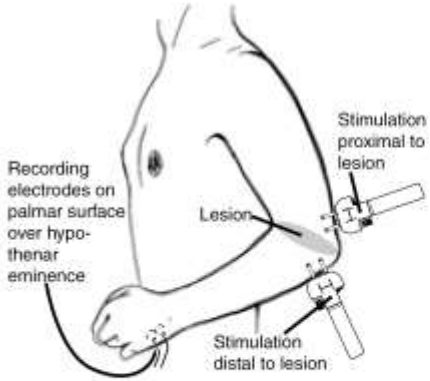
Seddon Classification



Characteristics	Neurapraxia		Axonotmesis		Neurotmesis	
Etiology	Nerve compression injury		Nerve crush injury		Nerve transection injury	
Description	Axon is intact Local myelin injury Conduction block		Axonal interruption Connective tissue/ Schwann cell intact Conduction failure		Axonal interruption Connective tissue disruption Conduction failure	
Nerve Conduction Studies	The signal is normal distal to the lesion and abnormal across it		Conduction resembles neuropraxia for 4 to 5 days, until Wallerian degeneration occurs		Conduction initially resembles axonotmesis, but does not demonstrate recovery	
	Wave Form Distal to Lesion	**Wave Form Proximal to Lesion**	**Wave Form Proximal to Lesion**	**Wave Form Distal to Lesion**	**Wave Form Distal to Lesion**	**Wave Form Proximal to Lesion**
	Immediate 	—	Immediate 	—	Immediate 	—
	2 weeks 	—	2 weeks —	—	2 weeks —	—
	> 2 weeks 		weeks–months 		2 years —	—
EMG	Normal/decreased recruitment		Abnormal activity		Abnormal activity	

Sunderland Classification

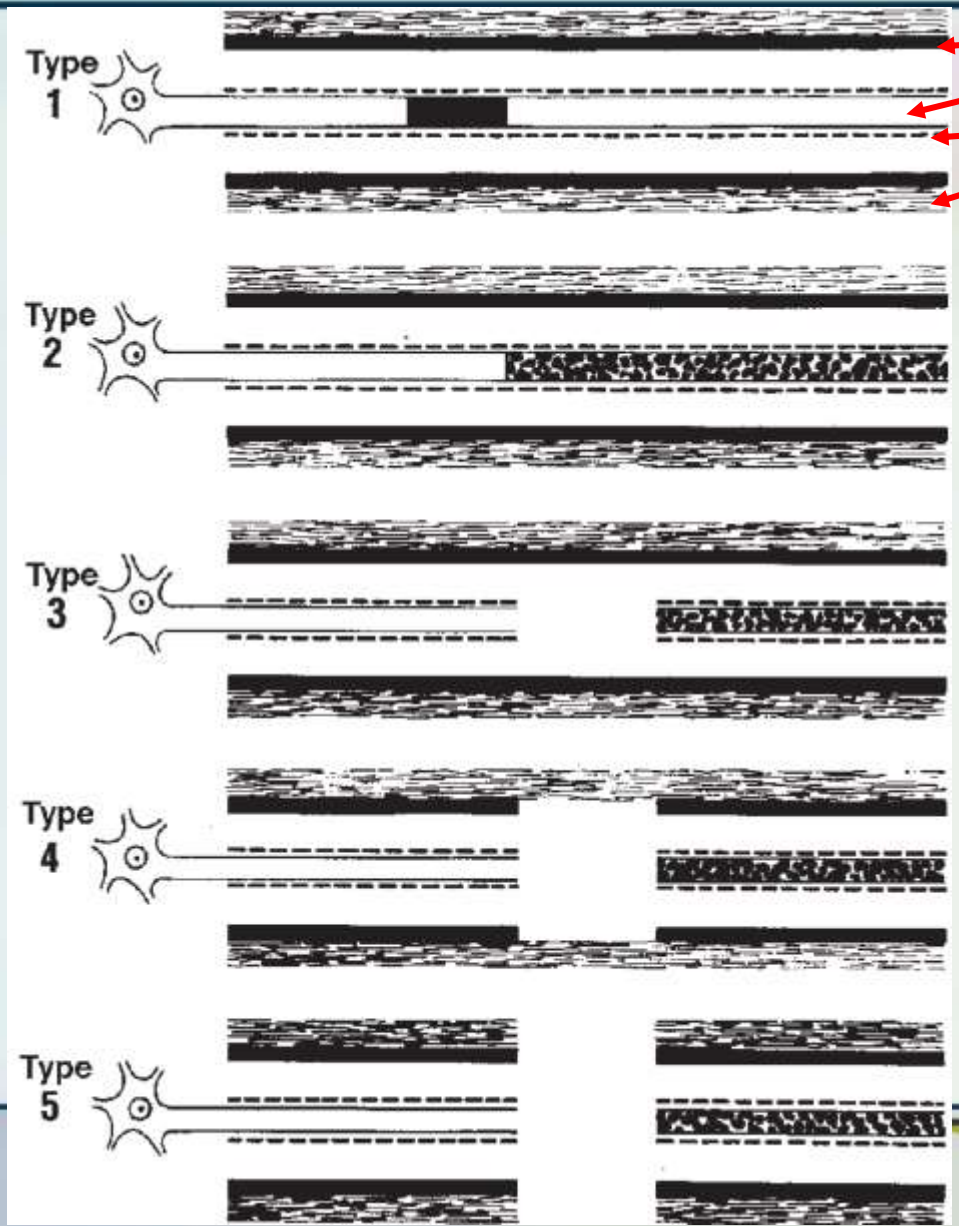
Conduction block (neurapraxia)

Axonal injury (axonotmesis)

Type2 + Endoneurium injury

Type3 + Perineurium injury

Type4 + Epineurium injury (neurotmesis)



Degree of Nerve Fiber Injury

- **Demyelinating Conduction Block (Neuropraxia, First-Degree Injury)**
  - abrupt onset by moderate traction or compression
  - 자동차 사고, 추락, 출산, pack use, classic postop. paralysis
  - only large diameter nerve fiber damage
  - 6-12 weeks

- **Axonotmesis**
  - Axon degeneration: 대부분의 증상 발현
  - Recovery: good to excellent
  - length가 제일 중요

Degree of Nerve Fiber Injury

- **Neurotmesis** (3rd & 4th degree injury)
  - stretch or stretch/contusion lesion
  - spontaneous recovery is generally poor

- **Neurotmesis** (5th degree injury)
  - avulsion injury
  - rupture (UT, axillary terminal N)

- **Co-existence** of neuroparaxia with 1-5th degree injury

전기진단 검사의 대표적 말초신경

상지

혼합신경 (운동+감각)

- Median nerve
- Ulnar nerve

하지

운동신경

- Common peroneal nerve
- Posterior tibial nerve

감각신경

- Sural nerve
- Superficial peroneal nerve

신경전도검사의 일반적인 지침

1. 환자에게 검사에 대한 설명 후 실시
2. 편안한 자세로 환자의 긴장 완화
3. 검사부위의 온도측정
4. 피부저항 줄임
5. 검사 시 전기자극을 서서히 증가시킴
6. 운동신경 검사부터 실시

