

Neuropathies Caused by Physical Forces

Mechanisms, morphology and clinicopathologic localization

Peripheral nerve injury • morphology • localization

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Learning goals

Recognize

Differentiate laceration, avulsion and chronic compression.

Explain

Relate axonal degeneration and repair to physical nerve injury.

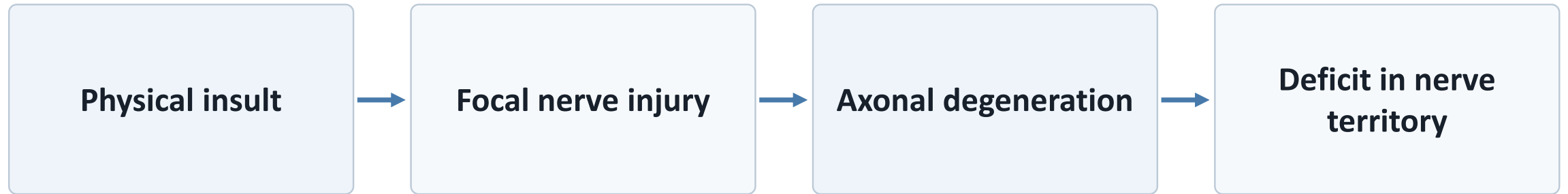
Localize

Identify named entrapment neuropathies from site and deficits.

Distinguish

Separate traumatic neuroma from Morton neuroma.

From force to focal neurologic deficit



The chapter identifies traumatic disruption and entrapment as causes of axonal degeneration.

Three principal mechanisms

Laceration

Cutting force may sever a nerve.

Avulsion

Tension may tear a nerve from its attachment or course.

Compression

Persistent pressure injures a nerve, often in anatomic confinement.

Shared consequence

The principal tissue response emphasized here is axonal injury.

Mechanical damage is usually focal

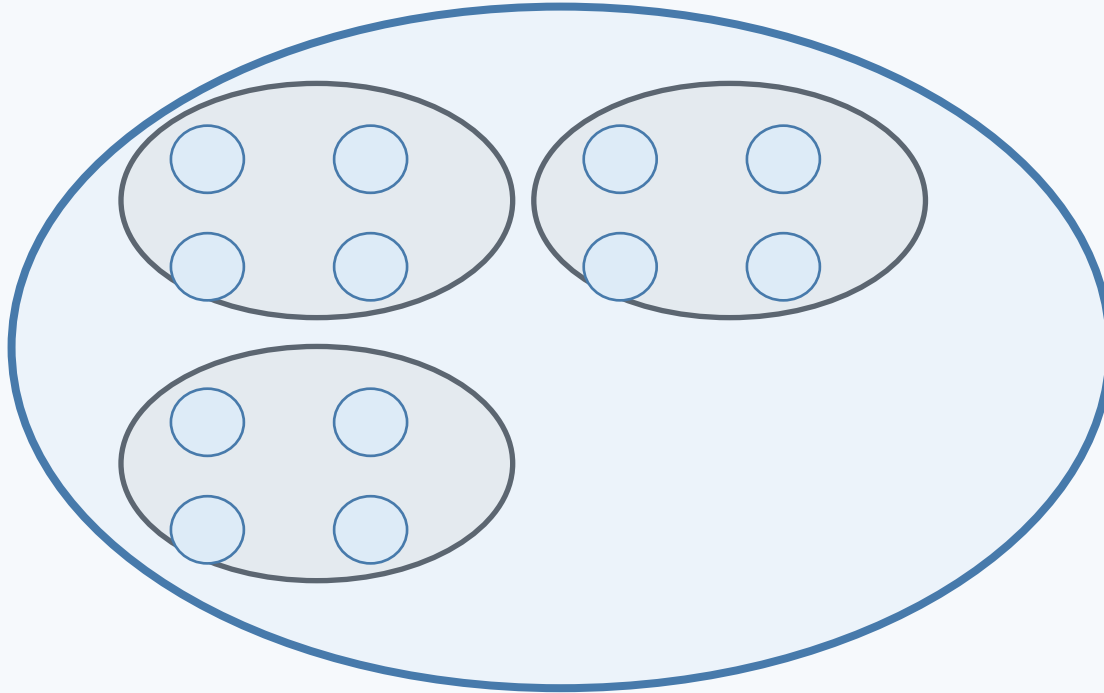
Mononeuropathy

- One named peripheral nerve
- Restricted deficit in its anatomical distribution
- Typical causes include trauma and entrapment

Polyneuropathy

- Multiple peripheral nerves
- Often symmetric, length-dependent symptoms
- Metabolic disease is a common cause

