Upper Limb
Part IV
Hand
Tendons of the extensors of the hand

- In the place of passage over the wrist, tendons of the extensors of the hand run through the osseofibrous tunnels formed by extensor retinaculum, its fibrous septa and distal parts of the forearm bones.

- Tendons of the extensor digitorum, extensor indicis and extensor digiti minimi pass into extensor expansion.

- In the place of passage over the wrist tendons of the extensors of the hand are situated within the synovial sheaths which supply them and protect them from friction during movements.
Tendons of the extensors of the hand

Compartments of the extensor tendons

1. Abductor pollicis longus and extensor pollicis brevis
2. Extensor carpi radialis longus and extensor carpi radialis brevis
3. Extensor pollicis longus
4. Extensor digitorum and extensor indicis
5. Extensor digiti minimi
6. Extensor carpi ulnaris
Tendons of the flexors of the hand

- Tendons of the:
  - flexor digitorum superficialis,
  - flexor digitorum profundus,
  - flexor pollicis longus,
  - flexor carpi radialis

pass from the anterior compartment of the forearm to the central compartment of the palm via the carpal tunnel.
**Boundaries**

- **Bones of the proximal and distal rows of the wrist**
  - Laterally - tubercules of scaphoid and trapezium
  - Medially - pisiform bone and hook of hamate bone

- **Flexor retinaculum (transverse carpal ligament)**
Carpal tunnel

Contents

❖ Tendons of:
  ➢ *flexor digitorum superficialis*,
  ➢ *flexor digitorum profundus*,
  ➢ *flexor pollicis longus*
  ➢ *flexor carpi radialis*

  *enclosed within synovial sheaths*

❖ *Median nerve*
Synovial sheaths of the flexor tendons

- Tendons of the flexor digitorum superficialis and flexor digitorum profundus possess common flexor synovial sheath

- Flexor pollicis longus and flexor carpi radialis possess own separate flexor synovial sheaths
Flexor synovial sheaths run into digital synovial sheaths but actually only the digital synovial sheaths of the thumb and little finger communicate with the flexor synovial sheaths situated in the carpal tunnel.

Digital synovial sheaths are reinforced by the fibrous digital sheaths which stabilize the tendons and prevent them from the dislocation during movements of fingers.

Fibrous digital sheaths are bounded to the phalanges by the alternating strong annular and weaker cruciform fibers.
Surgical access to the tendons of flexors

Access to the palmar aspect of the tendon of digit flexor

Lateral access to the tendon of digit flexor
Synovial sheaths of flexor tendons as potential pathways of spreading inflammatory processes

- Injuries of digits (puncture by dirty, rusty wires or nails) may cause infection of synovial sheath

- In the case of injury of the 2nd, 3rd or 4th digits the inflammation is restricted only to the digits because their synovial sheaths do not communicate with flexor synovial sheaths

- Injury of the 1st and 5th digits may cause inflammation of the flexor synovial sheaths situated in the carpal tunnel
Carpal tunnel syndrome

- Inflammation of the synovial sheaths (caused by infection, cysts or excessive exercises of fingers) may result in swelling of the flexor synovial sheaths which may lead to the injury of the median nerve.

- Compression of the median nerve in the carpal tunnel causes:
  - Disturbances of the sensation in the region of lateral three and half digits.
Carpal tunnel syndrome

Compression of the median nerve in the carpal tunnel causes:

- **Wasting of muscles of thenar and impairment of thumb movements, especially opposition (ape hand).**
Carpal tunnel syndrome - treatment
Ulnar (Guyon's) canal

Location

- Superiorly (anteriorly) to carpal tunnel, in the superficial layers of the flexor retinaculum, between pisiform bone and hook of hamate bone

Contents

- Place of passage of the:
  - ulnar nerve,
  - ulnar artery and vein
Ulnar (Guyon's) canal and Ulnar neuropathy (Cyclist's palsy)
Ulnar (Guyon’s) tunnel

Ulnar neuropathy (Cyclist’s palsy)