운동신경전도 검사(예: 정중신경)

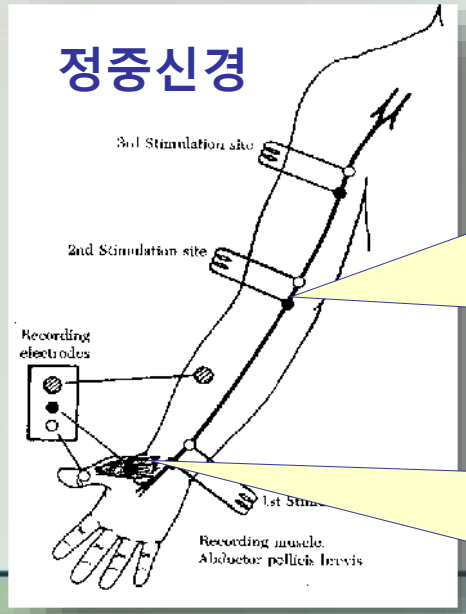
전기자극 | **유발** | **기록** | **분석**

운동신경
(혼합신경)

복합근육활동전
위 (CMAP)

근육에서 기록

잠복시간
tency)



- **자극 부위**
  - 손목: 활성전극 5cm 위
  - 팔꿈치: brachial a. 외측
  - 겨드랑이: 이두박근 내측
- **최대상 전기자극** : 최대자극 + 10~30%

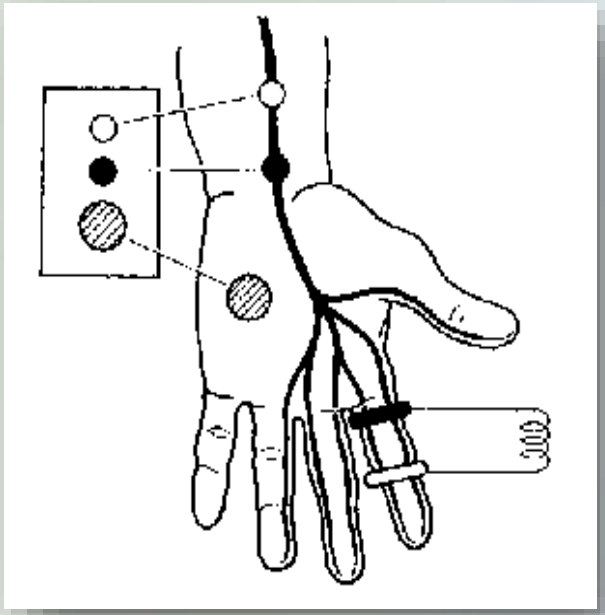
  Cf) 최대자극 : CMAP의 진폭이 더 이상 커지지 않는 자극

- 활성전극 : APB의 중앙
- 기준전극 : APB의 tendon
- 접지전극 : 기록전극과 자극전극의 사이

감각신경전도 검사

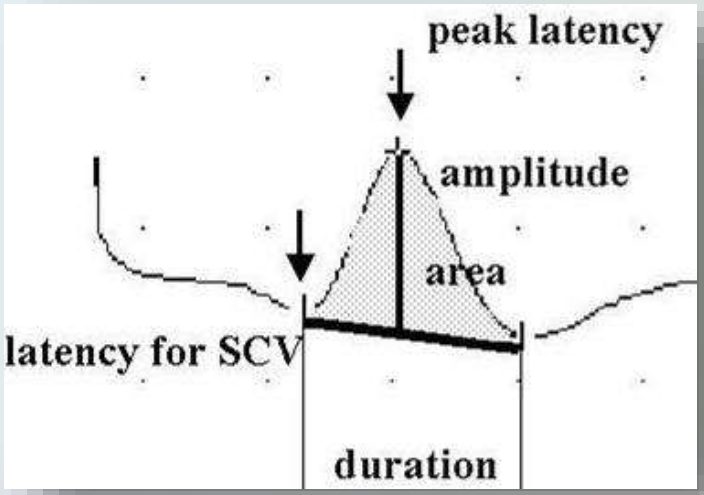
전기자극

감각신경
(혼합신경)



유발

감각신경활동전위 (SNAP)



기록

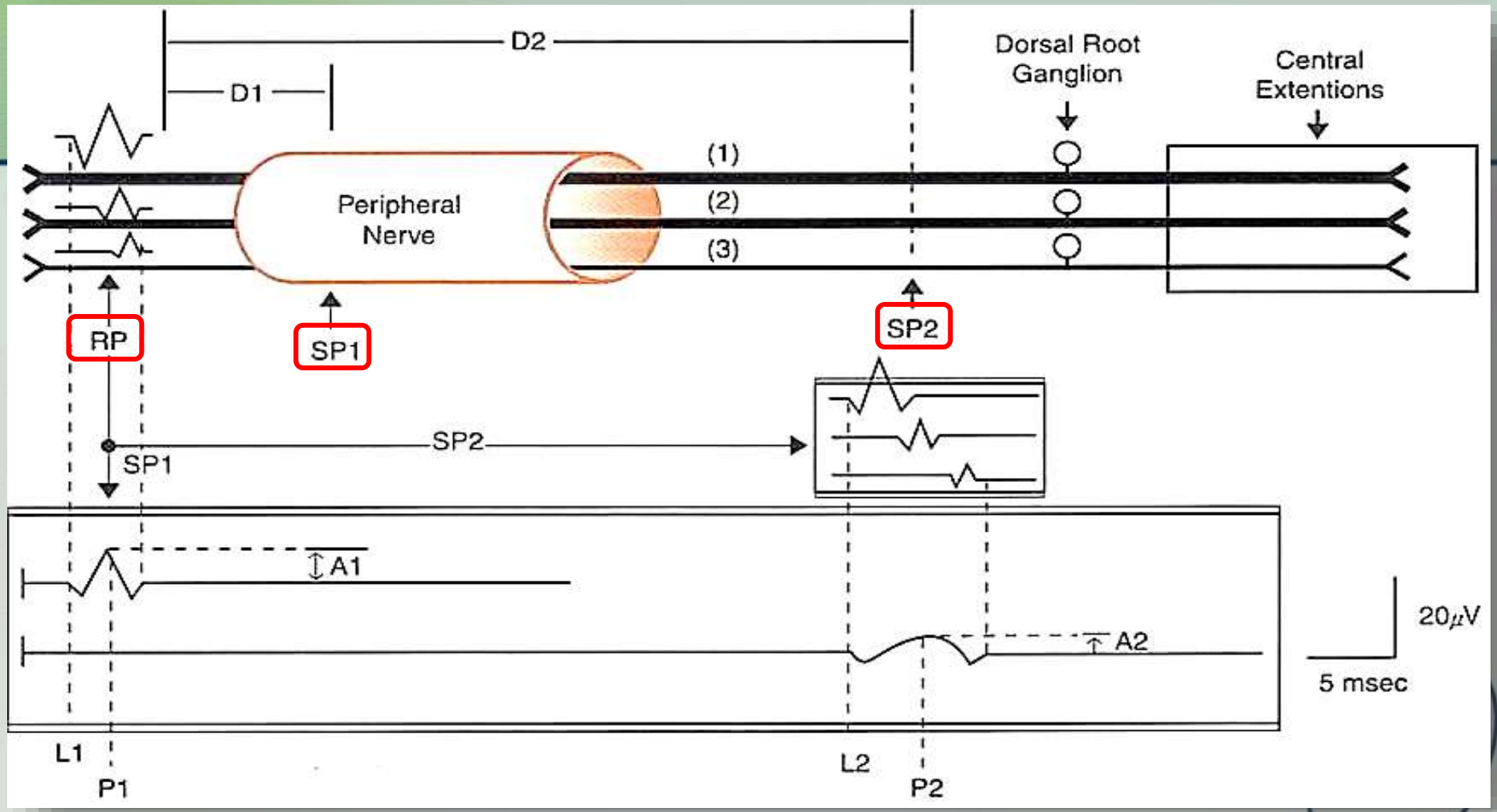
감각신경 내 축삭

분석

잠복시간
(latency)