Three connective-tissue levels of a peripheral nerve



Whole nerve / epineurium

Fascicle / perineurium

Fiber / endoneurium

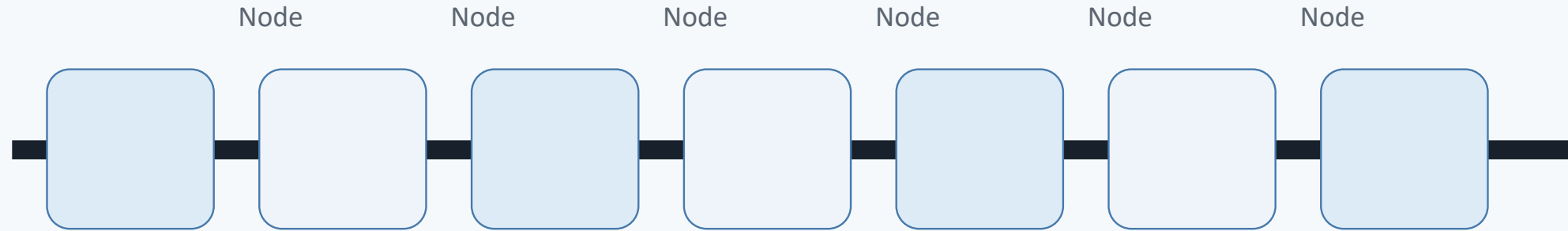
Schematic transverse organization; Not a histologic image.

Why compartments matter in entrapment

- A peripheral nerve travels within surrounding connective tissue and anatomic spaces.
- The perineurium organizes fibers into fascicles.
- Pressure within a bounded compartment can affect a nerve at a predictable site.
- The resulting deficit follows the injured nerve, not necessarily a generalized pattern.

Axons and Schwann cells provide the injury substrate

Myelin internodes produced by individual Schwann cells



Axon

Simplified longitudinal schematic

Fiber caliber determines baseline conduction

Large myelinated fibers

- Thick myelin and larger axon diameter
- Fast transmission
- Motor, light touch and proprioception

Thin unmyelinated fibers

- Small axon diameter and no myelin
- Slower transmission
- Autonomic, selected pain and temperature pathways

Axonal degeneration is not primary demyelination

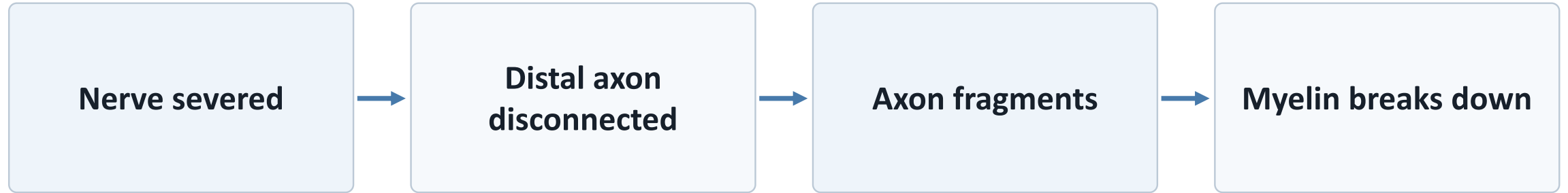
Axonal pattern

- Primary lesion of axonal process
- Distal axon may fragment after transection
- Myelin breaks down secondarily

Demyelinating pattern

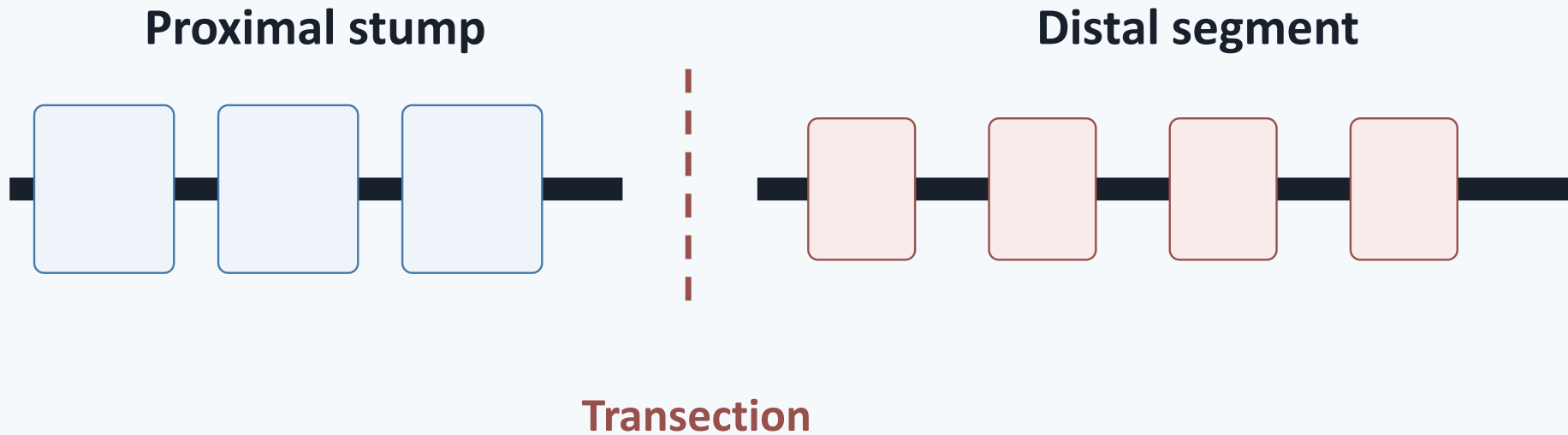
- Primary lesion of Schwann-cell myelin
- Segmental myelin loss with initial axon sparing
- Regeneration produces shorter, thinner internodes

