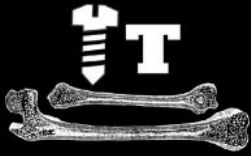


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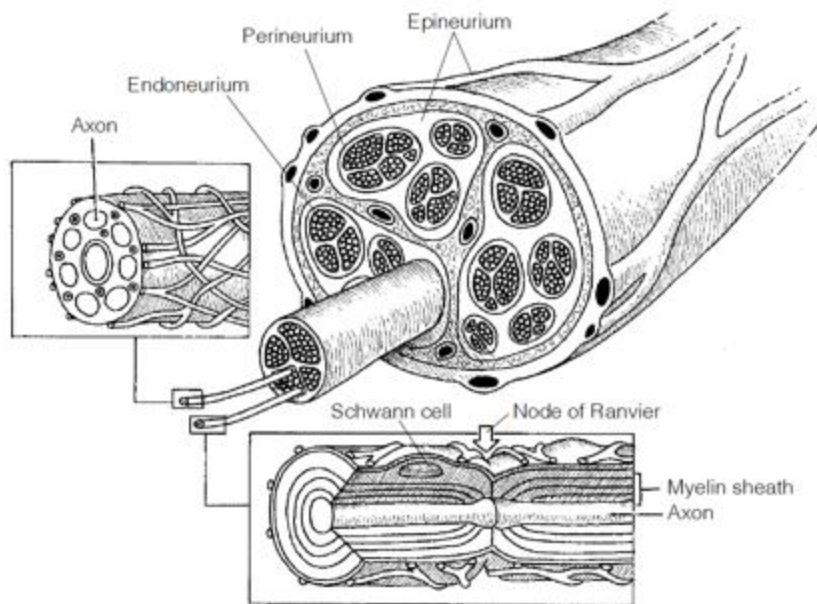
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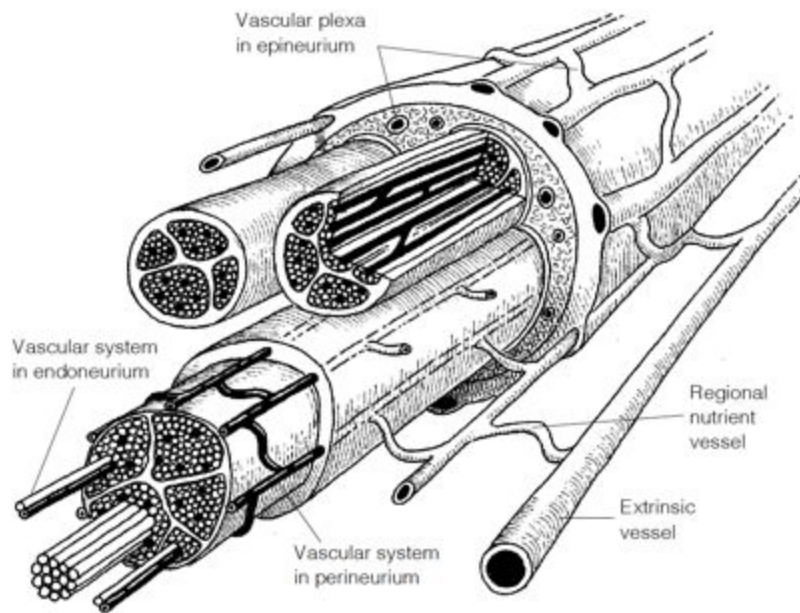
Nerve Assessment/ Repair Notes w/ Dr. Dy [@chrisdymd](#)

Nerve Anatomy

- Epineurium - encircles and runs between fascicles (nourishes and protects fascicles)
- Perineurium- Around fascicle bundle- contributes to nerve tensile strength
- Endoneurium- innermost collagenous matrix within fascicles- nourishes axons