- Long pressure (keeping hands on wheel or handlebar) in the region of pisiform bone and hook of hamate bone may cause compression of ulnar nerve and sensory loss on the medial side of the hand and weakness of the intrinsic hand muscles
Fascia of the palm

- Is continuous with the antebrachial fascia
- Is thin in the lateral and medial parts (over thenar and hypothenar)
- Is thick in the central part of the palm where forms the palmar aponeurosis
- Palmar aponeurosis is connected to the flexor retinaculum and palmaris longus muscle and fibrous digital sheaths
Fascia and compartments of the palm

- Palmar aponeurosis sends 2 fibrous septa (lateral to the 3rd metacarpal and medial to the 5th metacarpal) which divide the palm into 3 compartments
  - Lateral or thenar compartment
  - Central compartment (between septa)
  - Medial or hypothenar compartment

- Beneath the thenar compartment is situated the adductor compartment. These two compartments are separated by the thenar space

- Beneath the central compartment is situated the midpalmar space
Muscles of the hand

Muscles of the thumb

- Thenar muscles (attached to the flexor retinaculum, scaphoid and trapezium bones)
  - Abductor pollicis brevis (attached to the proximal phalanx of the thumb)
  - Flexor pollicis brevis (attached to the proximal phalanx of the thumb)
  - Opponens pollicis (attached to the metacarpal of the thumb)
- Adductor pollicis
Muscles of the thenar

- **Abductor pollicis brevis**
  - Is the most superficial among muscles of thenar
  - Abduces and opposes the thumb

- **Flexor pollicis brevis**
  - Has 2 heads—superficial and deep
  - Its heads are separated by the course of tendon of flexor pollicis longus
  - Situated beneath and medial to the abductor pollicis brevis
  - Flexes and opposes the thumb

- **Opponens pollicis**
  - Situated beneath and lateral to the abductor pollicis brevis
  - Opposes the thumb
Adductor pollicis

- Composed of two heads:
  - Oblique and transverse heads - attached to the 3rd metacarpal bone and medial side of proximal phalanx of the thumb
  - Its heads are separated by the course of radial artery

- Responsible for adduction of the thumb
Innervation of the short muscles of thumb

- Recurrent (motor) branch of the median nerve
  - Abductor pollicis brevis
  - Superficial head of flexor pollicis brevis
  - Opponens pollicis

- Deep branch of the ulnar nerve
  - Deep head of flexor pollicis brevis
  - Adductor pollicis
Movements of the thumb

Flexion of the thumb
- Flexor pollicis longus
- Flexor pollicis brevis

Extension of the thumb
- Extensor pollicis longus
- Extensor pollicis brevis
- Abductor pollicis longus
Movements of the thumb

Abduction of the thumb
- Abductor pollicis brevis
- Abductor pollicis longus

Adduction of the thumb
- Adductor pollicis
- First dorsal interosseus

Opposition of the thumb
- Opponens pollicis
- Abductor pollicis brevis
- Flexor pollicis brevis
Muscles of the hand

Muscles of the little finger

- **Hypothenar muscles** (attached to the flexor retinaculum, pisiform and hook of hamate bones)
  - Abductor digiti minimi (attached to the proximal phalanx of the little finger)
  - Flexor digiti minimi brevis (attached to the proximal phalanx of the little finger)
  - Opponens digiti minimi (attached to the 5th metacarpal)

- **Palmaris brevis**
  - Situated in the subcutaneous tissue of the hypothenar eminence
  - Covers and protects the ulnar nerve and artery
Muscles of the hypothenar

- **Abductor digiti minimi**
  - Is the most superficial among muscles of hypothenar
  - Abducts and flexes the little finger

- **Flexor digiti minimi brevis**
  - Situated beneath and medial to the abductor digiti minimi
  - Flexes the little finger

- **Opponens digiti minimi**
  - Situated laterally to the flexor digiti minimi brevis
  - Opposes the little finger

- **All muscles of the hypothenar are innervated by deep branch of the ulnar nerve**
Lumbricalis