Wallerian degeneration follows transection



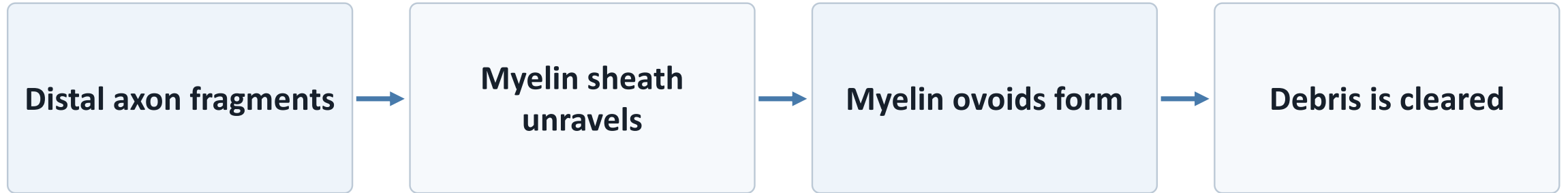
Experimental transection provides the chapter's prototype for understanding axonal neuropathy.

Disconnection of the distal axon is decisive



After transection, the portion beyond the lesion cannot remain connected to its neuronal cell body.

Early morphologic response to injury



Fragmentation beginning within a day of experimental transection.

Myelin ovoids signify sheath breakdown

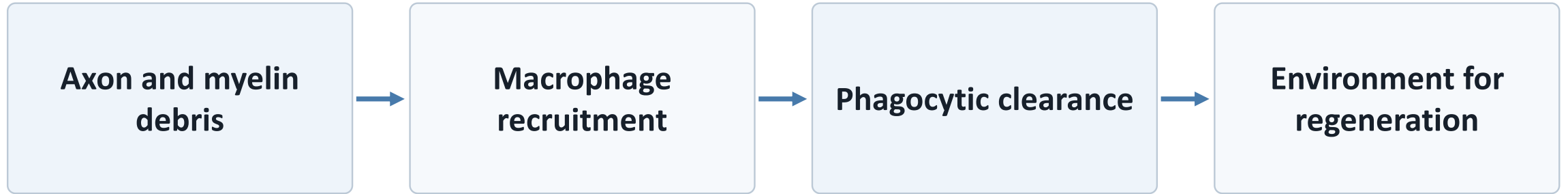
Intact nerve segment

- Continuous axon
- Organized myelin sheath

Injured distal segment

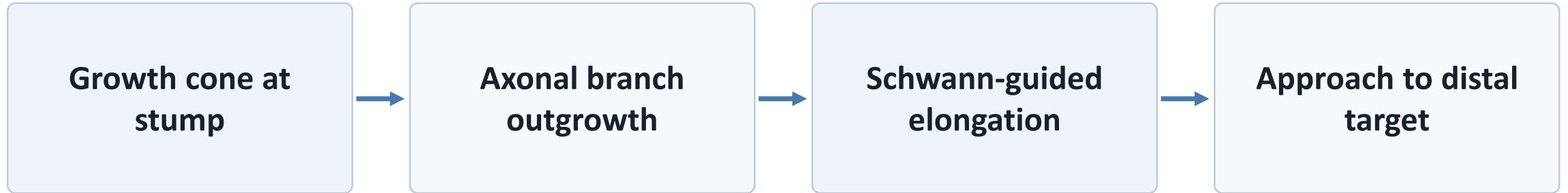
- Axonal fragments
- Myelin dispersed as ovoid structures

Macrophages prepare the injured path



The macrophage response clears material left by axonal and myelin degeneration.

The regenerative response begins proximally



Follow the lesion from force to anatomical and functional consequences.

Schwann-cell scaffolding guides axons

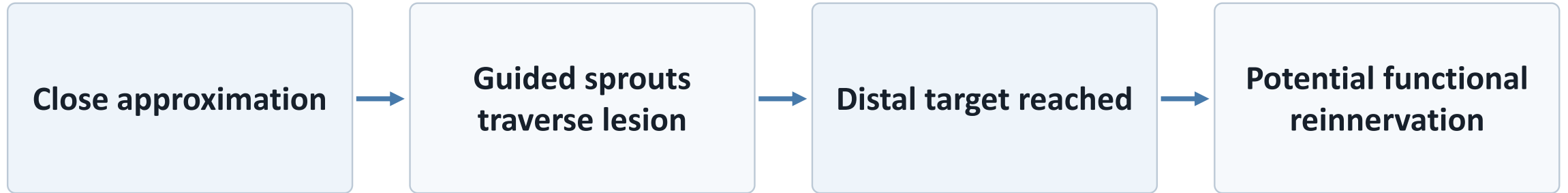
- Sprouting axons arise from the proximal surviving axon.
- Schwann cells and their basement membranes provide directional guidance.
- Misguided branches are progressively pruned.
- Successful navigation is distinct from mere axon sprouting.

Axonal outgrowth has a finite speed

~1–2 mm/day

Regenerating axons grow toward their distal target at approximately this rate description.

Why proximity of cut ends matters



The text states that successful regeneration requires the transected ends to remain closely approximated.

