

Needle EMG

- Selected muscles

- Uncommon spontaneous activity

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1

Outline 45 min

- Contraindications and cautions
- How work with the electrodes
- **What muscles to study**
- **Special tricks and techniques**
- **Uncommon spontaneous activity**

2

Before you start: Contraindications

3

Anticoagulation

- Anticoagulants/antiplatelet medications should not be discontinued for needle EMG
- Warfarin: EMG safe if INR values < 3.0.
- If INR > 3.0, EMG may be performed at discretion of the doctor
- **Beware! Anterior tibial compartment hematoma**
- New anticoagulants (dabigatran, rivaroxaban) safe
- Safe in patients on antiplatelet agents
 - Aspirin, Clopidogrel

4

Contraindications for EMG

- Skin infection in region of study
- Hemophilia
 - Needle EMG must be done in collaboration with a hematologist
- von Willebrandt's disease
 - There are different forms
 - In some types EMG can be done safely
 - Usually, the patient will know whether needles are safe
 - If in doubt consult hematologist

5

Cardiac pace-makers

- Modern cardiac pace-makers are not a contraindication

6

Endocarditis prophylaxis

- Antibiotics are not indicated for prophylaxis of endocarditis

7

Introduction to testing

- Introduce yourself and your specialty
- Confirm patient's name
- Establish contact with the patient
- Explain why the patient has been referred for EMG
- Explain test components and duration of testing
- Check for relevant medication and contraindications
 - Anticoagulation
- EMG is painful and the patient is uneasy
 - Tell patient that examination will not be as unpleasant as he thinks

8

Before starting

- Check relevant history – has any changes occurred after the referral
- During the investigation you will have time to get a detailed history
- Clinical examination of relevant area
- Make sure that the patient is comfortable on the examination table
- Always warn the patient before you start
- When you give instructions – show visually and give verbal instruction
 - The patient is anxious, therefore not as smart as usually

9

Examination table

- Wide >90 cm
- No electric motors
- Adjustable height
- Pillows



10

Patient comfortable



11

Electrodes

12

Electrodes

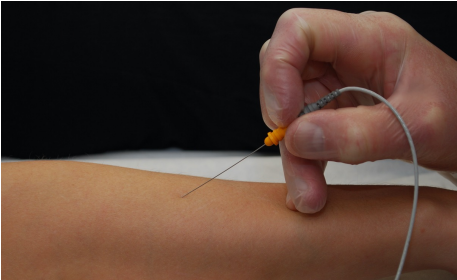
| | Length (mm) | Diameter (mm) | Use |
|----------|-------------|---------------|-----------------------|
| Standard | 50 | 0.45 | Most studies |
| Long | 75 | 0.50 | Obese patients |
| Facial | 37 | 0.36 | Facial muscles/jitter |

13

Handling electrodes


14

Hold electrode - forwards



15

Hold electrode - backwards



16

Hold the electrode

- Stable grip, like a pen
- Mostly "forwards" away from the hand
- Sometimes "backwards" toward the hand

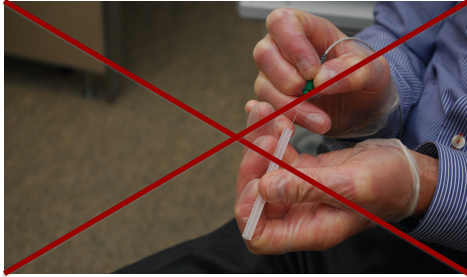
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Not like this! Middle finger!!



