

Brachial plexus injury Neurophysiology role

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ST4 in Clinical Neurophysiology

- Basic concepts of nerve injury
- Electrophysiological features of nerve injury
- Questions which can be answered
- Timing of neurophysiology
- Localisation of injury & how to prognosticate

Purpose of electrophysiology studies

- To localise pathology
- Type of pathology / nerve damage
- Prognosticate - To intervene/not intervene

Electrophysiology tests used

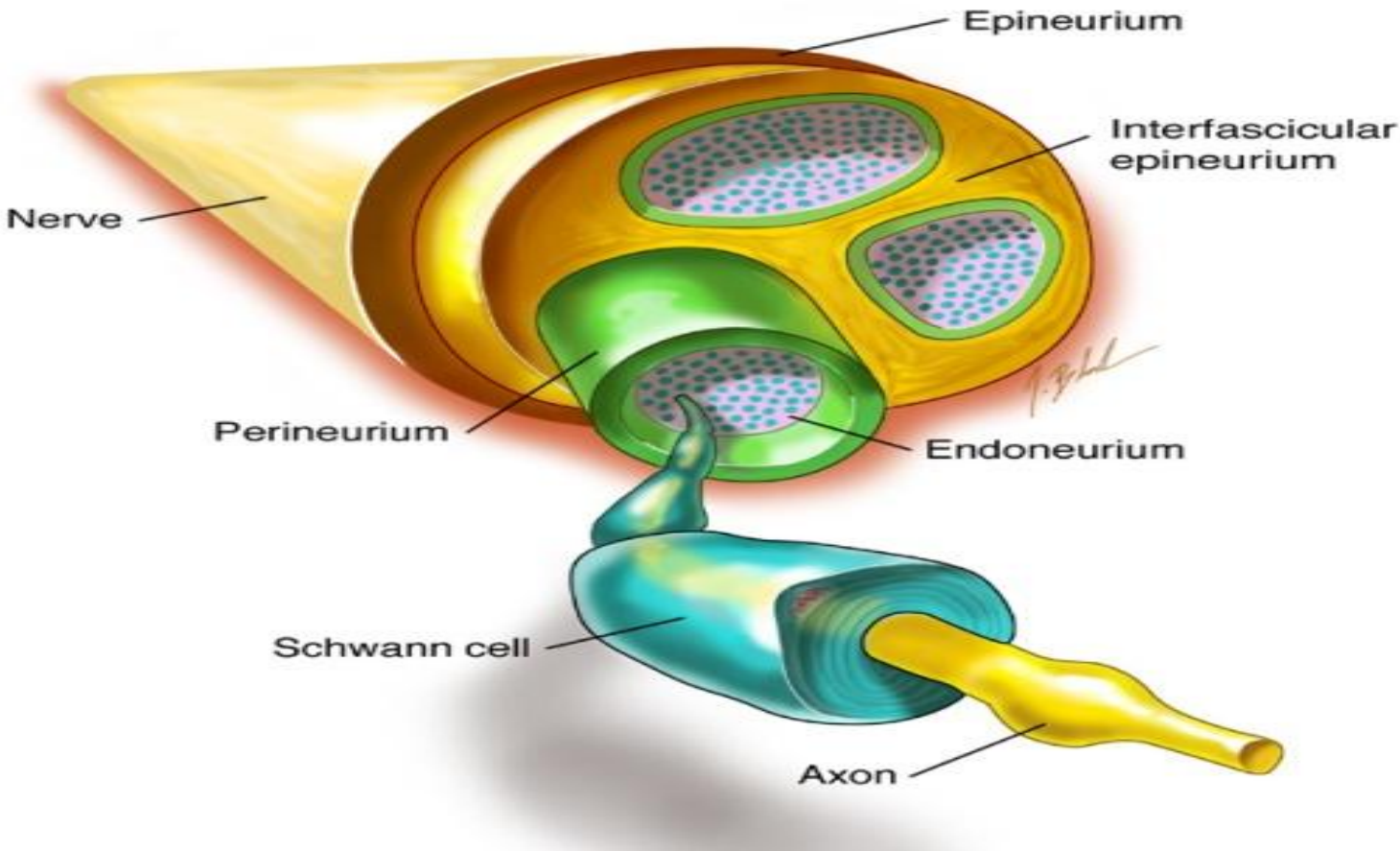
Sensory Nerve Conduction studies

Motor Nerve Conduction studies

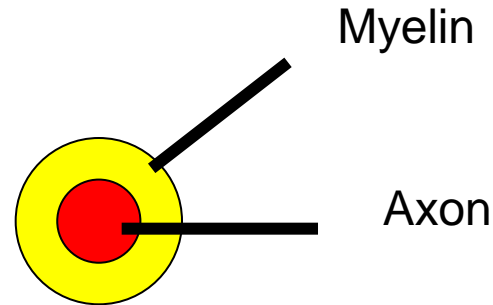
Electromyography (EMG)

Sensory Evoked Potentials (SEP)

Cross section of nerve



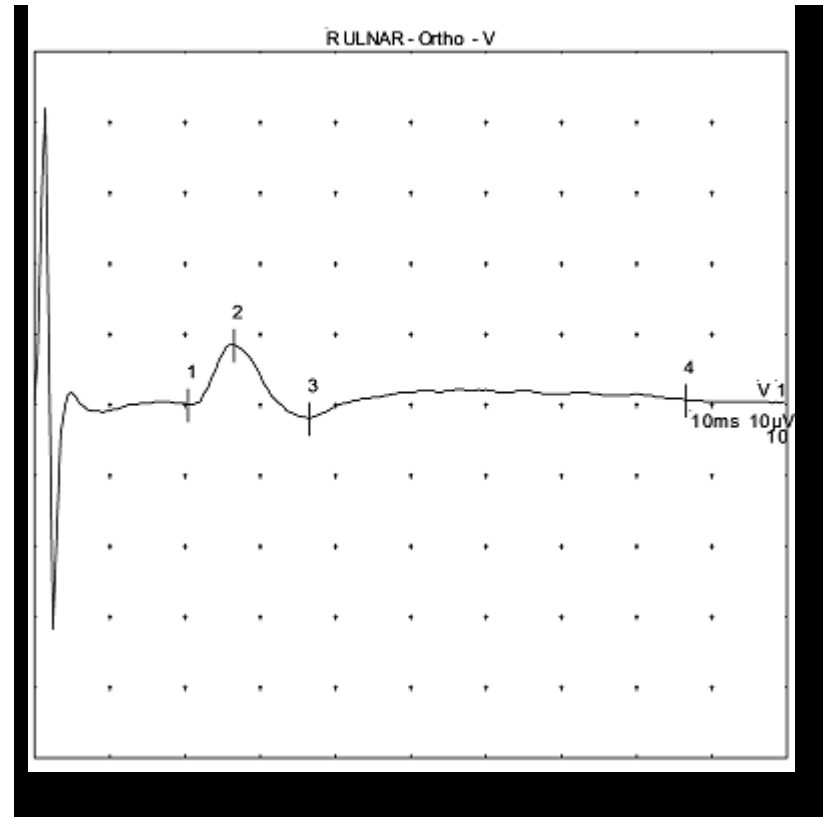
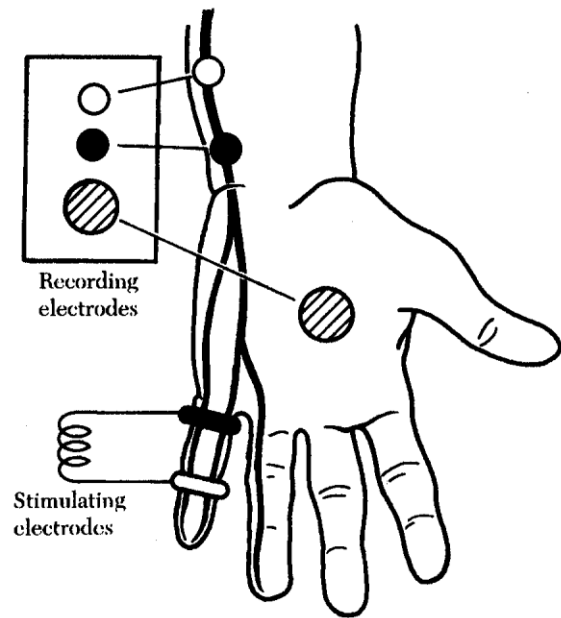
The Nerve As An Electrical Wire



