

Cervical radiculopathies

Neurophysiological evaluation

Björn Falck, PhD, MD
Turku, Finland

1

Outline

- Anatomy
- Clinical picture
- Diagnosis
- Neurophysiological methods
- EMG strategies
- Patient

2

Focal neuropathies

EMG laboratory, University hospital Turku

	Men	Women	Total
Lumbar radiculopathy	191 (21%)	250 (24%)	441 (23%)
CTS	140 (15%)	273 (27%)	413 (21%)
Ulnar neuropathy	98 (11%)	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%)
Peroneal 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 plexus	20 (2%)	19 (2%)	39 (2%)

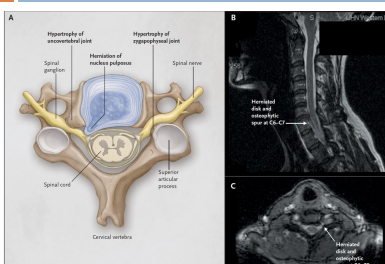
3

Etiology

- **Herniated intervertebral disc**
- Cervical spondylosis
- Trauma
- Neuroma
- Immune mediated inflammatory

4

Anatomy of cervical radiculopathies



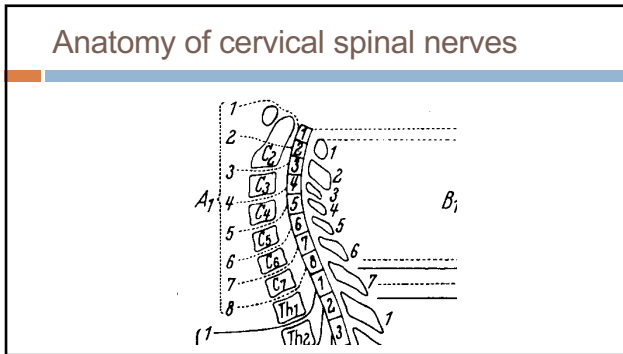
S. Carette, M. Fehlings.
Cervical Radiculopathy.
NEJM 2005;:353:392-9.

5

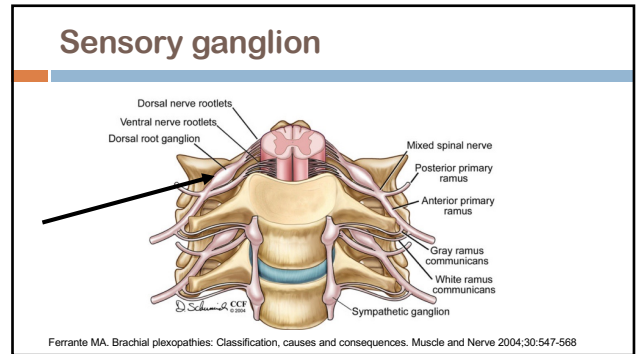
Epidemiology of cervical radiculopathies

- Rochester Minnesota, USA
 - ▣ Men 107/100 000 per year
 - ▣ Women 63/100 000 per year
- Peak incidence 50-55 years

6



7



8

Cervical radiculopathy – disc herniation

- Acute or subacute neck pain radiating into the arm
 - Onset often during the night
 - 15% related with trauma
- Usually very severe pain, > 8/10 NRS
- Numbness of the affected dermatome
- Weakness of muscles in affected myotome
- Pain often related to head position

9

Cervical radiculopathy – spondylosis

- Insidious pain
- Symptoms develop over several months
- Numbness of the affected dermatome
- Weakness of muscles in affected myotome
- Pain often related to head position
- If cervical spinal canal stenotic
 - Myelopathy

10

Cervical radiculopathies

Spinal nerve	Frequency
C5	14%
C6	18%
C7	56%
C8	12%
Th1	2%

11

Neurofibromatosis type 1

- Autosomal dominant 17q11.2
- Haploid deficiency of neurofibromin (tumor suppression)
- 1/3000, new mutations in 50%
- Café-au-lait spots in 99%
- Neurofibromas
 - Number and size varies, some malignant

12

Neurofibromatosis type 2

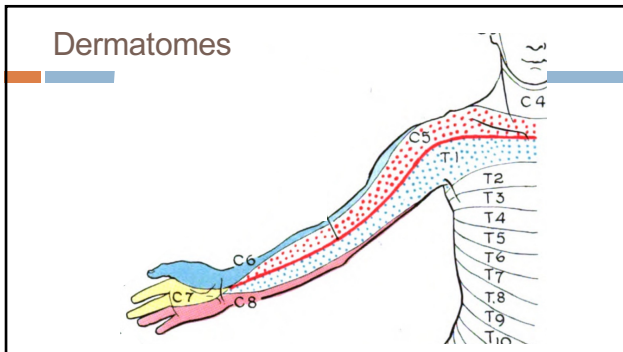
- ▣ Autosomal dominant 22q12.2
- ▣ Prevalence 1/1 000 000
- ▣ Mutated protein: merlin
- ▣ Vestibular schwannomas, tumours, meningiomas, schwannomas
- ▣ Café-au-lait spots
- ▣ Axonal sensory and motor polyneuropathy

