Basic Principle of Nerve Conduction Study

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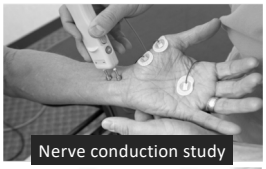
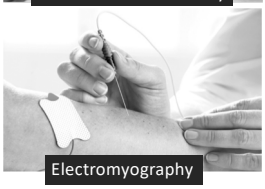
Electrodiagnosis

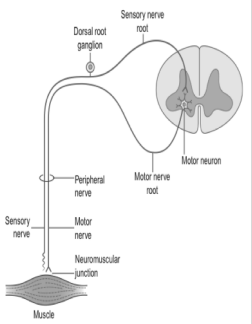




- Nerve conduction study
  - motor conduction study
  - sensory conduction study
  - F wave
  - H reflex
  - blink reflexes
  - RNS
- Electromyography

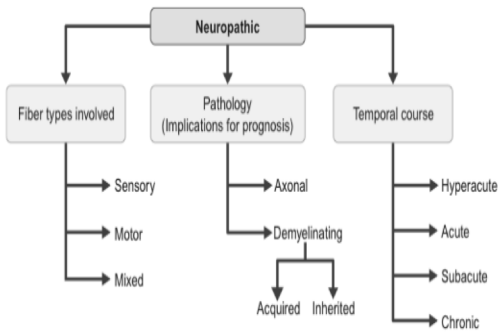
Goals

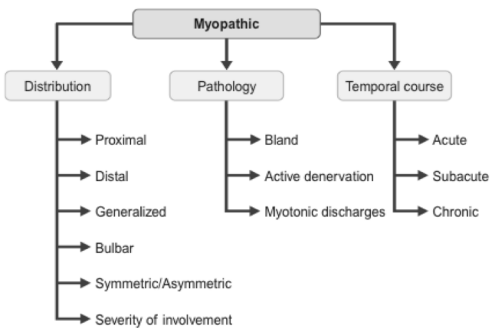
- Localization
  - motor neuron
  - sensory neuron
  - nerve root
  - plexus
  - peripheral nerve
  - NMJ
  - muscle
  - central nervous system
- Severity
- Disease duration

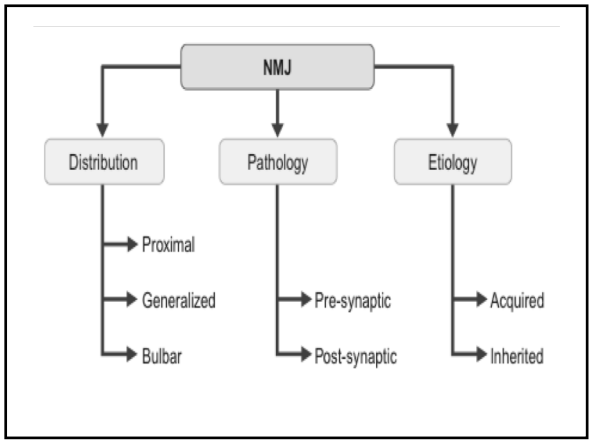


Localization

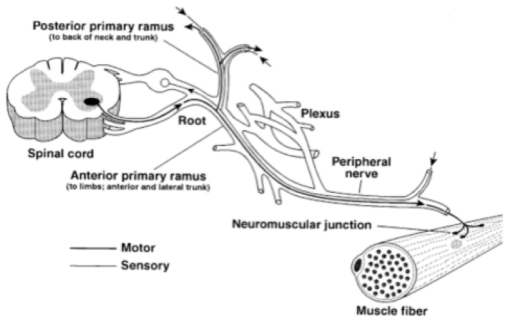
	MND	Neuropathy	NMJ disease	Muscle disease
NCS	Normal or axonopathy	Axonopathy, demyelination	Normal	Normal
RNS	Normal	Normal	Decremental, incremental	Normal
EMG				
MUAP	Increased	Increased	Normal	Decreased
Recruitment	Reduced	Reduced	Normal	Early



