

# Peripheral nerve injuries

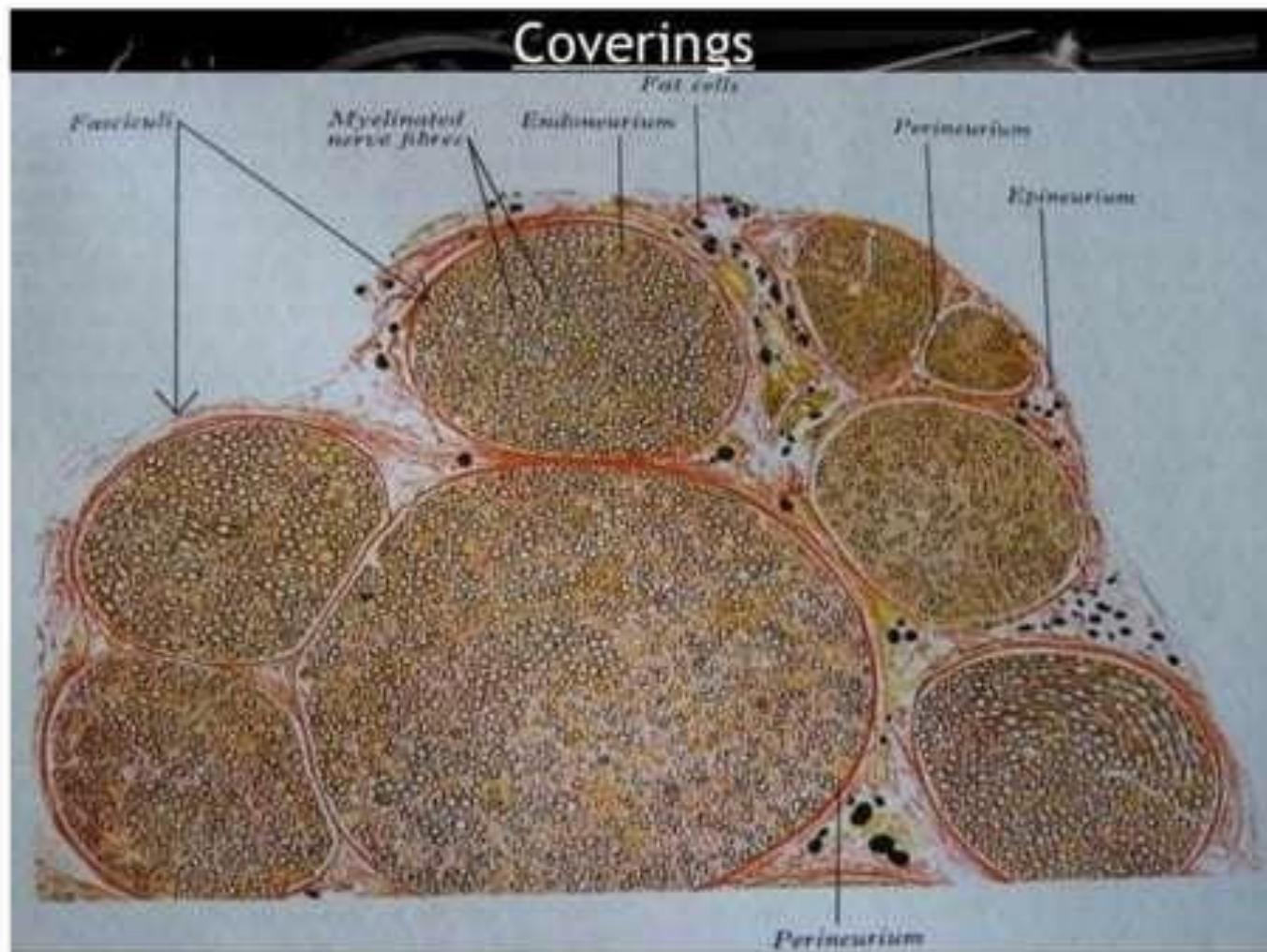
Presented by:

Dr. Binod Chaudhary

Chitwan Medical College

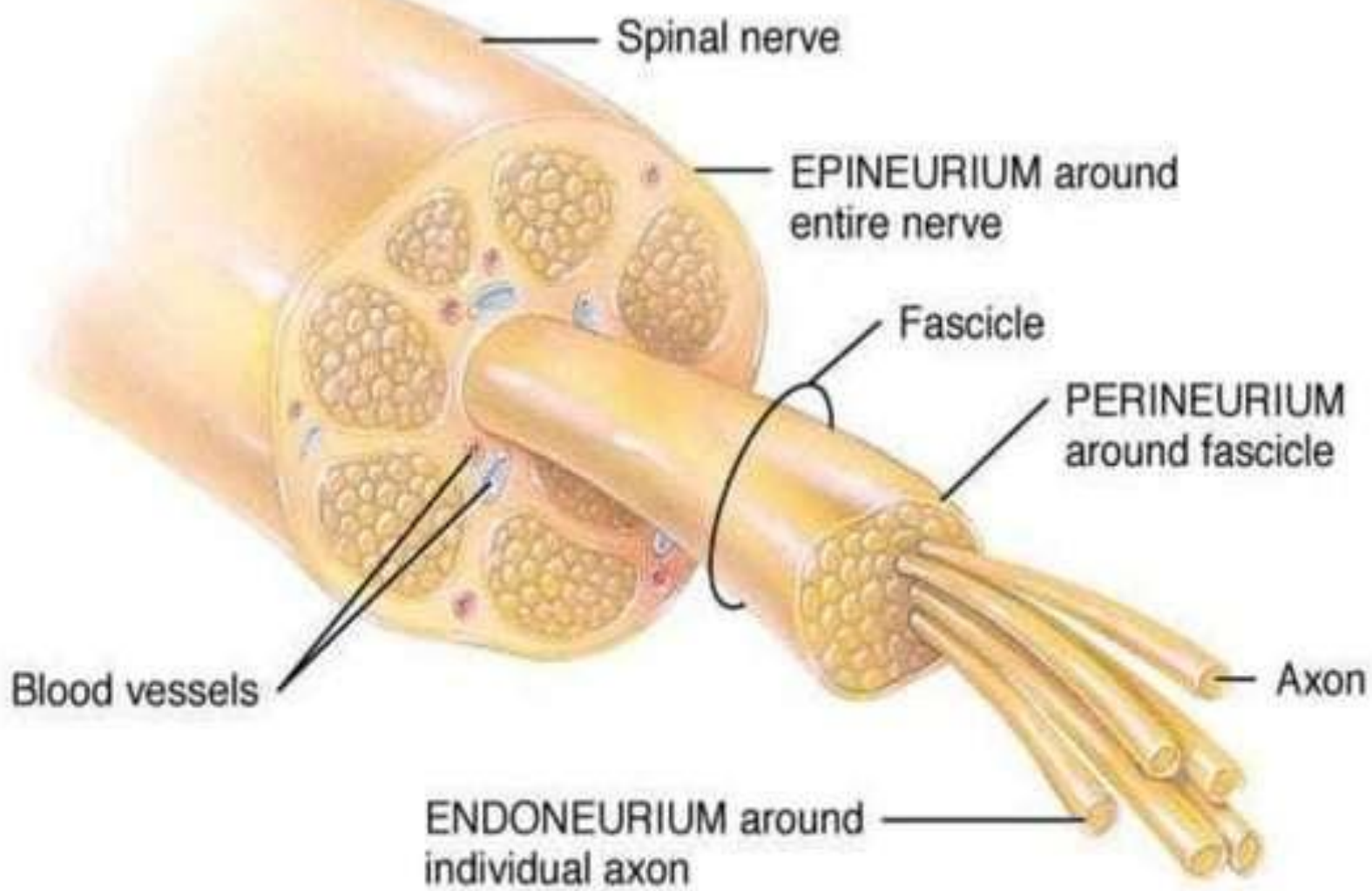
Bharatpur, Nepal

# Relevant anatomy (structure of peripheral nerve)



- Peripheral nerves are bundles of axons conducting efferent impulses from cells in anterior horn of the spinal cord to the muscles, and afferent impulses from peripheral receptors via cells in the posterior root ganglia to the cord
- All motor axons and sensory axons are coated with myelin sheath, interrupted with nodes of Ranvier

- Outside Schwann cells, axon is covered by a connective tissue stocking called **endoneurium**
- The axons that make up a nerve are separated into bundles(fascicles) by fairly dense membranous tissue, the **perineurium**
- The group of fascicles that make up a nerve trunk are enclosed in an even thicker connective tissue coat, the **epineurium**



# Sensory innervation of limbs

- Area of hypoaesthesia due to nerve injury may be less than area of skin supplied by that nerve because of overlap of sensory supply.
- **Autonomous zone**= a relatively small area of complete anaesthesia .
- These zones are found in all nerve injury.

