Strategies in diagnostic EMG

Planning and performing a successful study

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Outline 35 min

- What is strategy in EDX?
- Quality assurance
- Guidelines
- How we plan our investigation
- Differential diagnosis
- Diagnostic criteria
- Diagnostic errors
  - Overdiagnosis

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Definition of strategy

Strategy. *(greek strategia = generalship)* 1. The art of combining and employing the means of war in planning and directing large military movements

2. A plan, method, or series of of maneuvers for obtaining a specific goal or result.

Random House Compact Unabridged Dictionary. Random House, New York, 2006

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Goal of diagnostic EMG

- Is there a peripheral neuromuscular disorder?
  - Focal neuropathy
  - Polyneuropathy
  - Motor neuron disorder
  - Neuromuscular transmission disorder
  - Myopathy
- Characterize the disorder
  - Severity (mild, moderate, severe)
  - Pathophysiology (axonal, demyelinating, conduction block)
  - Time course (acute, chronic, inactive)
  - Distribution (symmetric, distal, proximal…..)

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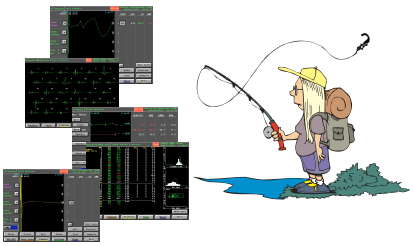
EMG is not a fishing trip



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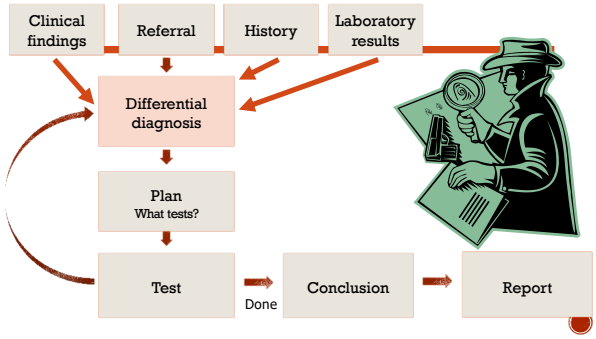

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Patients referred for a diagnostic EMG
Turku University Hospital, Turku, Finland

	Total		Men		Women	
	nr	% of total	nr	% of men	nr	% of women
No abnormalities	2360	48.3	858	40.3	1502	54.4
Focal neuropathy	1931	39.5	907	42.7	1024	37.1
Polyneuropathy	443	9.1	285	13.4	158	5.7
Myopathy	78	1.6	34	1.6	44	1.6
Motorneuron dis.	32	0.7	34	1.8	28	1.0
Myasthenia	9	0.2	4	0.2	5	0.2
Spinal cord	2	<0.1	1	<0.1	1	<0.1
Other	2	<0.1	0	<0.1	2	<0.1
Total	4891		2129		2762	

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Local nerve lesions - top 12

	men	women	total
Lumbar radiculopathy	191 (21%)	250 (24%)	441 (23%)
CTS	140 (15%)	273 (27%)	413 (21%)
Ulnar neuropathy	98 (115)	56 (6%)	154 (8%)
Cervical radiculopathy	96 (11%)	55 (5%)	151 (8%)
Plexus brachialis	61 (7%)	39 (4%)	100 (5%)
Morton's metatarsalgia	11 (1%)	86 (8%)	97 (5%)
Peronal nerve lesion	66 (7%)	27 (3%)	93 (5%)
Radial nerve lesion	36 (4%)	42 (4%)	78 (4%)
Median nerve lesion	39 (4%)	17 (2%)	56 (3%)
Meralgia paresthetica	16 (2%)	15 (2%)	31 (2%)
Sciatic nerve lesion	15 (2%)	14 (1%)	29 (2%)
Lumbosacral plexopaty	20 (2%)	19 (2%)	39 (2%)

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We need strategies!