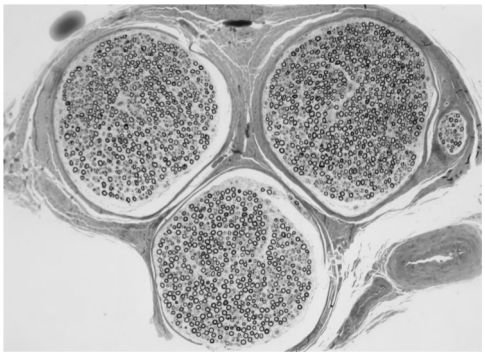




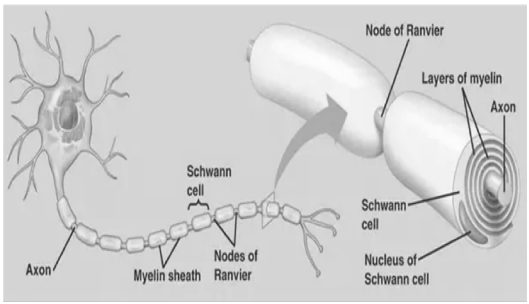
Anatomy of peripheral nerve



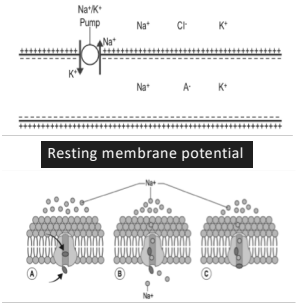
Peripheral nerve

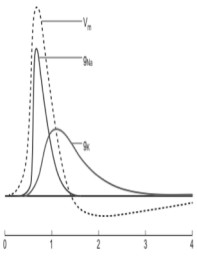


Myelinated nerve fiber

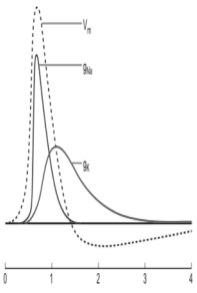


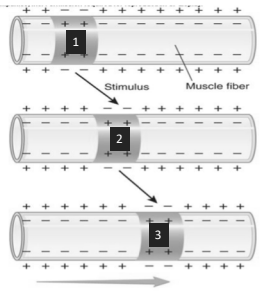
Nerve conduction





Nerve conduction





Saltatory conduction

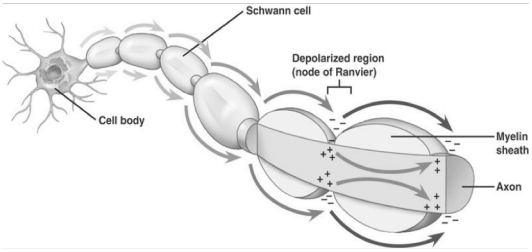


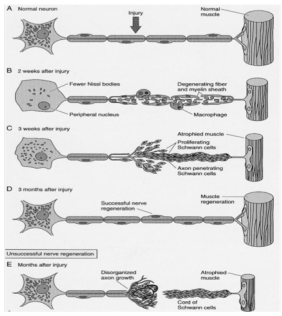
Table 2–1. Peripheral Nerve Classification Schemes

Fiber Type(s)	Name	Subtype	Diameter (mm)	Conduction Velocity (m/s)
Myelinated Somatic Afferent/Efferent				
Cutaneous afferent	A	β δ	6–12 1–5	35–75 5–30
Muscle afferent	A	α β δ	12–21 6–12 1–5	80–120 35–75 5–30
Muscle efferent Anterior horn cells (α and γ motor neurons)	A		6–12	35–75
Myelinated Autonomic Efferent				
Preganglionic efferent	B		3	3–15
Unmyelinated Somatic/Autonomic Afferent/Efferent				
Postganglionic efferent	C		0.2–1.5	1–2
Afferent to dorsal root ganglion (pain)	C		0.2–1.5	1–2

Type of neuropathy

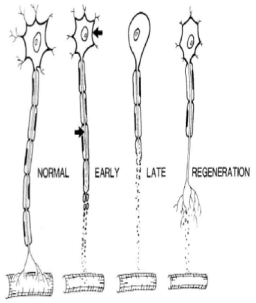
- Axonal degeneration
  - wallerian degeneration
  - dying-back degeneration
  - neuronopathy
- Demyelination

Wallerian Degeneration



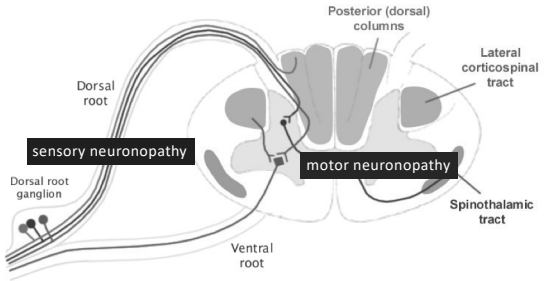
- Axonal degeneration following transection of nerve
- Axon separated from neuron
  - axonal degeneration in distal portion (gradually)
- Nerve cell chromatolysis
  - severe cases

Dying – back Axonal Degeneration

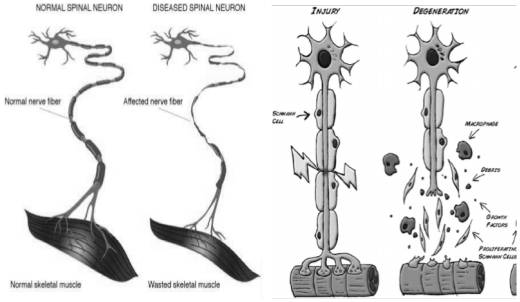


- Degeneration of distal axons
  - metabolic abnormality
  - failure of axon transport
- Degeneration from distal to proximal part of long or large axon

