Focal nerve lesions

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Outline
- Structure and function of peripheral nerves
- Pathophysiology of peripheral neuropathies
- Details of individual nerve lesions

Structure and function

Peripheral nerve

Fascicles

Cross section of nerve
Fascicle structure

Microscopic structure

Myelinated nerve = Ax
Unmyelinated axons = a

Histogram of axon diameter

Microscopic anatomy

- Myelinated nerves
  - Diameter 2-20 µm
  - 7000/mm²
  - Distance between nodes of Ranvier 0.2-2 mm
- Unmyelinated nerves
  - Diameter 0.2-2.5 µm
- Unmyelinated : myelinated nerves = 4:1

Axon types

<table>
<thead>
<tr>
<th>Type</th>
<th>Diameter</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aα</td>
<td>12-20 µm</td>
<td>Touch, afferent neurons</td>
</tr>
<tr>
<td>Aβ</td>
<td>5-12 µm</td>
<td>Touch</td>
</tr>
<tr>
<td>Aγ</td>
<td>3-6 µm</td>
<td>Gamma motoneurons</td>
</tr>
<tr>
<td>Aδ</td>
<td>2-5 µm</td>
<td>Cold, pain</td>
</tr>
<tr>
<td>B</td>
<td>1-2 µm</td>
<td>Autonomic preganglionic</td>
</tr>
<tr>
<td>C</td>
<td>0.3-1 µm</td>
<td>Pain, heat, autonomic</td>
</tr>
</tbody>
</table>

Pathophysiology of peripheral neuropathies
Causes of focal nerve lesions

- Entrapment neuropathies
- Temporary compression
- Trauma
- Iatrogenic
- Unknown
  - Parsonage-Turner syndrome
- Infectious (herpes zoster)
- Tumours

Predisposing factors

- Anatomy – surrounding structures
  - Narrow passages (CTS)
  - Proximity to bone (radial nerve, humerus)
  - No protective subcutaneous tissue (peroneal nerve at the fibula)

- Patient related risk factors
  - Constitution
    - Obesity
    - Anorexia
  - Polyneuropathies

Median nerve

Predisposing factors

- Anatomy – surrounding structures
  - Narrow passages (CTS)
  - Proximity to bone (radial nerve, humerus)
  - No protective subcutaneous tissue (peroneal nerve at the fibula)

- Patient related risk factors
  - Constitution
    - Obesity
    - Anorexia
  - Polyneuropathies

Radial nerve over the humerus

Predisposing factors

- Anatomy – surrounding structures
  - Narrow passages (CTS)
  - Proximity to bone (radial nerve, humerus)
  - No protective subcutaneous tissue (peroneal nerve at the fibula)

- Patient related risk factors
  - Constitution
    - Obesity
    - Anorexia
  - Polyneuropathies
Different types of nerve lesions

- Acute physiological block
  - Minutes, < 1 hour
  - Conduction block - ischaemia

- Demyelinating reversible
  - Weeks to months
  - Conduction block - mechanical factors

- Axonal degeneration (Wallerian degeneration)
  - Mechanical factors with ischaemia

Pathophysiology in nerve compression

Ischaemia

- Alteration of nerve conduction within few minutes
- Complete conduction failure after 30-40 minutes
- 3 hours of ischaemia does not cause axonal degeneration
  - (Perry GJ, Linn DJ. Transient conduction block following acute peripheral nerve ischaemia. Muscle Nerve 1985; 8: 409-412)
- After 4 hours damage to blood vessels and infarction of muscle beneath the cuff

Experimental human compression

  - 16 human volunteers
  - 30 mm Hg pressure caused mild neurophysiological abnormalities with paresthesia
  - 60-90 mm Hg pressure for 30 to 90 min caused conduction block in 10-30 minutes
  - Authors concluded that ischaemia central

Experimental acute nerve compression

  - Peroneal nerve of the baboon at the ankle
  - 1.5 kg/cm for 60 min → 20 % of axons degenerated
  - After 3 hours → 90% of axons degenerated

Acute axonal degeneration
Axon diameter and susceptibility to damage during compression

- Ochoa J, Fowler TJ, Gilliatt RW. Anatomical changes in peripheral nerves compressed by a pneumatic tourniquet. J Anat 1972;433:433-
  - Demyelination tends to occur in the larger myelinated axons
  - Axons with a diameter < 5 μm not affected
  - Relative sparing of sensation, especially pain and temperature

Double crush syndrome

  - 115 patients with median or ulnar nerve entrapments
  - 70% had evidence of cervical radiculopathies on EMG!!!???
  - Critical analysis does not support the existence of a double crush syndrome in clinical practice