13

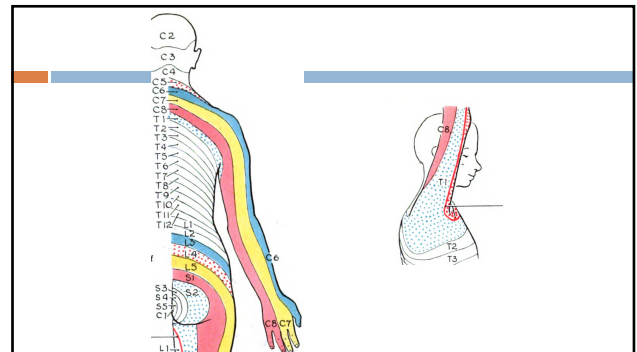
Clinical features

14

Dermatomes



15



16

Abnormal reflexes

- ▣ C5 – Supinator
- ▣ C6 – Biceps, brachioradialis
- ▣ C7 – Triceps

17

Weakness

- ▣ C5 – Infraspinatus, supraspinatus, deltoid,
- ▣ C6 – Biceps, brachioradialis
- ▣ C7 – Triceps, wrist flexion
- ▣ C8 – Thumb flexion and abduction, interossei

18

ENMG in cervical radiculopathies

19

Utility of neurography in radiculopathies

- Motor neurography usually normal
 - ▣ In severe C8 or Th1 radiculopathy low M wave amplitudes
- Sensory neurography
 - ▣ Usually, normal findings
 - ▣ Compression proximal to sensory ganglion
- CTS and other local neuropathies
- Polyneuropathies

20

Neurography - sensory

- N.radialis
 - ▣ C6/C7
- N.cutaneus antebrachii lateralis
 - ▣ C6
- M.medianus, digits 2-3
 - ▣ C7
- N.ulnaris, digits 4-5
 - ▣ C8
- N.cutaneus antebrachii medialis
 - ▣ Th1

21

Neurography - motor

- N.medianus
- N.ulnaris

22

Cervical radiculopathies: Comparison of surgical and EMG localization of single-root lesions

Kerry H. Levin, MD; Holly J. Maggiano, MD; and Asa J. Wilbourn, MD

Article abstract—To identify the various electrodiagnostic (EDX) patterns of C-5, C-6, C-7, and C-8 cervical radiculopathy, we compared 50 cases of surgically proven solitary-root lesions with their preoperative EDX patterns. We excluded patients with polyradiculopathy, myelopathy, and previous surgery. We classified EDX studies as abnormal only by the needle electrode examination, and only by the demonstration of fibrillation potentials (either the positive sharp wave or the biphasic spike form). Seven patients (14%) had C-5 radiculopathy, nine (18%) had C-6, 28 (56%) C-7, and six (12%) C-8. With C-5, C-7, and C-8 radiculopathies, changes were relatively stereotyped, with involvement of the spinati, deltoid, biceps, and brachioradialis with C-5; the pronator teres, flexor carpi radialis, triceps, and anconeus with C-7; and the first dorsal interosseus, abductor digiti minimi, abductor pollicis brevis, flexor pollicis longus, and extensor indicis proprius with C-8. The root lesion with the most variable presentation was C-6—in half the patients, the findings were similar to C-5 radiculopathies, except that the pronator teres tended to be involved, whereas in the other half, the findings were identical to those with C-7 radiculopathies.