진폭
(amplitude)

전도속도
(conduction velocity) 등



C. Velocity = (Distance2 - Distance1) / (Latency2 - Latency1)

Onset latency: Fastest fiber 반영 (Larger diameter)

Amplitude: Summation of each nerve fiber's action potential

1) Motor Nerve Conduction Studies

- **Erb's point stimulation**
  - more than supramaximal stimulation,
  - uselessness or usefulness of proximal motor NCS
  - **volume conducted** response
- **NCV, distal m. latency**
  - usually not of much help
- **Amplitude of CMAP**
  - **most important parameter useful for determining the amount of axonal loss**
  - **Baseline to major negative peak**
  - good estimation of No. axons excited
  - CMAP Amp. **bilaterally** difference of
    - 10-20 %: probably with normal variation
    - 40-50 % 이상: axonal loss

2) Sensory Nerve Conduction Studies

- **Routine NCS**
  - median, ulnar and/or sup. radial vs. uncommon NCS
  - **Bilateral** sensory NCS should be performed
  - **'Abnormal'** : 정상치라고 하더라도 ***50% or less*** than the contralateral side

- **Amplitude**
  - the **most sensitive** component for detecting **axon loss**

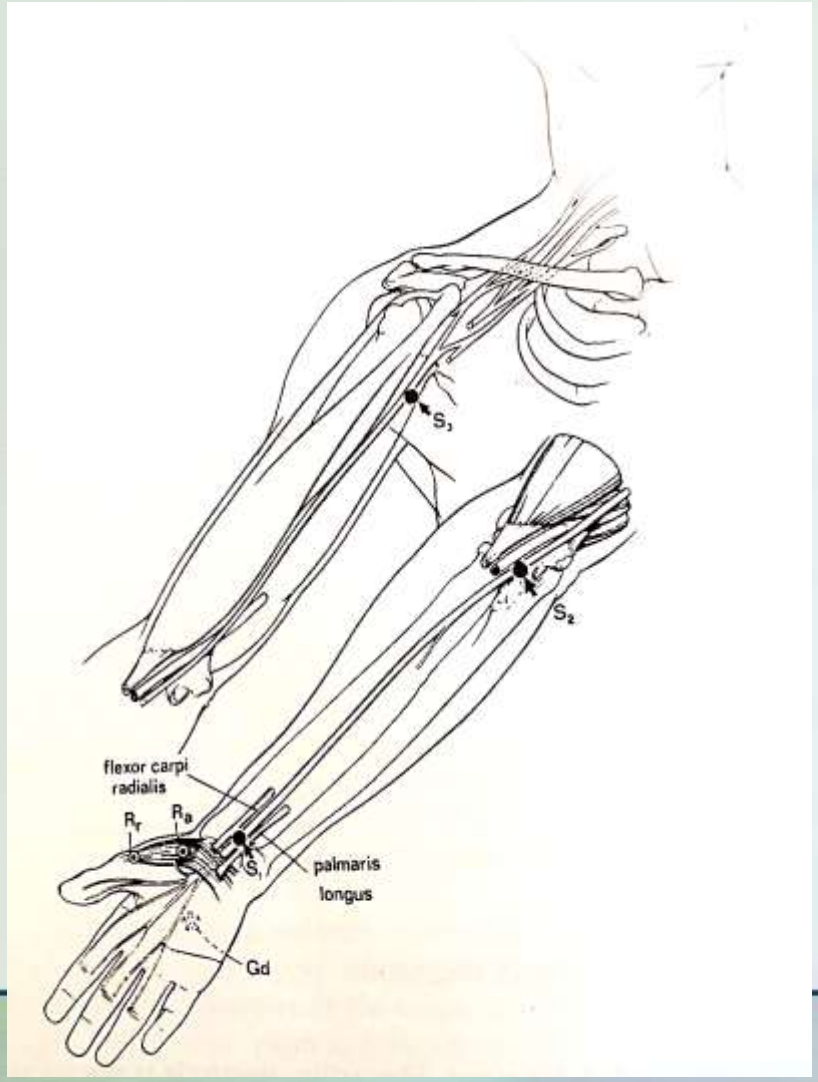
- **Latency**
  - NL or slightly delayed, absent

3) Needle EMG:

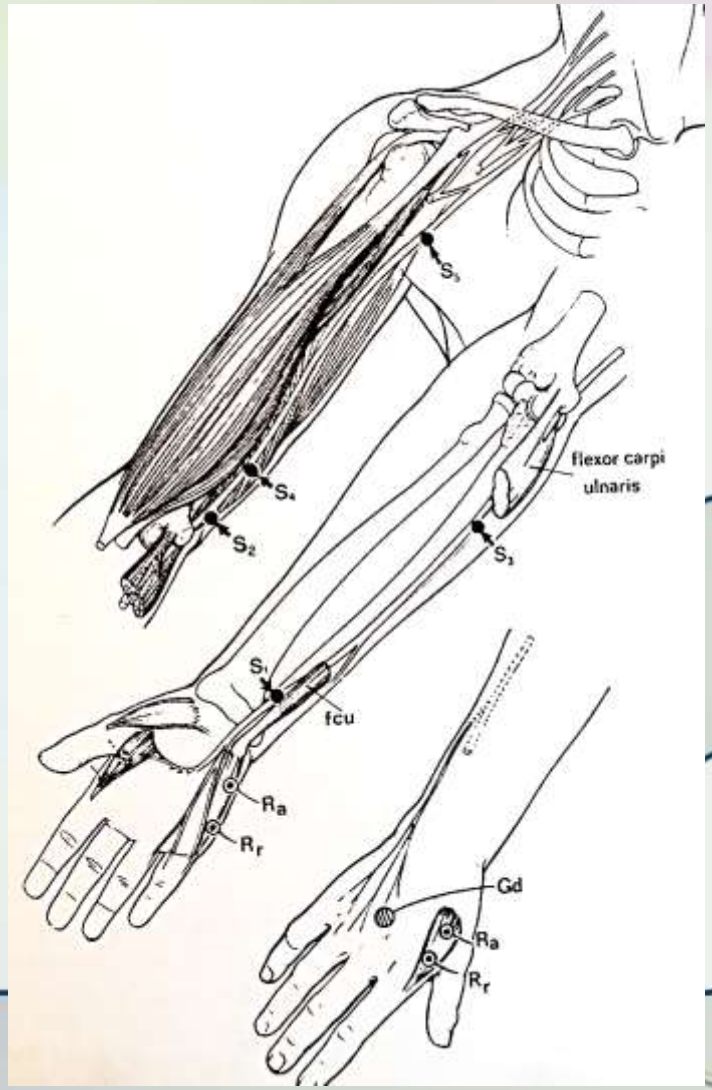
- useful in localization & determination of injury extent
- Single most important electrophysiologic tool