**Sensory Territories and Innervations  
(Volar View)**



**Sensory Territories and Innervations  
(Dorsal View)**



# Motor innervation of limb m/s

- Essential for diagnosis of nerve injury.
- Points to remember:
  - 1) Nerve supply of particular muscles?
  - 2 )Different muscles supplied by a nerve?
  - 3 )action of a muscle and by what manoeuvre can one appreciate its action in isolation?

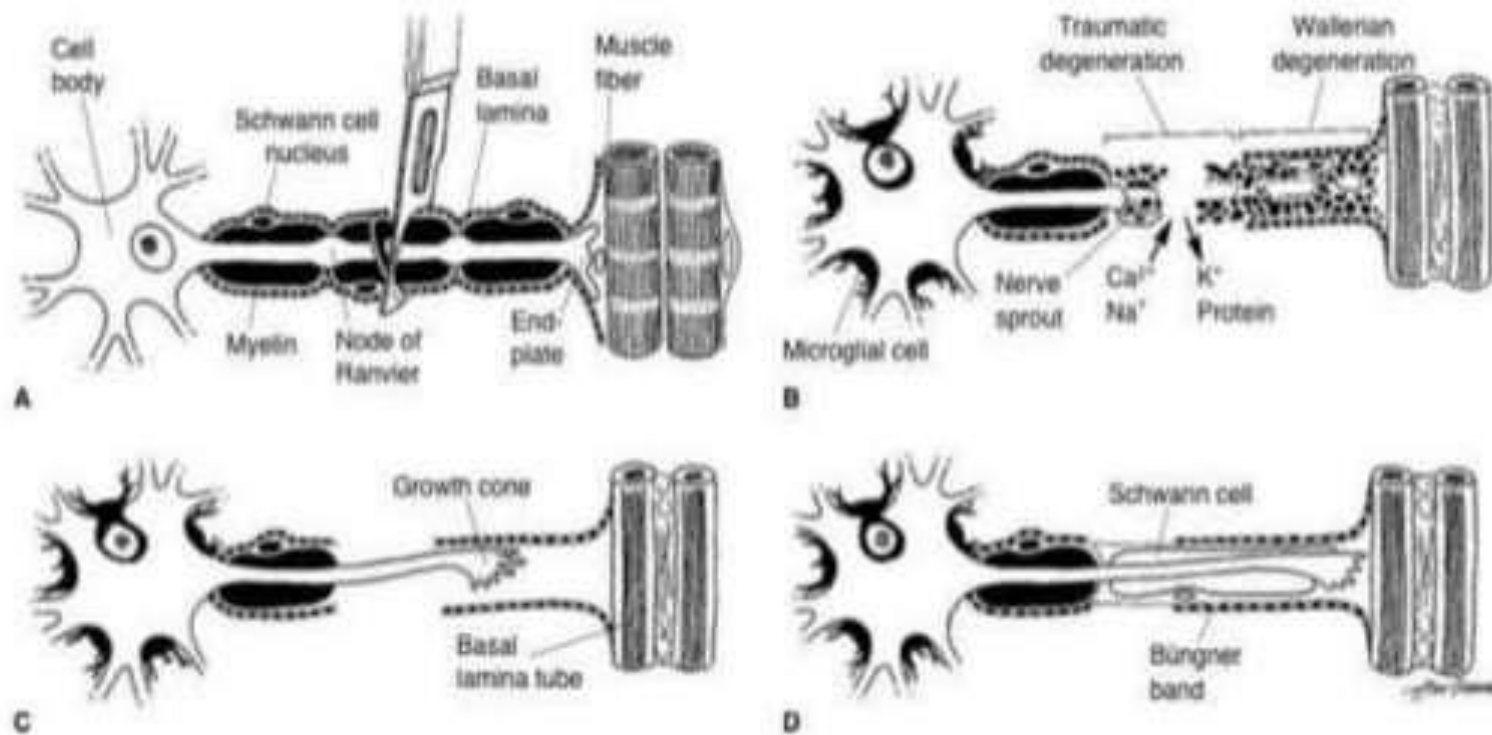


# Anatomical features relevant to nerve injuries

- Relation to surface: superficial nerves are more prone to injury by external object like median n. in wrist.
- Relation to bone: radial nerve injury in # humeral shaft
- Relation to fibrous septae: nerve may get entrapped in septae.
- Relation to major vessels
- Course in a confined space(eg: median n. compression in carpal tunnel syndrome)

# Pathology

## Degeneration & Regeneration



# Mechanisms of injury

<b>Injury and dislocation(most common)</b>	<b>Thermal injury</b>
<b>Cut and laceration</b>	<b>Electrical injury</b>
<b>Infection</b>	<b>Ischemic injury</b>
<b>Compression , traction and friction</b>	<b>Toxic agents</b>
<b>Cooling and freezing</b>	<b>Radiation</b>

# Classification of nerve injury

1. Transient ischaemia
2. Neurapraxia
3. Axonotmesis
4. neurotmesis



Seddon's classification

## **Transient ischemia**

- Due to transient endoneurial anoxia (due to acute nerve compression)
- Reversible condition
- Within 15 min: numbness and tingling
- After 30 min: loss of pain sensibility
- After 45 min: muscle weakness
- Relief of compression is followed by intense paresthesia upto 5 min.
- Feeling restored within 30 seconds and full muscle power after 10 minutes

## **Neurapraxia**

- Reversible physiological nerve conduction block in which there is loss of some types of sensation and muscle power followed by spontaneous recovery after few days or weeks.
- Due to mechanical pressure causing segmental demyelination
- Seen in crutch palsy or tourniquet palsy