NEUROLOGY 1996;46:1022-1025

23

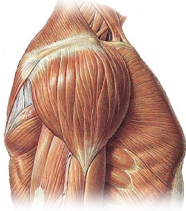
C5 muscles

- m.rhomboideus major
- m.deltoideus
- m.infraspinatus
- paravertebral muscles C5

24

Deltoid

C5-C6

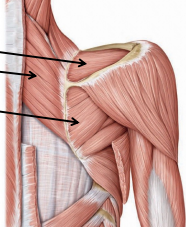


Schuenke et al. THIEME Atlas of Anatomy • General Anatomy and Musculoskeletal System © THIEME 2007 • All rights reserved. Usage subject to terms of use. • www.thieme.com/ta

Thieme

25

Infraspinatus/supraspinatus/rhomboides



m.supraspinatus
m.rhomboides major
m.infraspinatus

Innervation: n.suprascapularis
Spinal innervation: C5 (C6)

Schuenke et al. THIEME Atlas of Anatomy • General Anatomy and Musculoskeletal System © THIEME 2007 • All rights reserved. Usage subject to terms of use. • www.thieme.com/ta

Thieme

26

Findings in C5 radiculopathy

● Fibrillation potentials
● Neurogenic recruitment changes only
● Normal examination

	SUP	INF	DEL	BRAC	BC	PT	FCR	TRC	ANC	EDC	EIP	FPL	APB	FDI	ADM	PSP
C5 1	●	●	●	●	●	●		●			●	●		●		●
2	●	●	●	●	●	●		●			●	●		●		●
3	●	●	●	●	●	●	●	●			●	●	●	●		●
4	●	●	●	●	●	●	●	●			●	●	●	●		●
5	●	●	●	●	●	●	●	●			●	●	●	●		●
6	●	●	●	●	●	●	●	●			●	●	●	●		●
7	●	●	●	●	●	●	●	●			●	●	●	●		●

Levin, Holly, et al . Neurology 1996;46:1022-1025

27


C6 muscles

- m.biceps brachii
- m.brachioradialis
- m.pronator teres
- paravertebral muscles C6

28

Biceps brachii

C5-C6



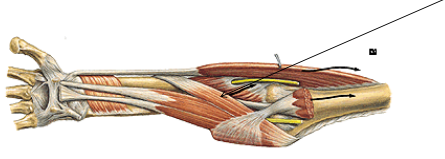
Schuenke et al. THIEME Atlas of Anatomy • General Anatomy and Musculoskeletal System © THIEME 2007 • All rights reserved. Usage subject to terms of use. • www.thieme.com/ta

Thieme

29

Pronator teres

C6-C7



Schuenke et al. THIEME Atlas of Anatomy • General Anatomy and Musculoskeletal System © THIEME 2007 • All rights reserved. Usage subject to terms of use. • www.thieme.com/ta

Thieme

30

Findings in C6 radiculopathy

	SUP	INF	DEL	BRAC	BC	PT	FCR	TRC	ANC	EDC	EIP	FPL	APB	FDI	ADM	PSP
8	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
9	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
10	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
11	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
12	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
13	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
14	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
15	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
16	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

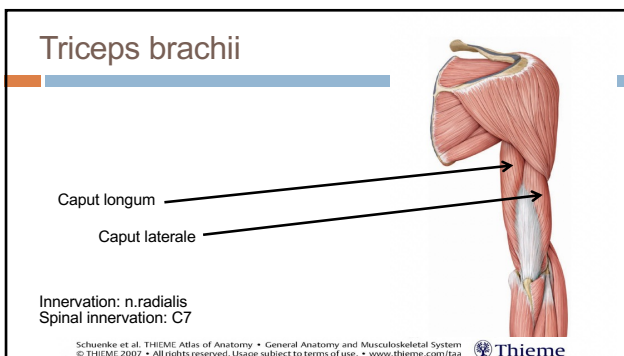
Legend: ● Fibrillation potentials, ● Neurogenic recruitment changes only, ● Normal examination

Levin, Holly, et al. Neurology 1996;46:1022-1025

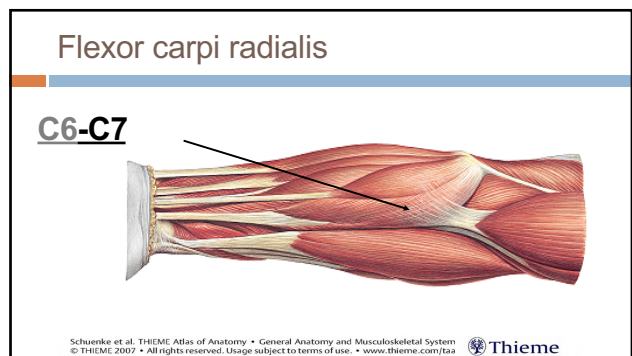
31

- ### C7 muscles
- m.triceps brachii
 - m.flexor carpi radialis
 - m.latissimus dorsi
 - m.pectoralis major
 - m.extensor digitorum
 - paravertebral muscles C7