Regrowth and reinnervation are not synonymous

Regrowth

- New axonal sprouts form
- Some branches may follow an incorrect course
- Anatomical outgrowth is necessary

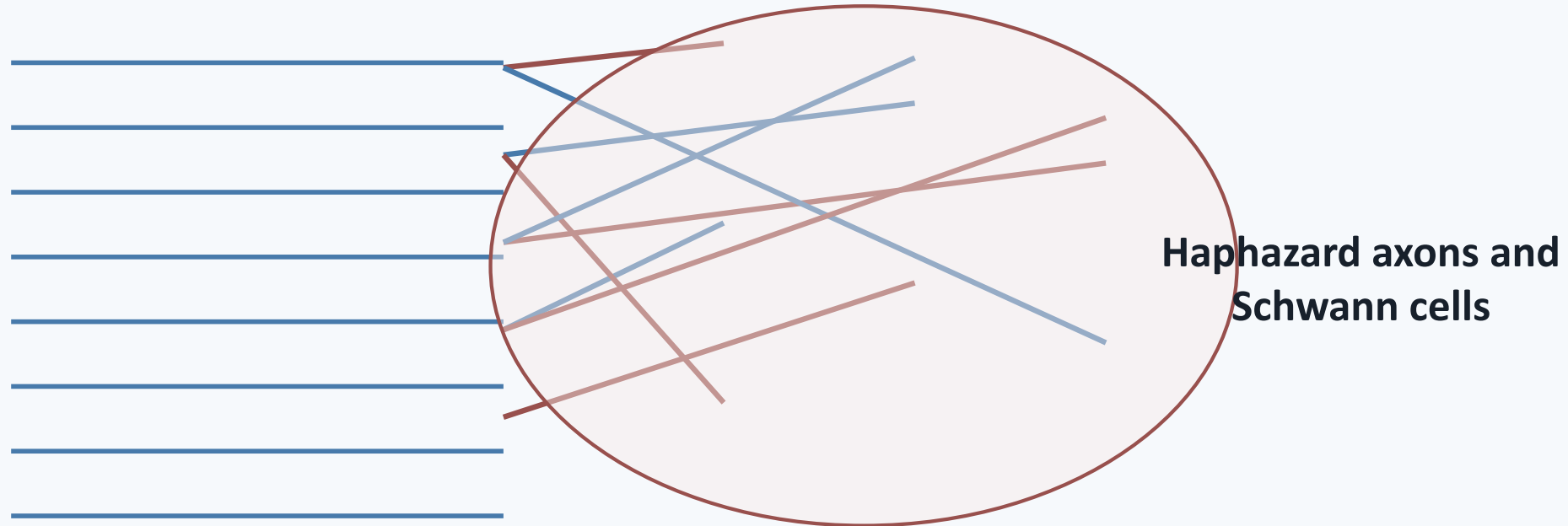
Target reinnervation

- Axons reach relevant distal structures
- Mistargeted sprouts are eliminated
- Connection to a target is the functional objective

Regenerated myelin is structurally different

- Schwann cells form new sheaths around regenerated axons.
- Regenerated internodes tend to be shorter.
- Their myelin sheaths tend to be thinner than original ones.
- Morphologic repair does not mean restoration of an identical preinjury architecture.

Failed guidance can produce traumatic neuroma



Interrupted nerve / regenerating sprouts

**Haphazard axons and
Schwann cells**

Schematic of traumatic neuroma — not a photomicrograph

Transection and chronic axonal disease differ

Acute experimental transection

- A discrete time of damage
- Distal degeneration proceeds as a wave
- Useful prototype for Wallerian change

Continuing axonal injury

- Damage unfolds over time
- Degeneration and regeneration coexist
- Eventually axonal loss can exceed repair

Electrophysiology reflects the injured substrate

Axonal neuropathy

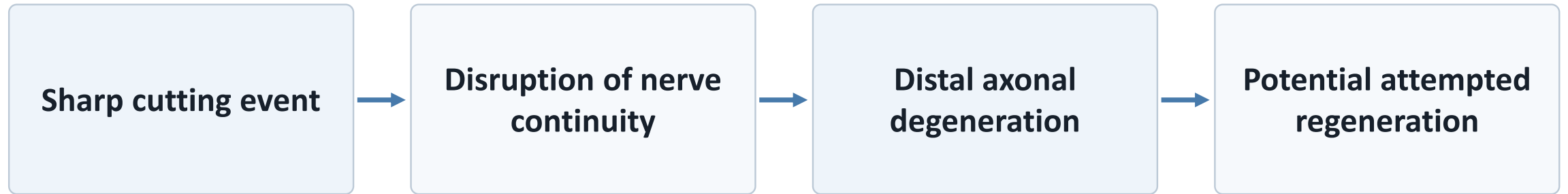
- Dropout of functioning axons
- Reduced signal amplitude
- Relative preservation of velocity

Demyelinating neuropathy

- Loss of saltatory conduction
- Slowed conduction velocity
- Amplitude may be relatively preserved

A general pathophysiologic comparison, not a definitive test for any specific entrapment lesion.

Laceration: A cutting-force mechanism



Follow the lesion from force to anatomical and functional consequences.