- Myelin Problem
 - Conduction failure across lesion (conduction block)
- Axon Problem
 - Small responses

Sensory Nerve studies

Example-Ulnar SNAP



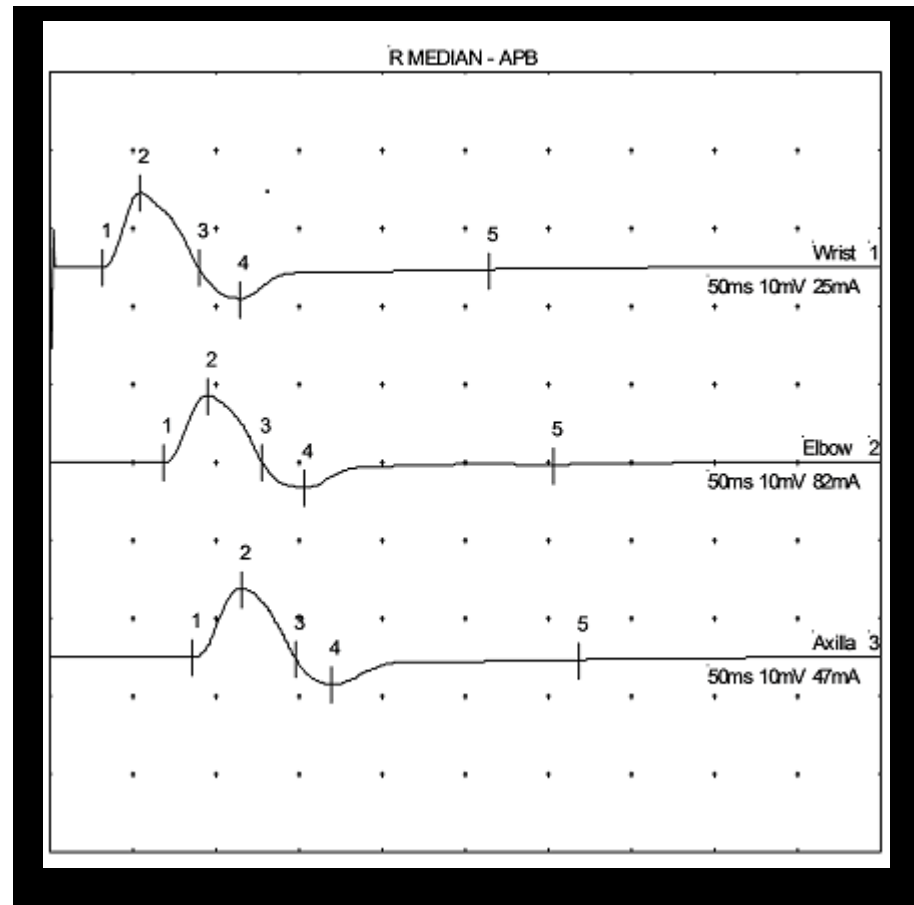
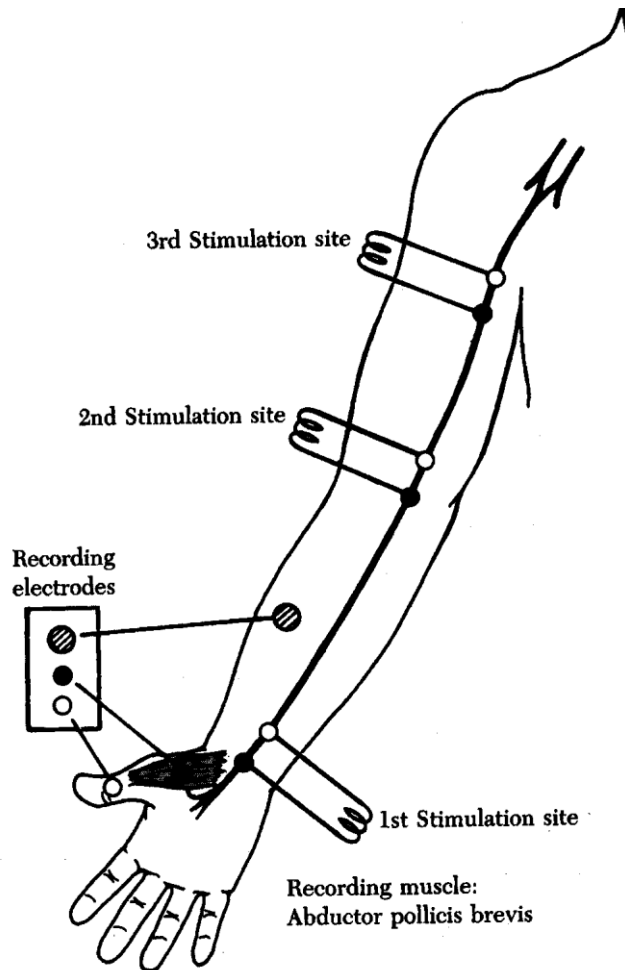
Sensory Responses in Pathology

- More useful for localisation than motor studies
- Axonal (majority of Brachial plexus pathologies)
 - Small
- Demyelinating
 - Depends whether nerve segment tested affected by demyelination

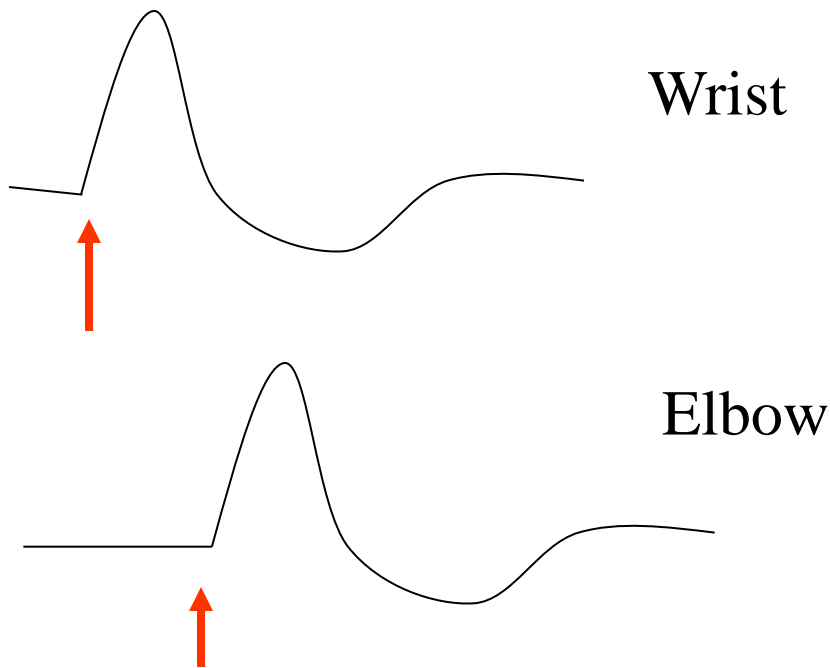
Sensory nerves checked - Median, Ulnar, Radial,
Medial ante brachial cutaneous nerve of forearm,
Lateral ante brachial cutaneous nerve of forearm