## **Axonotmesis**

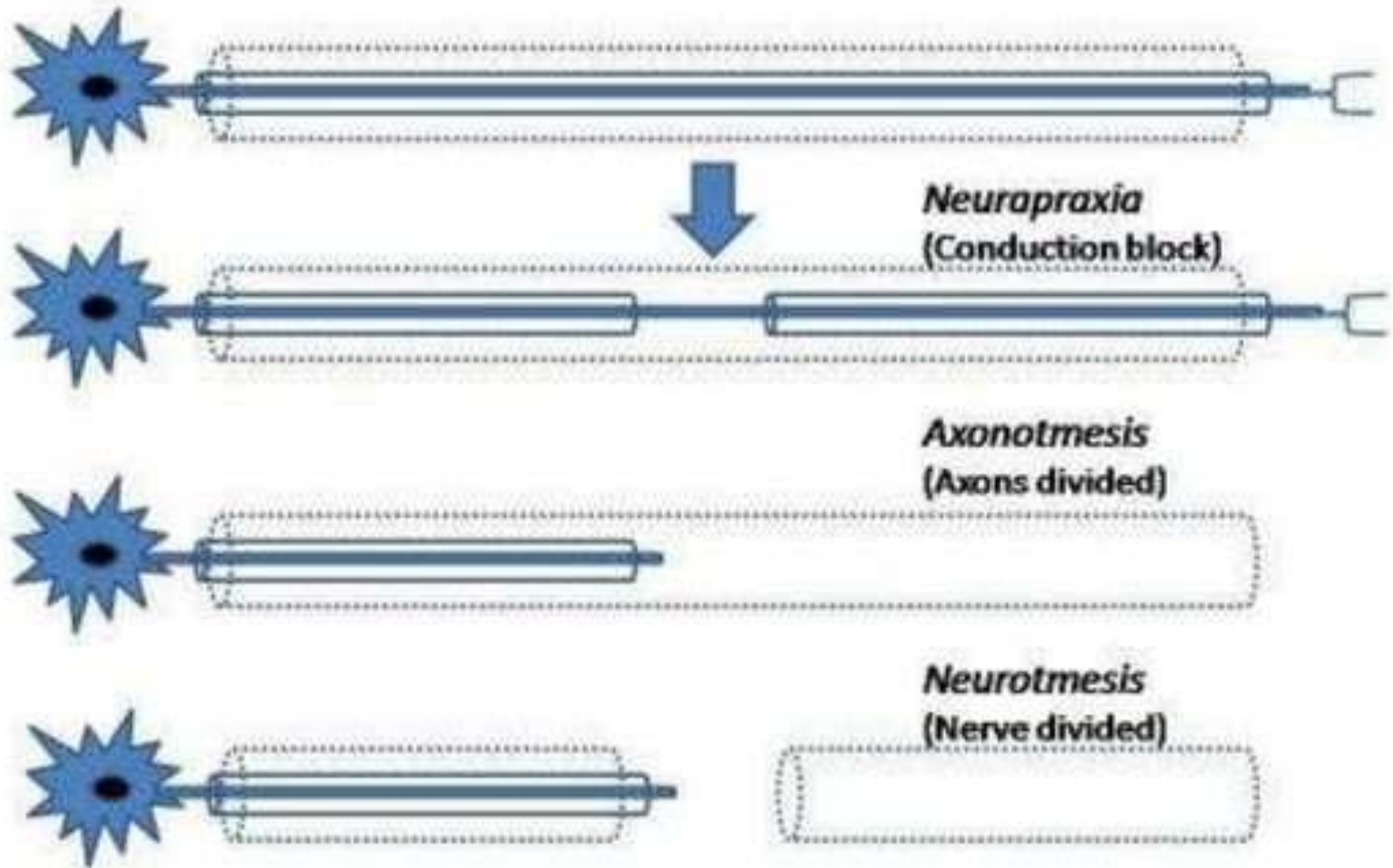
- Due to axonal interruption
- Loss of conduction but the nerve is in continuity and the neural tubes are intact
- Wallerian degeneration distal to the lesion and few millimeters retrograde
- Axonal regeneration occurs within hours of nerve damage (1-2 mm/day), and if they are not reinnervated within 2 years they will never recover

## **Neurotmesis**

- Division of nerve trunk
- Rapid wallerian degeneration
- Destruction of endoneurial tubes over a variable segment and scarring prevents regeneration of axons
- Surgical repair required
- Function may be adequate but is never normal




## Grades of Nerve Injury (Seddon 1942)



# Sunderland's classification

## Classification of Nerve Injuries

Sunderland 1951	I	II	III	IV	V
	Focal conduction block NO Wallerian degeneration	Axonal Disruption	Axon + Endoneurium Disruption	Axon + Endoneurium + Perineurium Disruption	Axon + Endoneurium + Perineurium + Epineurium Disruption

- Diagnosis

The diagnosis of a peripheral nerve lesion depends primarily on a precise history and an exact clinical examination

# History

- c/c= Inability to move a part of limb
- Weakness
- Numbness
- Cause may or may not be obvious.
- When cause is obvious: nerve affected and its level is easy to decide.
- When cause is not obvious: history of injection in nerve proximity, any medical causes like leprosy, diabetes should be asked.

# Examination

- Following observation should be made:

## 1. **Attitude and deformity:**

some peripheral nerve injuries present with classic attitude and deformity of limb.

- ❖ Wrist drop
- ❖ Foot drop
- ❖ Winging of scapula
- ❖ Claw hand
- ❖ Ape-hand deformity
- ❖ Pointing index
- ❖ Policeman-tip deformity

## **2. Wasting of muscles:**

- Will become obvious some time after paralysis.
- Compare opposite sound side. Slight wasting may go missed.

## **3. Skin**

- dry, glossy and smooth.
- pallor or cyanosis
- Trophic disturbances such as ridged and brittle nails, shiny atrophic skin, etc

#### **4. Temperature**

Paralysed part is usually colder and drier.

#### **5. Sensory examination**

-different forms of sensation to be tested in suspected case of nerve palsy.

#### **6. Sweat test**

-to detect sympathetic function in the skin supplied by a nerve.

-presence of sweating within an autonomous zone of an injured peripheral nerve reassures that complete interruption of the nerve has not occurred.

**-starch test or ninhydrin test.**

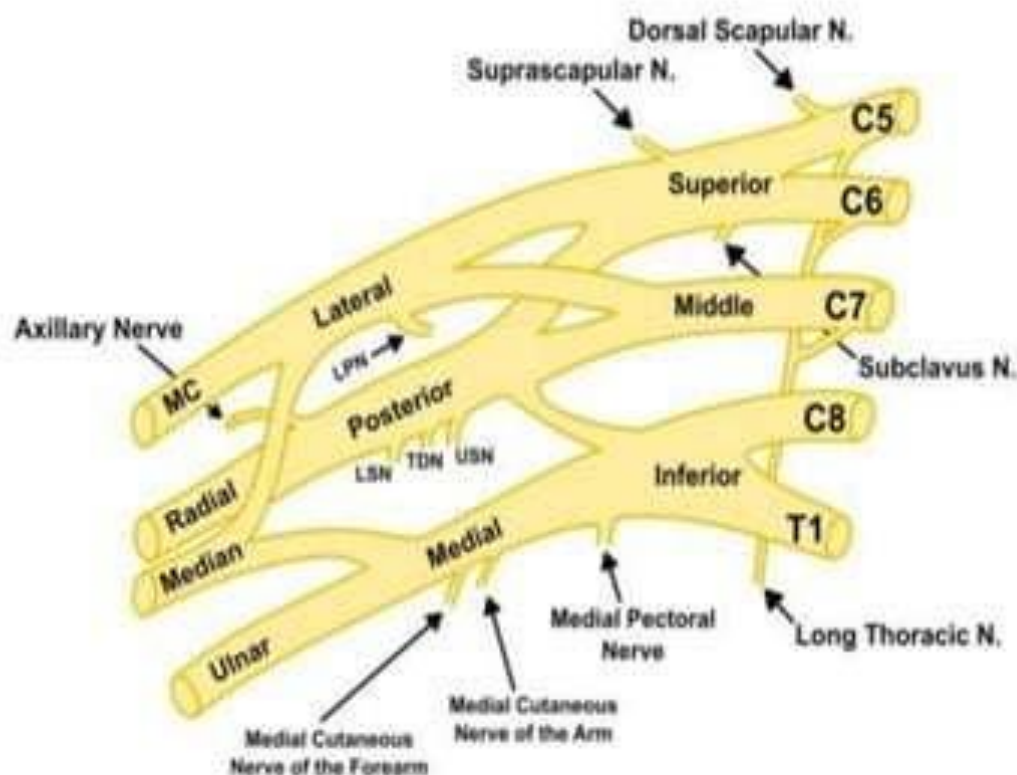
#### **7. Motor examination**

# Regional survey of nerve injuries

## Brachial Plexus injuries

Most commonly:

1. Erb's palsy
2. Klumpke's palsy





# Erb's palsy

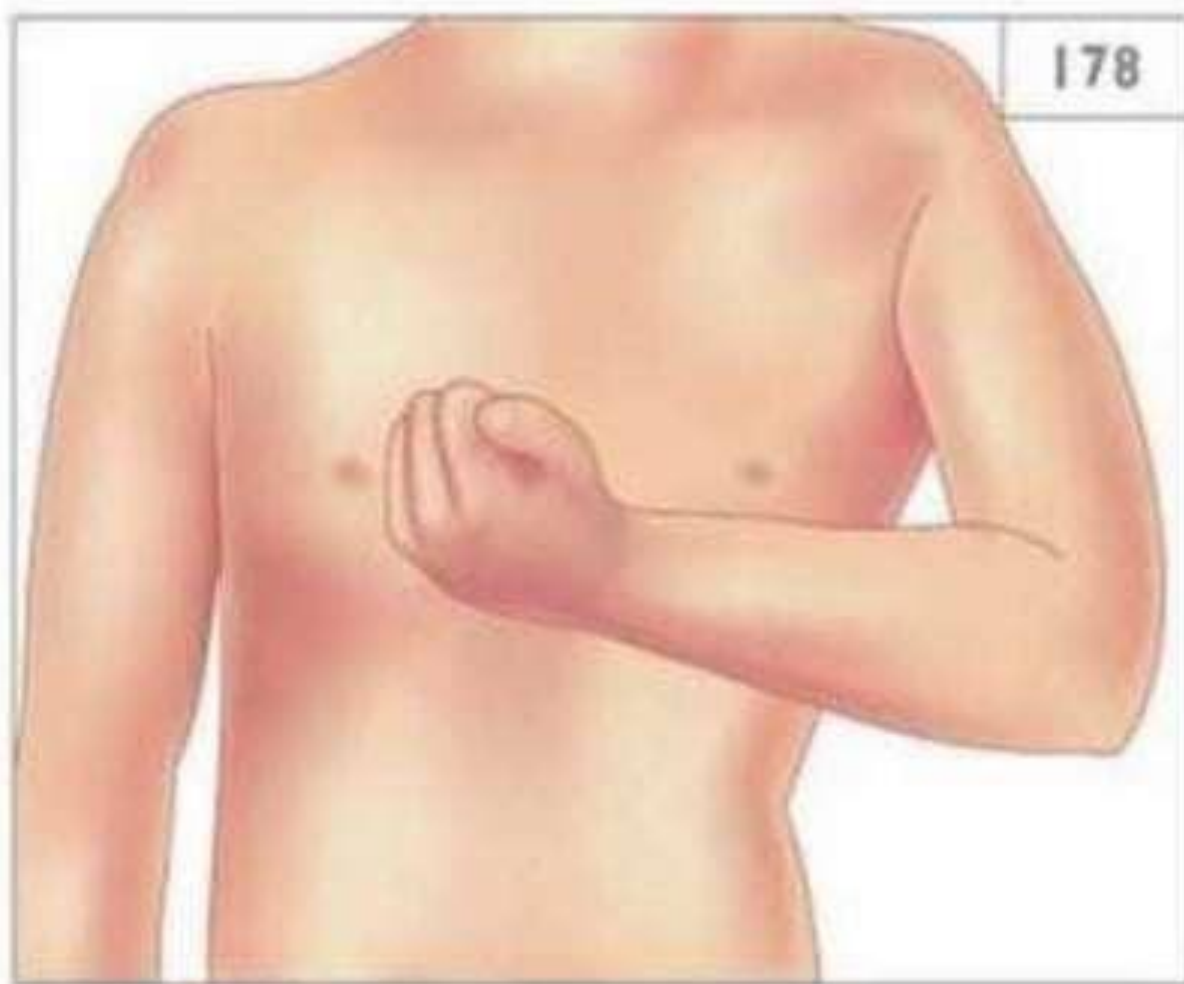
- Injury of C5, C6 and (sometimes) C7.
- Common in overweight babies with shoulder dystocia at delivery
- The abductors and external rotators of the shoulder and the supinators are paralyzed.
- Arm held to the side, internally rotated and pronated



**Erb's palsy**

# Klumpke's palsy

- Injury of C8 and T1
- Usually after breech delivery of smaller babies
- Baby lies with the arm supinated and the elbow flexed
- Loss of intrinsic muscle power in the hand



**178 Klumpke palsy.**

# Long thoracic nerve

- Roots C5, 6, 7
- Supplies serratus anterior muscle
- Injury cause paralysis of the muscle causing winging of scapula
- Complain of aching and weakness on lifting the arm
- Test by pushing against the wall.



**Test for long thoracic nerve injury  
(winging of right scapula)**

# Spinal accessory nerve

- Root value (C2-6)
- Supplies sternomastoid muscle and upper half of trapezius
- Injury causes severe pain and stiffness of the shoulder, reduced ability to hitch or hunch the shoulder, mild winging of scapula that disappears on flexion or forward thrusting of the shoulder