Two lacerating circumstances are specified

Direct cutting injury

- A sharp object can transect the nerve.
- The insult occurs at the cut site.

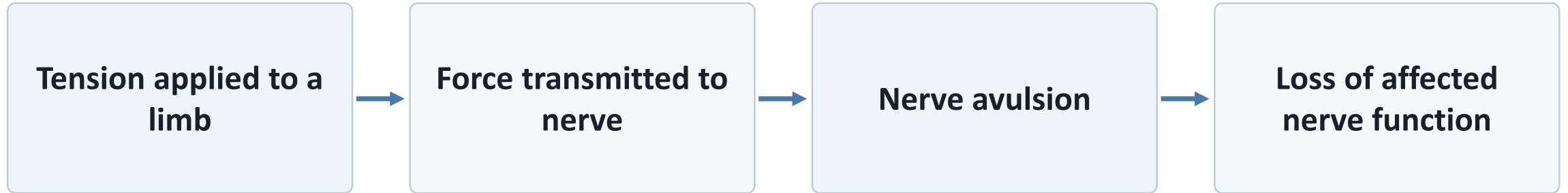
Fractured-bone fragment

- A sharp osseous fragment can damage the nerve.
- A skeletal injury can therefore include nerve transection.

A laceration has a structural consequence

- Cutting may completely sever a peripheral nerve.
- If severed, distal fibers undergo Wallerian-type degeneration.
- The location of the nerve determines the resulting deficit.
- Proximity of severed ends is a major condition for successful regrowth.

Avulsion: Traction as the damaging force



Follow the lesion from force to anatomical and functional consequences.

Laceration versus avulsion

Laceration

- Dominant force: Sharp cutting
- Examples: Wound or sharp fracture fragment
- May directly transect a nerve

Avulsion

- Dominant force: Traction/tension
- Often associated with limb tension
- May tear or avulse a nerve

Factors that frame recovery after a physical lesion

Site

Localization follows the involved nerve.

Continuity

Transection separates distal axon from neuronal soma.

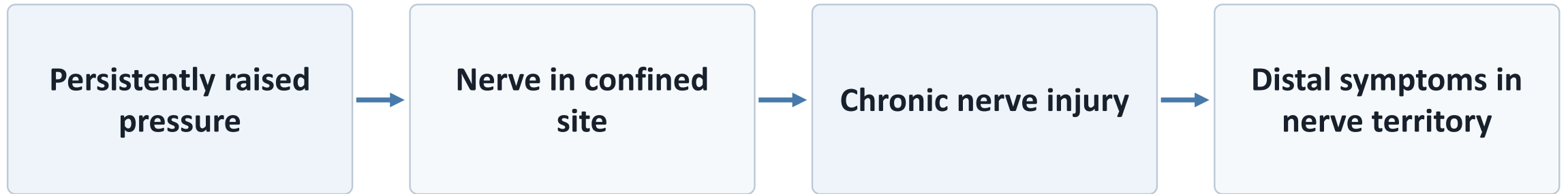
Guidance

Schwann cells/basement membranes direct growth.

Target

Regenerating sprouts must find distal tissue.

Compression: The entrapment sequence



Follow the lesion from force to anatomical and functional consequences.

Entrapment favors anatomical bottlenecks

- Chronic pressure is commonly concentrated at a specific anatomic site.
- A fixed boundary limits the space available to a nerve.
- The nerve involved can often be inferred from where the pressure occurs.
- Recognizing the site and neurologic pattern is central to localization.

Compression differs from mechanical severing

Severing mechanisms

- Laceration / avulsion
- Damage associated with discrete trauma
- Interruption of nerve continuity may occur