18

Do not recap the electrode



19

Handling electrodes

- Always wear gloves
- Keep the cap covering the electrode on until you use it
- **Do not reinsert the electrode into the cap!!!!**
- Inform patient what is going to happen
- Before insertion
 - Place the needle gently on the skin – the patient knows what is going on
- Skin penetration
 - Insert electrode through skin gently but firmly
- In the muscle
 - Very short, gentle movements
 - Just enough movement to elicit insertional activity

20

Moving the needle smoothly



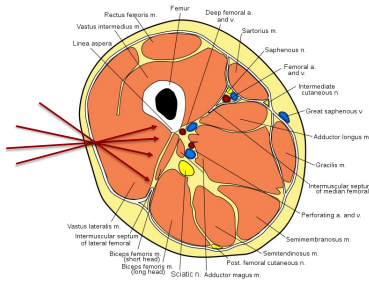
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EMG procedure

- Insertional activity
 - Short, gentle needle movements in one direction
 - Retract needle to fascia and move in another direction in the same plane
 - 20-25 insertions

22

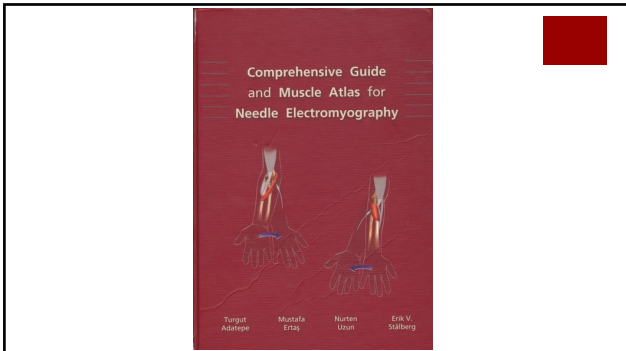
“Scanning” the muscle



23

Selected muscles
Difficult and important

24



25

Anatomic guides

- A Perotto. Anatomical Guide for the Electromyographer. 5th ed 2011
- S Geiringer. Anatomic Localization for Needle Electromyography. 2nd ed 1999

26

Upper extremity – most studied

- Deltoid
- Infrapinatus/supraspinatus
- Biceps
- Triceps
- Extensor indicis
- Pronator teres
- Flexor carpi radialis
- Interosseus dorsalis I
- Opponens pollicis

27

Study sequence of muscles

- Proximal to distal
 - You can observe bleeding
 - Start with least painful muscles
- Diagnostically important muscles have priority
 - Pain may upset the patient and limit testing
- Front to back
 - It is time consuming to rotate the patient back and forth

28

M.extensor indicis

Innervation: n.radialis
 Spinal innervation:(C7)-C8 (20%-80%)
 Action: Index finger extension

Utility

- Excellent C8 muscle.
- Abnormality rules out ulnar neuropathy

Palpate tendon and go proximal

Not here


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M.extensor indicis

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M.flexor carpi radialis



Innervation: n.medianus
 Spinal innervation: C7
 Action: Wrist flexion


Utility

- Excellent muscle for C7 radiculopathy

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31


M.pronator teres



Innervation: n.medianus
 Spinal innervation: C6-(C7)
 Action: forearm pronation

Utility

- Good C6 muscle

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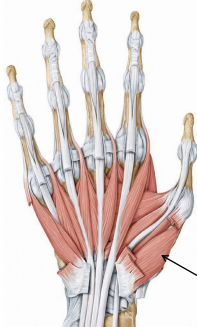
M.pronator teres



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33


M.opponens pollicis



Innervation: n.medianus
 Spinal innervation: (C8)-Th1
 Action: Opposition of thumb and little finger

Utility

- Th1>C8
- N.medianus neuropathy
- Truncus inferior
- Less painful than m.abductor pollicis brevis

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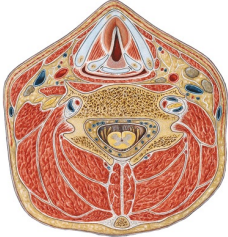
M.opponens pollicis



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M.multifidus cervical part



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36

Cervical paravertebral muscles - left

37

Fibs in healthy paraspinal neck muscles

- <40 years 0%
- 40-60 8%
- >60 90%

J Clin Neurophys 2006:23:573-

ORIGINAL ARTICLES

Cervical Paraspinal Electromyography: Normal Values in 100 Control Subjects

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

38

Upper extremity – sometimes studied

- Serratus anterior
 - Scapular winging
- Extensor digitorum
 - Radial nerve weakness
- Latissimus dorsi
 - C7
- Extensor carpi radialis longus/brevis
 - Radial nerve, localization of lesion