**Spinal accessory nerve injury**



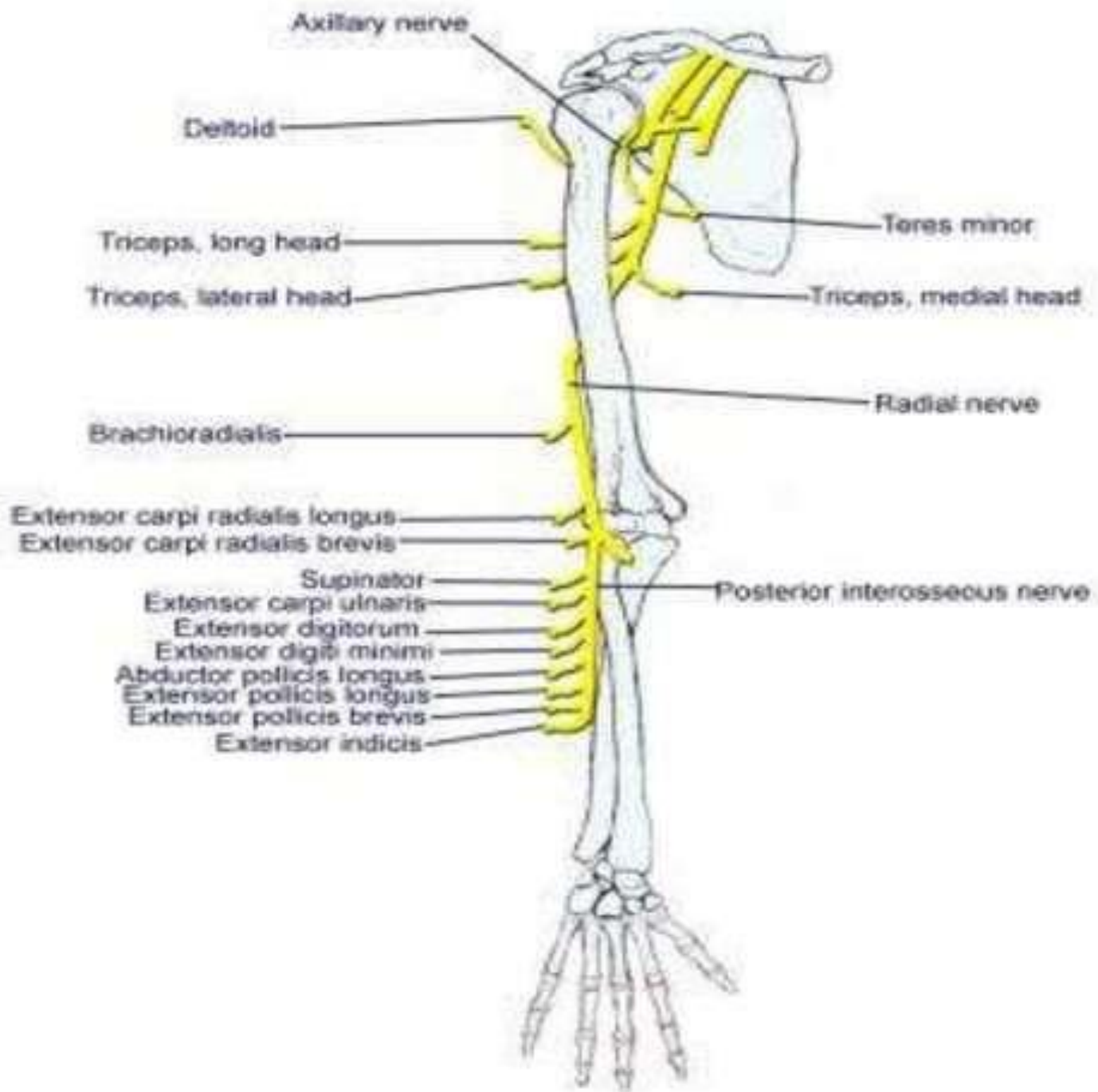
# Axillary nerve

- Root value (C5, 6)
- Supplies deltoid and teres minor muscles
- Cutaneous branch supplies the skin over the lower half of the deltoid (landmark: 5 cm below the tip of acromion)
- Injury caused shoulder weakness and wasting of the deltoid muscles
- Abduction can be initiated, but cannot be maintained

- Extension of the shoulder with the arm abducted to  $90^{\circ}$  is impossible
- Small area of numbness over the deltoid (sergeant's patch sign)
- Test: stabilize the scapula with one hand while the other hand is kept on the deltoid to feel for its contraction. Patient asked to abduct his shoulder, inability to abduct the shoulder and absence of the deltoid becoming taut indicates deltoid paralysis

# RADIAL NERVE

- Continuation of the posterior cord of the brachial plexus.
- Root value: C5- C8 , T1



# Motor branches

- Before the radial groove: long and medial heads of triceps
- After the radial groove, before crossing the elbow: lateral head of triceps, anconeus, brachioradialis, extensor carpi radialis longus
- After crossing the elbow: extensor carpi radialis brevis, the supinator
- After piercing the supinator: other extensor muscles of the forearm and hand

## Low lesions

- Due to # or dislocation at the elbow or to a local wound
- Complain of clumsiness , not being able to extend the MCP joints of the hand
- In thumb, weakness of extension and retroposition
- Wrist extension is preserved

## High lesions

- Due to # of the humerus or after prolonged tourniquet pressure
- Wrist drop due to weakness of the radial extensors of the wrist
- Inability to extend MCP joints or elevate the thumb.
- Sensory loss to a small patch on the dorsum around the anatomical snuff box

## Very high lesions

- Due to trauma or operations around the shoulder
- Also common in Saturday night palsy or crutch palsy
- In addition to high lesions, the triceps is paralysed and the triceps reflex is absent



## Anatomy of the Radial Nerve

The radial nerve is vulnerable to injury below the spiral groove when there is a fracture in the distal third of the humeral shaft.



# Tests for radial n.

- From proximal to distal, following muscles can be examined:

## 1. Triceps

-asked to extend his elbow against resistance

Where other hands feel for triceps contraction.

## 2. Brachioradialis:

-asked to flex his elbow from 90 degree onwards, keeping **the forearm in mid-prone** and against resistance, brachioradialis stands out and can be felt.

### 3. Wrist extensors:

- “**wrist drop**” occur in paralysis of wrist extensors (brachioradialis, ECRL, ECRB, extensor digitorum, extensor carpi ulnaris).



- Also called “**Saturday night palsy**” (d/t injury of radial n. in the axilla)

Radial nerve injury results from acute trauma or compression of the radial nerve.

Condition is often referred to as:

- **Saturday Night Palsy**

- alcohol is sometimes a factor as person falls asleep with the back of their arm compressed by a chair back, bar edge, etc.



#### 4. Extensor digitorum

- fn: extension at MCPJ
- **“finger drop”**

#### 5. Extensor pollicis longus:

- fn: extension at IPJ of thumb
- examined by stabilising the MCPJ of thumb while pt is asked to extend IPJ.
- **“thumb drop”**

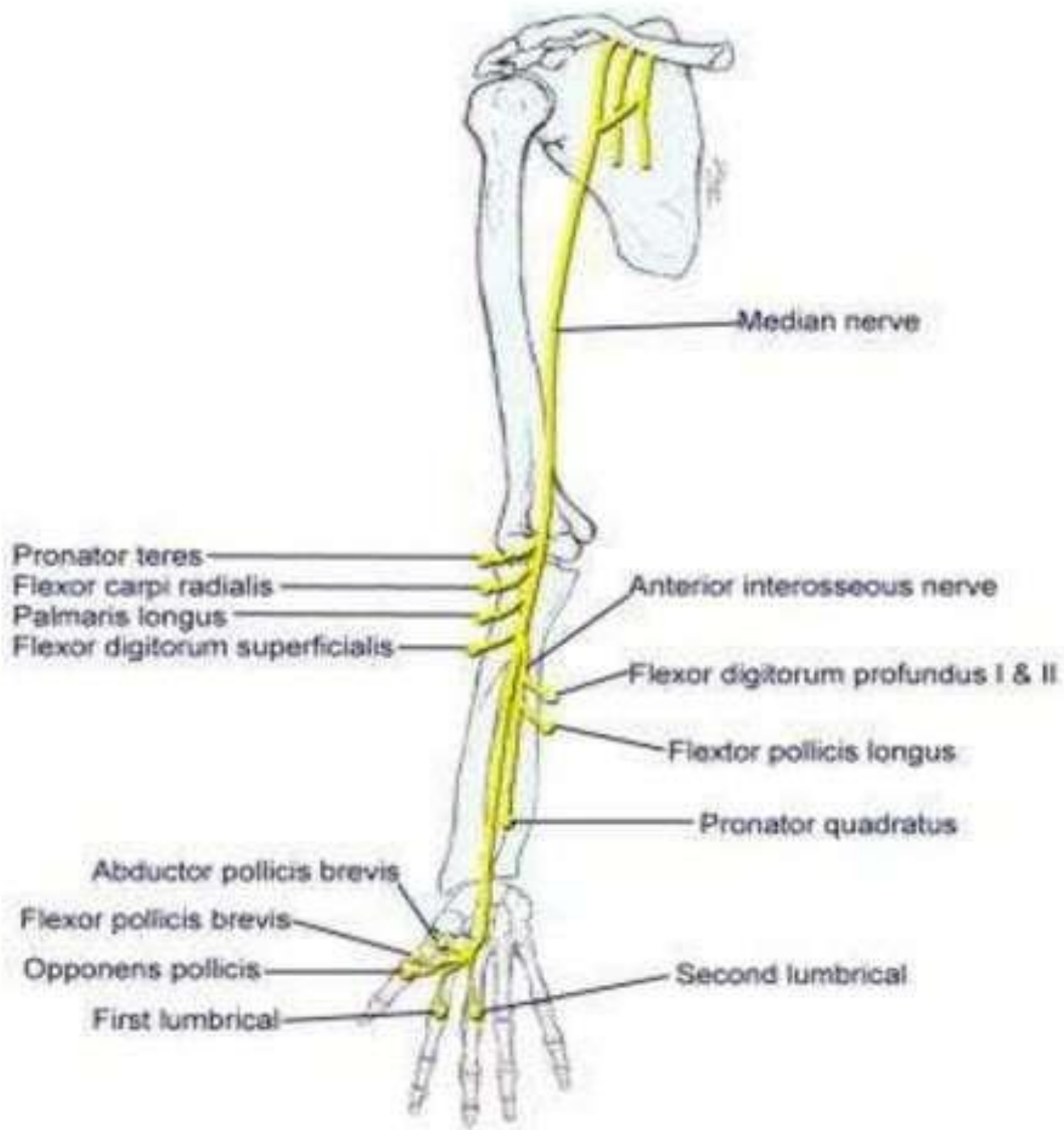
# PIN PALSY

- PIN is a branch of the radial nerve.
  - **purely motor innervation** to the extensor compartment.
- 1.finger metacarpal extension weakness.
  - 2.wrist extension weakness.
    - inability to extend wrist in neutral or ulnar deviation
    - the wrist will extend with radial deviation due to intact ECRL (radial n.) and absent ECU (PIN).