Motor Nerve conduction studies

Ex: Median CMAP

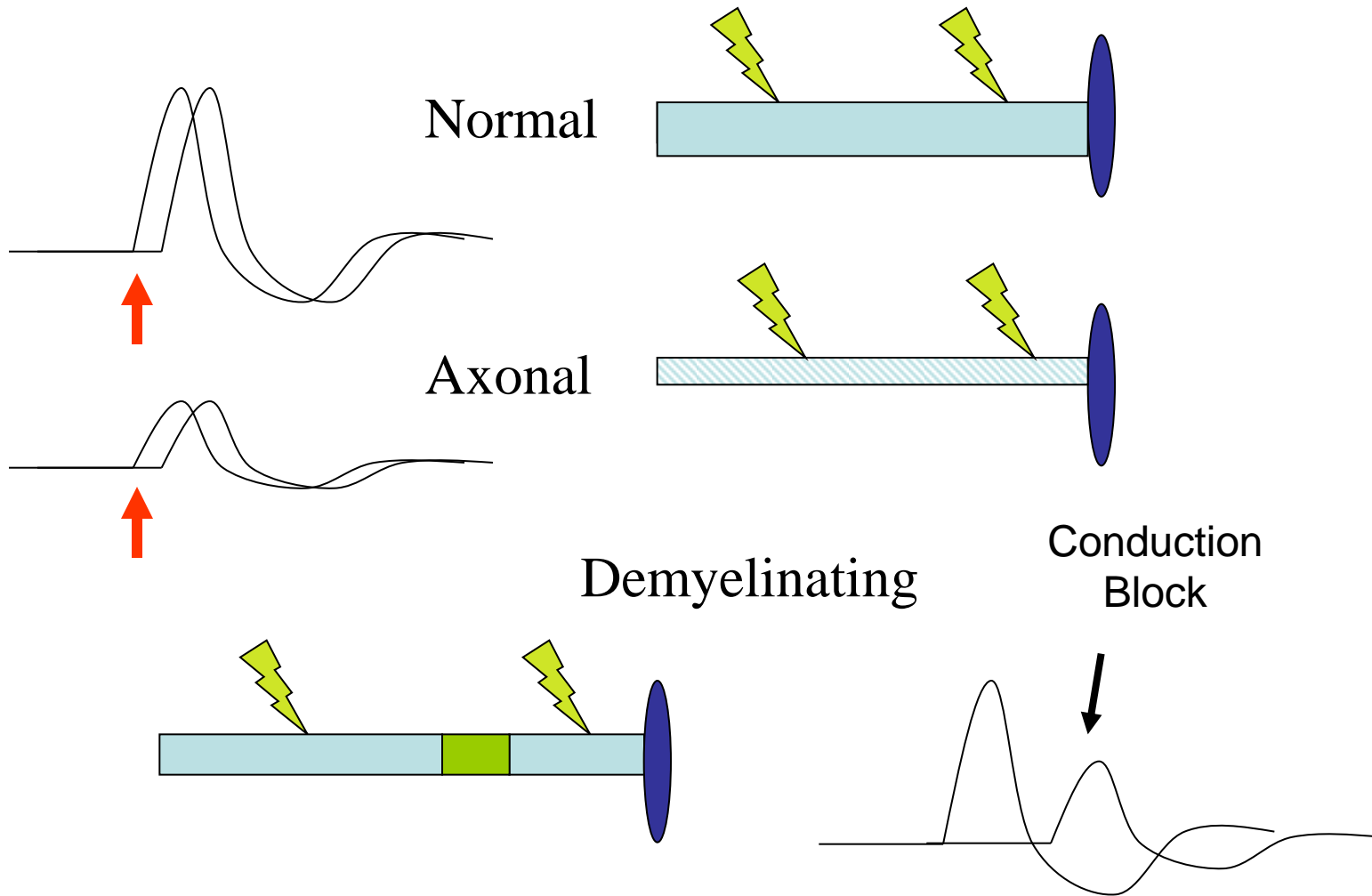


Motor Conduction Velocity



- Difference between two latencies
- Difference in distance (measuring tape)
- Nerve conduction velocity (distance/time)
 - Normal 50 m/s in upper limb

Axonal Vs Demyelinating



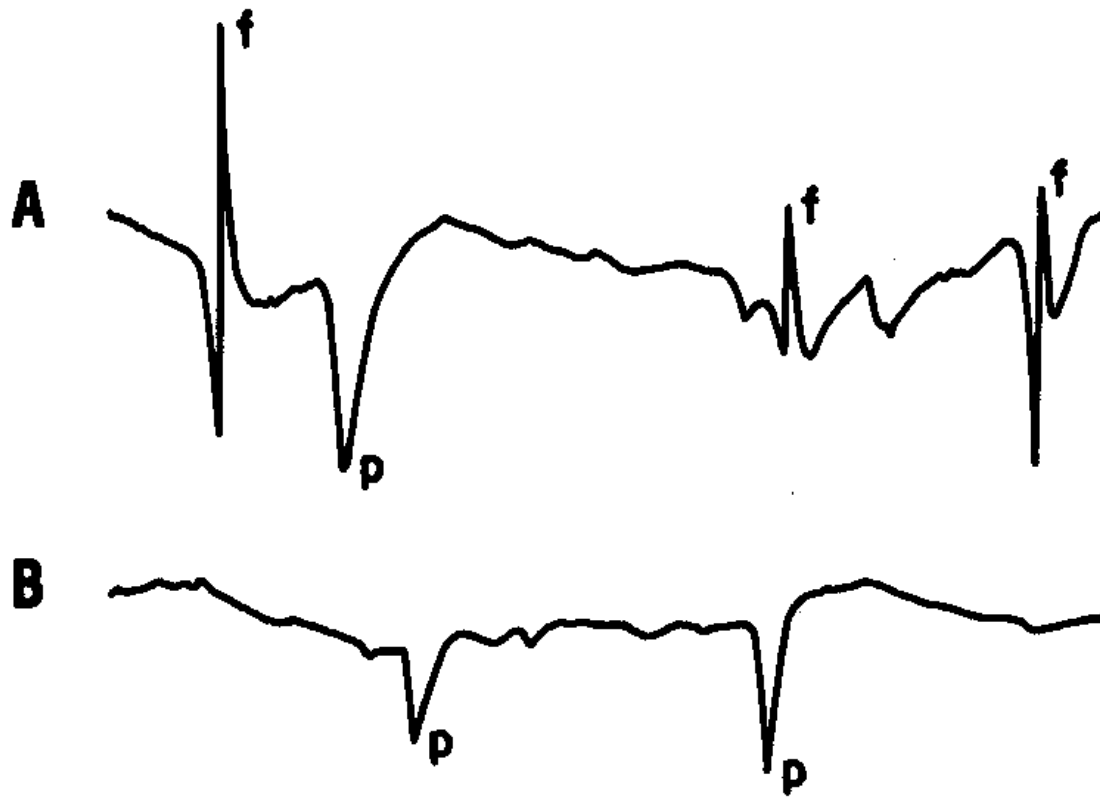
Needle EMG

- Use a needle electrode to record muscle activity
- Connected to amplifier
 - Waveforms & sound

Muscle at Rest

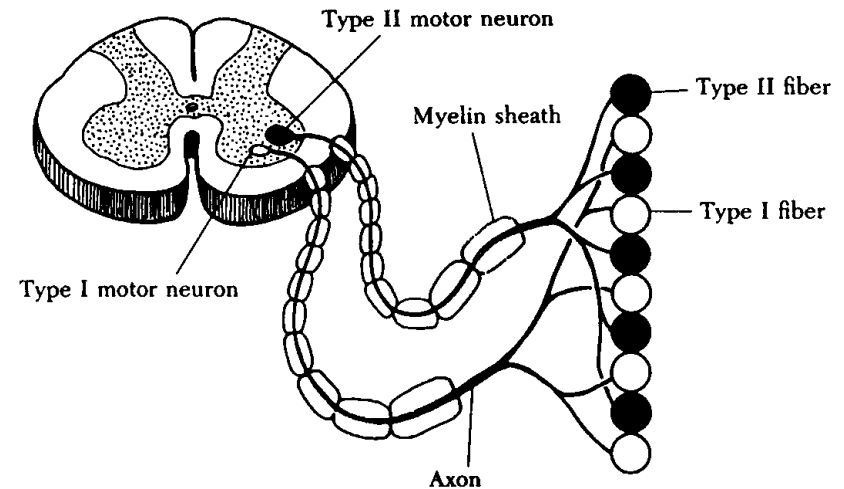
- Healthy muscle electrically silent
 - Muscle membrane at stable resting potential
- Resting membrane potential unstable if
 - Nerve axon loss so muscle loses its nerve connection (denervation)
- Spontaneous activity
- Fibrillations (fibs) and positive sharp waves (PSW) and fasciculations