39

Upper extremity – sometimes studied

- Trapezius
 - N.accessorius neuropathy
- Abductor digiti minimi
 - Ulnar nerve
- Abductor pollicis
 - Alternative to m.opponens pollicis
- Interosseus dorsalis II-IV
 - Localization of ulnar neuropathy in the hand
- Lumbricals

40

M.serratus anterior

Innervation: N.thoracicus longus
Myotomes: C5-7

Utility:

- Scapular winging
- N.thoracicus longus neuropathy

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M.serratus anterior

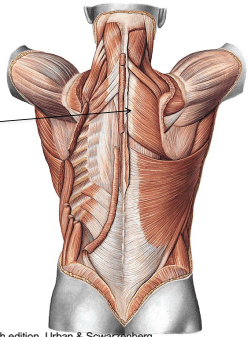
42

M.serratus anterior - activation



43

M.rhomboideus major



Innervation: n.dorsalis scapulae
 Spinal innervation: C5
 Leaves C5 spinal nerve right after exit


Utility

- Pure C5 innervation!
- C5 radiculopathy
- Erb's palsy

Putz and Pabst (ed) Sobotta, Atlas of Human Anatomy, 20th edition, Urban & Schwarzenberg

44

M.flexor pollicis longus



Innervation: n.medianus r interosseus anterior
 Spinal innervation: C7-(C8)

Utility

- N.anterior interosseus neuropathy

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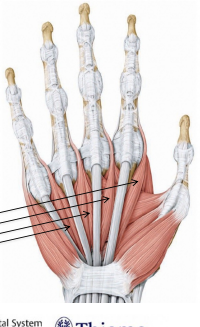
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M.flexor pollicis longus



46

M.lumbricales



Innervation: 1 and 2 n.medianus, 3 and 4 n.ulnaris
 Spinal innervation: C8 – Th1

Utility

- Local n.ulnaris neuropathy in the hand

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Lower extremity – Important muscles

- Tensor fascia latae
- Iliopsoas
- Adductor magnus
- Vastus lateralis
- Extensor hallucis longus
- Tibialis anterior
- Peroneus longus
- Gastrocnemius
- Biceps femoris

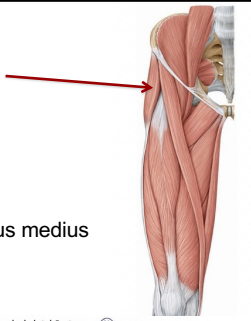
48

M.tensor fascial latae

Innervation: n.gluteus superior
Spinal innervation: L5

Utility

- L5 muscle
- N.gluteus superior
- Easier to examine than m.glutueus medius



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M.tensor fascial latae



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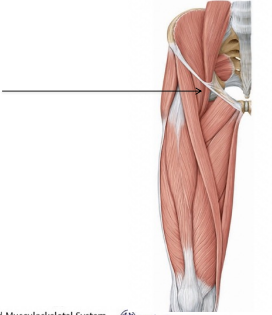
M.iliopsoas

Innervation: n.femoralis
Spinal innervation: L2 (L3-L4)

Palpate femoral artery and insert electrode 2-3 cm laterally

Utility

- L2 (L3-4) muscle
- N.femoralis
- Lumbar plexus



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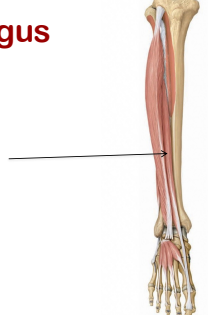
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M.extensor hallucis longus

Innervation: N.peroneus profundus
Spinal innervation: L5
Action: Dorsiflexion of great toe