- Latin: Lumbricus = English: Earthworm
Short muscles of the hand

Lumbricals

- **Proximal attachments**
  - Tendons of the flexor digitorum profundus

- **Distal attachments**
  - Extensor expansion

- **Action**
  - Flex 4 medial digits at the metacarpophalangeal joints and extend at the interphalangeal joints
Short muscles of the hand

Lumbricals

- **Innervation**
  - 1st and 2nd lumbricals - median nerve
  - 3rd and 4th lumbricals - deep branch of ulnar nerve
Short muscles of the hand

Interossei muscles

- **3 palmar interossei**
  - Proximal attachments
    - 2nd, 4th and 5th metacarpals

- **4 dorsal interossei**
  - Proximal attachments
    - Adjacent surfaces of two metacarpals

- **Distal attachments of interossei**
  - Extensor expansion

- **Action**
  - Flex 4 medial digits at the metacarpophalangeal joints and extend at the interphalangeal joints
  - Palmar interossei adduct digits
  - Dorsal interossei abduct digits

- **Innervation of interossei**
  - Deep branch of ulnar nerve
Innervation of the hand

- 3 nerves are responsible for innervation of the hand:
  - Median nerve
  - Ulnar nerve
  - Radial nerve (only sensory innervation)
Median nerve

- Before entering the carpal tunnel median nerve gives rise to the palmar branch
- After passing through the carpal tunnel median nerve divides into
  - Recurrent branch
  - Common palmar digital nerves which next divide into proper palmar digital nerves
Median nerve

Range of innervation within the hand

- **Motor innervation**
  - Abductor pollicis brevis
  - Superficial head of flexor pollicis brevis
  - Opponens pollicis
  - 1st and 2nd lumbricals

- **Sensory innervation**
  - Palmar surface of the lateral two thirds of the hand (medial three digits and medial half of 4th digit)
  - Dorsal surface of middle and distal phalanges of medial three digits and medial half of 4th digit
- Ulnar nerve

- Running in the forearm ulnar nerve gives rise to the dorsal cutaneous branch which innervates the dorsum of the hand

- Proximal to the wrist ulnar nerve gives rise to the palmar cutaneous branch which innervates the medial part of the palm of hand

- Ulnar nerve passes in the superficial layers of the flexor retinaculum (outside the carpal tunnel)
Ulnar nerve

- Ulnar nerve after passing the flexor retinaculum divides into 2 terminal branches:
  - Sensory- superficial branch of the ulnar nerve (dividing into common and proper palmar digital nerves)
    - Innervates palmar surface of the little finger and medial surface of the annular (4th) finger and palmaris brevis
  - Motor- deep branch of the ulnar nerve
    - Runs together with the deep palmar arch
    - Innervates short muscles of the hand, hypothenar muscles and adductor pollicis
Range of innervation within the hand

- **Motor innervation**
  - Palmaris brevis
  - Abductor digiti minimi
  - Flexor digiti minimi brevis
  - Opponens digiti minimi
  - All Interossei (dorsal and palmar)
  - 3rd and 4th lumbricals
  - Adductor pollicis
  - Deep head of flexor pollicis brevis
Range of innervation within the hand

- **Sensory innervation**
  - Medial 1/3 of the dorsum of the hand
  - Palmar surface of the medial one third of the hand (little finger and medial surface of 4th digit)
  - Dorsal surface of middle and distal phalanges of little finger and medial half of 4th digit
Potential places of compression or injury of the ulnar nerve

- Place of passage behind the medial epicondyle of humerus
- Place of passage above the carpal tunnel (canal of Guyon)

- Hand has image similar to the “clawhand” because of atrophy of the short interossei muscles of hand and inability of extension of digits at the interphalangeal joints and contracture of flexors of digits
Radial nerve

- Only the superficial branch of the radial nerve takes part in the direct innervation of the hand and is responsible for innervation of lateral half of the dorsum of the hand.