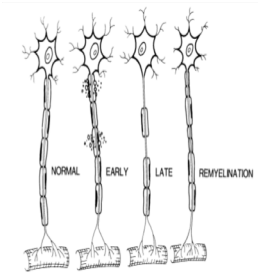
Neuronopathy



Neuronopathy vs. Wallerian degeneration

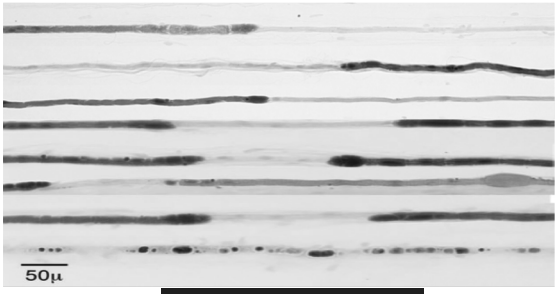


Segmental demyelination



- Primary damage of myelin sheath
- Beginning at nodes of Ranvier
- Diffuse, focal or multifocal
- Axon intact

Segmental demyelination and secondary axonal degeneration



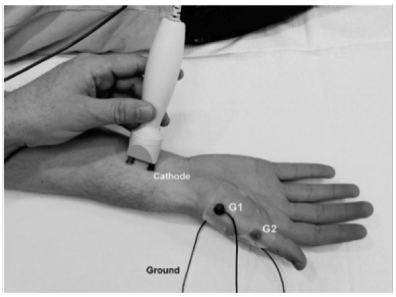
Teased fibers from CIDP patient

Causes of polyneuropathy

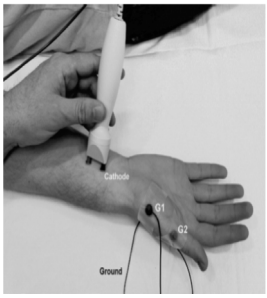
Axonopathy
- Inflammatory or Immune
  - GBS, vasculitis
- Toxic, metabolic
  - Porphyria, CIP, DM, uremia
  - B1 or B12 deficiency
  - Amiodarone, vincristine, arsenic, mercury, thallium
  - Amyloidosis
- Infection
  - Lyme disease, HIV
- Inherited
  - HMSN II

Demyelination
- Inflammatory or immune
  - GBS, CIDP
  - Paraproteinemia
- Toxic, metabolic
  - Amiodarone, lead
  - n-Hexane
  - Hypothyroid
- Infection
  - Diphtheria, HIV
- Inherited
  - HMSN I

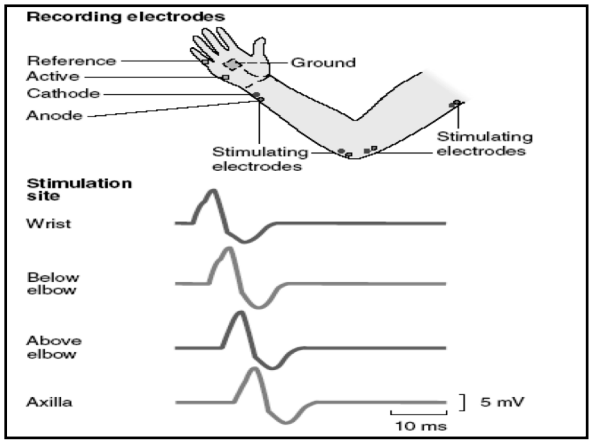
NCS

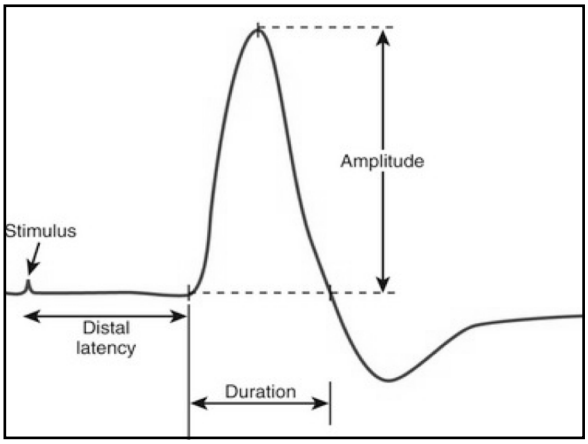


Direction of stimulation

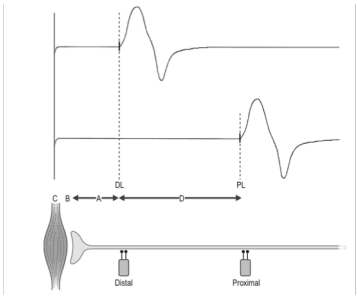


- Orthodromic
  - nerve action potentials carried in physiological direction
- Antidromic
  - nerve action potentials carried in direction opposite to physiological direction