Fibrillations & Positive Sharp Waves



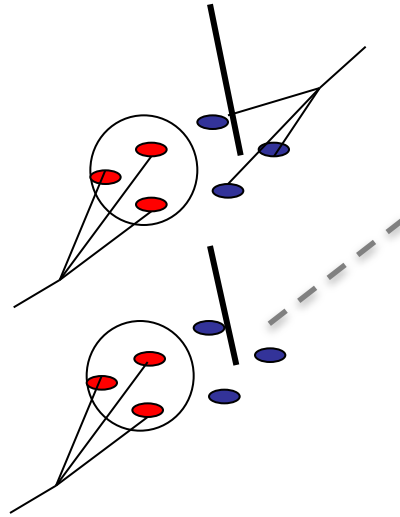
Motor Unit Potential (MUP) Analysis

- Needle in contracting muscle
- Records motor unit potential
- Made up of several muscle fibre potentials comprising that motor unit



REINNERVATION

Normal

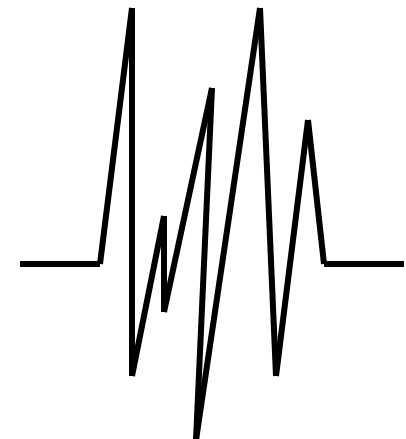
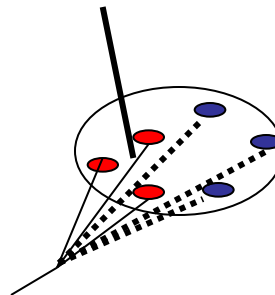