상지의 중요 운동신경전도 검사

정중신경 → APB

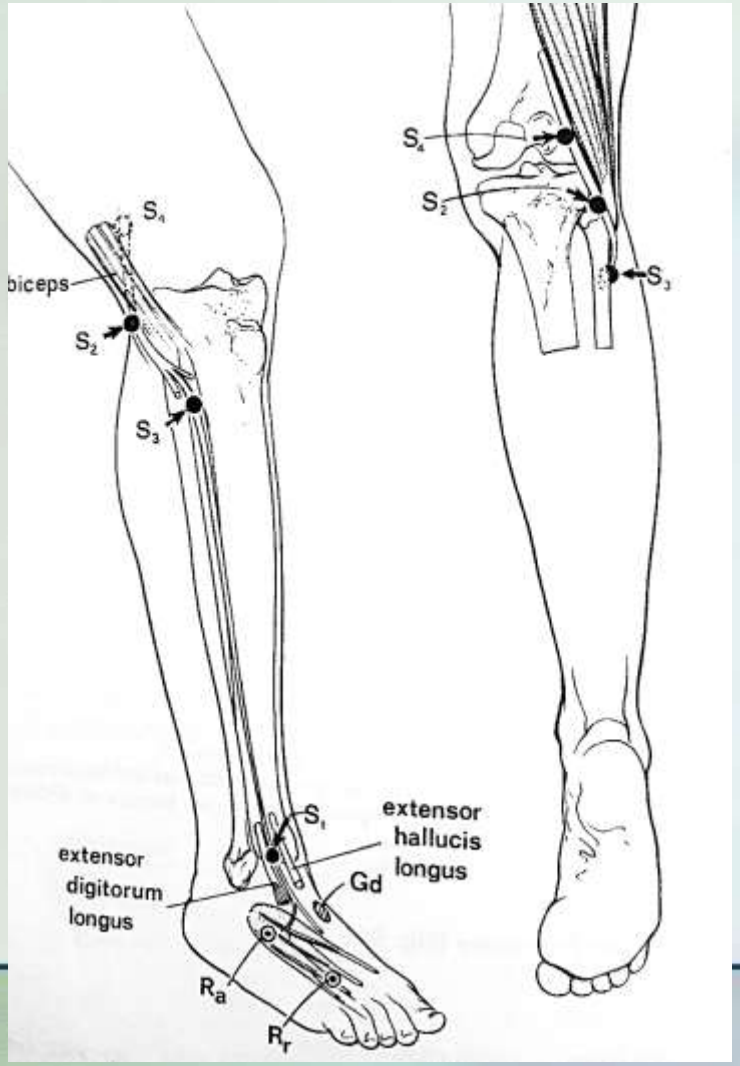


척골신경 → ADQ

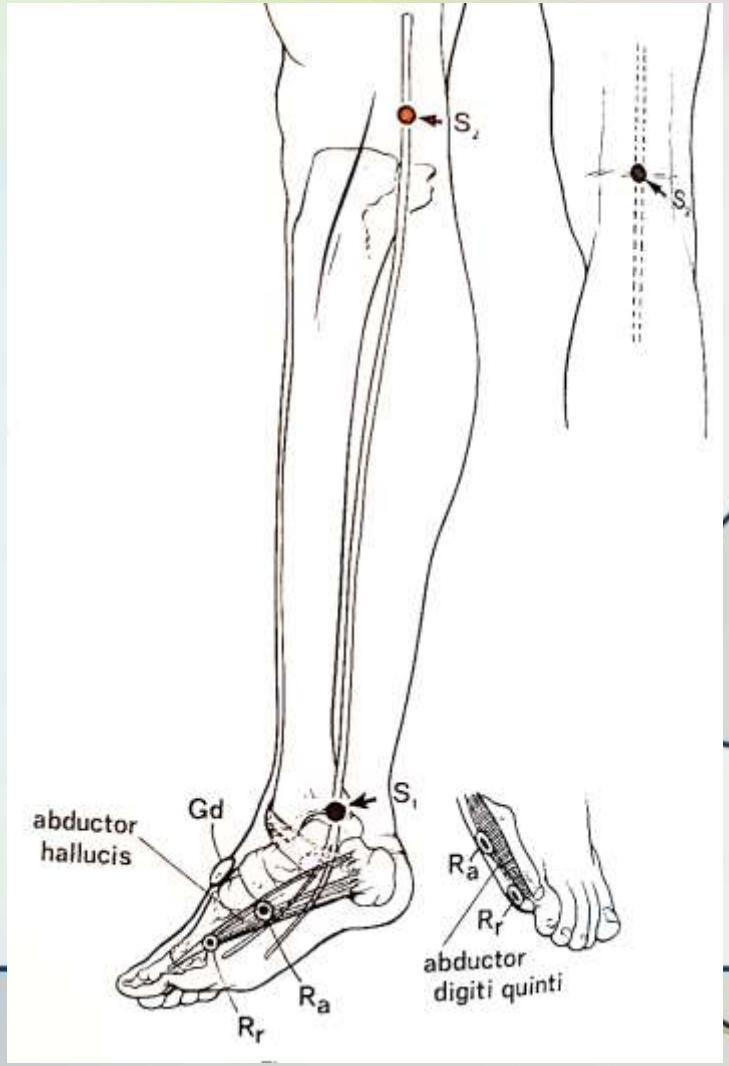


하지의 중요 운동신경전도 검사

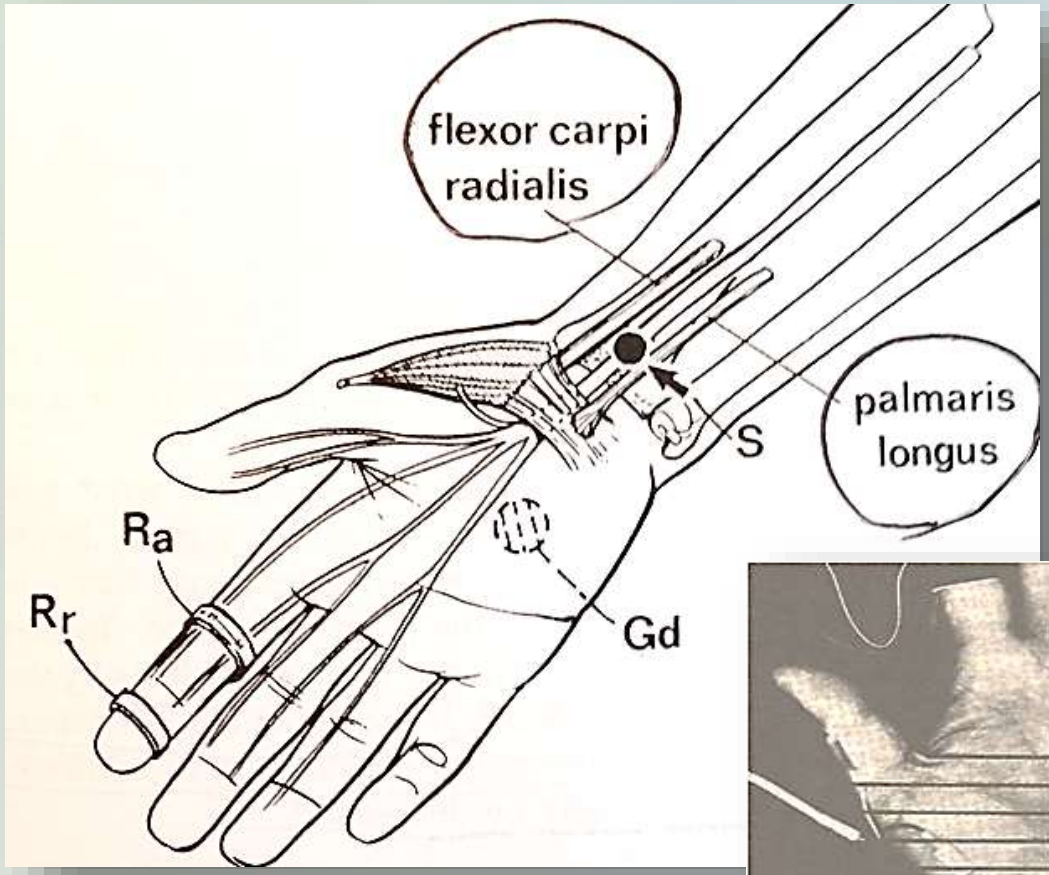
총비골신경→ EDB

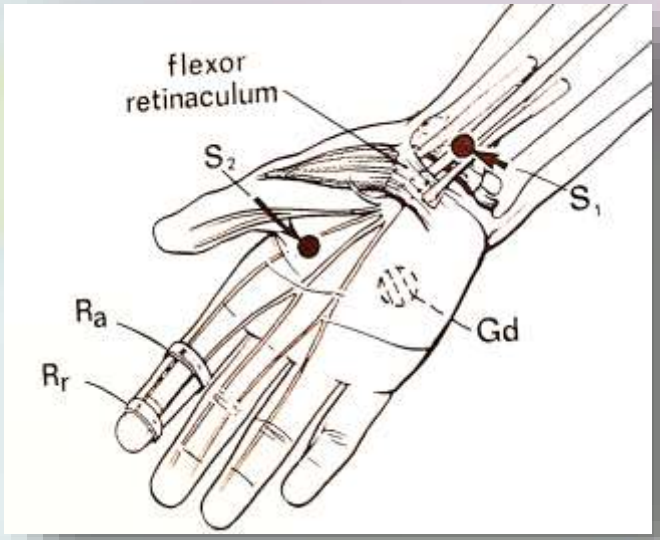


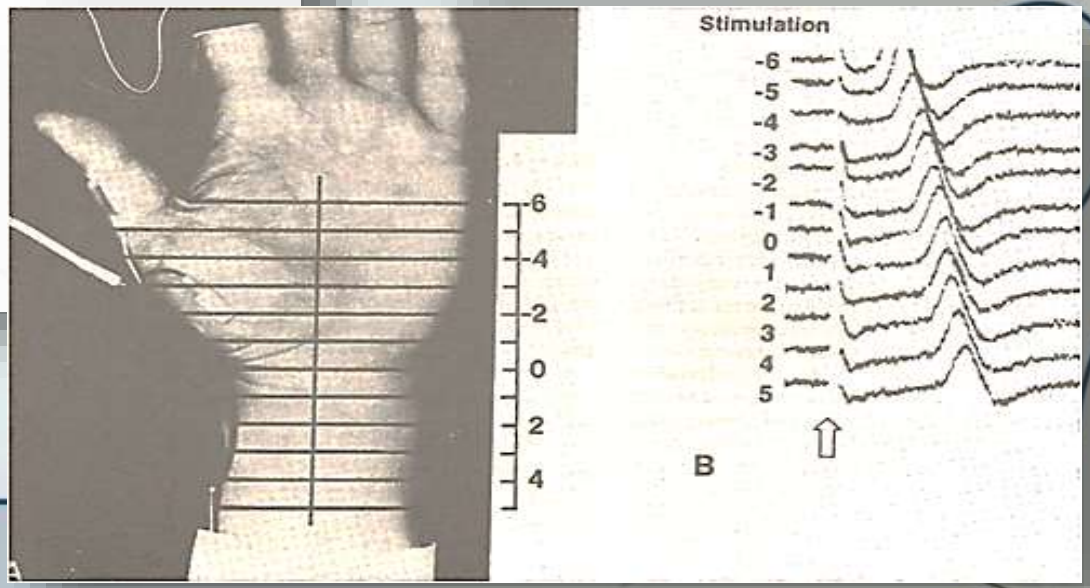
후경골신경 → AH



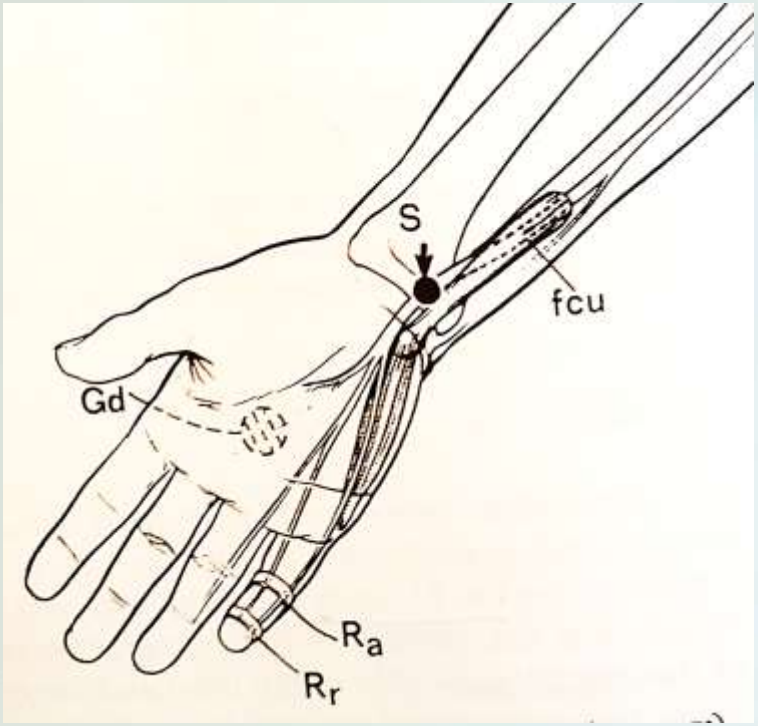
감각신경전도검사 - 정중신경





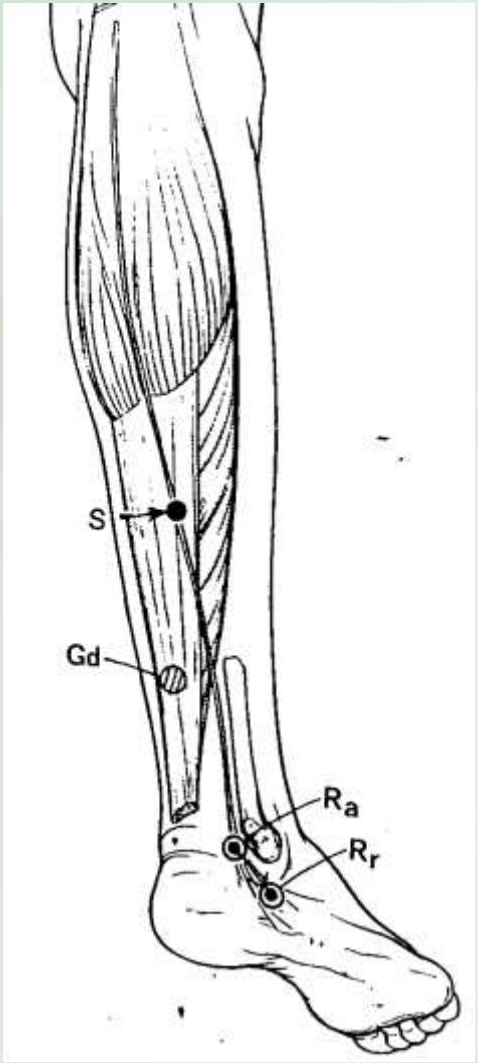


감각신경전도검사 - 척골신경



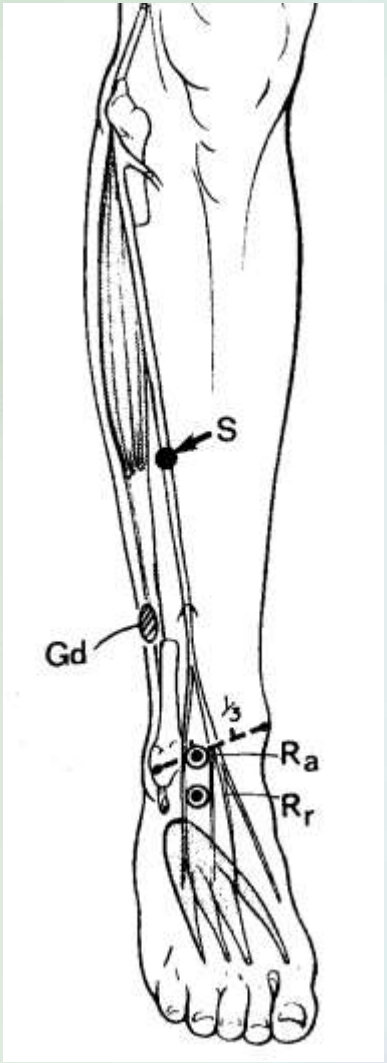
- 활성전극
  - 5th digit just distal to MCP joint
- 기록전극
  - 활성전극 4 ㎝ 뒤
- 자극위치
  - Lateral to FCU tendon

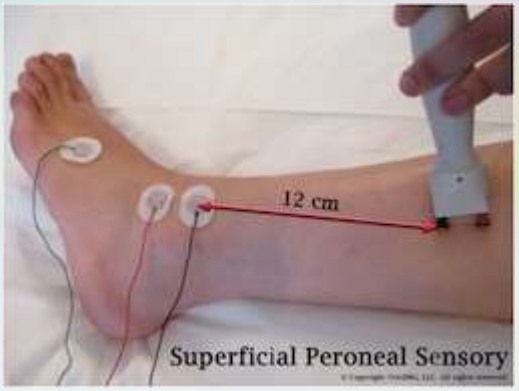
감각신경전도검사 - *비복신경*



- 활성전극
  - Lateral malleolus – Achilles tendon사이 at the malleolar level