Utility

- L5 radiculopathy



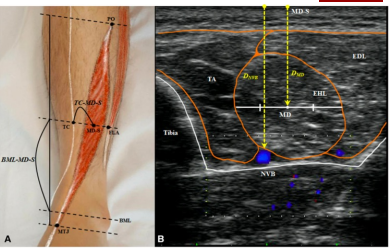
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M.extensor hallucis longus

10.5 cm above malleolus
3.6 cm lateral to tibia
1.6 cm depth



Kwak JM et al Optimal needle placement for extensor hallucis longus muscle using ultrasound verification. Muscle & Nerve 2019;59:331-336

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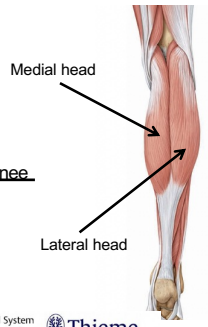
53

M.gastrocnemius

Innervation: n.tibialis
Spinal innervation: S1
Action: Plantar flexion of ankle, flexion of knee

Utility

- S1 radiculopathy
- Sciatic nerve neuropathy



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M.gastrocnemius -activation



Bend knee and extend ankle

55


M.biceps femoris c.longum



Innervation: N.ischiadicus
 Spinal innervation: S1
 Action: Flexion of knee

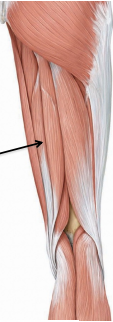
Utility

- S1 radiculopathy

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M.semimembranosus



Innervation: n.ischiadicus
 Spinal innervation: L5 (S1)
 Action: Flexion of knee

Utility

- L5 radiculopathy

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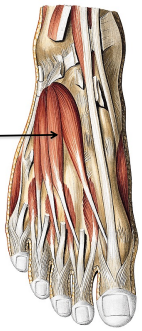
57

Lower extremity – helpful muscles

- Gluteus maximus
- Semimembranosus/semitendinosus
- Flexor digitorum longus
- Extensor digitorum brevis
- Abductor digiti minimi
- Adductor hallucis

58

M.extensor digitorum brevis



Innervation: (L5)-S1-(S2)
 Spinal innervation: n.peroneus profundus
 Action: Dorsiflexion of toes

NOTE!

- Abnormalities (fibs and fasciculations) common in healthy subjects (25%)
- If normal - significant

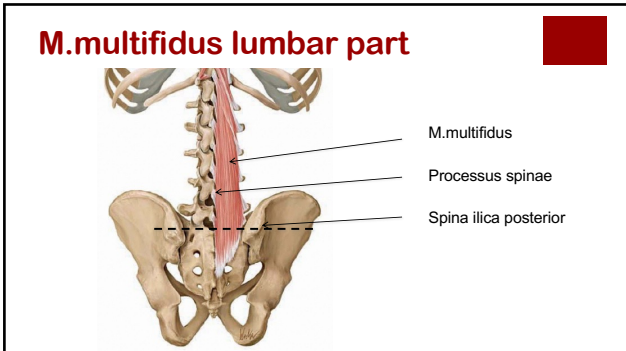
Putz and Pabst (ed) Sobotta, Atlas of Human Anatomy, 20th edition. Urban & Schwarzenberg

59

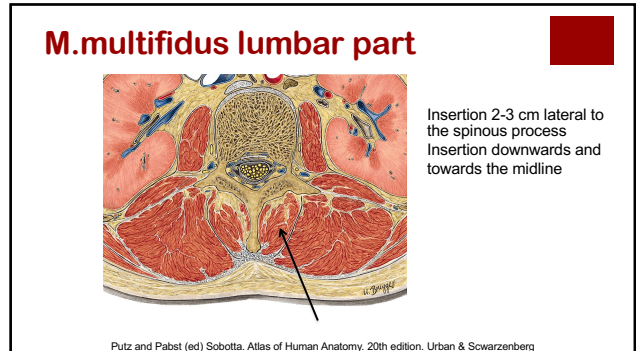
Trunk – Important muscles

- Paraspinal muscles
- M.diaphragma
- M.rectus abdominis
- M.transversus abdominis
- M.sphincter ani