Motor symptoms

- Negative symptoms
  - Loss of strength
  - Muscle atrophy
- Positive symptoms
  - Muscle cramps
Sensory symptoms

- Negative symptoms
  - Hypoesthesia
- Positive symptoms
  - Paresthesia
  - Dysesthesia
  - Alldynia
  - Hyperpathia

Goal of ENMG

- Localize lesion
- Characterize lesion
  - Axonal
  - Demyelinating
  - Conduction block
- Severity
- Time course

Goal of ENMG

- The neurophysiological findings do not differentiate between a lesions caused by an entrapment and temporary compression
- Careful history is essential

Skills required

- Good anatomical knowledge
  - Acquired slowly
  - Anomalies
- EMG techniques
  - Basic
  - Advanced
- Medical knowledge
- Experience

Entrapment neuropathies

Most common focal neuropathies in the EMG lab at Turku University Hospital

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
<th>Chi-sq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbar radiculopathy</td>
<td>192</td>
<td>49</td>
<td>241</td>
<td>23.66</td>
</tr>
<tr>
<td>Brachial plexus neuropathy</td>
<td>38</td>
<td>61</td>
<td>99</td>
<td>0.03</td>
</tr>
<tr>
<td>Cervical radiculopathy</td>
<td>50</td>
<td>60</td>
<td>110</td>
<td>7.61</td>
</tr>
<tr>
<td>Median nerve palsy</td>
<td>42</td>
<td>36</td>
<td>78</td>
<td>4.00</td>
</tr>
<tr>
<td>Median nerve palsy (not CTS)</td>
<td>55</td>
<td>50</td>
<td>105</td>
<td>3.31</td>
</tr>
<tr>
<td>Median nerve palsy (not CTS)</td>
<td>17</td>
<td>30</td>
<td>47</td>
<td>2.93</td>
</tr>
</tbody>
</table>
Definition of entrapment neuropathy

"...a region of localized injury and inflammation in a peripheral nerve that is caused by mechanical irritation from some impinging anatomical neighbour"

HP Kopell and VAL Thompson
Peripheral Entrapment Neuropathies
The William and Wilkins Company
Baltimore, 1963

"Chronic compressive neuropathy caused by surrounding anatomical structures"

55 syndromes ?!

All that shines is not gold!!!

Entrapments in the upper extremeties

Common
- Carpal tunnel syndrome
- Ulnar nerve at the elbow

Rare
- Plexus brachialis (TOS)
- Ulnar nerve at the wrist

Neuromyothology - arms

- Posterior interosseus syndrome
  - Poorly documented in the literature
  - Lesions of the posterior interosseus nerve may occur but they are not entrapments
- Pronator syndrome
  - Does not exist
- Anterior interosseus syndrome
  - Not an entrapment
  - Acute neuralgic amyotrophy

Posterior interosseus syndrome
Pronator syndrome

Entrapments in the legs
- Morton's metatarsalgia
- Meralgia paresthetica

Neuromyothology - legs
- Tarsal tunnel syndrome
  - Poorly documented in the literature
  - Lesions of the tibial nerve at the ankle occur but they are not entrapments
- Peroneal nerve at the knee
  - Not an entrapment
  - Acute temporary or repeated temporary compression
- Piriformis syndrome
  - Sciatic nerve compression by m.piriformis

Tarsal tunnel syndrome

Carpal tunnel syndrome
- Constellation of symptoms and signs due to median nerve compression in the carpal canal
Identification of CTS

- Identification of CTS is usually simple for skilled clinicians
- Specification of diagnostic criteria is challenging
- No gold standard is available

Diagnosis

- Symptoms
- Clinical findings
- Neurophysiological tests
- Imaging studies
  - CT
  - MRI
  - Ultrasound

Carpal tunnel

Crossection of CT

Lumbricals
Pathophysiology

A. Entrapment site

B.

C.

D.

E.

1 mm

Macroscopic finding

CTS age and gender

Women

Men

Predisposing factors

- Gender female: male 4:1
- Age > 45
- Obesity
- Heavy manual work
- Diabetes
- Wrist fractures
- Pregnancy
- Acromegaly
- Hypothyreosis
- Surgery for breast cancer
- Hereditary liability to pressure palsies

CTS in diabetes

- 2% in healthy controls
- 15% in diabetics without PNP
- 30% in diabetics with PNP

Diagnosis

- Symptoms
- Clinical findings
- Neurophysiological methods
- Imaging studies
  - MRI
  - Ultrasound

Bruce A. Perkins, David Olaleye and Vera Bril
Carpal Tunnel Syndrome in Patients With Diabetic Polyneuropathy
Severity of CTS