- 기록전극
  - 활성전극 3 ㎝ 뒤
- 자극위치
  - Lateral malleolus 10~16 ㎝ 상방
  - Midline 조금 외측

감각신경전도검사 – *표재성 비골신경*





- 활성전극
  - Medial <–>1/3<—> Lateral malleolus
- 기록전극
  - 활성전극 3 ㎝ 뒤
- 자극위치
  - 활성전극의 10~15 ㎝ 상방
  - Peroneus longus 앞

말초신경전도 검사의 정상치

Nerve	Values	Nerves	Values
Median Motor		**Sup. Radial Sensory**	
Distal latency	3.7 ± 0.3 (8 cm)	Distal latency	2.3 ± 0.4 (10 cm)
Amplitude	13.2 ± 5.0	Amplitude	31.0 ± 20.0
Conduction velocity	56.7 ± 0.2	Conduction velocity	58 ± 6.0
Median Sensory		**Peroneal Motor**	
Distal latency	3.2 ± 0.5 (14 cm)	Distal latency	4.5 ± 0.8 (8 cm)
Amplitude	41.2 ± 25.0	Amplitude	4.4 ± 1.4
Conduction velocity	56.9 ± 4.0	CV below fibula head	51.6 ± 4.1
		CV Above fibula head	53.9 ± 4.3
Ulnar Motor			
Distal latency	3.2 ± 0.5 (8 cm)	**Tibial Motor**	
Amplitude	6.0 ± 1.9	Distal latency	3.4 ± 0.5 (10 cm)
CV below elbow	61.8 ± 5.0	Amplitude	11.8 ± 4.5
CV above elbow	62.7 ± 5.5	Conduction velocity	53.9 ± 4.3
Ulnar Sensory		**Sural Sensory**	
Distal latency	3.2 ± 2.5 (14 cm)	Distal latency	3.5 ± 0.2 (14 cm)
Amplitude	34.0 ± 12.1	Amplitude	16.6 ± 7.5
Conduction velocity	57.0 ± 5.0	Conduction velocity	39.6 ± 2.3
Radial Motor		**Sup. Per. Sensory**	
Distal latency	2.4 ± 0.5 (10 cm)	Distal latency	2.9 ± 0.3 (14 cm)
Amplitude	14.0 ± 8.8	Amplitude	20.5 ± 6.1
Conduction velocity	61.9 ± 5.9	Conduction velocity	65.7 ± 3.7