60



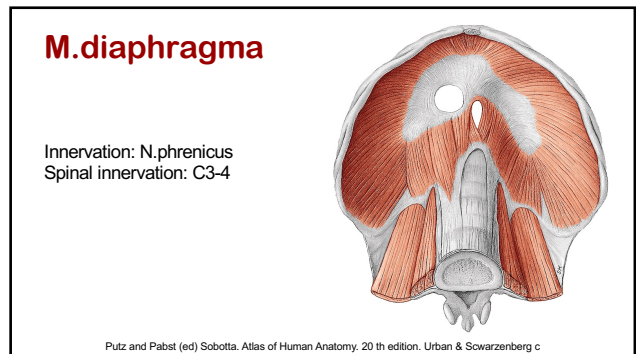
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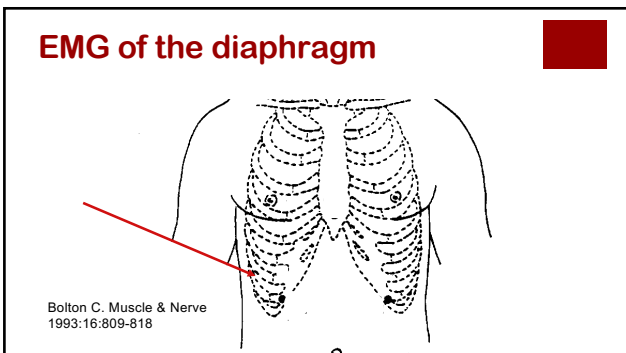
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63



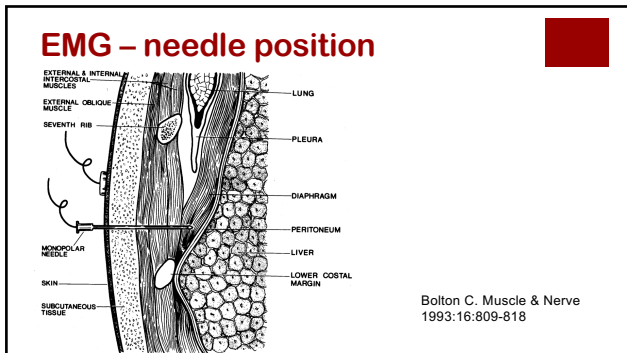
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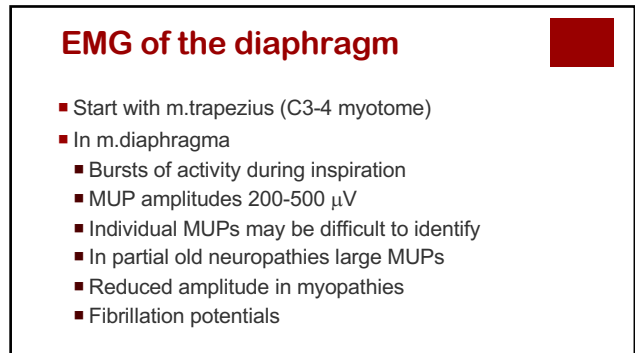
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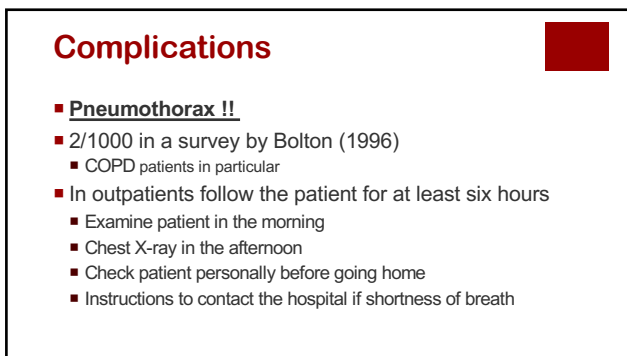
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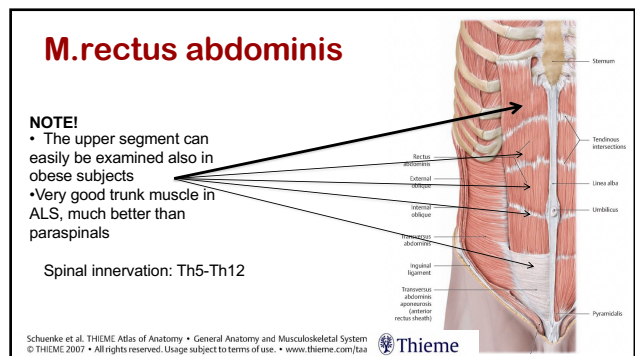
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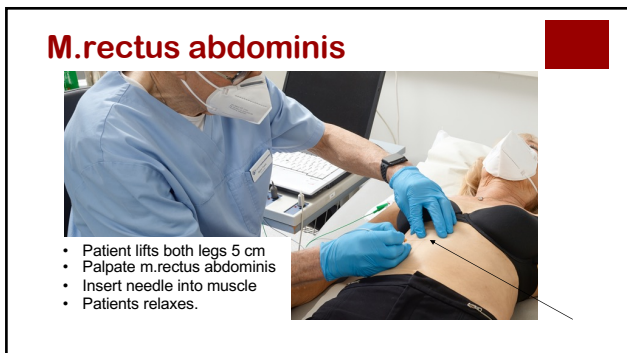
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69