- Quality assurance
  - To reach correct diagnosis as often as possible
  - Comparability between studies done by different doctors and labs
- Standardization
  - Between examinations
  - Between doctors within department
  - Between different hospitals
  - International standardization
- Economy
  - To ensure optimal use of resources

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Quality assurance - Accreditation

- Allows a laboratory to determine whether it is performing its work correctly to appropriate standards
- Guarantees patients and service users reliable testing
- International standards
  - ISO 15189 or ISO 17025
- National standards
  - AANEM, Sweden, Norway

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Difficulties in guidelines

- Medicine is complicated and knowledge incomplete
- There are few gold standards
  - Some disorders are neuromythology ("alternative truth")
- Guidelines should be evidence based
  - There are few studies
- Expert opinion
  - Experts rarely agree – different schools
- Criteria should be simple and practical
- Guidelines should be accepted internationally

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Norwegian society for clinical neurophysiology

RETNINGSLINJER FOR METODER I KLINISK NEVROFYSIOLOGI DEL 1 (2. REVIDERTE UTGAVE)

NORSK FORENING FOR KLINISK NEVROFYSIOLOGI

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Norwegian society for clinical neurophysiology

4.10.4 N. Cutaneus antebrachii lateralis (Figur 11)

Figur 11. Antidrom undersøkelse av n. cutaneus antebrachii lateralis.

Sensorisk terminal grein av n. musculocutaneus.
Fra **C5-C6**. Passerer i truncus superior og medius og laterale fasciculus i plexus brachialis.

Antidrom teknikk, overflateelektroder.
Posisjon: Pasienten ligger på rygg, arm langs siden, supinert.

Registreringssted: Aktiv elektrode plasseres på en rett linje på underarm som forbinder processus styloideus radius med stimulerings-stedet og 12 cm fra dette. Referanseelektroden plasseres 3 cm lengre distalt.

Stimuleringssted: I albuebøyen, lateralt inn mot biceps-senen. Hvis motor respons skulle opptre, trykk fastere og lengre inn mot selve senen.

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C7 radikulopati:
En bør påvise denervering i C7-innervert muskulatur som er mm triceps brachii, flexor carpi radialis/pronator teres, latissimus dorsi/pectoralis major, extensor digitorum communis og paraspinal muskulatur.
Det er forventet normale funn i mm biceps brachii og abductor digiti minimi/interosseus dorsalis I.
Sensorisk ledningshastighet av n. medianus til 2. og 3. finger forventes å være normal dersom tilstanden ikke også affiserer det dorsale sensoriske ganglion.

C8 radikulopati:
En bør påvise denervering i C8-innervert muskulatur som er mm extensor indicis proprius, interosseus dorsalis I/abductor digiti minimi, abductor pollicis brevis og paraspinal muskulatur.
Det er forventet normale funn i mm pronator teres og triceps.
Sensorisk nerveledning fra 5. finger er normal.

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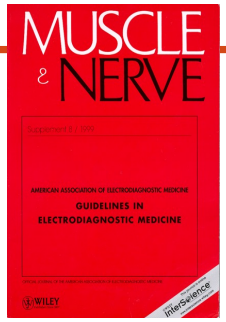

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AANEM - Guidelines

- CTS
- Cervical radiculopathy
- Myasthenia gravis
- Polyneuropathy criteria for research
- Tarsal tunnel syndrome !!!!!!!!!!!!
- Ulnar neuropathy at the elbow
- Peroneal neuropathy
- Distal symmetric polyneuropathy

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Uppsala guidelines

- Description of disorders
- Strategy
  - Goal(s) of the examination
  - Differential diagnosis
- Diagnostic criteria
  - Expected abnormal findings
    - EMG, neurography, other tests
  - Expected normal findings
    - EMG, neurography other tests
- Procedure
  - Muscles and nerves to be tested
- Differential diagnosis
- Predisposing factors

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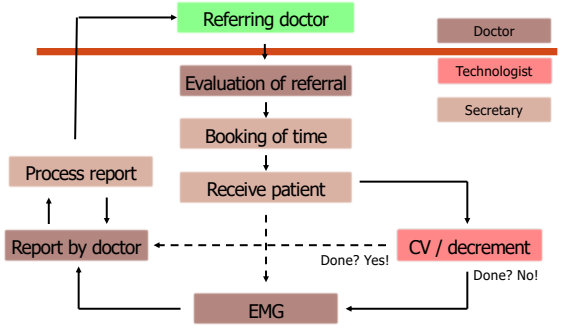

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Role of technologist

- Doctor's assistant during EMG
- Secretary
- Maintenance of electrodes etc..
- Independent nerve conduction studies
  - 20-30% of patients have disorders where neurography is diagnostic
- Study and report CTS!!!
- Doctor and technologist form a team!