- Deep branch of the radial nerve is responsible for innervation of the extensors of the hand—crucial for function of hand.
“Hand of benediction”
(a) Median nerve injury
Ape Hand
Carpal Tunnel Syndrome

Clawhand
(b) Ulnar nerve injury

“Funny Bone” damage

Wrist-drop
(c) Radial nerve injury
Innervation of the skin of the hand
General division of the spinal nerve

- Radicular innervation of the body
  - One spinal nerve innervates so called somite - part of the body consisting of
    - skin area (dermatome),
    - muscles (myotome)
Radicular innervation

- Segmental pattern of dermatomes is typical for the trunk and is not present in the limbs because of the mutual connections of the spinal nerves forming the nervous plexuses giving rise to the peripheral nerves.
- Peripheral nerves of the limbs contain sensory fibers of several spinal nerves.
Radicular and peripheral innervation of the body

Radicular innervation of the body is different than peripheral nerve innervation.
Radicular and peripheral innervation in the aspect of the injuries of the peripheral nervous system

- **Injury of the roots of trunks of the spinal nerves** (for example because of compression caused by the prolapse of the nucleus pulposus, viral infection i.e. herpes simplex or herpes zoster) results in radiation of pain or loss of sensation in the dermatome of the injured root or trunk of the spinal nerve.

- **Injury of the peripheral nerve** (for example because of injury of the limb or compression in the course of the peripheral nerve) results in radiation of pain or loss of sensation in the region of skin innervated by the injured peripheral nerve.
Significance of the radicular innervation of the body

- Knowledge of the radicular innervation is important for localization the place of the lesion of the spinal nerves roots.
- The most often reason of the spinal nerves roots lesion is protrusion of the intervertebral disc.
Segmental innervation (dermatomes) of the upper limb

- Knowledge of the segmental innervation of the skin of upper limb is useful in assessing the place of injury of the roots of spinal nerves supplying the upper limb (for example during radiculitis in the course of degenerative changes of the vertebral column)
Segmental innervation (dermatomes) of the upper limb

- Knowledge of the segmental innervation of the skin of upper limb is useful in assessing the place of injury of the roots of spinal nerves supplying the upper limb (for example during radiculitis in the course of degenerative changes of the vertebral column-discopathies).

- The most often places of the nucleus pulposus prolapse:
  - C5-C6 - with compression of C6 nerve
  - C6-C7 - with compression of C7 nerve
  - C7-Th1 - with compression of C8 nerve

- In the dermatomes of these nerves the patient can have paresthesia or loss of sensation.
Injury of the roots of the peripheral nerves is often connected with the diminishing or lack of the myotatic reflexes.

**Biceps brachii tendon reflex**  
C5-C6

**Triceps brachii tendon reflex**  
C7-C8
Injury of the roots of the spinal nerves must be differentiated with the injury of the following peripheral nerve:

- Musculocutaneous nerve (contains fibers of the C5- C6 nerves)
- Median nerve (contains fibers of the C5- T1 nerves)
- Ulnar nerve (contains fibers of the C8- T1 nerves)
- Radial nerve (contains fibers of the C5- T1 nerves)
Injury of superior part of brachial plexus (superior trunk containing C5- C6)
Erb- Duchenne palsy

- **Reason**
  - Excessive increase of the angle between the neck and the shoulder (falling and landing on the shoulder, improper delivery) can result in rupture of superior part of brachial plexus or avulsion of the roots of brachial plexus from the spinal cord

- **Position of the limb**
  - "waiter's tip position" - the limb hangs by the side in the medial rotation, adduction, and extension of the elbow

- **Symptoms**
  - Palsy of muscles innervated by the C5-C6 nerves (deltoid, biceps brachii, brachialis, brachioradialis)
  - Loss of sensation on the lateral aspect of the forearm
Injury of superior part of brachial plexus (superior trunk containing C5- C6)  
Erb- Duchenne palsy

**Reason**

- Chronic microtrauma to the superior trunk of the brachial plexus from carrying **heavy backpack** can produce motor and sensory deficits in the distribution of the musculocutaneous and radial nerves.
Injury of inferior part of brachial plexus (inferior trunk containing C8- T1) Klumpke palsy

- **Reason**
  - Sudden superior pull of the upper limb can result in rupture of inferior part of brachial plexus or avulsion of the roots of brachial plexus from the spinal cord

- **Position of the limb**
  - "clawhand"- the short muscles of the hand are affected

- **Symptoms**
  - Are similar to the injury of the ulnar nerve
Injuries of C4 root may cause phrenic nerve paralysis and respiratory distress.