70



71



72

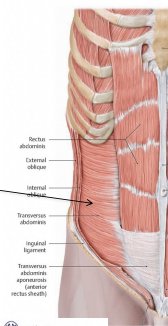
M.transversus abdominis

NOTE!
•Test in lesions of

Innervation: n.iliohypogastricus, n.ilioinguinalis
Spinal innervation: TH11-L1
Action: Rotation of the upper body to contralateral side

Utility

- n.ilioinguinalis neuropathy
- n.iliohypogastricus neuropathy



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73

M.transversus abdominis



74

Ilioypogastric nerve lesion



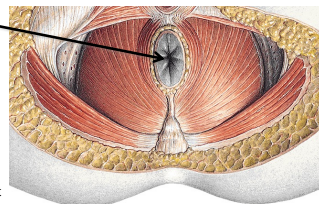
75

M.sphincter anii

Innervation: N.pudendus
Spinal innervation: S2-S4

Utility

- S2-S4 neuropathies
- Anal insufficiency
 - Examine front, back and both sides
 - Obstretic injury results in damage to the anterior part



Putz and Pabst (ed) Sobotta. Atlas of Human Anatomy. 20th edition. Urban & Swarzenberg

76

Podnar et al: Muscle & Nerve ,1999: 22:400-409

SHORT REPORT

ABSTRACT: The external anal sphincter (EAS) anatomy is complex, and no exact technique of needle electrode insertion into it for electromyography (EMG) has been described. To define optimal positions for needle electrode insertions, EAS muscle topography was studied by concentric needle EMG. Fifteen women without urological disorders were examined. Perpendicular insertions were made superficially (just under the mucosa) at the mucocutaneous junction, 5 and 10 mm more proximally (toward the anus), and at the anal orifice. In addition, at the anal orifice, deeper insertions were made. Superficially, EMG activity was detected at the mucocutaneous junction in 9 (60%) subjects. In the remaining 6, the muscle was found either 5 mm (n 5) or 10 mm (n 1) more centrally. At the anal orifice, superficial EMG activity was present in 67% of women. On deep insertion (15–25 mm) at the anal orifice, muscle was always present. It is suggested that, in further studies, the portions of the EAS muscle examined should be specified.