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Strategy from technologist's view

- Guidelines are a starting point
  - What to measure
- Guidelines are not a substitute for thinking
  - Modifications may be required during study
- Technologists also report
  - CTS

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Different types of referral

- Differential diagnosis
  - Numbness and pain in digits 4-5
- Symptoms – generate your own alternatives
  - Foot drop
- Confirmation of diagnosis
  - CTS
  - Polyneuropathies with known etiology
- Follow-up
  - Recovery
  - Effect of therapy
- Exclusion
  - Benign fasciculation

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Planning an EMG examination

- Referral
- Symptom chart
- History
- Clinical findings
- Findings from other tests
  - Imaging
  - Laboratory findings
    - CK
    - DNA

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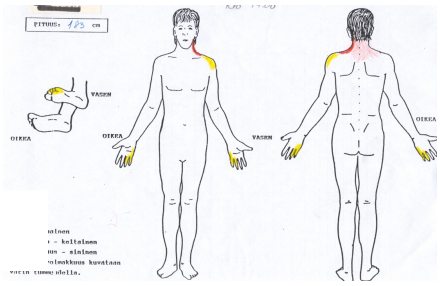
Symptom chart

paresthesia

hypoesthesia

pain



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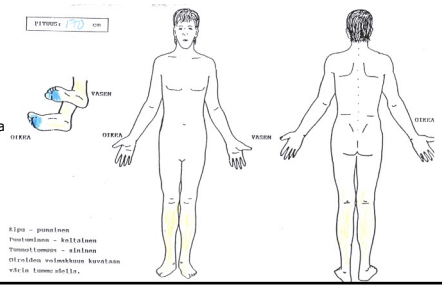
Symptom chart

paresthesia

hypoesthesia

pain



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History is most important

- When and how did it start
- Course of symptoms
- Paresthesia
- Weakness
- Pain
- Trauma
- Surgery
- Drugs
- Radiation therapy
- Etc...

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Clinical examination

- Tendon reflexes
- Muscle strength
- Sensation (unreliable)
- Scars
- Tumors
- Swelling

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Differential diagnosis

- Predisposing factors to neuromuscular problems
  - Diabetes
  - Rheumatoid arthritis
  - Surgery, drugs
- Diagnostic alternatives
- Don't forget the referral

"If you ask the right questions,
you are going to get the right answers"

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Disorders diagnosed with neurography

- CTS
- Ulnar neuropathy at the elbow
- Peroneal neuropathy at the knee
- Polyneuropathies

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Predisposing factors

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PART 3.

NEUROMUSCULAR ABNORMALITIES ASSOCIATED WITH VARIOUS DISEASES, THERAPY AND TOXINS

1. CONNECTIVE TISSUE DISEASES AND VASCULITIS

RHEUMATOID ARTHRITIS

- carpal tunnel syndrome
- axonal sensory-motor polyneuropathy
- ulnar nerve lesion at the medial epicondyle
- Morton's metatarsalgia
- myasthenia gravis
- polymyositis

SYSTEMIC LUPUS ERYTHEMATOSUS, SLE

- axonal sensory-motor polyneuropathy
- polymyositis
- multiple mononeuropathies
- myasthenia gravis

POLYARTERITIS NODOSA AND CHURG STRAUSS DISEASE

- sensory-motor axonal polyneuropathy
- multiple mononeuropathies
- cranial nerve lesions
- optic nerve lesions
- polymyositis

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Breast cancer

- Tumor infiltration or metastatic complications
  - Brachial plexus lesion
  - Recurrent nerve lesion
  - Spinal cord compression
- Paraneoplastic complications
  - Axonal sensory-motor polyneuropathy
  - Axonal sensory polyneuropathy
  - Dermatomyositis
- Related with therapy
  - Axonal sensory-motor polyneuropathy (cytostatic drugs: vincristine)
  - Axonal sensory polyneuropathy (cytostatic drugs: sisplatin, taxol)
  - Brachial plexus lesion (radiation therapy)
  - Carpal tunnel syndrome (oedema in hand)

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Differential diagnosis of symptoms

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PART 2.