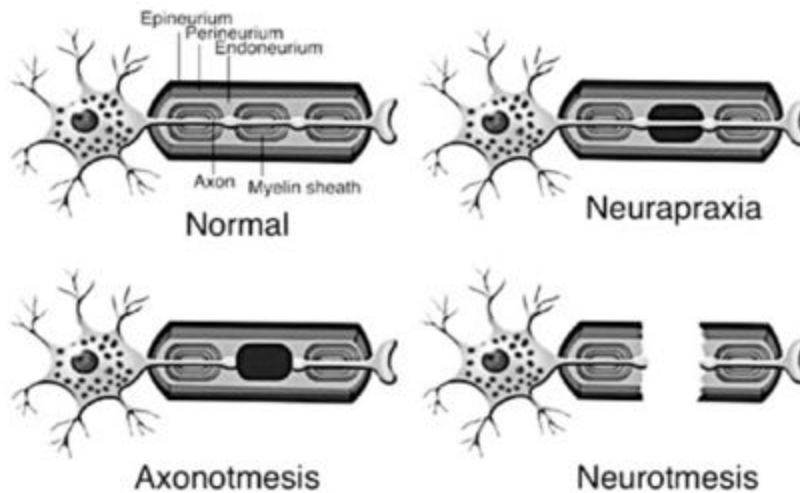


-
- Blood supply
 - 2 major arterial systems + one minor longitudinal system linked by anastomoses
 - 1 Major system- lies superficially on nerve
 - 1 major system- within interfascicular epineurium
 - 1 Minor system- in endoneurium + perineurium



Injury Definitions/ Classification

- Neurapraxia
 - Local myelin damage- usually secondary to compression (axons preserved)
- Axonotmesis
 - Loss of continuity of axons w/ preservation of connective tissue of nerve elements
- Neurotmesis (most severe)
 - Equivalent to physiologic disruption of entire nerve
- W/ injury function fails in:
 - Motor, proprioception, touch, temperature, pain, and sympathetic
 - Recovery is OPPOSITE



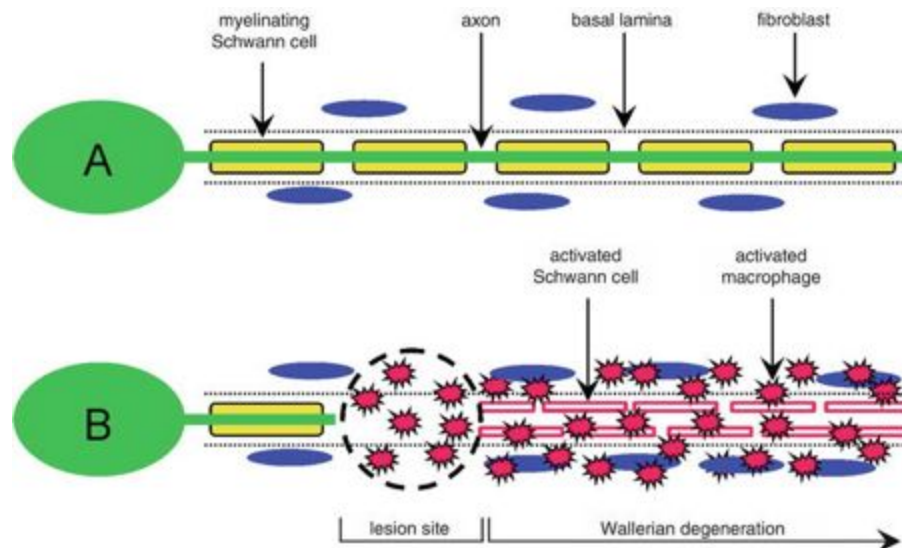
Sutherland Classification

**Table 1
Injury Classification**

Seddon ²	Sunderland ¹	Pathophysiologic Features
Neurapraxia	Type 1	Local myelin damage usually secondary to compression
Axonotmesis	Type 2	Loss of continuity of axons; endoneurium, perineurium, and epineurium intact
	Type 3	Loss of continuity of axons and endoneurium; perineurium and epineurium intact
	Type 4	Loss of continuity of axons, endoneurium, and perineurium; epineurium intact
Neurotmesis	Type 5	Complete physiologic disruption of entire nerve trunk

Nerve degeneration physiology

- Axonal transection > cell body swells + chromatolysis.
 - Proximal axon degeneration w/i injury zone.
 - Wallerian degeneration (axon breakdown distal to injury) initiates 48-96hrs after transected



Nerve regeneration physiology

- After wallerian degeneration > schwann cell basal lamina persists > align themselves longitudinal
- Filopodia explore microenvironment > promotes axon growth