Motor

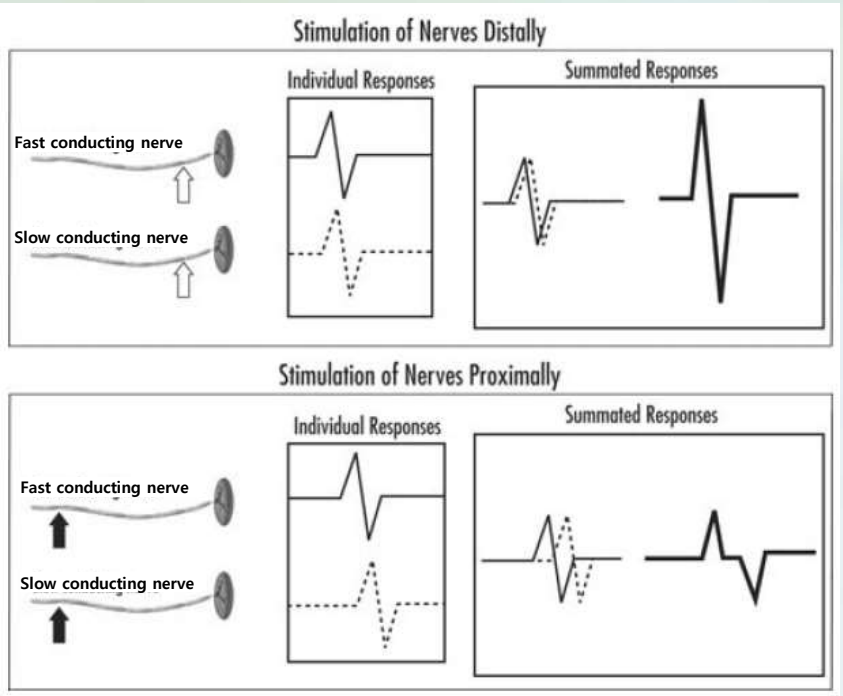
Latency 6.0

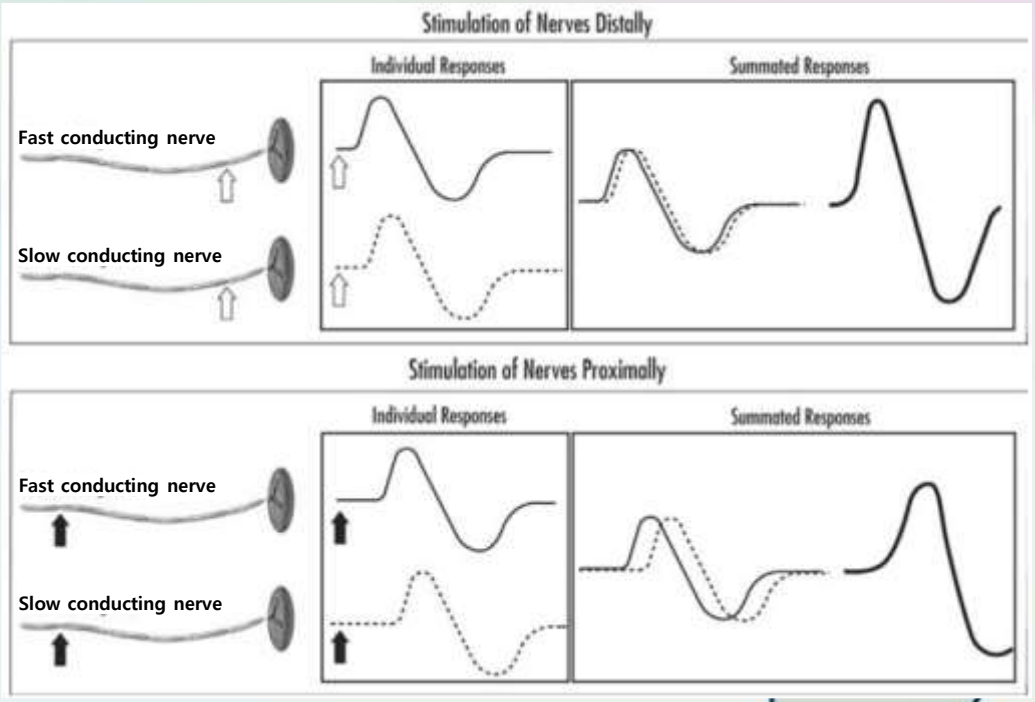
C. Velo 40

Amplitu 2mV

비고

시간 분산 (temporal dispersion)





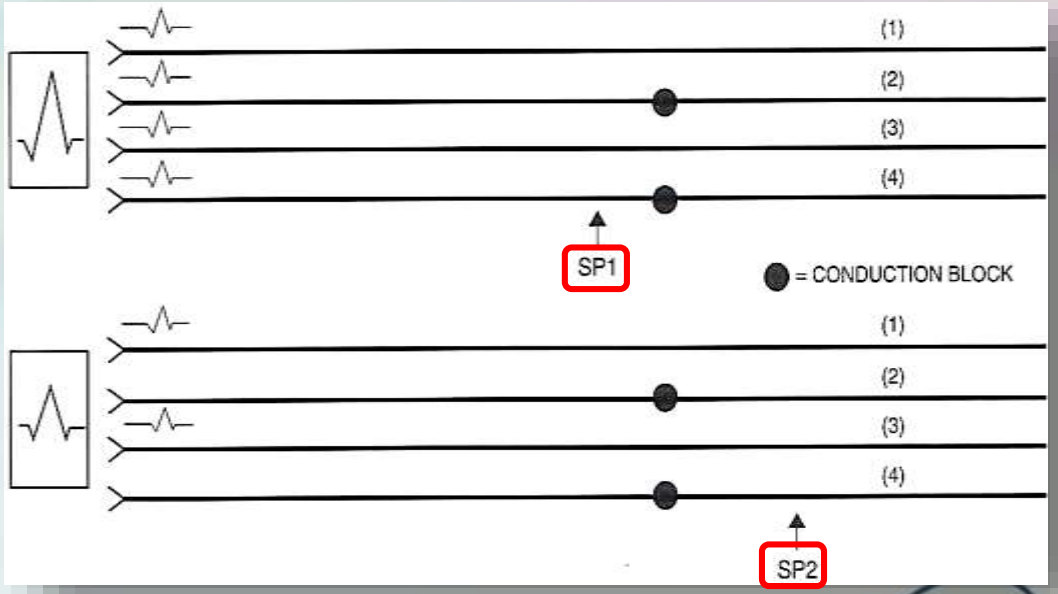
- 운동신경의 잠시 (감각신경 보다 길다)

  = 운동신경 전도 + 신경근 접합부의 지연 + 근섬유의 활동전위 발생시간
- 시간분산은 감각신경이 크다.
- **Area 일정**

전도차단 (conduction block)

≈ Neuropraxia

- Failure of an AP to propagate past a particular point
- Conduction is possible below the point of the block.