ELECTRODIAGNOSTIC DIFFERENTIAL DIAGNOSIS OF COMMON SYMPTOMS AND SIGNS

1. PAIN

FACIAL PAIN

- lesion of the trigeminal nerve
- trigeminal neuralgia
- facial nerve lesion
- atypical facial pain

NECK PAIN

- C4 radiculopathy
- C5 radiculopathy
- C6 radiculopathy
- C7 radiculopathy
- C8 radiculopathy
- Th1 radiculopathy

SHOULDER PAIN

- suprascapular nerve lesion
- axillary nerve lesion
- long thoracic nerve lesion
- accessory nerve lesion
- brachial plexus lesion

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Dropfoot

Unilateral

- **L5 radiculopathy**
- **Peroneal nerve at knee**
- Sciatic nerve lesion
- Lumbosacral plexus lesion
- ALS
- Polio
- MMN
- Rupture of m.tibialis anterior tendon

Bilateral

- Axonal PNP
- Demyelinating PNP
- Myotonic dystrophy type 1
- Distal myopathy

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Diagnostic criteria

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Diagnostic criteria - difficulties

- No gold standard
- Variability of findings
  - Patient related
    - Age
    - Obesity
  - Severity
  - Time from onset
- Combination of multiple disorders

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Diagnostic criteria - difficulties

- Common sense!!!
- What types of error are preferable
  - False positives
  - False negatives
- Very strict criteria may be restrictive
  - ALS El Escorial, Awai preferable

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Severity of CTS

Padua, L, Lo Monaco M, Padua R, Gregori B and Tonali P.

Neurophysiological classification of carpal tunnel syndrome: assessment of 600 symptomatic hands

Ital J Neurol Sci 1997;18:145-150

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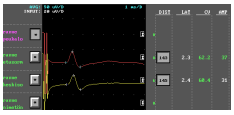
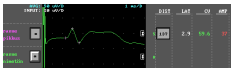
Normal finding

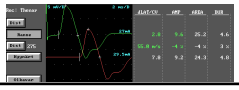
N.medianus, sens



N.ulnaris, sens



N.medianus, mot



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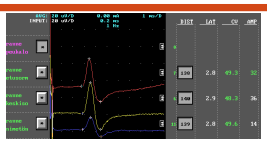
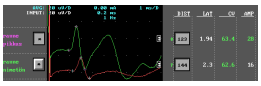
Very mild CTS

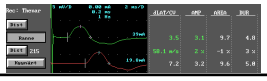
N.medianus, sens



N.ulnaris, sens



N.medianus, mot



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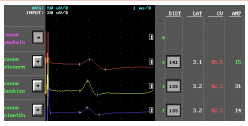
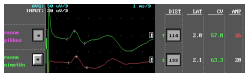
Mild CTS

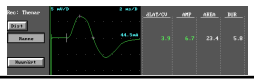
N.medianus, sens



N.ulnaris, sens



N.medianus, mot



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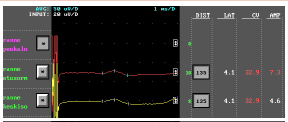
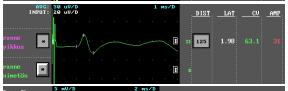
Moderate CTS

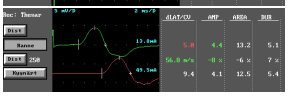
N.medianus, sens



N.ulnaris, sens



N.medianus, mot



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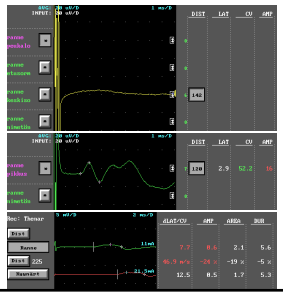
Severe CTS

N.medianus, sens

N.ulnaris, sens

N.medianus, mot



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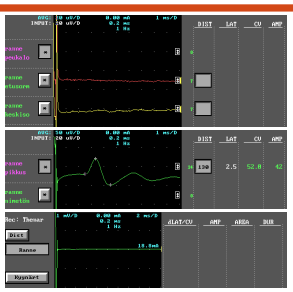
Extreme CTS

N.medianus, sens

N.ulnaris, sens

N.medianus, mot



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Z-score to predict abnormality