# Median nerve

- Formed by joining of branches from lateral and medial cords of brachial plexus.





# MOTOR BRANCHES OF MEDIAN NERVE

<b>In the arm:</b>	<b>nil</b>
<b>In the forearm:</b> <b>1. proximal 1/3</b>  <b>2. distal 1/3</b>	<b>All flexors of forearm (except FCU and medial half of FDP)</b>  <b>nil</b>
<b>In the hand:</b>	<b>Thenar muscles 1<sup>st</sup> two lumbricals</b>

## Low lesions

- Generally due to cuts in front of the wrist or by carpal dislocations
- Unable to abduct the thumb
- Sensation lost over the radial three and a half digits
- Long standing condition, atrophy of thenar eminence

## High lesions

- Generally due to forearm fractures or elbow dislocation
- Signs: in addition to low lesions, paralysis of long flexors to the thumb, index and middle fingers, radial wrist flexors and the forearm pronator muscles
- Typically hand is held with the ulnar fingers flexed and the index straight, **pointing sign**
- Characteristic pinch defect (patient pinches with distal joints in full extension)

## Isolated anterior interosseous nerve lesions

- Extremely rare
- Signs similar to high median nerve injury but without any sensory loss
- Usual cause: brachial neuritis which is associated with shoulder girdle pain after immunization or viral illness

- Tests: from proximal to distal, following muscles can be examined-

1. Flexor pollicis longus:

-fn: flexion at IPJ of thumb

-asked to flex distal phalynx of thumb against resistance while proximal phalanx is steady by examiner.

2. Flexor digitorum superficialis and lateral half of flexor digitorum profundus:

-**"pointing index"**



- Pointing index**= on asking pt to make a fist, index finger remains straight.
- Occurs due to paralysis of both flexors of index finger due to median nerve palsy at level proximal to elbow.

### 3. Flexor carpi radialis:

- in a pt with paralysis of this muscles, the wrist deviates to ulnar side while palmar flexion occurs.



4. Muscles of thenar eminence: out of the three m/s of thenar eminence (abductor pollicis brevis, opponens pollicis, flexor pollicis brevis) only two can be examined for their isolated action.

a) Abductor pollicis brevis:

- fn: abduction of thumb
- **“pen test”**
- pt is asked to lay his hand flat on the table with palm facing the ceiling, and a pen is held above the thumb and asked him to touch the pen with tip of his thumb.



# Pen test



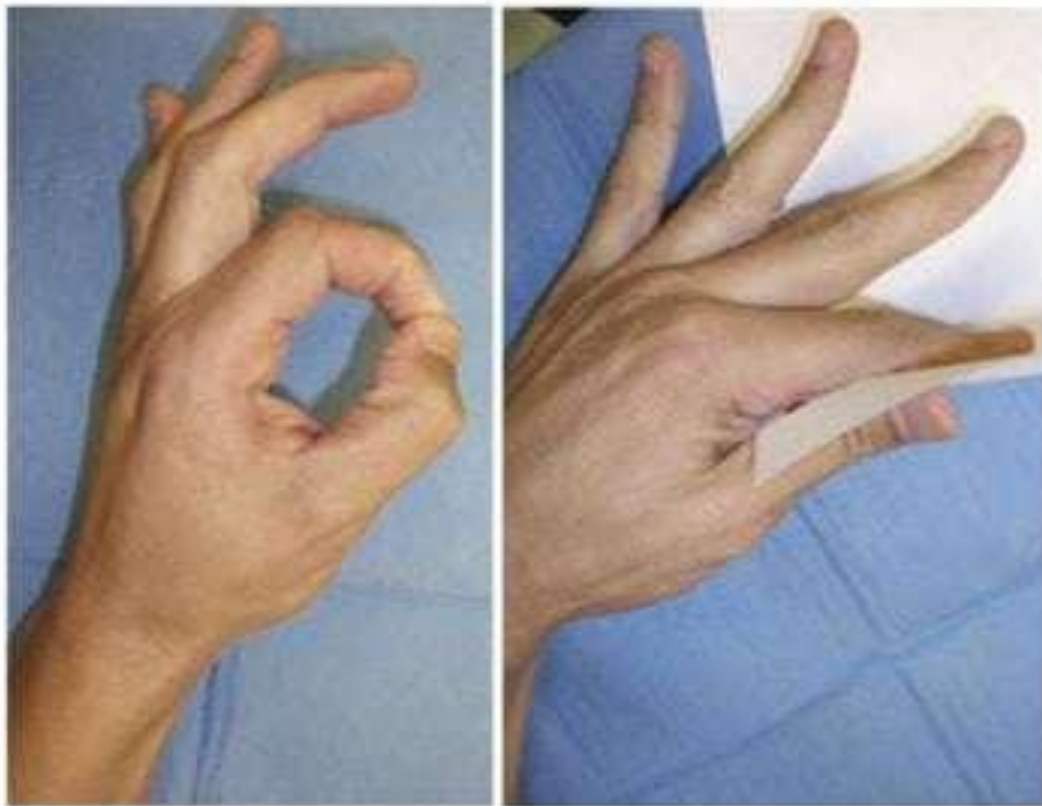
b) *Opponens pollicis*:

- fn: to appose the tip of the thumb to other fingers.

(swinging movement of thumb across the palm is by *adductor pollicis* –supplied by ulnar n.)

**Thumb  
Opposition**





## **Anterior interosseous nerve palsy**

-patient unable to make OK sign (test FDP and FPL)