Post
denervation

Fibrillations
no motor
units

Polyphasic complex
motor unit

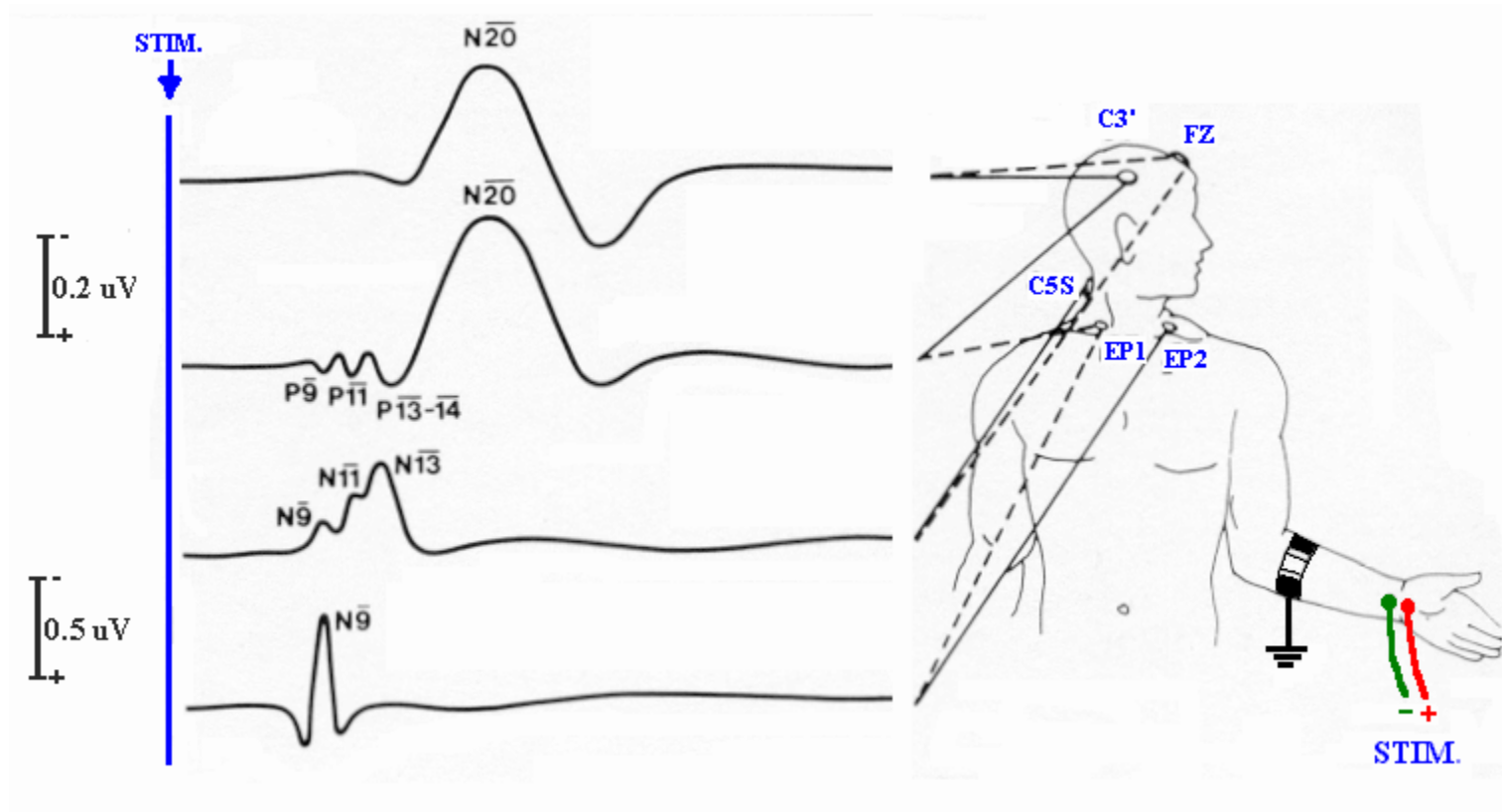
Months later



Example of EMG study report

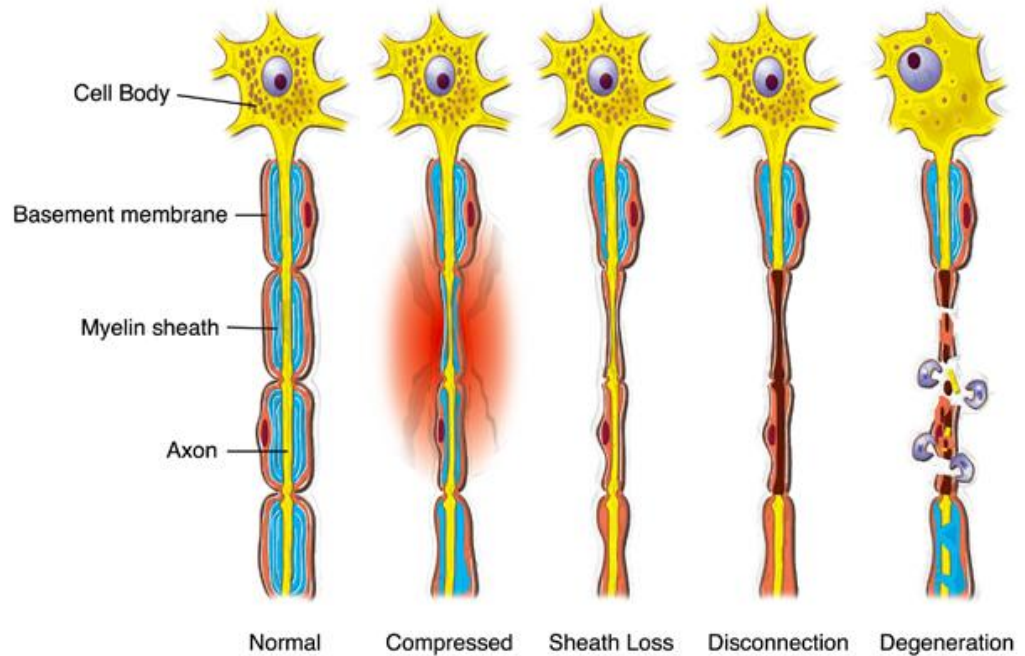
EMG Summary Table									
	Spontaneous					MUAP			Recruitment
	IA	Fib	PSW	Fasc	H.F.	Amp	Dur.	PPP	Pattern
R. DELTOID	N	2+	2+	None	None	N	N	N	Discrete
R. BICEPS	N	1+	None	None	None	N	N	N	N
R. TRICEPS	N	1+	None	None	None	2+	1+	N	Reduced
R. FIRST D INTEROSS	N	None	None	None	None	N	N	N	N
R. PECTORALIS MAJ	N	None	None	None	None	N	N	N	N
R. SERR ANT	N	None	None	None	None	N	N	N	N
R. LAT DORSI	N	None	None	None	None	N	N	N	Reduce
R. TRAPEZIUS (U)	N	None	1+	None	None	N	N	N	N

Sensory Evoked Potentials (SEP)



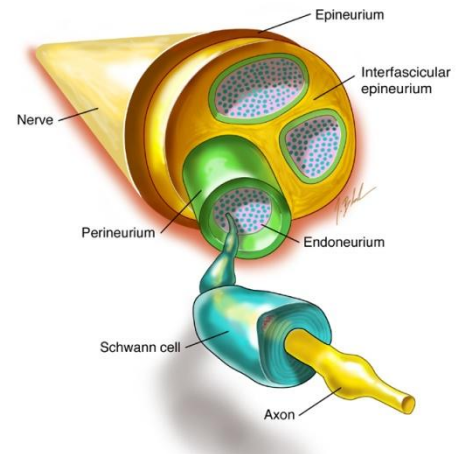
Nerve Injury Classification

- Neurapraxia
- Axonometry
- Neurometry



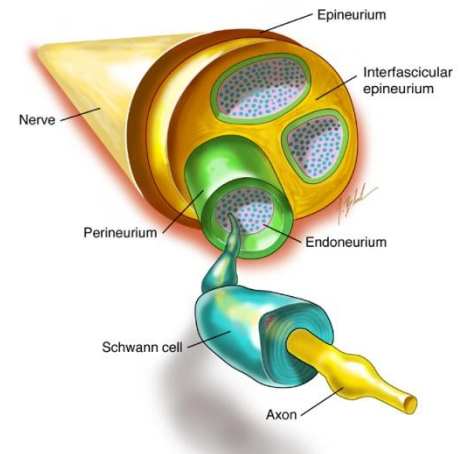
Neurapraxia

- Segmental demyelination, no interruption of axons
- Conduction block on NCS
- EMG reduced motor units but no fibrillations
- Recovery within few weeks
- “Saturday night palsy”
- No anatomical disruption



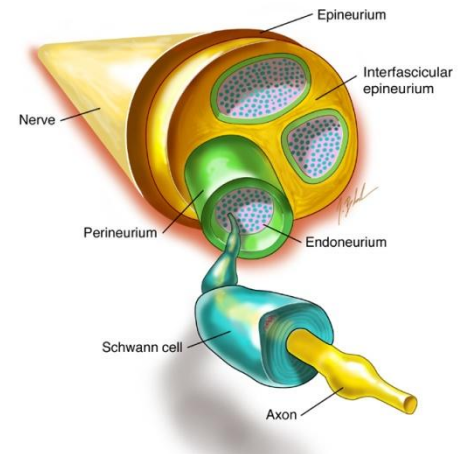
Axonotmesis

- Interruption of axons and myelin sheaths but
 - Endoneurial tube and surrounding connective tissue intact
 - Wallerian degeneration (3-9 days)
 - Regeneration spontaneous and good quality (wks to months but up to 2 years)
-
- Stretching/traction
 - prolonged compression



Neurotmesis

- Nerve completely severed, including axons and endoneurium
- Severe scar tissue → neuroma → pain & disorganisation
- Spontaneous regeneration impossible
- Knife injuries, severe traction, gunshot wounds
- Surgical treatment required



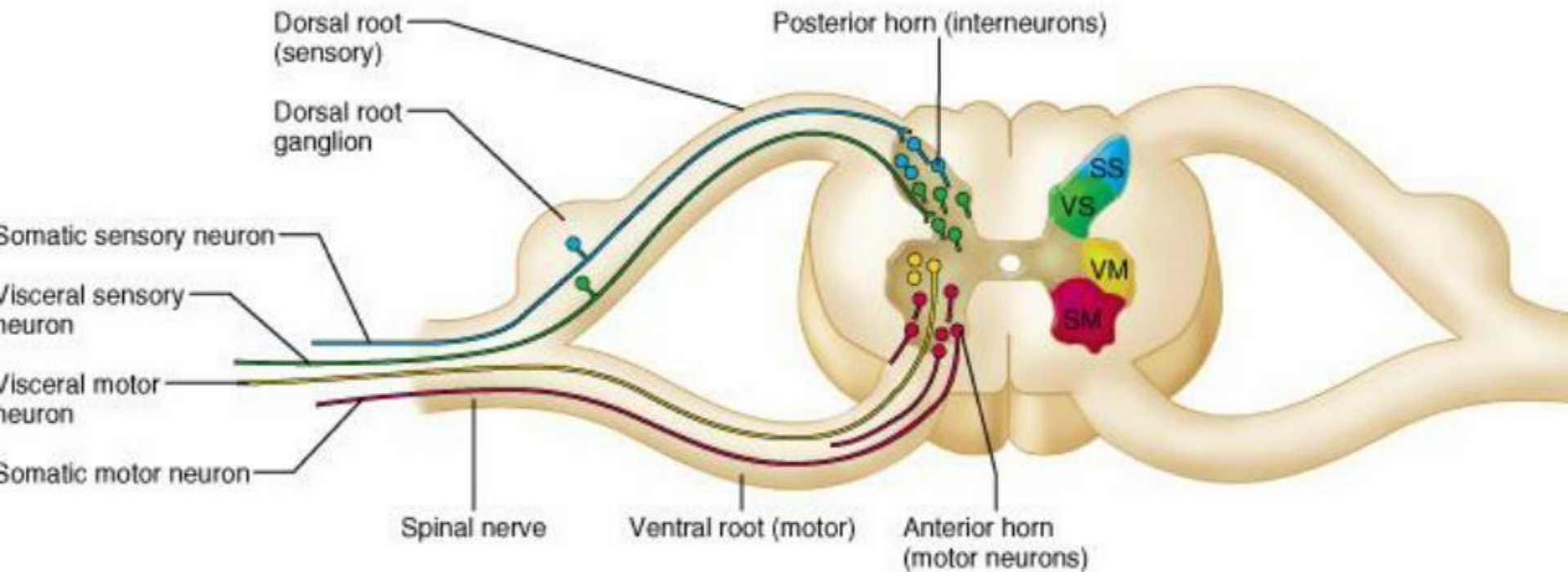
In Real Life

- Nerve injuries don't fall neatly into these categories
- Pure traumatic neurapraxia is rare
- Most partial nerve injuries fit under partial axonotmesis
- Most complete nerve injuries complete axonotmesis or neurotmesis

Spinal nerve formation.