	% of population observed	
Z-score	one-tailed	two-tailed
1	15,87	13,36
2	**2,28**	4,55
2,5	0,62	1,24
3	0,13	0,27

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Probability of Z score > 2 or < -2

number of tests	number of abnormal findings (> 2 sd)			
	1	2	3	5
1	0,023			
2	0,045	0,001		
5	0,110	0,005	0,000	0,000
10	0,208	0,021	0,001	0,000
25	0,441	0,112	0,019	0,000
50	0,688	0,320	0,108	0,006

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Interpretation of findings

- Number of tests performed
- Magnitude of abnormality
- Clinical situation
- Pattern of abnormal findings

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Sensory nerves

SENSORY NERVES:	Lat (ms)	SD	Amp (uV)	SD	CV (m/s)	SD	Amp% (%)	SD
Right Medianus								
Palm - Wrist	1.42		16	-2.1	49.3	-1.2		
Dig III - Wrist	2.6		3.8	-0.8	48.1	-1.1		
Dig IV - Wrist	2.9		1.2	-3.4	44.8	-2.3		
Right Ulnaris								
Palm - Wrist	1.35		5.8	-1.3	48.1	-1.8		
Dig IV - Wrist	2.3		0.8	-2.7	50.0	-1.9		
Dig V - Wrist	1.73		3.0	-0.2	54.9	-0.4		
Right Radialis								
Forearm - IOD 1	2.5		7.4	-1.5	56.0	-0.9		
Left Peroneus super								
Foreleg - Ankle	--		--		--			
Right Peroneus super								
Foreleg - Ankle	--		--		--			
Left Suralis								
Foreleg - Ankle	--		--		--			
Right Suralis								
Foreleg - Ankle	--		--		--			

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Motor nerves

MOTOR NERVES:	Lat [ms]	SD	Amp [mV]	SD	CV [m/s]	SD	Amp% [%]	SD	F-M [ms]	SD
Right Medianus									25.2	0.5
Wrist - APB	3.2	-0.5	6.1	-0.9						
Ab Elb - Wrist	9.0		5.4		43.1	-4.1	-12	-1.2		
Right Ulnaris									29.3	3.5
Wrist - ADM	2.5	-1.3	5.5	-1.4						
Be Elb - Wrist	7.4		5.8		49.0	-2.4	4	2.6		
Ab Elb - Be Elb	9.7		5.5		43.5	-2.4	-4	0.1		
Left Tibialis									--	
Ankle - AHB	9.8	6.6	0.1	-2.0						
Knee - Ankle	19.9		0.1		42.6	0.0	67	6.2		
Right Tibialis									65.3	5.7
Ankle - AHB	7.8	3.9	0.2	-1.9						
Knee - Ankle	18.5		0.2		41.6	-0.2	14	2.7		
Left Peroneus									61.7	5.2
Ankle - EDB	4.8	0.4	0.3	-2.4						
Be knee - Ankle	13.5		0.3		34.5	-2.5	9	1.6		
Right Peroneus									--	
Ankle - EDB	5.2	0.9	0.6	-2.2						
Be knee - Ankle	13.5		0.5		37.3	-1.7	-14	-0.7		

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Neurography in PNP

- 3 or more abnormal parameters
- Distal axonal PNP abnormalities mainly in leg nerves
- In axonal PNP median nerve CV > 38 m/s
- In demyelinating PNP median nerve < 38 m/s
- Specific criteria for different types of GBS

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Grading of axonal PNP

Nerve tested	Mild	Moderate	Severe	Very severe
Per.sup sensory	abnormal	no response	no response	no response
Sural sensory	normal/slight	no response/severe	no response	no response
Radial sensory	normal	slight	moderate	no response
Peroneal motor	slight/normal	moderate	no response	no response
Tibial motor	slight/normal	moderate	no response	no response
Median motor	normal	slight	moderte/severe	no response
EMG tib ant	normal	slight	moderate/severe	total
EMG vast lat	normal	normal	slight	moderate/severe

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Back pain

- Is there a radiculopathy?
- Which root is affected?
- Severity?
- Time course (acute, subacute, inactive)
- PNP?