Injuries of upper brachial plexus or its nerve roots (C5, C6) cause Erb palsy.

Injuries of lower brachial plexus or its nerve roots (C7, C8; T1) cause Klumpke palsy and often Horner syndrome.

Musculocutaneous n.
Axillary n.
Radial n.
Median n.
Ulnar n.

White ramus communicans (fibers to cervical sympathetic trunk)
Infant with Erb palsy on right side. Muscles of shoulder and upper arm chiefly affected. Elbow extended and wrist flexed, but grasp normal.

Young girl with Klumpke palsy on right side. Muscles of forearm and hand chiefly affected. Grasp weak and affected limb small. Horner syndrome present, due to interruption of fibers to cervical sympathetic trunk.
Terminal division of the brachial artery

- Brachial artery enters the cubital fossa where it divides into terminal branches:
  - Radial artery
  - Ulnar artery
Terminal division of the brachial artery

- Place of the terminal division of the brachial artery in the cubital fossa is a typical place of applying the stethoscope during measuring the blood pressure.
Radial artery

*Origin*
- Is a terminal branch of the brachial artery (begins in the cubital fossa)

*Course*
- In the forearm runs along the brachioradialis muscle together with superficial branch of the radial nerve
- In the distal lateral part of forearm runs very superficially (place of taking its pulse—anteriory to the distal end of radius)
- Enters the anatomical snuff box
- Pierces the 1st dorsal interosseous and adductor pollicis muscle
- Ends in the deep palmar arch (joining the branch of ulnar artery)
Branches of the radial artery

- **Radial recurrent artery**
  - Takes part in arterial anastomoses around the elbow

- **Superficial palmar branch**
  - Joining the ulnar artery to form the superficial palmar arch
Branches of the radial artery

- Palmar and dorsal carpal branches
  - Form palmar and dorsal carpal arches
Ulnar artery

- **Origin**
  - Is a terminal branch of the brachial artery (begins in the cubital fossa)

- **Course**
  - In the forearm runs along the flexor carpi ulnaris together with the ulnar nerve
  - Passes superficially to the flexor retinaculum
  - Ends in the superficial palmar arch (joining the superficial palmar branch of radial artery)
Branches of the ulnar artery

- **Anterior and posterior ulnar recurrent artery**
  - Take part in arterial anastomoses around the elbow

- **Common interosseous artery dividing into**
  - Anterior interosseous artery
  - Posterior interosseous artery
Branches of the ulnar artery

- **Anterior interosseous artery**
  - Runs on the anterior aspect of the interosseous membrane,
  - pierced by the pronator quadratus and ends in the dorsal carpal arch
Branches of the ulnar artery

- **Posterior interosseous artery**
  - Gives rise to the recurrent interosseous artery
  - Runs on the posterior aspect of the interosseous membrane and ends in the dorsal carpal arch
Branches of the ulnar artery

- **Deep palmar branch**
  - Joining the radial artery to form the deep palmar arch

- **Palmar and dorsal carpal branches**
  - Form palmar and dorsal carpal arches
Arteries of the hand—palmar arterial arches

Superficial palmar arch

- **Is formed by the terminal part of the ulnar artery joining the superficial palmar branch of the radial artery**

- **Gives rise to the common palmar digital arteries dividing next into the proper palmar digital arteries**
Deep palmar arch

- Is formed by the terminal part of the radial artery joining the deep palmar branch of the ulnar artery
- Gives rise to the
  - Palmar metacarpal arteries terminating in the common palmar digital arteries
  - Princeps pollicis and radialis indicis arteries

Arteries of the hand—palmar arterial arches
Arteries of the hand - blood supply of the dorsum

**Dorsal carpal arch**

- Is formed by the dorsal carpal arteries of the radial and ulnar arteries

- Gives rise to the dorsal metacarpal arteries dividing into dorsal digital arteries
Blood supply of the fingers