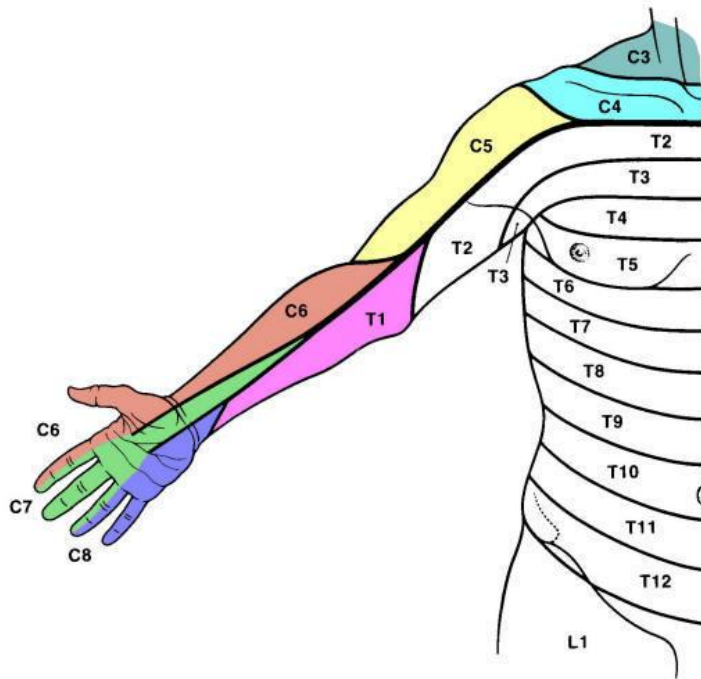
Dorsal root – sensory function

Ventral root – motor function

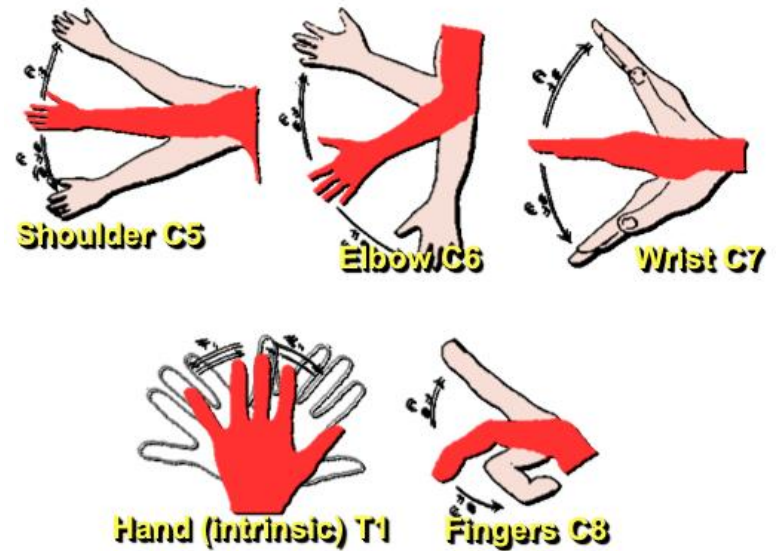


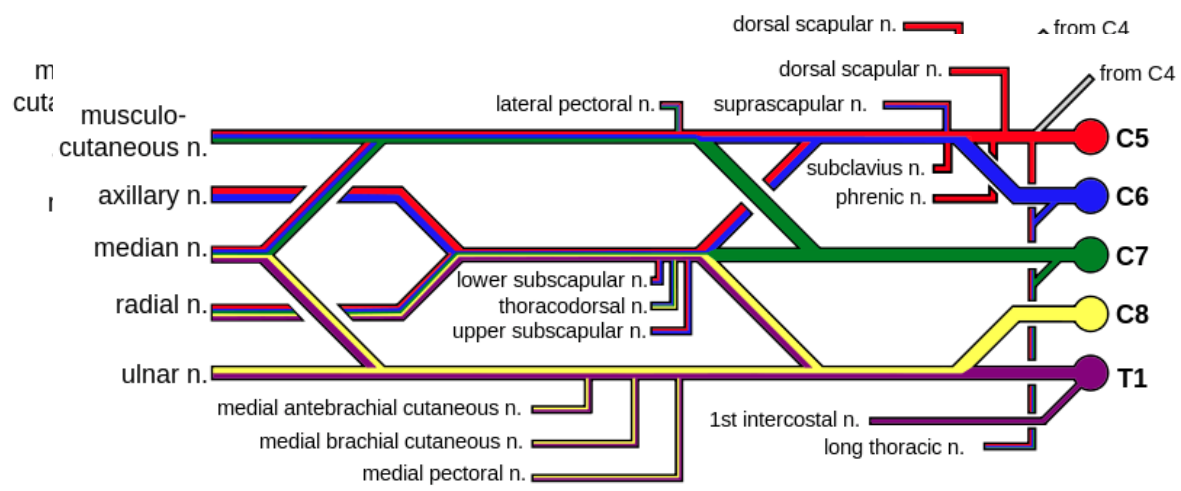
Dermatomes & Myotomes

- Dermatomes



Myotomes of upper limb





Questions to Ask Your Neurophysiologist

- Is the lesion -PRE (root) or POST GANGLIONIC
- Are nerves in CONTINUITY & its QUALITY
- Extent of AXONAL injury and REINNERVATION
- LOCALISATION OF SITE of injury

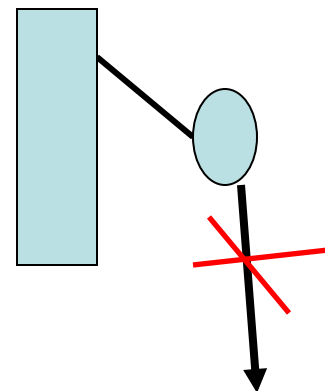
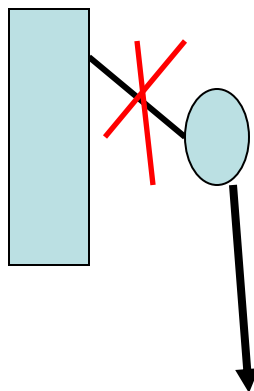
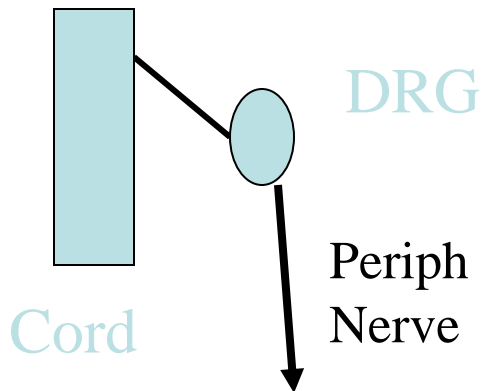
Pre vs. Post Ganglionic Lesion

- Sensory responses help with this localisation
 - Normal if pre-ganglionic (Nerve roots in this context)
 - Abnormal if post-ganglionic (Mixed nerve)

No lesion

Preganglionic lesion eg root avulsion

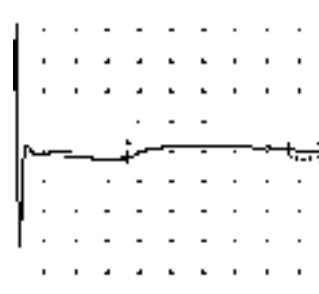
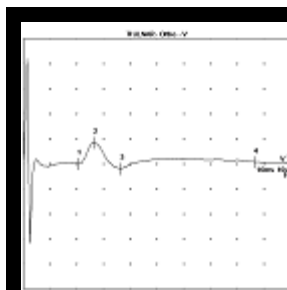
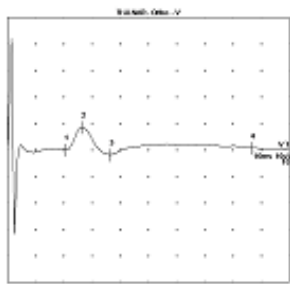
Postganglionic lesion eg neuropathy/plexopathy