- Neurotrophic factors from denervated motor/sensory receptors> help neurite survival, extension, and maturation
- Neurite (axonal) promoting factors help promote growth
 - Laminin, fibronectin, fibrinogen
- Growth factors assist (FGF, insulin like growth factor, etc)

Diagnosis

- H&P

Surgical decision making

- Lac + neuro deficit- nerve transection presumed.
- Early repair improves axon survival.
 - Repair can decrease stump retraction + fibrosis
- Assoc w/ blunt trauma (compared to clean lac)- greater zone of injury
 - Primary repair at exploration time- failure rate can be as high as 100%.
 - If noted, blue 2-0 prolene to suture stumps and facilitate delayed reconstruction.
- Closed injuries
 - Will axon regenerate or is excision + recon needed?
 - Delay NCV/EMG at least 3 weeks
 - Allows injury zone to demarcate (same w/ open)
 - determine if neuropraxic and need to wait.
 - Can also see ruptured nerves w/ physical changes at this time by high res MRI or ultrasound. Operator dependent
- Delay of 3-4 mo in exploration
 - Allows 3-4 inches of recovery.
 - Possible neuroma formation.
 - Common f/u EMG at 3-4 months after 3 wk EMG

SURGICAL TX

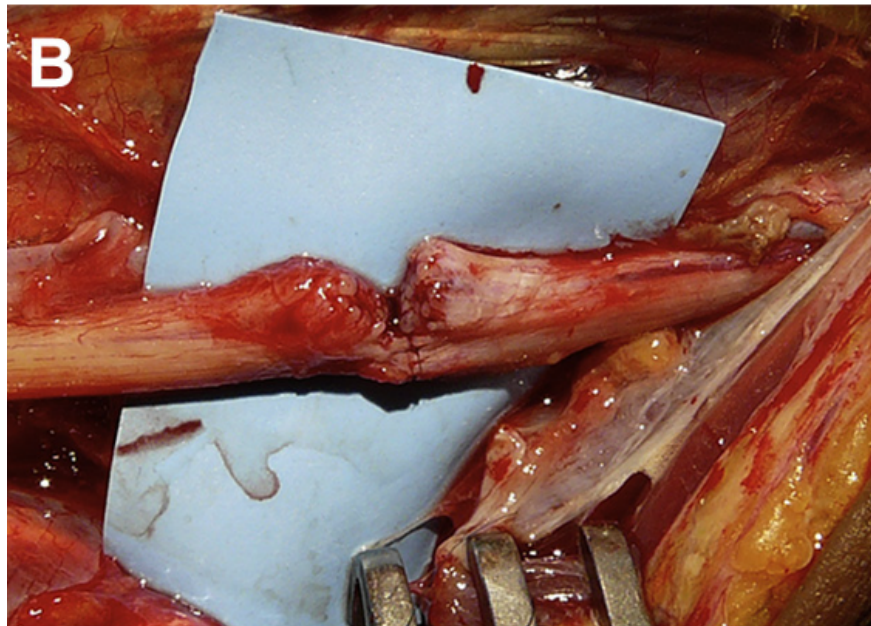
Distal reinnervation

- After major injuries:
 - Muscle atrophies and fibrose (viable for 2 years)
 - Weight loss (30% first mo, 80% by 4mo)
 - Motor endplates inc- muscle hypersensitive- fasciculates
 - Chances of reinnervation dec if nerve does not reach motor endplates w/i 12 mo
 - Nerves seek target organs distally (Meissner, ruffini, merkel)
- Early re-innervation superior

Neurorrhaphy (primary repair)

- Early repair better
- Should have: clean wound, good vascular supply, no crush component, adequate soft tissue coverage
- Modest tension does better than tension free
- Monofilament nylon suture (minimal foreign body reactivity) 9-0 nylon
- Sharp resection w/ blade
 - If nerve bleeding>
 - Microbipolar under irrigation

- Epinephrine application to nerve stump
- Thrombin spray
- Group fascicular repair v epineurial?
 - Group fascicular:
 - Epineurium removed + Visual alignment w/ topographic sketches of cut ends
 - Possible inc fibrosis + blood supply disruption
 - Electrical stimulation identify sensory/motor in awake pt
 - Nerve staining- carbonic anhydrase (12 min) + cholinesterase staining (1hr)