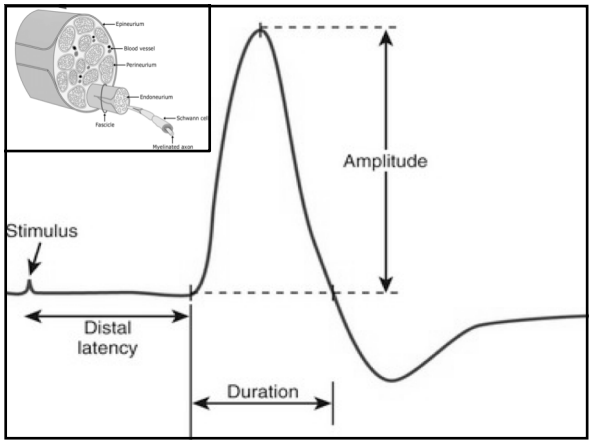
Conduction velocity

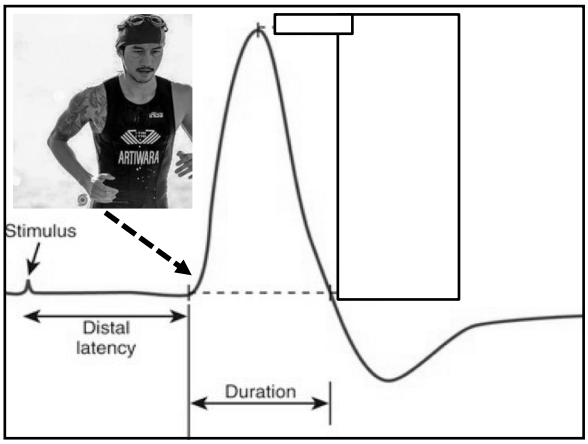


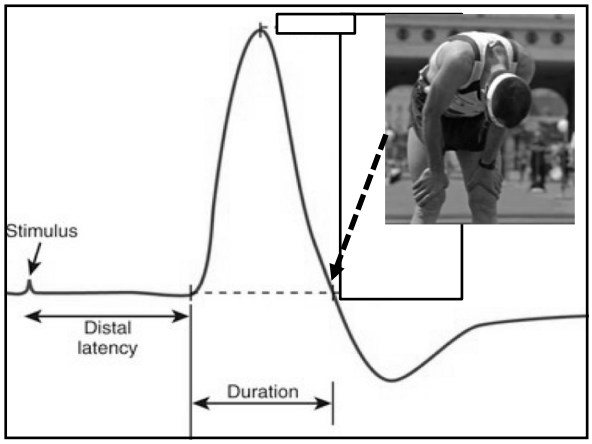
Distance
Proximal latency – distal latency

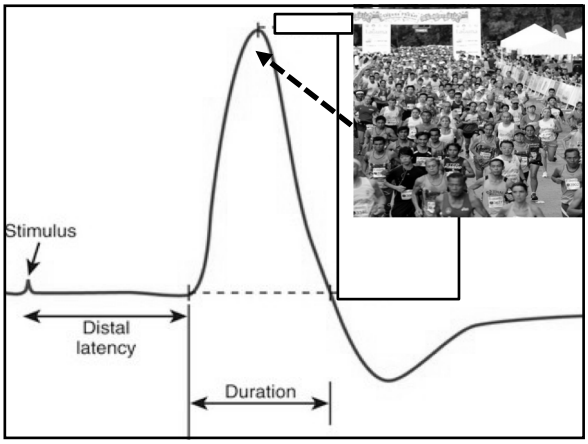
Type of NCS abnormality

	Axonal loss	Demyelination
Distal motor latency	Normal or slightly prolonged	Prolonged
CMAP amplitude	Decreased	Normal
Conduction Block or temporal dispersion	Not present	Present
Motor nerve CV	Normal or slightly decreased	Decreased
F-wave latency	Normal or slightly prolonged	Prolonged
Sensory response	Decreased or absent	Decreased or absent









Nerve conduction velocity

Table 2–1. Peripheral Nerve Classification Schemes

Fiber Type(s)	Name	Subtype	Diameter (mm)	Conduction Velocity (m/s)	Alternative Classification	
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Cutaneous afferent	A	β δ	6–12 1–5	35–75 5–30	α	
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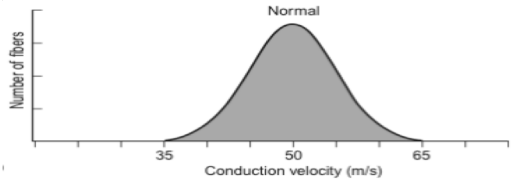
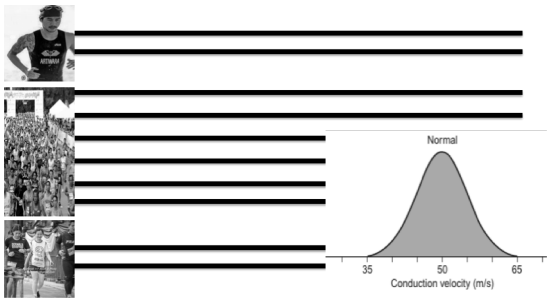
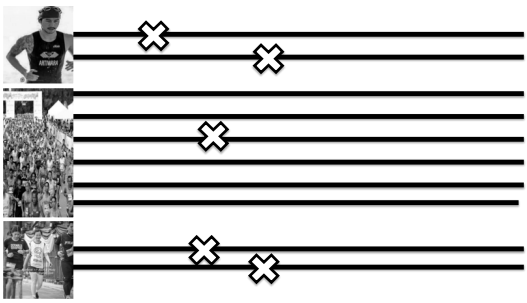