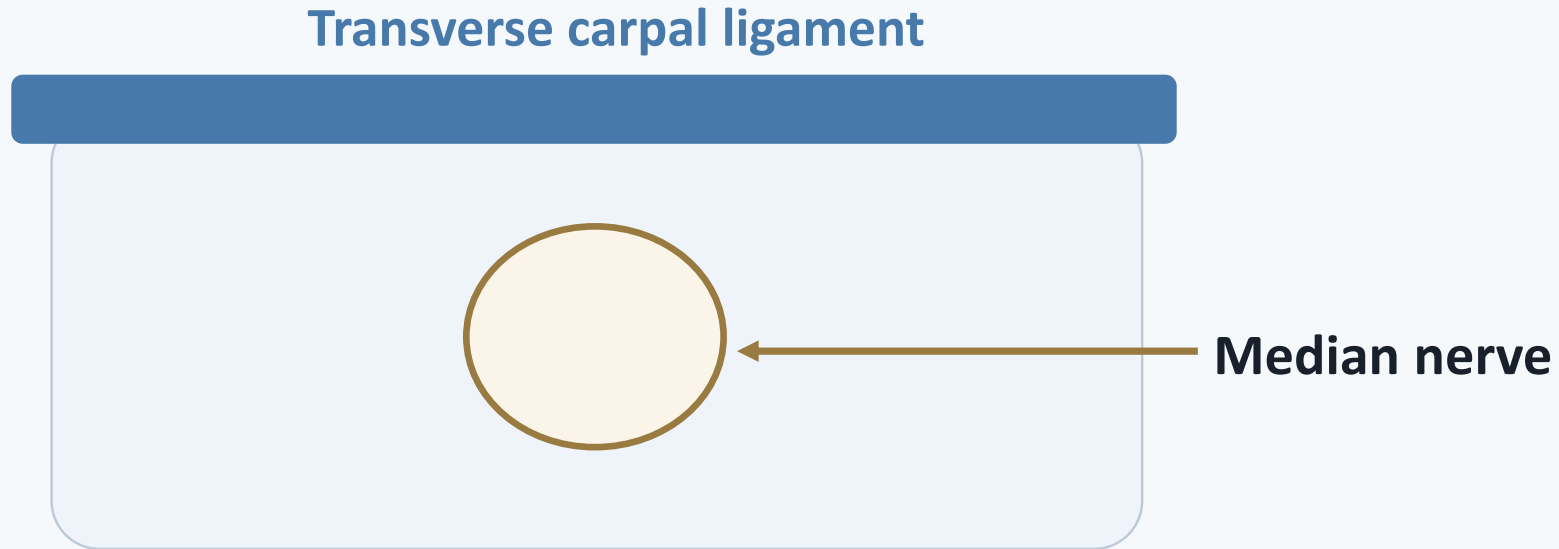
Chronic entrapment

- Sustained elevated local pressure
- Often confined anatomic compartment
- Focal neuropathy develops with ongoing compression

Named compression sites

Nerve	Typical level	Recognizable association
Median	Wrist	Carpal tunnel syndrome
Ulnar	Elbow	Entrapment neuropathy
Peroneal	Knee	Entrapment neuropathy
Radial	Upper arm	Awkward sleeping position
Interdigital	Intermetatarsal foot	Morton neuroma

Carpal tunnel: A bounded passage



Schematic wrist-level bounded compartment

Not drawn to anatomical scale

The median nerve is compressed at the wrist

- Carpal tunnel syndrome is a compression neuropathy.
- The median nerve traverses the wrist in the carpal tunnel.
- The transverse carpal ligament defines a principal boundary.
- Local compartment pressure accounts for a focal median-nerve deficit.

Carpal tunnel is the dominant entrapment example

Most common

Carpal tunnel syndrome as the most common entrapment neuropathy.

Sex distribution and laterality in carpal tunnel

Sex pattern

- Female patients are affected more commonly than male patients.
- The observation is epidemiologic, not a diagnostic criterion.

Laterality

- Bilateral involvement is frequent.
- Bilateral symptoms still reflect local involvement of median nerves.

Conditions associated with carpal tunnel syndrome

Fluid / tissue changes

Edema and pregnancy

Inflammation

Inflammatory arthritis

Endocrine / growth

Hypothyroidism and acromegaly

Metabolic / deposition

Diabetes and amyloidosis

Edema and pregnancy occur in the association list

- Tissue edema among conditions associated with carpal tunnel syndrome.
- Pregnancy is separately identified as an association.
- Both should prompt consideration of median-nerve compression when symptoms localize to the wrist.
- The presence of an associated condition alone does not establish the neuropathy.

Inflammatory arthritis is a relevant association

- Inflammatory arthritis is listed among carpal tunnel–associated conditions.
- The relevant neurologic lesion remains compression of the median nerve.
- A systemic inflammatory disorder and a focal mononeuropathy can coexist.
- Symptoms must still be interpreted by anatomical nerve territory.

Hypothyroidism and acromegaly

Hypothyroidism

- Listed among systemic associations
- Consider in the setting of compatible focal symptoms

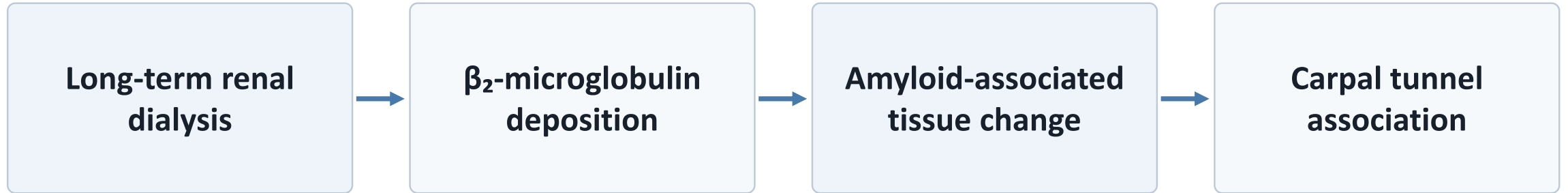
Acromegaly

- Also associated with carpal tunnel syndrome
- The presenting neurologic pattern remains focal median neuropathy

Diabetes does not imply only diffuse neuropathy

- Diabetes mellitus is among conditions associated with carpal tunnel syndrome.
- Diabetes is also a common cause of distal symmetric polyneuropathy.
- A patient with diabetes can therefore have a focal entrapment pattern.
- Distinguish focal nerve distribution from stocking–glove symptoms.

Dialysis-related amyloid is a named association



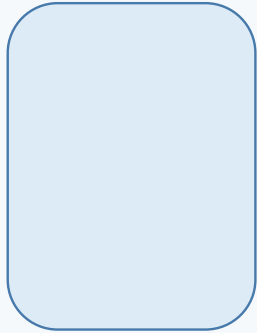
The textbook specifically identifies β₂-microglobulin amyloidosis in patients receiving renal dialysis.