- Epineurial repair-
 - ends should be barely touching (overtightening can lead to bunched up misdirected fascicles)



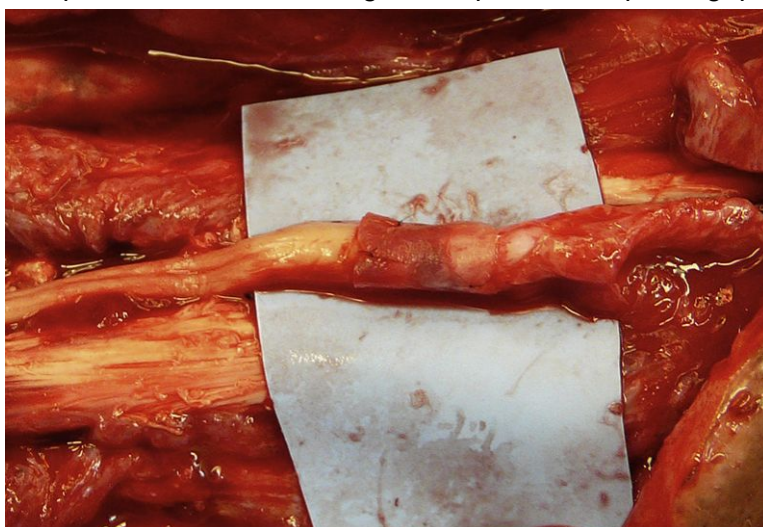
- Fibrin glue alone?
 - Not FDA approved
- Nerve connectors?
 - Each stump pulled 4-5mm into connector. Sutures placed on end of connectors through outer epineurium

Gap noted after resection?

- Bridging a gap more than 3-4cm fails. Some studies show 6cm

Nerve graft

- Autograft
 - For primary repair that can't be done with too much tension
 - Cable/Trunk/ Vascularized nerve grafts
 - Cable
 - Multiple small caliber nerve grafts in parallel to span a gap



- Trunk
 - Mixed motor-sensory nerve grafts

- Poor functional results
- Vascularized nerve grafts
 - Conflicting results. Donor site morbidity.
- Graft choice
 - Sural nerve is common.
 - Anterior branch of medial antebrachial cutaneous n + superficial radial sensory n are others
- Technique:
 - Sharp transect injured n.
 - Nerve ends should display good fascicular pattern
 - If injured nerve has large diameter- several cable grafts placed parallel
 - Epineural sutures +/- fibrin glue
 - Graft should be 10-20% longer than gap to fill
 - Graft gets same tensile strength by 4 weeks - immobilize limb to protect graft
- Allograft
 - Advantage: they can be banked, less donor site morbidity, quicker OR time
 - Disadvantage: immune host response

Rehab

- Splint
- ROM exercises- helps prevent lymphatic flow and tendon adherence
- Keep extremity warm. Bandaging protects & limits venous congestion / edema
- Pool therapy?
- Biofeedback?

Evaluating recovery

- Medical research council - based on PE

Table 2
Medical Research Council Grading System for Nerve Recovery

Motor recovery

- M0 No contraction
- M1 Return of perceptible contraction in the proximal muscles
- M2 Return of perceptible contraction in the proximal and distal muscles
- M3 Return of function in proximal and distal muscles to such a degree that all important muscles are sufficiently powerful to act against gravity
- M4 All muscles act against strong resistance, and some independent movements are possible
- M5 Full recovery of all muscles

Sensory recovery

- S0 No recovery
- S1 Recovery of deep cutaneous pain
- S1+ Recovery of superficial pain
- S2 Recovery of superficial pain and some touch
- S2+ As in S2, but with overresponse
- S3 Recovery of pain and touch sensibility with disappearance of overresponse
- S3+ As in S3, but localization of the stimulus is good, and there is imperfect recovery of two-point discrimination
- S4 Complete recovery

Results

- 1956 Woodhall and Beebe- poor results. (b4 antibiotic era and new techniques)
- Newer results w/ better results- Mackinnin & dellon

Other considerations

- Gangliosides? - neurotrophic
- Azathioprine/hydrocortisone- dec levels of anti-ganglioside antibody
- Entubation chamber?

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