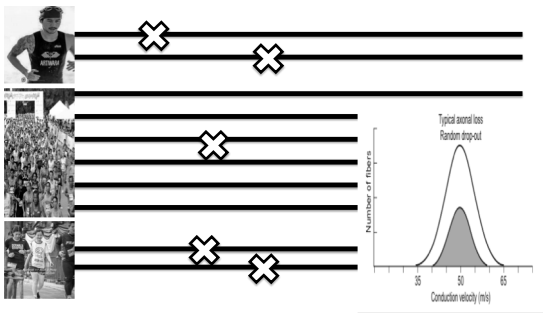
Normal conduction velocity



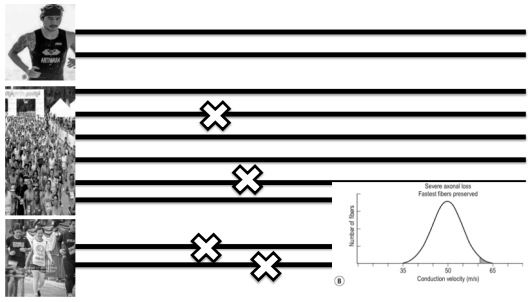
Axonal loss



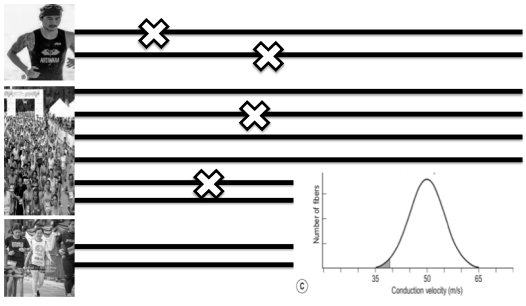
Axonal loss – large and small fibers



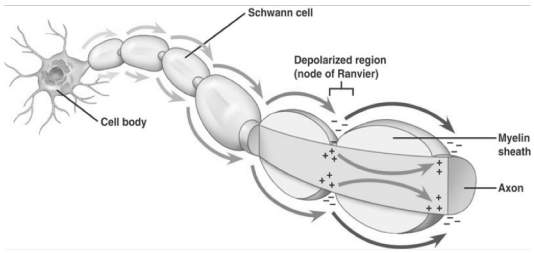
Axonal loss – small fiber



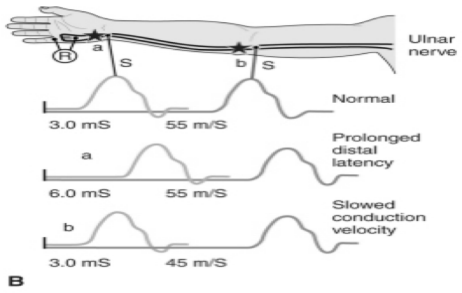
Axonal loss – large fiber



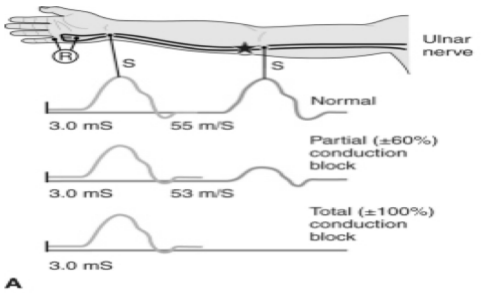
Demyelination



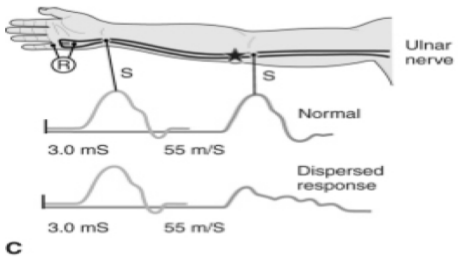
Prolonged distal latency in demyelination



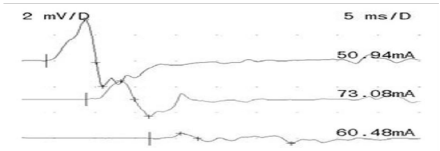
Conduction block in demyelination



Temporal dispersion in demyelination



CB and TD



	CB	TD
P-CMAP/ D-CMAP amplitude	< 50%	< 50%
Duration	Increased < 15 %	Increased > 20%
Area under curve	Decreased	Normal