Padua L, Lo Monaco M, Padua R, Gregori B and Tonali P

Neurophysiological classification of carpal tunnel syndrome: assessment of 600 symptomatic hands

Ital J Neurol Sci 1997;18:145-150

Normal finding

N.medianus, sens
N.ulnaris, sens
N.medianus, mot

Very mild CTS

N.medianus, sens
N.ulnaris, sens
N.medianus, mot

Mild CTS

N.medianus, sens
N.ulnaris, sens
N.medianus, mot

Moderate CTS

N.medianus, sens
N.ulnaris, sens
N.medianus, mot

Severe CTS

N.medianus, sens
N.ulnaris, sens
N.medianus, mot
Extreme CTS

N.medianus, sens

N.ulnaris, sens

N.medianus, mot

Severity of carpal tunnel syndrome

<table>
<thead>
<tr>
<th>Severity</th>
<th>Special techniques</th>
<th>Routine sens neurography</th>
<th>Motor dist latency</th>
<th>EMG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very slight</td>
<td>Abnormal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Slight</td>
<td>Abnormal</td>
<td>Reduced CV</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Moderate</td>
<td>No response</td>
<td>No response</td>
<td>Prolonged</td>
<td>Neurogenic</td>
</tr>
<tr>
<td>Severe</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>Neurogenic</td>
</tr>
<tr>
<td>Total</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>Neurogenic</td>
</tr>
</tbody>
</table>

CTS following surgery

n.medianus, sens
tohoneupeus

n.medianus, distalinen motorinen latensi
Damage to the sensory palmar branch of median nerve


Damage to the motor branch of median nerve


Damage to the sensory palmar branches of median nerve


Ulnar neuropathy at the elbow


Ulnar nerve at the elbow


Cubital tunnel syndrome - Etiology

- Entrapment of the ulnar nerve at the flexor retinaculum of the m.flexor carpi ulnaris (1-2 cm distal to the medial epicondyle)
Retroepicondylar ulnar neuropathy

- Entrapment in the ulnar sulcus at the medial epicondyle or just proximal to it, often related with arthrosis of the elbow (tardy ulnar palsy)
- Temporary compression during sleep (often following alcohol consumption) or anesthesia
- Trauma to the elbow

Fractionated ulnar nerve neurography

Ulnar nerve - fractionated MCS

Retroepicondylar lesion

Ulnar nerve short segment study

Ulnar nerve inching - normal
**Retroepicondylar ulnar nerve lesion**

Mild cubital tunnel syndrome

**Ulnar nerve entrapments at the elbow**

- Retroepicondylar region
- Humeroulnar aponeurotic arch (cubital tunnel)
- Aponeurosis of the flexor carpi ulnaris muscle at the ulnar nerve exit??

**Morton’s metatarsalgia**

- Lewis Durlacher (1792-1864): *A treatise on corns, bunions, the disease of nails, and the general management of the feet.* Simpkin, Marshall & Co, 1845. Durlacher, surgeon chiropodist to Queen Victoria, gave the first description of anterior metatarsalgia.


**Etiology**

- Entrapment of the plantar digital nerves between the distal metatarsal heads
- Usually the digital nerves II and III (between the II/III and III/IV metatarsal heads)
Plantar nerves

Clinical features
- Common in 50-70 year old women, sometimes in younger persons (youngest I have seen 16 years)
- Pain in the forefoot when walking, symptoms are alleviated if shoes are taken off
- On palpation painful area between affected metatarsal heads
- Associated with hallux valgus and rheumatoid arthritis
- Plantar digital nerve to interspaces II/III and III/IV may be affected

Predisposing factors

Plantar digital nerves

n.digitalis plantaris medialis

Morton 2/3, (woman, 58 years)
Meralgia paresthetica

- Numbness of the lateral side of the thigh
  - Standing
  - Walking
  - Lying prone with straight legs
- Rarely pain
- Severe obesity

Subclinical entrapment neuropathies

  - 12 ulnar nerves were obtained at autopsies
  - Enlargement of cross-sectional area due to an increase in connective tissue elements was commonly present in the ulnar nerve at the elbow
  - Nerve fibers teased apart and examined, localized changes were found at the elbow in 5 ulnar nerves
  - The changes were similar in character to those seen in entrapment syndromes.
Temporary compression neuropathies

- Radial nerve in the humerus
  - Saturday night palsy
- Ulnar nerve at the elbow
- Ulnar nerve at the wrist
  - Cyclists palsy
- Brachial plexus
  - Rucksack
- Peroneal nerve at the knee
  - Strawberry pickers palsy
- Sural nerve in the foot
  - Ski boots
- Digital nerves in the hand
  - Scissors
- Radial nerve branches in the hand
  - Hand-cuffs