Normal Sensation

Abnormal Sensation

Abnormal Sensation



Normal SNAP

Normal SNAP

Absent SNAP

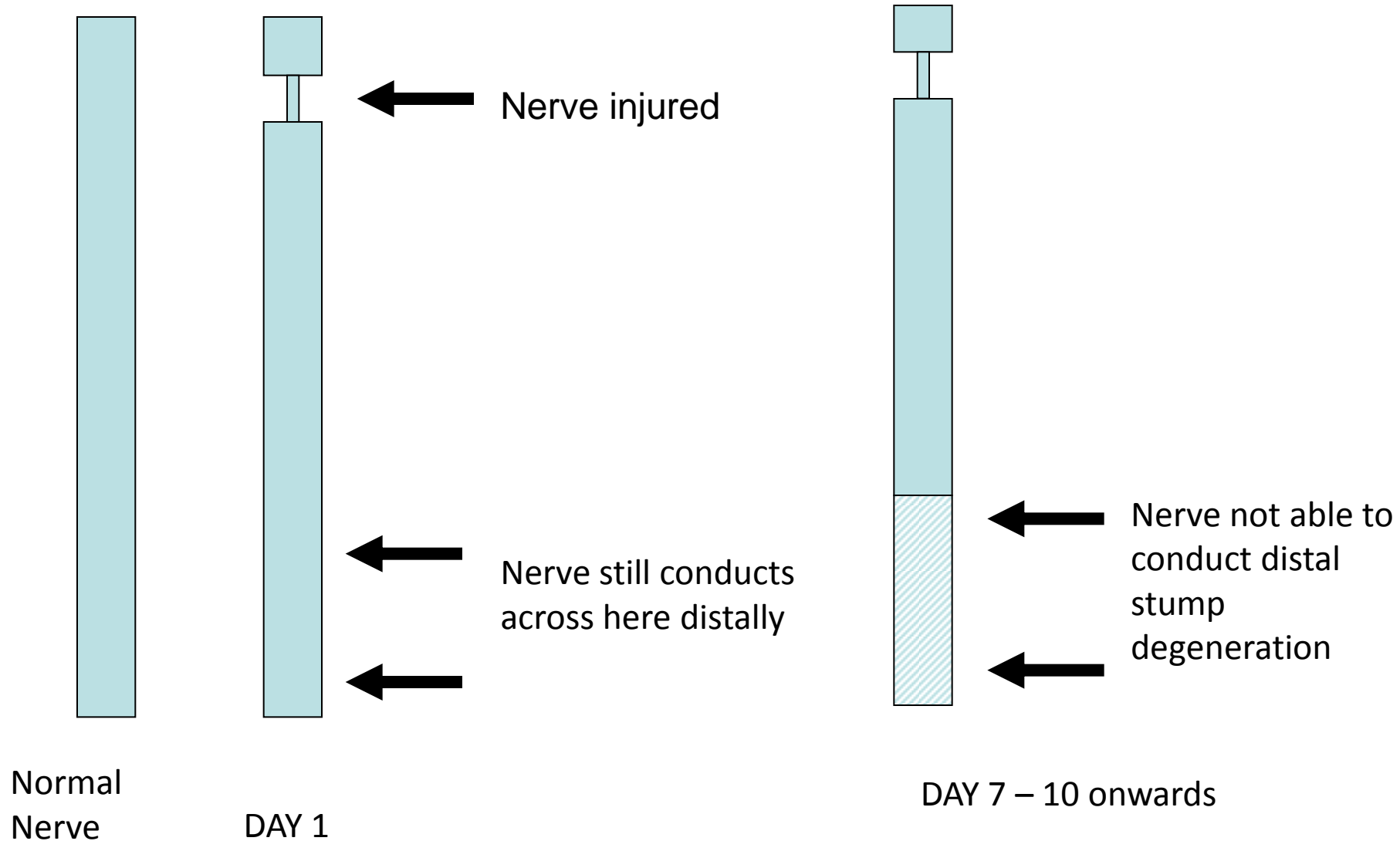
Pre and post ganglionic lesion

	Pre ganglionic (Nerve Roots)	Post ganglionic (Mixed Nerve)
Sensory studies (SNAPs)	Normal	Small/ absent
Motor studies (CMAPs)	Small/absent	Small/absent
EMG	Abnormal in both paraspinal and limb muscles.	Paraspinal muscles- Normal. Limb muscles-Denervation
SEP's	No response	No response

Continuity- to muscle

- Can a compound muscle action (CMAP) potential be recorded?
 - If yes nerve supply to that muscle in continuity
- Can motor units be recorded with EMG?
 - If yes nerve supply to that muscle in continuity

Time Course Distal Stump Degeneration- Timing of studies



Time Course Motor And Sensory- When to do NCS?

- Motor
 - CMAPS normal 2 to 3 days
 - Max drop by day 7
- Sensory
 - Normal first 7 days
 - Max drop by day 10
- Degeneration most marked in distal stump fibres
- Motor NCS impulses must pass thru most distal fibres and neuromuscular junction

Time Course Needle EMG

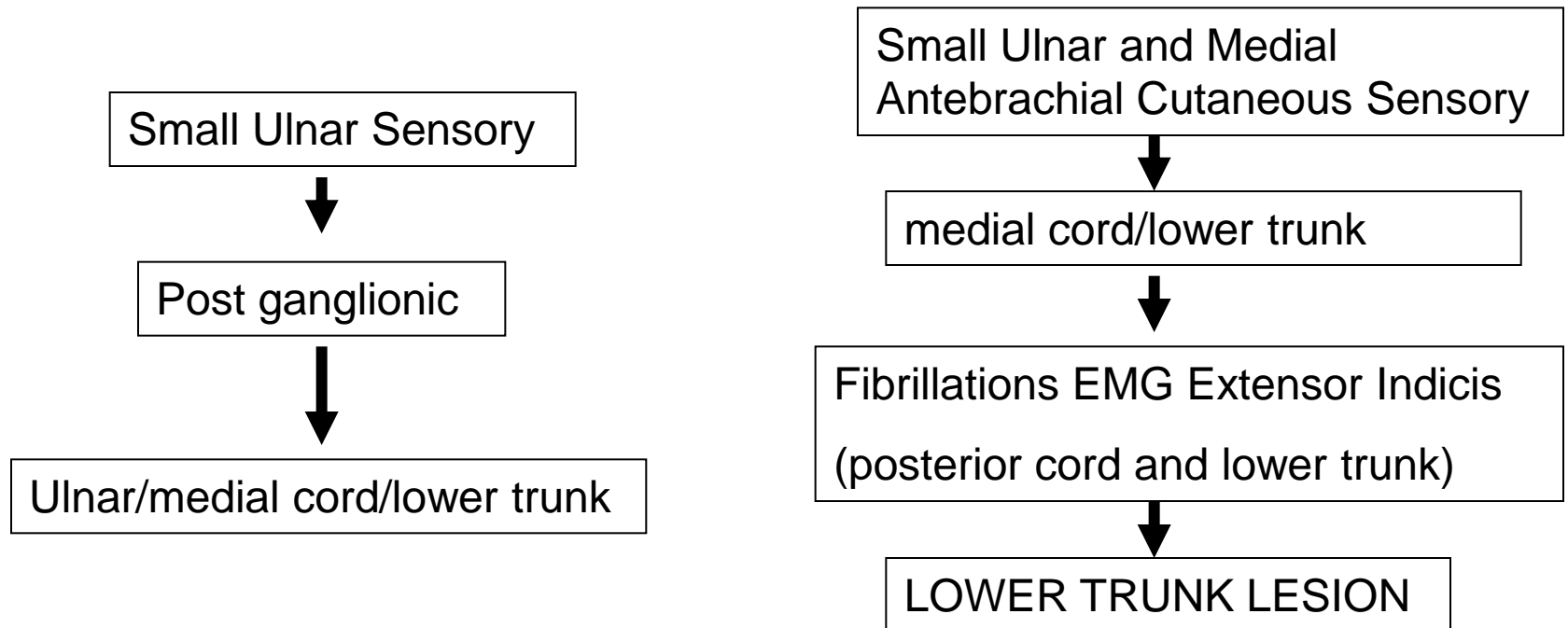
- Fibrillation potentials
 - Appear 3 weeks onwards
 - May be as early as 7 days in paraspinal muscles
- Disappear
 - Muscle fibre reinnervated or
 - Muscle fibre degenerate