Type of NCS abnormality

	Axonal loss	Demyelination
Distal motor latency	Normal or slightly prolonged	Prolonged
CMAP amplitude	Decreased	Normal
Conduction Block or temporal dispersion	Not present	Present
Motor nerve CV	Normal or slightly decreased	Decreased
F-wave latency	Normal or slightly prolonged	Prolonged
Sensory response	Decreased or absent	Decreased or absent

Primary demyelination
or
primary axonal degeneration

NC Data - Motor

Motor NCS Nerve	Takeoff Lat. ms	Amp. mV	CV. m/s	Distance mm	F-M(Shortest) Lat. ms	Duration ms
Medianus Motor Left						
Wrist - APB	5.65	2.9			29.1	8.3
Elbow-Wrist	10.4	2.8	41.1	195		8.5
Medianus Motor Right						
Wrist - APB	5.35	4.9			29.4	6.9
Elbow-Wrist	10.9	4.5	35.1	195		7.2
Peroneus Motor Left						
Ankle - EDB	--	--			16.5	--
Fib. head-Ankle	--	--	--			--
Peroneus Motor Right						
Ankle - EDB	--	--			--	--
Fib. head-Ankle	--	--	--			--
Tibialis Motor Left						
Ankle - Abductor hallucis	--	--			--	--
Popliteal Fossa - Abductor hallucis	--	--				--
Popliteal Fossa-Ankle	--	--	--			--
Tibialis Motor Right						
Ankle - Abductor hallucis	10.8	0.33			--	4.3
Popliteal Fossa - Abductor hallucis	22.8	0.32				5.3
Popliteal Fossa-Ankle	22.8	0.32	27.5	330		5.3
Ulnaris Motor Left						
Wrist - ADM	5.25	3.6			30.9	7.7
Bl. elbow-Wrist	11.1	2.6	32.5	190		6.8
Ulnaris Motor Right						
Wrist - ADM	4.98	4.5			31.0	6.7
Bl. elbow-Wrist	10.1	4.0	36.1	185		7.0

NC Data - Sensory

Sensory NCS Nerve	Onset Lat. ms	Peak Lat ms	Amp uV	Peak CV m/s	Distance mm	Temp °C
Medianus Sensory Left						
Dig II - Wrist		**	**			
Medianus Sensory Right						
Dig II - Wrist		**	**			
Suralis Sensory Left						
Mid. lower leg 10 cm - Lat. Malleolus				**		
Mid. lower leg 10 cm - Lat. Malleolus				**		
Suralis Sensory Right						
Mid. lower leg 10 cm - Lat. Malleolus		**	**			
Mid. lower leg 10 cm - Lat. Malleolus				**		
Ulnaris Sensory Left						
Dig V - Wrist		**	**			
Ulnaris Sensory Right						
Dig V - Wrist						

F-Wave

Nerve	F-M(Shortest) Lat ms	F(Shortest) Lat ms	M-Lat ms	#F #
Medianus F-Response Left				
Wrist - APB	23.1	26.1	3.0	1.00
Medianus F-Response Right				
Wrist - APB	22.7	29.2	6.5	1.00
Peroneus F-Response Left				
Ankle - EDB	--	--	3.6	0
Peroneus F-Response Right				
Ankle - EDB	--	--	1.00	0
Tibialis F-Response Left				
Ankle - Abductor hallucis	--	--	1.92	0
Tibialis F-Response Right				
Ankle - Abductor hallucis	--	--	4.1	0
Ulnaris F-Response Left				
Wrist - ADM	30.0	34.7	4.8	1.00
Ulnaris F-Response Right				
Wrist - ADM	37.9	39.9	1.96	1.00

H-Reflex

Left Tibialis HReflex	M-Lat ms	H-Lat ms	H/M Amp -
Knee - Soleus	--	--	--

Right Tibialis HReflex	M-Lat ms	H-Lat ms	H/M Amp -
Knee - Soleus	--	--	--

Nerve conduction velocity

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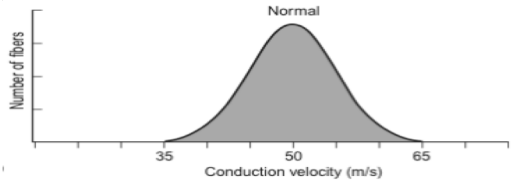