32



33



34

Findings in C7 radiculopathy

	SUP	INF	DEL	BRAC	BC	PT	FCR	TRC	ANC	EDC	EIP	FPL	APB	FDI	ADM	PSP
C7	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
17	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
18	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
19	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
20	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
21	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
22	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
23	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
24	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
25	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
26	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
27	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
28	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
29	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
30	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
31	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
32	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
33	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
34	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
35	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
36	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
37	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
38	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
39	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
40	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
41	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
42	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
43	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

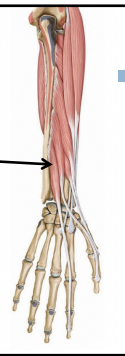
Legend: ● Fibrillation potentials, ● Neurogenic recruitment changes only, ● Normal examination

35

- ### C8 muscles
- m.extensor indicis proprius
 - m.interosseus dorsalis I/abductor digiti minimi
 - m.opponens pollicis
 - paravertebral muscles C8

36

Extensor indicis



NOTE!

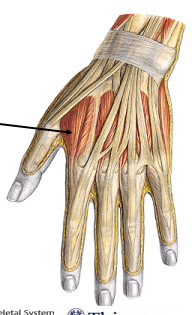
- Good C8 muscle.
- Abnormality rules out ulnar neuropathy
- Palpate tendon and go proximal

Innervation: n. radialis
Spinal innervation: (C7)-C8

Schuenke et al. THIEME Atlas of Anatomy • General Anatomy and Musculoskeletal System © THIEME 2007 • All rights reserved. Usage subject to terms of use. • www.thieme.com/ta

37

Interosseus dorsalis I



C8-Th1

Schuenke et al. THIEME Atlas of Anatomy • General Anatomy and Musculoskeletal System © THIEME 2007 • All rights reserved. Usage subject to terms of use. • www.thieme.com/ta

38

Findings in C8 radiculopathy

● Fibrillation potentials
● Neurogenic recruitment changes only
● Normal examination

	SUP	INF	DEL	BRAC	BC	PT	FCR	TRC	ANC	EDC	EIP	FPL	APB	FDI	ADM	PSP
45			●	●	●	●		●		●	●	●	●	●	●	●
46			●	●	●	●		●		●	●	●	●	●	●	●
47			●	●	●	●		●		●	●	●	●	●	●	●
48	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●
49			●	●	●	●		●		●	●	●	●	●	●	●
50			●	●	●	●		●		●	●	●	●	●	●	●

Levin, Holly, et al . Neurology 1996;46:1022-1025

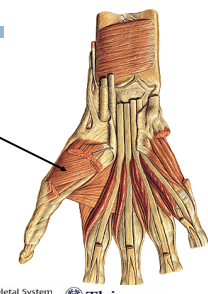
39

Th1 muscles

- m.opponens pollicis/m.abductor pollicis brevis
- m.interosseus dorsalis
- paravertebral muscles Th1

40

Thenar muscles



C8-Th1

Schuenke et al. THIEME Atlas of Anatomy • General Anatomy and Musculoskeletal System © THIEME 2007 • All rights reserved. Usage subject to terms of use. • www.thieme.com/ta

41

Fibs in healthy paraspinal neck muscles

- <40 years 0%
- 40-60 8% J Clin Neurophys 2006:23:573-
- >60 90%

ORIGINAL ARTICLES

Cervical Paraspinal Electromyography: Normal Values in 100 Control Subjects

R. Gilad, R. Dabby, M. Boaz, and M. Sadeh

42

Spinal innervation of cervical muscles

	C5	C6	C7	C8	Th1
Rhomboideus	■				
Infraspinatus/supraspinatus	■				
Deltoidaeus	■	■			
Biceps	■	■			
Brachioradiale		■	■		
Pronator teres		■	■		
Triceps			■	■	
Extensor digitorum			■	■	
Flexor carpi radialis			■	■	
Extensor indicis				■	■
Flexor carpi ulnaris				■	■
Interosseus dorsalis				■	■
Abductor digiti minimi				■	■
Opponens pollicis				■	■

43

Cervical radiculopathy - EMG

- Deltoideus (C5/6)
- Supraspinatus (C5)
- Biceps (C5/6)
- Pronator teres (C6)
- Triceps (C7)
- Flexor carpi radialis (C7)
- Interosseus dorsalis (C8)
- Extensor indicis (C8)
- Opponens pollicis (C8-Th1)
- Paravertebral muscles C5-Th1
 - If abnormalities found in limb muscles
- Add muscles, if level not clear
 - Rhomboideus (C5)
 - Brachioradialis (C6)
 - Latissimus dorsi (C7)

Extent of study depends on how well the patient tolerates needle EMG

45

Summary

- Cervical radiculopathies reliably diagnosed with EMG
- EMG does not give the etiology
 - Clinical picture is helpful
- The exact spinal nerve affected is sometimes difficult to determine
 - +/- one level
 - C6 radiculopathy confused either with C5 or C7
 - C8 usually quite distinct but may sometimes be difficult to differentiate from Th1 (Th1 is rare)
- Paraspinal muscles are abnormal in about 50%

46

Patient

47

Referral

- Previously healthy 47 year old man
- Eighth weeks prior to EMG woke up in the morning with severe neck pain
- Pain has subsided considerably
- Still numbness of digits 1-3
- CTS? Cervical radiculopathy?

