stimulation, topical modalities.

**Specific therapy** - depends on etiology:

1) epidual or meningital tumor → radiation to affected cord segments + corticosteroids, intrathecal methotrexate → surgical decompression.
2) bony deformity → surgical decompression.
3) epidual/subdural abscess → immediate surgical drainage + antibiotics.
4) herpes zoster → antiviral drugs + corticosteroids.

**DORSAL ROOT GANGLION SYNDROMES (SENSORY GANGLIONITIS)**

- inflammatory changes and loss of neurons in dorsal root ganglion associated with degeneration of their central and peripheral processes (i.e. NEURONOPATHY).

**Etiology**

1) idiopathic sensory neuropathy - no associated systemic disease.
2) neoplasia!! (most frequent associations - small cell carcinoma of lung, breast carcinoma, ovarian carcinoma)
3) Sjögren syndrome
4) arsenic poisoning
5) diphtheria
6) mononetalal ganguopathies
7) tabs dorsals

**Clinical features** - (subacute rapidly progressive sensory symptoms;)

- severity is variable.
- asymmetrical numbness, paresthesias, lancinating pains in different body segments (incl. face).
- loss of proprioception & vibration (sensory ataxia, areflexia) > loss of pain & temperature; sensory loss is not strictly length dependent - may be more pronounced in upper extremities than lower extremities (vs. polyneuropathy).
- Adie's pupils (pupils that react to accommodation but not to light) are common in Sjögren syndrome.
- autonomic dysfunction may be present.

**Idiopathic** disease may be self-limiting or chronic (with relapses or slow progression).

**Differential**

- sensory loss is similar to radiculopathies and dorsal horn lesions.
- dorsal horn lesions tend to have dissociated loss - as dorsal root fibers separate into medial (large myelinated) and lateral (thiani myelinated and unmyelinated) bundles as they enter dorsal horn.

**Diagnosis**

- sural nerve biopsy - loss of large myelinated fibers.
- sensory nerve action potentials [1].
- normal EMG.
- check for Sjögren syndrome (anti-Ro and La antibodies, anti-sulfatide antibodies).
- presence of anti-Hu antibodies strongly suggests underlying carcinoma!

**Treatment**

**Idiopathic** disease - poor response to plasmapheresis or immunosuppression.
Occipital neuralgia – see p. S20 >>

BIBLIOGRAPHY for ch. “Peripheral Neuropathies” → follow this LINK >>