N.ULNARIS

Ulnar nerve at the elbow

N.ULNARIS - symptoms

- Numbness of digits 4-5
- Weakness of intrinsic hand muscles
  - Unability to turn key
- Wasting of intrinsic hand muscles

N.ULNARIS at the elbow

- Most ulnar neuropathies at the elbow are due to temporary compression
  - Perioperative – most lesions occur after surgery
  - During sleep – alcohol or drugs
- Acute onset
- Good recovery
N. ulnaris at the wrist

- Temporary compression
  - Cyclist’s palsy
  - Crutches
- Entrapment
  - Ganglion
  - Aneurysm
  - Lipoma

Ergonomy

- Strawberry picker’s palsy
  - Often bilateral
- Slimmer’s palsy
- Static flexion of knee
- During night
  - Probably compression
**Peroneal nerve at knee**

- **Stimulation sites**

**Peroneal nerve inching - normal**

**Slimmer’s palsy**

**Radial nerve in upper arm**

- “Saturday night palsy”
- Temporary compression in the radial groove
- Acute onset, notices symptoms in the morning
- Good prognosis

**Saturday night palsy**

- Abnormal EMG
  - Brachioradialis
  - Extensor digitorum communis
- Normal
  - Triceps
  - Muscles innervated by other nerves
Saturday night palsy

- Abnormal neurography
  - N.radialis motor (humerus-forearm)
  - N.radialis ramus superficialis
- Normal neurography
  - N. ulnaris
  - N. medianus

Radial nerve

- Traumatic nerve lesions
  - Incisions by sharp objects
    - Median and ulnar nerves at the wrist
  - Dislocation of joint
    - Axillary nerve in humerus luxation
    - Median and ulnar nerves in elbow
  - Crush
    - Radial nerve in upper arm
  - Gunshot wounds
  - Stretch
    - Plexus brachialis

Traumatic neuropathies

Axillary nerve
Axillary nerve lesions

- Humerus luxation
- Affected muscles
  - M.deltoides
  - M. teres minor
- Sensation
  - Lateral aspect of upper arm

Iatrogenic neuropathies

Handbook for iatrogenic neuropathies

Iatrogenic

- Direct injury during surgery
- Compression
- Hematoma
- Needlestick
- Injection of material close to nerve
- Radiation therapy

Causes of perioperative nerve lesions

- Compression
- Stretch
- Ischaemia
- Direct trauma by instruments
  - scalpel
  - needle
- Toxicity due to drugs

American Society of Anesthesiologists claims filed for intraoperative nerve lesions

  - Ulnar nerve 34%
    - 69% men
  - Brachial plexus 23%
    - 60% women
  - lumbar and sacral nerve roots 6%
A male medical doctor was bitten in the neck by a nurse in an obviously friendly love-making situation. The patient was a 28-year-old man with no history of neurological disease. The bite struck the anterior border of the left trapezius muscle and was described as vigorous, but the skin was not punctured. The shoulder felt immediately paralysed and soon a dull ache developed, diffusely locating in the shoulder and upper arm. The patient found it difficult to raise the shoulder and the arm above the horizontal plane and impossible to bring the elbow behind the shoulder in the horizontal plane. He himself made the diagnosis.
Inferior alveolar nerve lesions

- Extraction of wisdom teeth
- Split mandibular osteotomy for micrognatia

Direct injury during surgery

- Varicose veins
  - Saphenous nerve
- Knee surgery
  - Inferior patellar nerve
- Achilles tendon
  - Sural nerve

N. saphenus

Inferior patellar nerve

Sural nerve

Direct injury during surgery

- Clavicle
  - Suprasclavicular nerves
- DeQuervain’s tenosynovitis
  - Sensory branch of radial nerve
- Carpal tunnel syndrome
  - Digital nerve branches
  - Motor branches
Direct injury during surgery

- Dupuatre’s contracture
  - Digital nerve lesions
- Surgery in the groin and abdomen
  - Iliohypogastric nerve
  - Iliinguinal nerve
  - Genitofemoral nerve

N.supraclaviculares

N.iliohypogastricus

N.iliohypogastricus r. anterior

N.iliohypogastricus r. lateralis

N.ilioinguinalis

N.genitofemoralis

N.genitofemoralis r.femoralis

N.genitofemoralis r.genitalis

N.cutaneus femoris lateralis
Needlestick injuries

- Plexus anesthesia
- Vein puncture for blood samples
  - N.cutaneus antebrachii lateralis
  - N.cutaneus antebrachii medialis

Plexus anesthesia

Vein puncture in the elbow

- 1/20 000
- N.cutaneus antebrachii lateralis
- N.cutaneus antebrachii medialis

Venipuncture

Parsonage-Turner sdr
Acute idiopathic mononeuropathies

- Parsonage–Turner syndrome
- Neuralgic amyotrophy
- Neuritis

Etiology

- Not known
- Immune mediated?
- Vascular??
- Infectious - Herpes sine herpete???