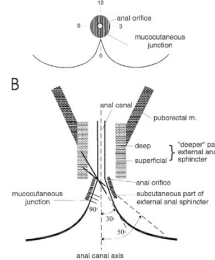
© 1999 John Wiley & Sons, Inc. Muscle Nerve 22: 400–403, 1999

STANDARDIZATION OF ANAL SPHINCTER EMG: TECHNIQUE OF NEEDLE EXAMINATION

SIMON PODNAR, MD, MSc,* ZORAN RODI, MD, MSc,† ADOLF LUKANOVIC MD, MSc,† BOJAN TRŠINAR, MD, DSc,† and DAVID B. VOJUSEK, MD, DSc†

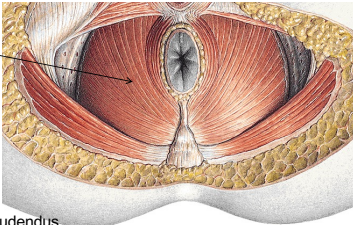
77

M.sphincter anii



78

M.levator anii (m.puborectalis)



Innervation: N.pudendus
Spinal innervation: S2-S4

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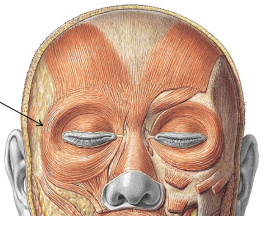
79

Cranial muscles - important

- M.orbicularis oris
- M.orbicularis oculi
- M.zygomaticus major
- M.masseter
- M.trapezius
- M.sternocleidomastoideus
- M.geniohyoideus
- M.genioglossus
- M.cricothyroideus

80

M.orbicularis oculi

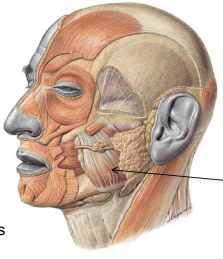


Innervation: N.facialis

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81

M.masseter

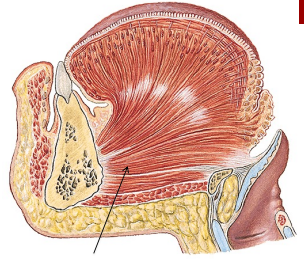


Innervation: n.trigeminus

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M.genioglossus

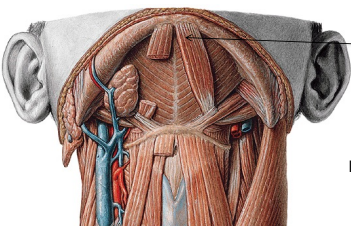


Innervation: n.hypoglossus

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83

M.geniohyoideus



m.geniohyoideus

Innervation: n.hypoglossus

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84

M.mylohyoideus

Innervation: n.trigeminus, n.alveolaris inferior

Putz and Pabst (ed) Sobotta, Atlas of Human Anatomy, 20th edition, Urban & Scharzenberg

85

M.cricothyroideus

Innervation: N.laryngeus superior (N.vagus)

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86

M.cricothyroideus

Innervation: N.laryngeus superior
Activation: Sing musical scale, especiall high notes effective

87

M.thyroarytenoideus

Innervation: N.recurrens

- Needle in midline between cricoid and thyroid cartilage
- 70° up and 15° lateral
- Activate: High pitched "E"

A.Rodriguez & D.Simpson, Approach to the patient with bulbar symptoms, AAEM Course 1996

88

M.cricoarytenoideus lateralis

Innervation: N.recurrens

- Needle in midline between cricoid and thyroid cartilage
- LCA: 40° up and 40° lateral
- Vocalization

A.Rodriguez & D.Simpson, Approach to the patient with bulbar symptoms, AAEM Course 1996

89

Unusual spontaneous activity

90

Spontaneous activity

- *Activity in the muscle at rest*
- Some present constantly
- Some provoked by movement of electrode
 - Not truly spontaneous!
- Some types are normal
- Some types are abnormal