Repetitive wrist movement is also listed

- Excessive repetitive wrist motions are included among carpal tunnel associations.
- The anatomical lesion remains median-nerve compression at the wrist.
- An exposure history supplements—rather than replaces—localization.
- The textbook does not provide a numerical exposure threshold.

Carpal tunnel symptoms follow median-nerve function

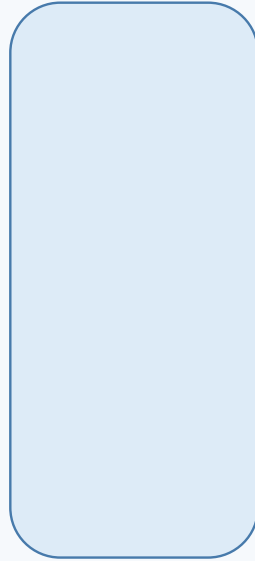
Schematic digit labels; Not a complete sensory territory map



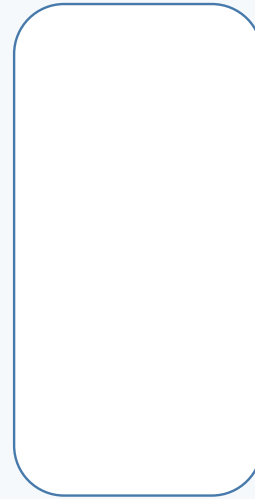
Thumb



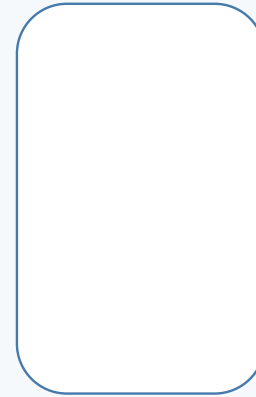
Index



Middle



Ring



Little

Textbook emphasis: Thumb and first two digits

Paresthesias and numbness are typical

- Symptoms typically include numbness and paresthesias.
- Robbins specifically highlights the tips of the thumb and first two digits.
- The deficit is restricted to median-nerve dysfunction.
- The symptom distribution is more informative than a systemic association alone.

Focal median symptoms versus a length-dependent pattern

Carpal tunnel pattern

- Nerve-specific hand involvement
- Wrist-level median-nerve entrapment
- May be bilateral

Distal polyneuropathy pattern

- Usually symmetric involvement of multiple nerves
- Often begins in the feet
- Stocking–glove sensory distribution

Clinical exercise: Hand tingling

Hypothetical teaching scenario

A patient with hypothyroidism reports recurrent numbness and pins-and-needles sensations at the tips of the thumb, index and middle fingers.

Clinical question

Which nerve and which compartment are implicated?

Teaching answer is in presenter notes.

Ulnar nerve entrapment occurs at the elbow

- The ulnar nerve is among the nerves prone to compression neuropathy.
- Robbins localizes the example to the elbow.
- The lesion is best framed as a focal mononeuropathy.
- Confirming the involved nerve requires correlating site and neurologic territory.

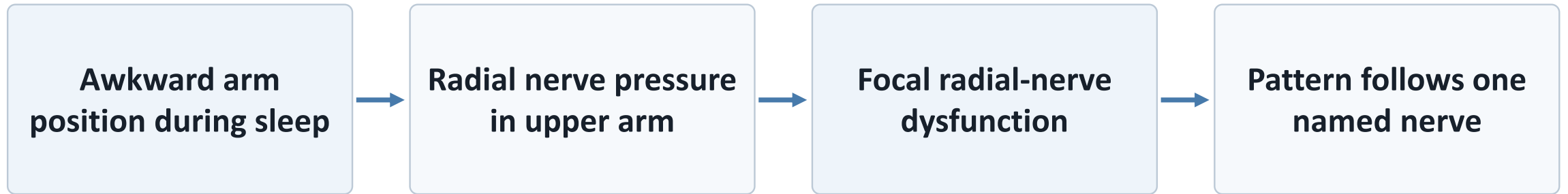
Peroneal nerve entrapment occurs at the knee

- The peroneal nerve is listed as vulnerable to compression.
- The knee is the typical site cited in this chapter.
- The focal site helps separate it from diffuse distal neuropathy.
- Localization should be integrated with the affected motor and sensory functions.

Radial neuropathy may result from arm positioning

- The radial nerve can be compressed in the upper arm.
- Sleeping with the arm awkwardly positioned.
- The colloquial name is “Saturday night palsy.”
- This is an example of a posture-related focal compression neuropathy.

Saturday night palsy: Clinical mechanism



Follow the lesion from force to anatomical and functional consequences.

Clinical exercise: After sleeping awkwardly

Hypothetical teaching scenario

A patient awakens after sleeping with an upper arm in an awkward position and has a new deficit localizing to the radial nerve.

Clinical question

What lesion category and site are most consistent?

Teaching answer is in presenter notes.