Electrodiagnostic criteria for demyelinating polyneuropathy

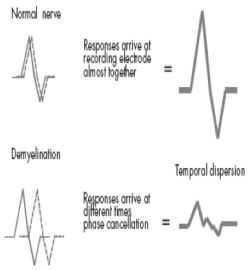
- Decreased CV in ≥ 2 motor nerves
  - <80% lower limit of normal(LLN) if CMAP amplitude >80% LLN
  - <70% LLN if CMAP amplitude <80% LLN
- Partial conduction block or abnormal temporal dispersion in at least one motor nerve
- Prolonged distal latencies > 2 nerves
  - > 125% of upper limit of normal(ULN) if amplitude > 80% LLN
  - > 150% of ULN if amplitude < 80% LL
- Absent F waves or prolonged minimum F-wave latencies in ≥2 nerves
  - > 120% of ULN if amplitude > 80% of LLN
  - > 150% of ULN if amplitude < 80% of LLN

Electrodiagnostic criteria for demyelinating polyneuropathy

- Decreased CV in ≥ 2 motor nerves
  - If CMAP amplitude > 80% LLN – CV < 80% LLN
  - if CMAP amplitude < 80% LLN – CV < 70% LLN
- Partial conduction block or abnormal temporal dispersion in at least one motor nerve
- Prolonged distal latencies > 2 nerves
  - If CMAP amplitude > 80% LLN – DL > 125% ULN
  - if CMAP amplitude < 80% LLN – DL > 150% of ULN
- Absent F waves or prolonged minimum F-wave latencies in ≥2 nerves
  - If CMAP amplitude > 80% LLN – F-wave latency > 120% of ULN
  - if CMAP amplitude < 80% LLN – F-wave latency > 150% of ULN

Caution, artifacts and technical factors

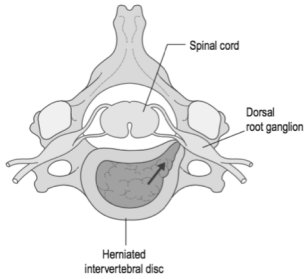
Normal temporal dispersion and phase cancellation



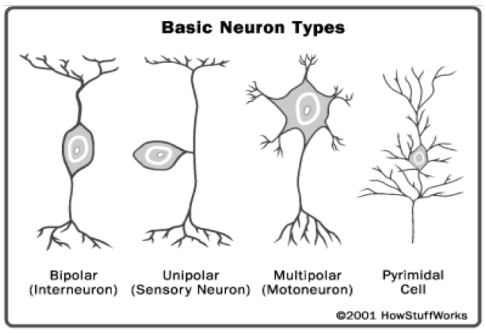
Proximal stimulation

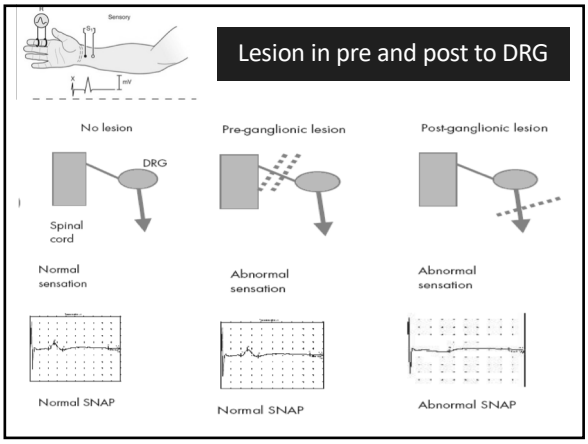
- Proximal CMAP
  - duration slightly increased
  - area and amplitude slightly decreased

Dorsal root ganglion cell

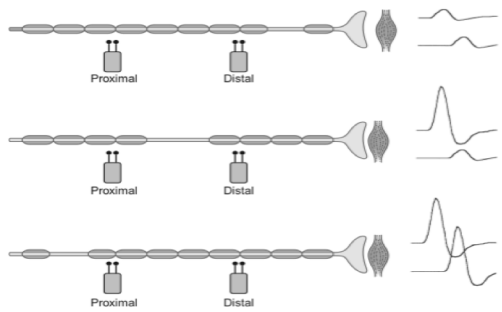


Neuron

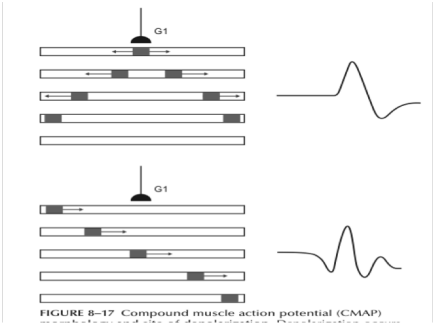




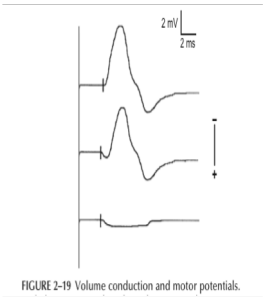
Site of stimulation and CB



Action potential

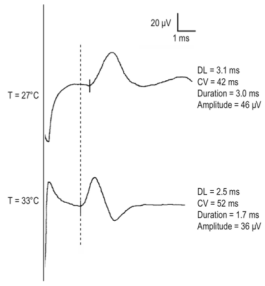


Site of recording electrode

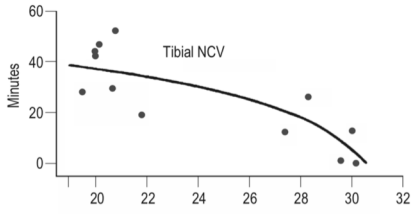


- Top trace
  - active recording electrode (G1) over motor point
- Middle trace
  - active recording electrode is off motor point
- Bottom trace
  - depolarization occurs at a distance and never travels under the recording electrode