Sensory Studies Available

- Thumb - Median
 - Upper Trunk
 - Lateral Cord
- Thumb – Radial
 - Upper or Middle Trunk
 - Posterior Cord
- Middle finger
 - Middle trunk
 - Lateral Cord
- Little finger - Ulnar
 - Lower trunk
 - Medial Cord
- Lateral antebrachial cutaneous
 - Musculocutaneous
 - Lateral Cord
 - Upper trunk
- Medial Antebrachial Cutaneous
 - Medial Cord
 - Lower trunk

Localisation of Injury

- Single NCS gives limited information
- Multiple studies lead to localisation
- For Example;



Case

- 33 y, Male, had polytrauma 6 weeks ago in an RTA, injury to the right brachial plexus.
- There is no active abduction of the shoulder or external rotation and no active flexion at the elbow. Pectoralis major sternal head is contracting.
- There is near normal power in wrist flexion extension and finger movements and intrinsic activity.
- severe pain in right index and thumb.
- Which Myotomes/ Dermatomes ? C5,C6,C7

Sensory Nerve studies

Nerve / Sites	Lat. 2 ms	Lat. ms	Amp.1-2 μ V	Amp.2-3 μ V	Dur. ms	Area μ Vms	Vel. Pk m/s
R MEDIAN - Ortho_radial							
Index	2.92	2.29	9.5	11.3	1.15	5.7	
Middle	2.76	2.34	14.5	18.5	1.04	8.2	
Thumb Median	2.50	1.72	6.6	4.4	1.46	3.5	
Thumb Radial	NR	NR	NR	NR	NR	NR	
L MEDIAN - Ortho_radial							
Index	3.13	2.60	25.0	35.0	1.25	18.2	
Middle	3.02	2.45	27.0	34.0	1.30	18.1	
Thumb Median	3.02	2.45	22.9	30.5	1.30	15.7	
Thumb Radial	2.66	2.08	18.0	31.0	1.56	18.1	
R ULNAR - Ortho - V							
V	2.55	2.03	7.6	7.6	1.20	4.0	
L ULNAR - Ortho - V							
V	2.81	2.29	6.3	11.6	1.25	5.8	
L ABRACH C N FORE - Lateral							
Elbow	2.66	2.14	8.8	1.9	0.94	2.9	45.2
Elbow	2.55	2.19	8.4	5.2	0.89	3.8	47.0
3	2.45	1.56	20.1	5.7	1.56	8.5	
R ABRACH C N FORE - Lateral							
Elbow	NR	NR	NR	NR	NR	NR	NR
Elbow	NR	NR	NR	NR	NR	NR	NR
Elbow							
4							

Motor Nerve studies

Nerve / Sites	Lat.	Amp.1-2	Dur.	Area	Amp.1-2	Dur.	Area	Dist.	Vel.
	ms	mV	ms	mVms	%	%	%	cm	m/s
R MEDIAN - APB									
Wrist	3.02	9.2	6.72	34.3	100	100	100	8	
R ULNAR - ADM									
Wrist	2.40	6.6	7.34	28.3	100	100	100	8	
B.Elbow	7.24	7.5	7.45	31.1	113	101	110	25	51.6
A.Elbow	8.59	8.5	7.34	31.8	129	100	112	8	59.1

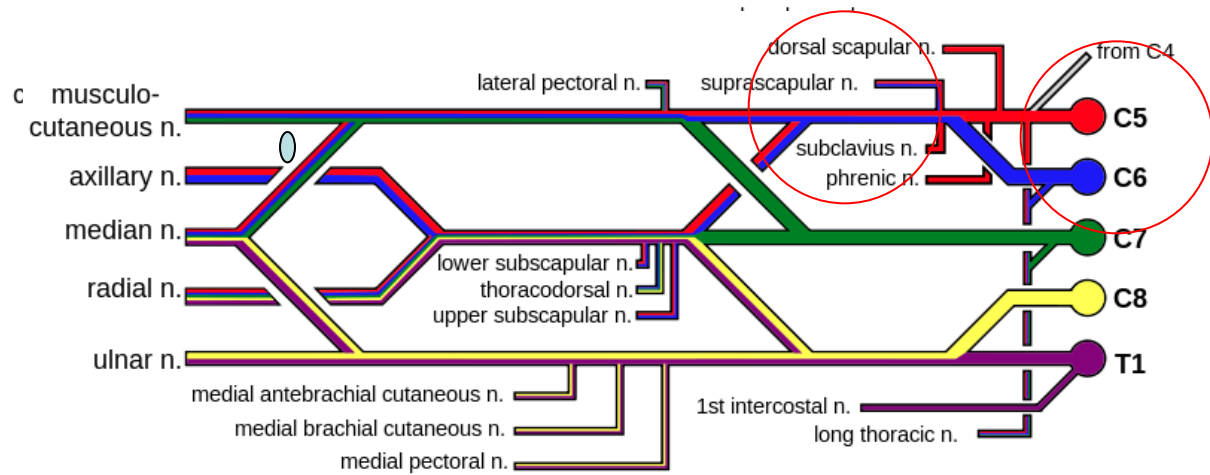
Needle EMG

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	IA	Fib	PSW	Fasc	H.F.	Amp	Dur.	PPP	Pattern
R. TRICEPS	N	None	None	None	None	1+	N	N	Reduced
R. BICEPS	N	1+	1+	None	None	-	-	-	No Activity
R. DELTOID	N	3+	3+	None	None	-	-	-	No Activity
R. PECTORALIS MAJ	N	1+	1+	None	None	N	2+	2+	Reduced

Opinion

- **There is electrophysiological evidence of active denervation in right C5/6 innervated muscles (biceps and deltoid).**
- **There was no evidence of continuity of the right axillary or musculocutaneous nerves, and no voluntary motor units were seen in the muscles.**
- **Evidence of axonal injury was also seen in the right pectoralis major. There was evidence of reinnervation in the voluntary motor units seen. Therefore reasonable function in medial pectoral nerve**
- **EMG to the right triceps showed large motor units with fairly good recruitment.**
- **Right ulnar motor and sensory studies were normal.**

- **There is evidence of a postganglionic component of the right brachial plexus injury given that the right upper limb sensory nerve responses are reduced in amplitude as described above, and the right superficial radial nerve response from the thumb is absent.**
- **However there may also be a significant preganglionic injury to the right upper trunk given that there is no active contraction in upper trunk muscles but still a median sensory response recordable (of slightly reduced amplitude) from the right index finger and thumb**



PITFALL

- If sensory abnormal
 - Looks like post ganglionic lesion
 - CANNOT exclude a coexisting preganglionic lesion as well
- Pre and post ganglionic lesions often coexist in high velocity trauma
- **Absent motor response but still recordable small sensory response suggestive of preganglionic**
- Intraoperative SEP may help
 - Stimulate root
 - If SEP present preganglionic portion is working

Summary

- NCS/EMG assess
 - Site of brachial plexus injury
 - Whether lesion in continuity
 - Degree of axonal loss
- Timing of studies important 3 weeks or later
- Follow up studies may be helpful
- Provide information to aid with decision to surgically intervene or not