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Spinal innervation of lumbar muscles

	L2	L3	L4	L5	S1	S2-4
Ileopsoas						
Adductor magnus						
Vastus lateralis						
Tibialis anterior						
Extensor hallucis longus						
Peroneus longus						
Tibialis posterior						
Semimebranosus						
Tensor fascia latae						
Gastrocnemius						
Biceps femoris						
Gluteus maximus						
Puborectalis						

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Lumbar radiculopathy procedure

- L2 muscle: m.iliopsoas
- L3 muscle: m.adductor magnus
- L4 muscle: m.vastus lateralis/m.vastus medialis
- L5 muscle, distal : m.extensor hallucis longus/flexor digitorum longus/m.tibialis anterior/m.peroneus longus/m.tibialis posterior
- L5 muscle, proximal : m.tensor fascia latae/m.semitendinosus
- S1 muscle, proximal: m.biceps femoris/m.gluteus maximus
- S1 muscle , distal: m.gastrocnemius caput mediale/laterale
- Paravertebral muscles L2-S1

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Neurography

- Motor
  - n.peroneus
  - n.tibialis
- Sensory
  - n.suralis
  - n.peroneus superficialis

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EMG - Likelihood of radiculopathy

	Vertbral muscle	Distal muscle	Prox. muscle
Normal	-	-	-
Normal	+	-	-
Possible	-	+	-
Possible	-	-	+
Probable	-	+	+
Definite	+	+	+
Definite	+	-	+
Definite	+	+	-

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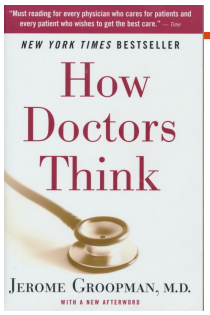

Jerome Groopman

How Doctors Think

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Cognitive errors due to heuristics

- Heuristics
  - Shortcuts in decision making
- Often help us to solve quickly complex problems
- May lead to serious errors

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Framing error heuristic

- Focus too much on just one aspect
- *Solution*
  - *"Let's review the elements of the case"*

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Anchoring heuristic error

- Relying too much on initial impressions
  - *"Have I properly weighed the data?"*
- Not taking into consideration new facts
- Example
  - *Referral asks for L5 radiculopathy*
  - *Neurography shows slowing of conduction in the peroneal nerve at the knee*

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Availability heuristic error

- Recalling past cases
  - *"Am I unduly influenced by a previous case?"*

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Representativeness heuristic error

- Ignoring prior probabilities
  - Common disorders are more likely
- *"If you hear hoof beats, think about horses not zebras"*
- Example
  - Referral asks for ulnar neuropathy at the wrist
  - Most ulnar neuropathies are at the elbow

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"Blind obedience" heuristic error

- Undue dependence on
  - Technology
  - Authority
- Too much test reliance
  - *"How common are false positives?"*
- Example
  - *False positive diagnosis of spinal stenosis in a 70 year old based on only lumbar MRI findings*

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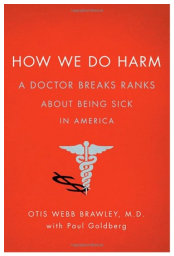
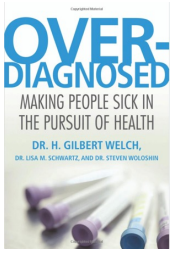
Overdiagnosis





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Overdiagnosis - Definition

- People without appropriate symptoms and findings are diagnosed with a disease that ultimately is not causing them symptoms or early death

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Driving factors

- Good intentions of doctors
- Pressure from patients
- Screening
- Widened disease definitions
- Advances in technology, increasing sensitivity of diagnostic testing
- Avoidance of litigation – Defensive medicine
  - Legal incentives punish underdiagnosis but not overdiagnosis
- Cultural beliefs
  - More is better
  - Early detection unmodified by its risks
  - Prevention is better than cure

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Consequences

- Overmedicalization
- Unnecessary testing
- Overtreatment
- Complications
- Excessive costs

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Common overdiagnosis

- CTS
- Polyneuropathy
  - Older people
- Ulnar neuropathy at the elbow
- Radiculopathies

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Consider

- Consequences of a false positive diagnosis?
  - Diagnostic labelling
  - Psychological handicap
  - Treatment side-effects
- Consequences of a false negative diagnosis?
  - Diagnostic delay
  - No test has 100% sensitivity

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Sir Willam Osler (1849-1919

"Medicine is a science of uncertainty and an art of probablity"

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