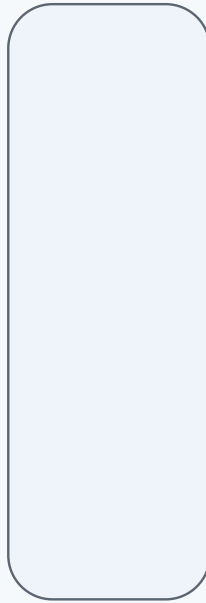
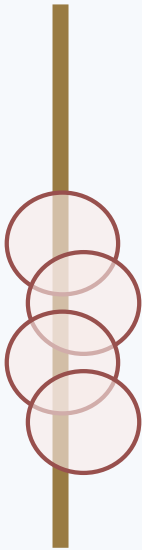
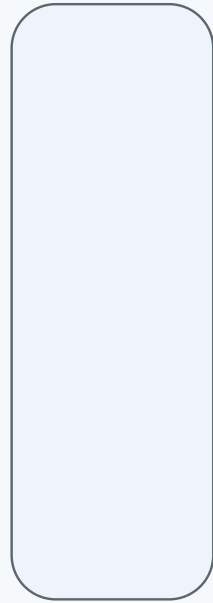
Link entrapment site to nerve

Anatomic clue	Most relevant nerve	Textbook lesion
Wrist under transverse carpal ligament	Median	Carpal tunnel syndrome
Elbow	Ulnar	Ulnar compression neuropathy
Knee	Peroneal	Peroneal compression neuropathy
Upper arm / sleep positioning	Radial	Saturday night palsy

An interdigital nerve may be trapped in the foot

- The foot also contains a compression-associated neuropathy.
- The affected nerve is an interdigital nerve.
- The site is intermetatarsal.
- The clinical manifestation emphasized is foot pain.

Morton neuroma: Perineural fibrosis



Interdigital nerve

Perineural fibrosis

Schematic: Nerve between metatarsals; Not a histologic image

Morton neuroma produces metatarsalgia

- The problem affects an interdigital nerve at an intermetatarsal site.
- Patients develop forefoot pain described as metatarsalgia.
- It is more frequent in females than in males.
- Histology is marked by significant perineural fibrosis.

Two neuromas have different morphology

Traumatic neuroma

- Regenerating axonal processes are haphazard.
- Associated Schwann cells form a non-neoplastic nodule.
- Follows unsuccessful target finding after injury.

Morton neuroma

- Interdigital nerve lesion at intermetatarsal location.
- Significant perineural fibrosis is the named feature.
- Associated with metatarsalgia.

Clinical exercise: Forefoot pain

Hypothetical teaching scenario

A woman presents with focal pain in the forefoot. Evaluation localizes the problem to an interdigital nerve between metatarsals.

Clinical question

Which named lesion is suggested and what histologic change characterizes it?

Teaching answer is in presenter notes.

Clinical exercise: Displaced fracture fragment

Hypothetical teaching scenario

A sharp fragment of fractured bone lies next to a peripheral nerve with abrupt loss of its function.

Clinical question

Which mechanical injury mechanism is described?

Teaching answer is in presenter notes.

Clinical exercise: Traction to a limb

Hypothetical teaching scenario

A limb undergoes a sudden substantial traction force, followed by dysfunction in an anatomically defined peripheral nerve distribution.

Clinical question

Which mechanism should be distinguished from a cutting wound?

Teaching answer is in presenter notes.

Anatomic logic for localizing a focal neuropathy

Identify the deficit

Is it sensory, motor or both?

Map the territory

Which named nerve supplies it?

Locate the bottleneck

Does the site match a known compression level?

Assess the mechanism

Cut, traction or persistent pressure?

A single-nerve deficit is not mononeuritis multiplex

Mechanical mononeuropathy

- One nerve at a definable site
- Trauma or entrapment commonly relevant
- Deficit tracks local nerve anatomy

Mononeuritis multiplex

- Multiple individual nerves injured irregularly
- May cause distinct deficits in different limbs
- Vasculitis is a common cause

Physical compression versus tumor compression

Entrapment by physical forces

- Often in predictable anatomical compartments
- Median wrist, ulnar elbow, radial arm
- Presented as a mechanical neuropathy

Malignancy-associated compression

- Neoplasm may locally infiltrate or compress nerves
- Can cause a focal axonal mononeuropathy
- Different etiology despite possible focal distribution

Four distinguishing pathologic ideas

Axon

Distal fragmentation follows transection.

Myelin

Ovoid breakdown accompanies axonal injury.

Repair

Schwann guidance enables directed sprouting.

Fibrosis

Morton neuroma features perineural fibrosis.

Integrated clinicopathologic synthesis

- Physical forces produce focal peripheral nerve injury through cutting, traction or sustained pressure.
- The tissue response prominently includes axonal degeneration, with repair constrained by nerve continuity and targeting.
- Entrapment syndromes are localized by the nerve and its characteristic compression site.
- Traumatic neuroma and Morton neuroma are distinct lesions with different pathologic features.

Core reading and source scope

Robbins, Cotran & Kumar: Pathologic Basis of Disease

11th edition (2026)

Lecture content: physical nerve injury, peripheral nerve architecture, axonal degeneration and repair.

Conceptual figures are original editable schematics; no clinical specimens are represented.