48

Clinical findings

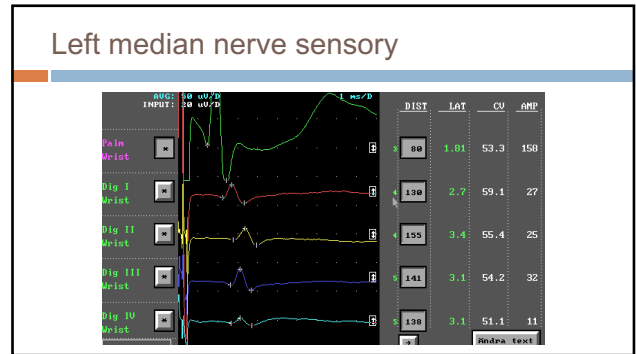
- Slight weakness
 - Elbow extension
 - Wrist flexion
- Triceps reflex cannot be elicited
- Otherwise, unremarkable

49

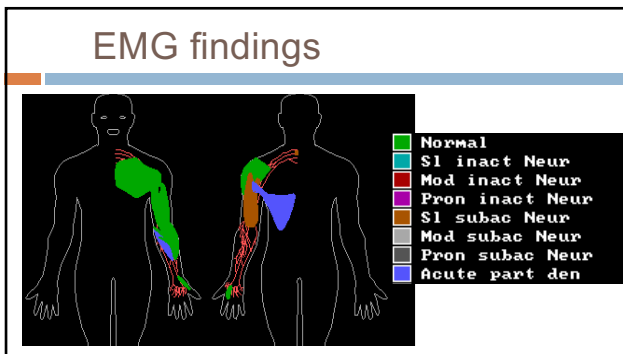
Neurography

MOTOR NERVE:	dLat	dAmp	CV	Amp%	F-M
Medians					
Wrist - Ab E1b	■	■		■	■
Ulnaris					
Wrist - Be E1b	■	■		■	■
Be E1b - Ab E1b			■		
SENS. NERVE :	Lat	Amp	CV	Amp%	
Medians					
Palm - Wrist	■				
Dig I - Wrist	■				
Dig II - Wrist	■				
Dig III - Wrist	■				
Dig IV - Wrist	■				
Ulnaris					
Dig IV - Wrist	■				
Dig V - Wrist	■				
Radialis					
IO I - Forearm		■		■	

50



51



52

EMG findings

Muscle	Fibs	IP	Ampl	Conclusion
Deltoid	0		φ	Normal
Biceps	0		φ	Normal
Triceps	5/10	↓ ↓	φ	Moderate acute neurogenic
Latissimus dorsi	4/10	↓ ↓	φ	Moderate acute neurogenic
Flexor carpi radialis	5/10	↓ ↓	φ	Moderate acute neurogenic
Extensor indicis	0		φ	Normal
First dorsal Interosseus	0		φ	Normal
Opponens pollicis	0		φ	Normal
Paraspinal muscles	3/10			Slight acute neurogenic

53

Summary

- Neurography: Normal findings in examined sensory and motor nerves in the left arm.
- EMG: C7 innervated muscles on the left side show moderate acute neurogenic abnormalities. Cervical paraspinal muscles at the C7 level show mild acute neurogenic findings. Other examined muscles in the left arm are intact.
- Summary: EMG findings are compatible with a moderate acute C7 radiculopathy on the left side. The acute onset 8 weeks ago with severe pain suggest that the neuropathy is caused by a cervical disc herniation C6/7 on the left iside.

54

MRI findings and follow-up

- MRI: disc herniation C6/7 on the left side
- With conservative treatment the pain subsided in a few weeks after the EMG and muscle strength of the elbow extension was regained 6 months later
- Slight sensory abnormalities persisted still 6 months later

55

Summary

- If the history and clinical findings are clear-cut EMG does not provide additional information
- If clinical or MRI findings are not clear-cut EMG provides unique and useful information
- EMG has limited value in the follow-up of patients operated on for cervical herniated intervertebral discs unless the patient had a preoperative EMG

56



57