Predisposing factors

- Infection
  - Days to weeks following onset of infection
- Surgery
  - May start within hours of the surgery
  - Usually 1-3 days
- Childbirth
  - Within days or weeks after delivery
- Unusual physical activity
- Diabetes

Typical nerves affected

- Plexus brachialis
- Spinal nerves (= radiculopathy)
- N. supraspinalis
- N. thoracicus longus
- N. interosseus anterior
- N. axillaris
- Plexus lumbaralis
- Phrenice nerve
- Accessory nerve
- …………..

Symptoms

- Usually severe pain (VAS 8-9/10)
  - Few days
  - Rarely mild or no pain
- During the initial symptoms the patient is not aware of the weakness or sensory abnormalities
- When the pain subsides the patient is aware of the weakness and loss of sensation

Prognosis

- Usually good
- Some deficits may be left
- May recur in 5%
Hereditary neuralgic amyotrophy (HNA)
- Linked to chromosome 17q24, SEPT9 gene
- Families not linked to this exist
- Autosomal dominant inheritance
- Variable penetrance
- Onset often in early childhood

EMG findings in HNA
- In unaffected individuals normal EMG and neurography
- Differ from HNPP (hereditary liability to pressure palsies)
- Abnormalities only in affected nerves

Nerves affected
- Any nerve may be affected
- Predilection
  - Plexus brachialis
  - Long thoracic nerve
  - Suprascapular nerve
  - Anterior intersseus nerve

N. thoracicus longus
- Winging of the scapula
- Slow recovery
  - Axonal reinnervation starts at 6-8 months after onset
  - Recovery completed at two years after onset
[N. thoracicus longus]

[M. serratus anterior]

[Weakness of m. serratus anterior]

[Examined of m. serratus anterior]

[EMG of m. serratus anterior]

[Suprascapular nerve]
**N.suprascapularis**
- Shoulder pain
- Weakness of upper arm outward rotation
- Weakness of shoulder abduction
- Atrophy of m.infraspinatus and m.supraspinatus

**Etiology**
- Parsonage-Turner sdr
- Fracture of the collum of scapula
  - Only m.infraspinatus affected
- Entrapment
  - Does not fulfill evidence based criteria

**N.interosseus anterior**
- M.flexor pollicis longus
- M.flexor digitorum profundus
- M.pronator quadratus

**N.anterior interosseus**
- Anterior interosseus syndrome is not an entrapment and the patients do not benefit from surgery
- Weakness of flexion of the distal phalanx of the thumb

**Facial nerve lesions**

**Facial nerve**

*NEJM 2004;351;1323-*
Peripheral part of the facial nerve

Facial weakness

Facial nerve lesions
- Bell’s palsy
- Ramsay Hunt syndrome
  - Herpes zoster oticus
- Surgery for acoustic neuroma
- Lesions in the pons
  - Lymphoma, sarcoidosis, tumours…
- Lyme disease
  - Bilateral

Bell’s palsy
- Incidence 20-30/100,000
- Men:women 1:1
- All ages
  - Increases with age, most >70
- Etiology
  - Unknown
  - Ramsay-Hunt syndrome (herpes zoster oticus)

Bell’s palsy
- Predisposing factors
  - Pregnancy
  - Diabetes
- Prognosis usually good
  - Severe axonal damage (<90%) prognosis not so good

Bell’s palsy
- Treatment
  - Steroids beneficial
  - Antiviral therapy?
  - Surgical decompression controversial
- Rarely recurs
- Site of lesion
Bell’s palsy – utility of EMG
- The diagnosis is usually clinically obvious
- EMG will characterize pathophysiology
  - Axonal
  - Conduction block
- Prognosis

Herpes zoster

Etiology
- Varicella virus
- Older people
- Patients with suppressed immune system

Symptoms
- Pain
- Skin changes over affected dermatome
- Weakness of muscles in affected myotome!!

Peripheral nerve tumours
- May occur anywhere
- Mostly benign
- Suspect if a nerve lesion occurs in an unusual place
  - Sciatic nerve lesion in the buttock
  - Median nerve lesion in the forearm
Recommended handbook

Game over