Temperature effect on NCS



Temperature effect on NCS



Age and Height

- Age
  - CV decrease slightly with age
  - especially > 60 yrs.
  - CV decrease 0.5 - 4.0 m/s/decade
  - sensory more than motor fibers
- Height
  - taller have slower CV than shorter individuals
  - usually no more than 2 to 4 m/s below LLN

Demyelination

	Normal			CMAP > 80%			CMAP < 80%		
	CMAP	DL	CV	CMAP	DL	CV	CMAP	DL	CV
Median n.	5	4.2	50	4	5.25	40	<4	6.3	35
Ulnar n.	5	3.4	50	4	4.25	40	<4	5.1	35
Tibial n.	3	6.5	40	2.4	8.13	32	<2.4	9.8	28
Peroneal n.	2	5.8	40	1.6	6.86	32	<1.6	8.7	28

NC Data - Motor

Motor NCS

Nerve	Takeoff Lat. ms	Amp. mV	CV. m/s	Distance mm	F-M(Shortest) Lat. ms	Duration ms
Medianus Motor Left						
Wrist - APB	5.65	2.9			29.1	8.3
Elbow-Wrist	10.4	2.8	41.1	195		8.5
Medianus Motor Right						
Wrist - APB	5.35	4.9			29.4	6.9
Elbow-Wrist	10.9	4.5	35.1	195		7.2
Peroneus Motor Left						
Ankle - EDB	--	--			16.5	--
Fib. head-Ankle	--	--	--			--
Peroneus Motor Right						
Ankle - EDB	--	--			--	--
Fib. head-Ankle	--	--	--			--
Tibialis Motor Left						
Ankle - Abductor hallucis	--	--			--	--
Popliteal Fossa - Abductor hallucis	--	--				--
Popliteal Fossa-Ankle	--	--	--			--
Tibialis Motor Right						
Ankle - Abductor hallucis	10.8	0.33			--	4.3
Popliteal Fossa - Abductor hallucis	22.8	0.32				5.3
Popliteal Fossa-Ankle	22.8	0.32	27.5	330		5.3
Ulnaris Motor Left						
Wrist - ADM	5.25	3.6			30.9	7.7
Bl. elbow-Wrist	11.1	2.6	32.5	190		6.8
Ulnaris Motor Right						
Wrist - ADM	4.98	4.5			31.0	6.7
Bl. elbow-Wrist	10.1	4.0	36.1	185		7.0

NC Data - Sensory

Sensory NCS

Nerve	Onset Lat. ms	Peak Lat ms	Amp uV	Peak CV m/s	Distance mm	Temp °C
Medianus Sensory Left						
Dig II - Wrist		**	**			
Medianus Sensory Right						
Dig II - Wrist		**	**			
Suralis Sensory Left						
Mid. lower leg 10 cm - Lat. Malleolus				**		
Mid. lower leg 10 cm - Lat. Malleolus				**		
Suralis Sensory Right						
Mid. lower leg 10 cm - Lat. Malleolus		**	**			
Mid. lower leg 10 cm - Lat. Malleolus				**		
Ulnaris Sensory Left						
Dig V - Wrist		**	**			
Ulnaris Sensory Right						
Dig V - Wrist						

F-Wave

Nerve	F-M(Shortest) Lat ms	F(Shortest) Lat ms	M-Lat ms	#F #
Medianus F-Response Left				
Wrist - APB	23.1	26.1	3.0	1.00
Medianus F-Response Right				
Wrist - APB	22.7	29.2	6.5	1.00
Peroneus F-Response Left				
Ankle - EDB	--	--	3.6	0
Peroneus F-Response Right				
Ankle - EDB	--	--	1.00	0
Tibialis F-Response Left				
Ankle - Abductor hallucis	--	--	1.92	0
Tibialis F-Response Right				
Ankle - Abductor hallucis	--	--	4.1	0
Ulnaris F-Response Left				
Wrist - ADM	30.0	34.7	4.8	1.00
Ulnaris F-Response Right				
Wrist - ADM	37.9	39.9	1.96	1.00

H-Reflex

Left Tibialis HReflex	M-Lat ms	H-Lat ms	H/M Amp -
Knee - Soleus	--	--	--

Right Tibialis HReflex	M-Lat ms	H-Lat ms	H/M Amp -
Knee - Soleus	--	--	--