- Proximal phalanges are supplied by dorsal and palmar digital arteries
- Middle and distal phalanges are supplied only by proper palmar digital arteries
- Structures of nail are supplied by dorsal branches of the proper palmar digital arteries
Places of taking the pulse in the upper limb

- Axillary pulse
- Brachial pulse in mid-arm
- Radial pulse in distal forearm
- Brachial pulse in the cubital fossa
- Ulnar pulse in distal forearm
Veins of the limbs

Limbs possess 2 venous systems:

- **Deep veins** - very often paired (their course is similar to the course of arteries)
- **Superficial veins** - situated in the subcutaneous tissue (their course is independent from the course of arteries)
- **Perforating veins** joining the deep and superficial veins
Deep veins of the upper limb

- Deep palmar venous arches give rise to the radial and ulnar veins which in the cubital fossa unite to form the brachial veins
- Continuation of the brachial vein is axillary vein continuous with the subclavian vein which terminates in the brachiocephalic vein
Superficial veins of the upper limb

Dorsal venous network of the hand gives rise to the cephalic, basilic and median antebrachial veins

- **Cephalic vein** runs on the lateral aspect of the forearm and arm and terminates in the axillary vein (in the deltopectoral region)

- **Basilic vein** runs on the medial aspect of the forearm and arm and terminates in the brachial vein or beginning of the axillary vein (in the inferior thirds of arm)

- **Median antebrachial vein** runs on the middle aspect of the forearm and terminates joining the superficial veins of cubital fossa
Superficial veins of the upper limb

- **Basilic vein** runs on the medial aspect of the forearm and arm, pierces brachial fascia, runs together with brachial vein, and joins the axillary vein.
Superficial veins of the upper limb

Superficial veins of the cubital fossa region may form many variations

- **Median cubital vein** - joins cephalic and basilic veins
  - Median cubital vein is separated from brachial artery by bicipital aponeurosis

- **Median antebrachial vein** divides into median basilic and median cephalic veins joining basilic and cephalic veins, respectively
Lymphatic system of the limbs

Similarly to the venous systems limbs possess two lymphatic systems:

- **Deep lymphatic vessels and nodes** - (located beneath the fascia of the limb)
- **Superficial lymphatic vessels and nodes** - (located on the fascia of the limb in the subcutaneous tissue)
Superficial lymphatic system of the upper limb

Superficial lymphatic vessels accompany the superficial veins

- Some lymphatic vessels accompanying the basilic vein enter the cubital nodes
- Some lymphatic vessels accompanying the cephalic vein enter the deltopectoral nodes
Deep lymphatic system of the upper limb

- Deep lymphatic vessels accompany the deep veins
- Lymph from deep lymphatic vessels and superficial lymph nodes flow to the deep lymph nodes (axillary nodes)
Deep lymphatic system of the upper limb - axillary lymph nodes
Axillary lymph nodes form some groups

- **Lateral (humeral) axillary lymph nodes**
- **Central axillary lymph nodes**
- **Apical axillary lymph nodes** which give rise to the subclavian trunk
Deep lymphatic system of the upper limb - axillary lymph nodes

- Right subclavian trunk drains the right lymphatic trunk which finishes in the right venous angle
- Left subclavian trunk drains the thoracic duct which finishes in the left venous angle
Brachiocephalic trunk

Right subclavian artery

Right common carotid artery

Left subclavian artery

Brachiocephalic trunk
Axillary artery
Circumflex humeral artery
Subscapular artery
Circumflex scapular artery
Deltoid branch of deep artery of arm
Deep artery of arm (profunda brachii artery)
Thoracodorsal artery
Brachial artery
Thoraco-acromial artery
EKG lead
Subclavian artery
Catheter
Lateral thoracic artery
Internal thoracic (mammary) artery
(C) Anteroposterior view
Proper palmar digital arteries
Common palmar digital arteries
Superficial palmar arch
Deep palmar branch of ulnar artery
Ulnar artery
Radialis indicis artery
Princeps pollicis artery
Palmar metacarpal arteries
Deep palmar arch
Radial artery