## Ape Hand Deformity

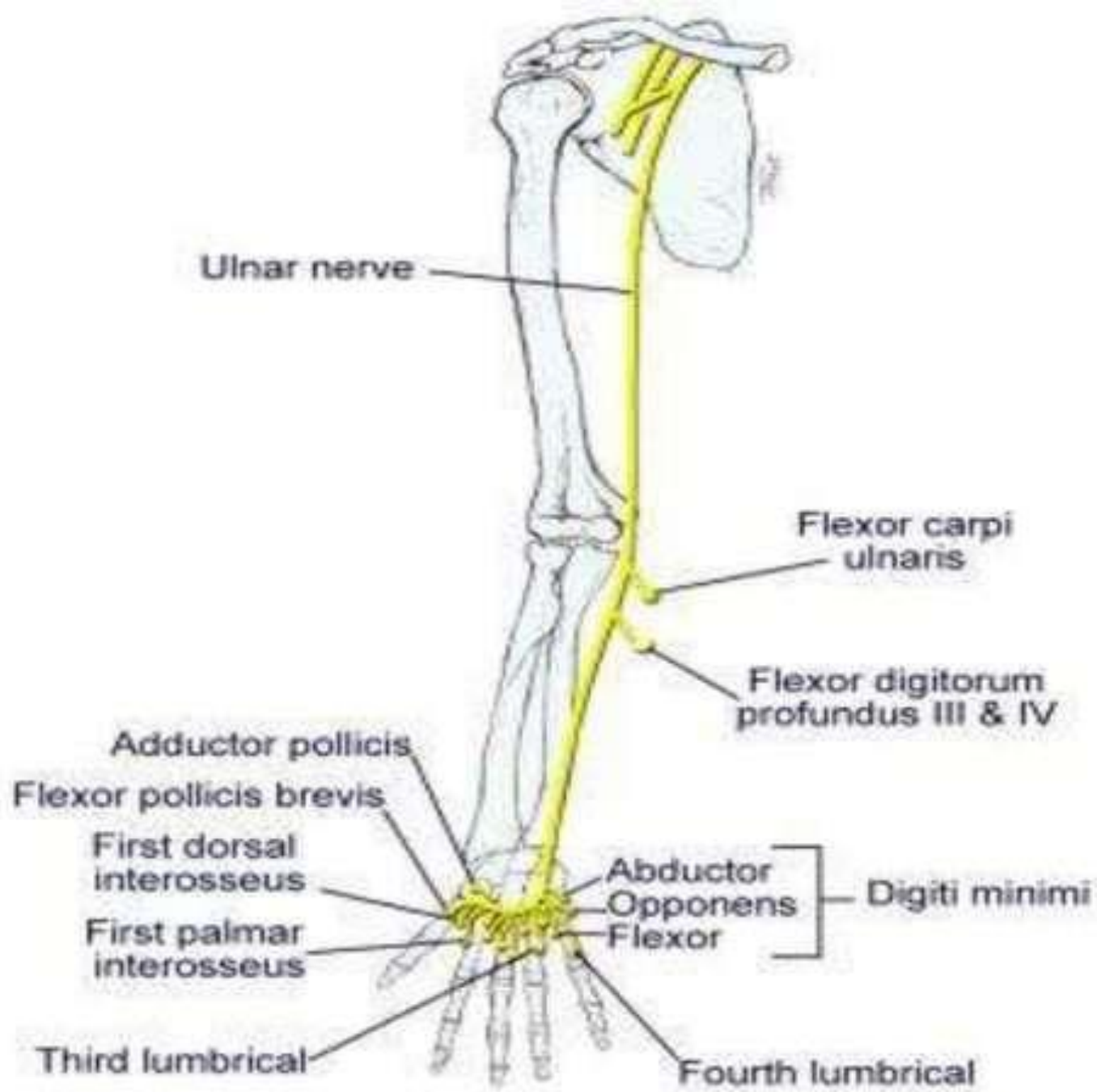
- Median nerve palsy
- Wasting of the thenar eminence of the hand
- Inability to oppose or flex the thumb



-thumb is in same plane as wrist(test thenar eminence )

# Ulnar nerve

- This nerve arises from the medial cord of the brachial plexus.
- Root value: C7,C8 and T1



# Major motor branches of the ulnar nerve

	Muscles supplied by ulnar nerve
In the arm:	nil
In the forearm: 1. proximal 1/3	Flexor carpi ulnaris, medial half of flexor digitorum profundus
2. distal 1/3	nil
In the hand: superficial branch deep branch	Hypothenar m/s  Adductor pollicis, All interossei and Medial two lumbricals

## Low lesions

- Injury in distal third of the forearm
- Sparing of forearm muscles but muscles of hand are affected
- Complain of numbness of ulnar one and a half fingers.
- Claw hand deformity with hyperextension of MCP joints of the ring and the little fingers
- Hypothenar and interosseous wasting
- Froment's sign positive



## High lesions

- Common in elbow fractures or dislocations
- Motor and sensory loss are the same as in low lesions.
- Hand is not markedly deformed because the ulnar half of flexor digitorum profundus is paralysed and the fingers are therefore less clawed (*high ulnar paradox*)

Examination of individual muscles in case of ulnar n. palsy:

1. Flexor carpi ulnaris

- asked to palmar flex the wrist against gravity and the hand deviates towards radial side.



2. Abductor digiti minimi

- Asked to abduct the little finger against resistance while keeping the hand flat on the table.

.

3. interossei:

-fn: **palmar interossei do adduction(PAD)**

**dorsal interossei do abduction(DAB)** of the fingers at MCP joints

### EGAWA'S TEST

- For **dorsal interossei(abductors) of the middle finger.**
- With the hand kept on a flat table palmar surface down, pt is asked to move his middle finger sideways.
- **First dorsal interossei muscle** can be separately examined by asking the pt to abduct the index finger against resistance.

# Egawa's test



- CARD TEST

- For palmar interossei (adductors) of the fingers



- examined by inserting a card between two extended fingers and asked to hold tightly while examiners try to pull the card out. <sup>(A)</sup>

- in case of weak palmar interossei, it is easy to pull out the card.

- **Claw hand**

- hyperextension at MCP joint and flexion at PIP and DIP joint( paralysis of lumbricals.)
- **Ulnar paradox**= clawing is more marked in low ulnar nerve palsy than high ulnar nerve palsy(flexors of fingers are also paralysed)
- In ulnar nerve palsy, only medial 2 fingers develop clawing while all 4 fingers develop clawing in combined median and ulnar nerve palsies.

# Claw hand (in ulnar n. palsy)



### 3. Adductor pollicis:

- **” book test” or froment’s sign**  
( use of adductor pollicis and 1<sup>st</sup> dorsal interosseous)
- In case of paralysis, pt will hold a book by using flexor pollicis longus (supplied by median n.) in place of the adductor.
- This produces flexion at the IPJ of the thumb.