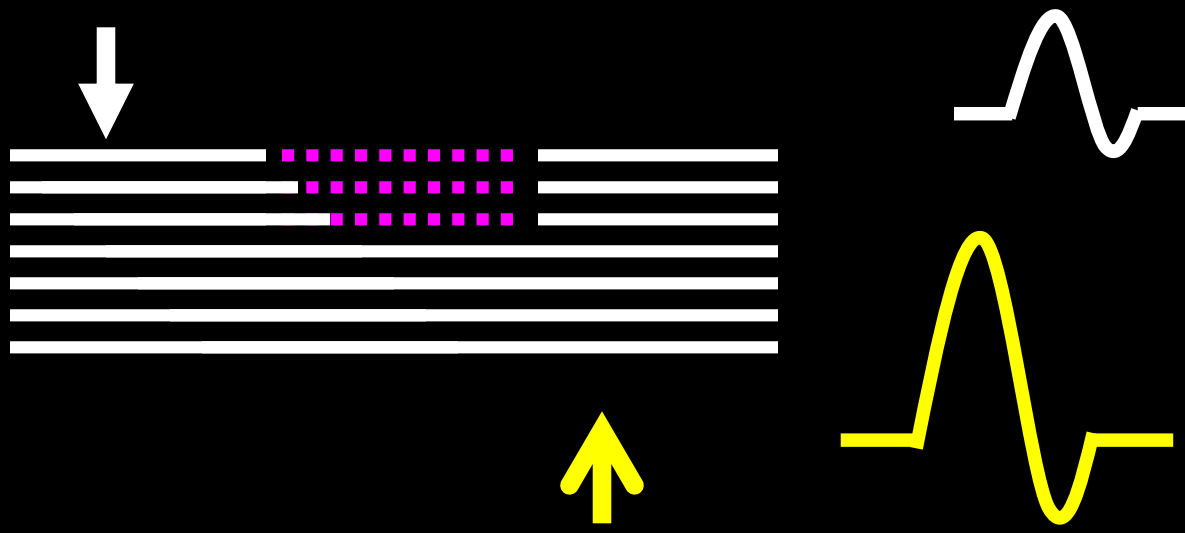


- **압박 시 주로 직경이 큰 빠른 신경의 손상이 많다!!!!**
  - **손상의 원위부(SP1) 자극 시: 빠른 신경측정치가 반영**
  - **손상의 근위부(SP2) 자극 시: 느린 신경측정치가 반영**

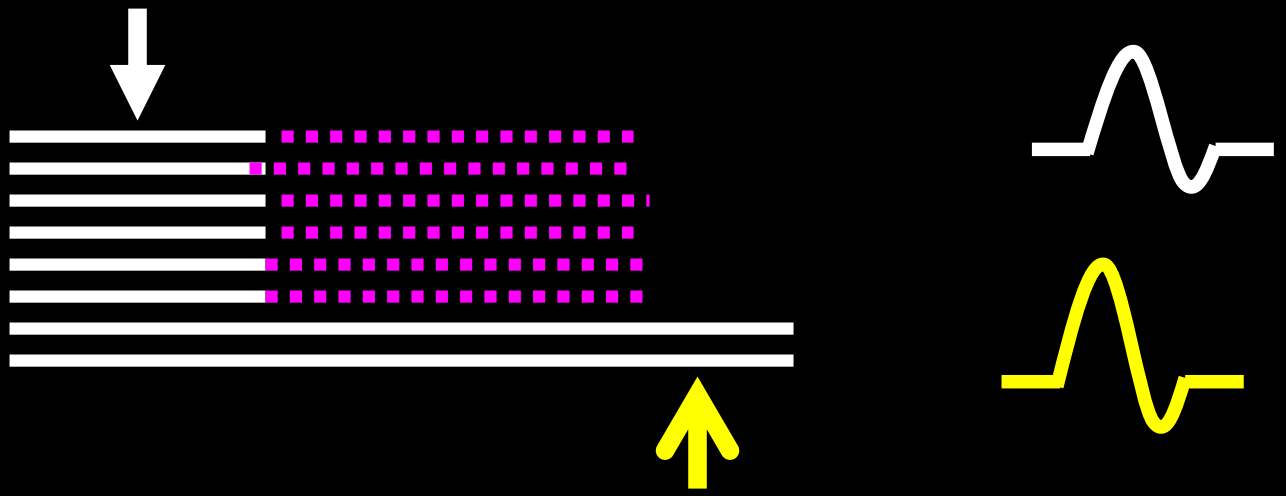
→ 손상부위를 지나가는 C. velocity의 저하

→ 근위부(SP2) 자극 시: Latency 저하 및 Amplitude & Area감소

Conduction Block



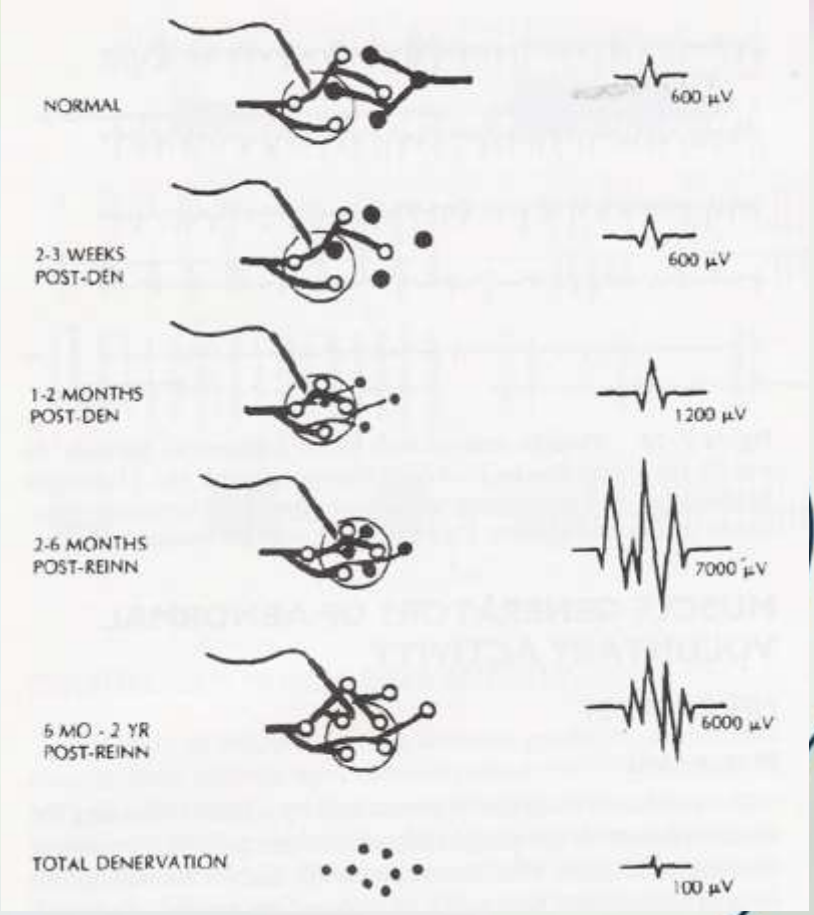
Axonal Degeneration



Two Mechanisms of Reinnervation

Progressive proximodistal regeneration

- Time-Distance Factor
- Nerve regeneration: **1 inch/month**
- Muscle survival: **18-20 months**



Collateral sprouting

- from nearby intact axons
- Regeneration is critically dependent upon the completeness of lesion

Timing of EDx

- **CMAP Amplitude:**
  - **2-3일**부터 감소하여 **7일**에 최대
  - ***more reliable indicator of axon loss*** than MUP dropout on needle EMG
- **SNAP Amplitude:**
  - **5일**부터 감소하여 **10-11일**에 최대
- **수상 후 3-4 주가 적절**

Some Guidelines

1. **Timing of EDX:** 3-4 weeks after the injury
2. **In BPI, Sensory NCS:** where sensory complaints

   Motor NCS: muscles that are clinically weak
3. **CMAP Amplitude:** reliable indicator of axonal loss amount than Needle EMG
4. **SNAP Amplitude** is borderline or in lower range of normal → NCS on contralateral normal limb
5. Possibility of conduction block

감사합니다.. ^^