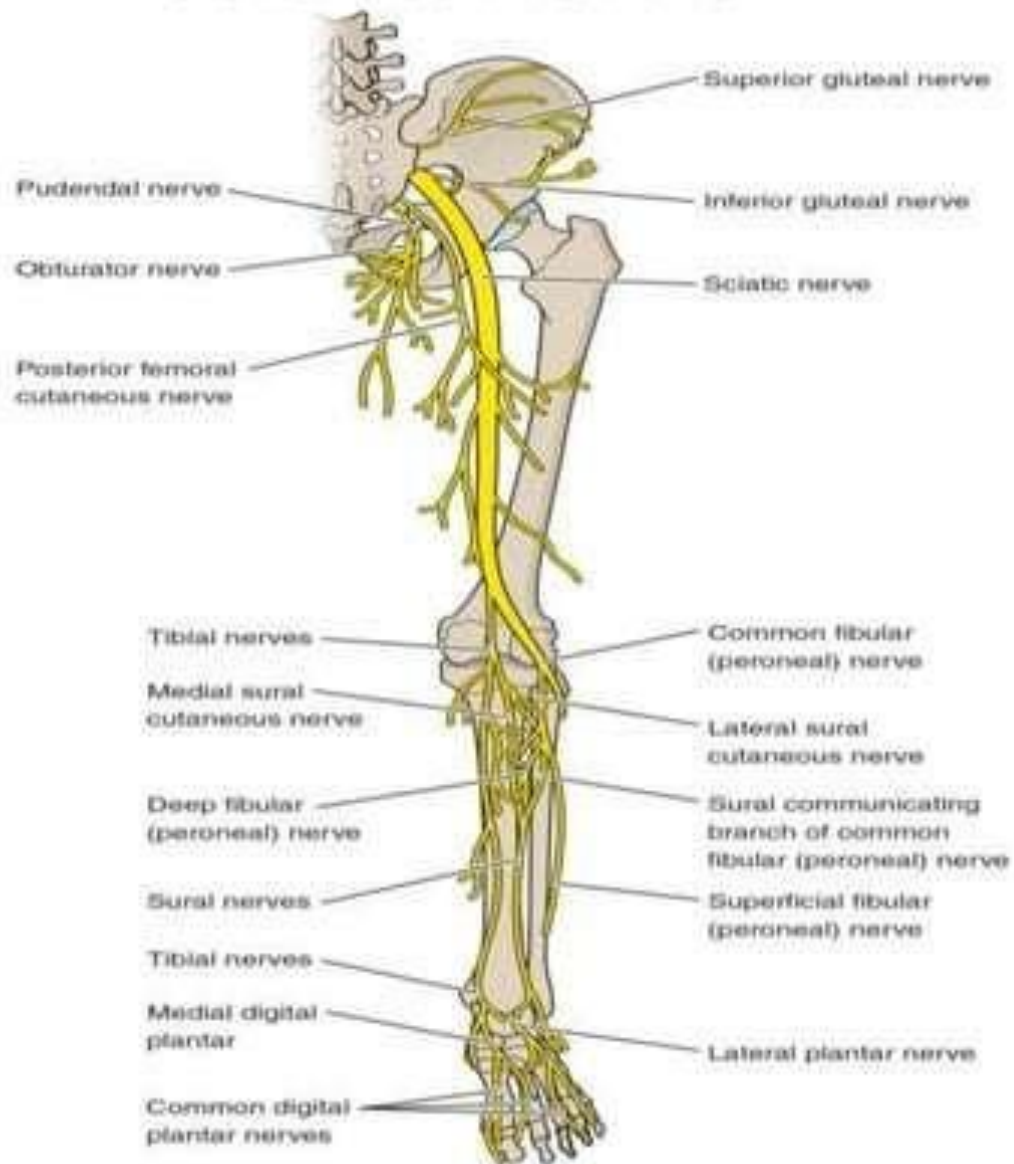
# Book test



# Femoral nerve

- May be injured by a gunshot wound, by pressure or traction during an operation or by bleeding into the thigh
- Features indicate paralysis of quadriceps and the patient is unable to extend the knee actively.
- There is numbness of the anterior thigh and medial aspect of the leg
- Knee reflex is depressed
- Severe neurologic pain

# Sciatic nerve



- Most commonly injured in traumatic hip dislocation (posteriorly) and pelvic fractures

Features include

- ❖ Paralysis of hamstrings and all muscles below the knee
- ❖ Absent ankle jerk
- ❖ Loss of sensation below knee except on medial side of the leg (saphenous branch of the femoral nerve)
- ❖ Patient walks with foot drop and a high stepping gait

## Foot drop



**A** Toes do not clear ground during swing phase

## Compensating for foot drop



**B** Waddling gait



**C** Swing-out gait



**D** Steppage gait

# Treatment of nerve injury

- Conservative management
  - ❖ Splintage of the paralysed limb
  - ❖ Preserve mobility of the joint
  - ❖ Care of skin and nails
  - ❖ Physiotherapy
  - ❖ Relief of pain: analgesics
- Operative management
  1. Neurolysis
  2. Nerve repair
  3. Nerve grafting
  4. Nerve transfer

# Neurolysis

- Application of physical or chemical agents to a nerve in order to cause a temporary degeneration of targeted nerve fibres
- Operation where nerve is freed from enveloping scar (perineural fibrosis) ; called **external neurolysis**
- The nerve sheath may be dissected longitudinally to relieve the pressure from the fibrous tissue within the nerve (intranearal fibrosis ; **internal neurolysis**

## Nerve repair

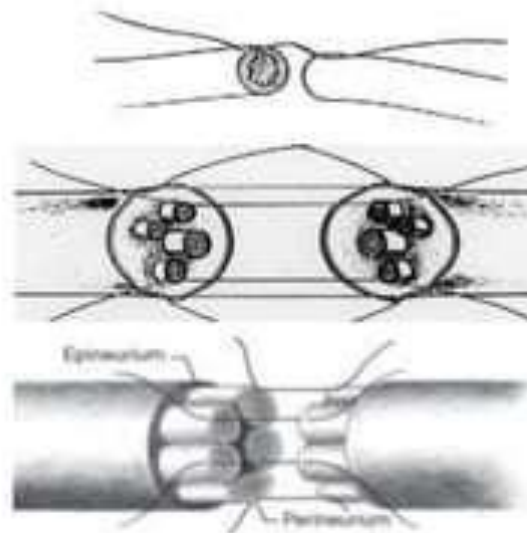
- May be performed within a few days of injury or later.
- Types:
  - ❖ Primary repair: Indicated in clean sharp nerve injuries; done in the first 6 to 8 hours of injury
  - ❖ Delayed primary repair: Done in the first 7 to 18 days of injury when the wound is clean and there are no other major complicating injuries
  - ❖ Secondary repair: Done in crushed, avulsed injuries; done at a delay of 3-6 weeks



# Techniques of nerve repair

## 1. Nerve suture

- Indicated when the nerve ends can be brought close to each other
- Techniques:
  - Epineural suture
  - Epi-perineural suture
  - Perineural suture
  - Group fascicular repair



## 2. Nerve grafting

- Indicated when the gap is more than 10 cm or end to end suture is likely to result in tension at the suture line.
- Most common nerve used is **sural nerve**
- Other source:
  - Medial antebrachial cutaneous nerve
  - Third webspace branch of median n
  - Lateral antebrachial cutaneous nerve
  - Palmar cutaneous and dorsal cutaneous branch of ulnar n

## Methods of closing nerve gaps

- Mobilization of the nerve on both sides of the lesion
- Relaxation of the nerve by temporarily positioning the joints in a favourable position
- Alteration of the course of the nerve
- Stripping the branches from the parent nerve without tearing them
- Sacrificing some unimportant branch if it is hampering nerve mobilisation

## Signs of regeneration of nerve

- 1. Tinel's sign:** On gently tapping over the nerve along its course, from distal to proximal, a pin and needle sensation is felt in the area of the skin supplied by the nerve. A distal progression of the level at which it occurs, suggests regeneration(1 mm/day)
- 2. Motor examination:** The muscle supplied nearest to the site of injury is the first to recover. The muscles in the more distal area begin to contract as they are reinnervated one after another (**motor march:** absent in neuropraxia)
- 3. Electordiagnostic test:** Helps in predicting nerve recovery even before it is apparent clinically.
  - Electromyography
  - Nerve conduction study

# Electromyography

- A graphic recording of the electrical activity of a muscle at rest and during activity.
- A concentric needle electrode is inserted into the muscle and connected to an oscilloscope screen and a loudspeaker.
- Useful in deciding:
  - Whether or not a nerve injury is present
  - Whether it is a complete or incomplete nerve injury
  - Whether any regeneration occurring
  - Level of nerve injury

## In normal muscles

- A normal muscle at rest shows no electrical activity.
- As the patient slowly contracts the muscle there is recruitment of one, then more and then multiple motor units.
- A motor unit defined as the anterior horn cell in the spinal cord, with its motor axon and the variable number of muscle fibres it innervates in the muscle.
- In strong contraction, impulses of a number of motor units firing simultaneously are superimposed, giving rise to an *interference pattern*.

## In denervated muscles

- The denervated muscle has spontaneous electrical activity at rest(denervation potentials)
- These potentials are normally suppressed by stronger nerve action potentials.
- Appears around 15-20 days after the muscle denervation.
- As denervation progresses, more and more denervation potentials appear.
- If these potentials have not appeared by the end of the 2<sup>nd</sup> week of after nerve injury, it is a good prognostic sign.

# Nerve conduction test

- It is a measure of the velocity of conduction of impulse in a nerve
- A stimulating electrode is applied over a point on the nerve trunk and the response is picked up by an electrode at a distance or directly over the muscle
- The velocity of the conduction of the impulse b/w any two points of the nerve can be calculated.
- The normal nerve conduction velocity of motor nerve is 70 m/s
- Helps to determine
  - Whether a nerve injury is present
  - Whether it is a complete or partial nerve injury
  - Compressive lesions



## Prognostic factors for the result of nerve repair (suture or grafting)

### ***Factors outside our influence***

- Nerve injured (motor, sensory, mixed)
- Level of lesion (proximal – distal)
- Accompanying lesion (fractures etc.)
- Age of patient

### ***Factors which we can influence***

- Delay between injury and surgery
- Surgical technique