91

Abnormal spontaneous activity

| | |
|---|---|
| <h4><u>Motor units</u></h4> <ul style="list-style-type: none"> ▪ Fasciculation potentials ▪ Neuromyotonia ▪ Myokymia ▪ Cramps | <h4><u>Muscle fibers</u></h4> <ul style="list-style-type: none"> ▪ Fibrillation potentials ▪ Positive sharp waves ▪ Complex repetitive discharges ▪ Myotonic discharges |
|---|---|

92

Myokymia and neuromyotonia

93

Definitions

Myokymia is undulating rippling of muscles

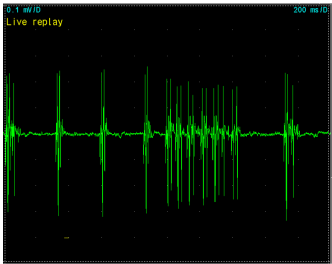
- Resemble worms crawling beneath the skin
- Usually focal in one part of the body
- May be generalized

Neuromyotonia is persistent muscle contraction

- Severe enough to cause deformity of hands
- Often facilitated by muscle contraction
- Usually generalized

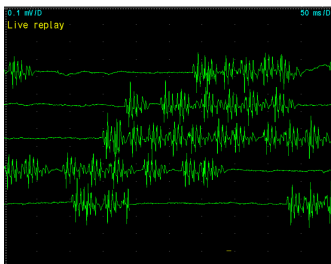
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Myokymic discharges



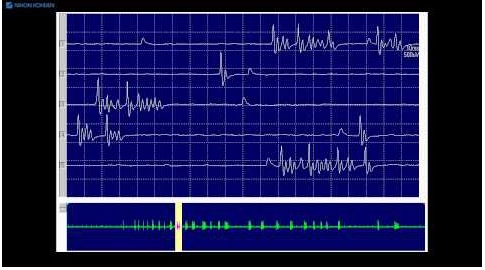
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Myokymic discharges



96

Myokymic discharges



<https://www.youtube.com/watch?v=SxhmV3uYcT0>

97

Myokymic discharges

- Motor unit action potentials that fire repetitively and may be associated with clinical myokymia.
- Burst of single motor units at 5 - 150 Hz followed by a brief period of silence (up to a few seconds), the bursts are repeated at regular intervals
- Longer bursts followed by longer intervals
- Usually spontaneous, may be triggered by exercise
- Less commonly uniform firing rate (1-5 Hz)
- Clinically undulating spontaneous movements or contractions

98

Myokymic discharges

- Generated in the motor axon
- Blocked by curare
- Spinal anesthesia has no effect
- Demyelination seems to be important

99

Myokymic discharges

- Focal myokymia
 - Brachial plexopathy following radiation therapy
 - Facial myokymia
 - MS, pontine glioma, GBS, ALS, trigeminal neuralgia
- Generalized myokymia (= neuromyotonia)
 - Idiopathic or hereditary form
 - GBS, metabolic disorders

100

Neuromyotonic discharges

- Bursts of *motor unit action potentials* at high rates (150-300 Hz) for a few seconds
- Often start and stop abruptly
- The amplitude of the potentials typically varies.
- Discharges may occur spontaneously or be initiated by needle movement, voluntary effort and ischemia or percussion of a nerve.
- Generated in the motor axon
- Continue during sleep
- Not blocked by local nerve blocks

101

Neuromyotonic discharges




Fig. 1. Continuous motor unit activity and myokymic discharges in Patients 1 and 2.

Kimiyoshi Arimura et al. The origin of spontaneous discharges in acquired neuromyotonia. A Macro EMG study. *Clinical Neurophysiology* 116 (2005) 1835-1839

102

Neuromyotonia

Kuva 1. Neuromyotoniapotilaamme relaksoituneen peukalon interosseuslihaksen EMG. Ylemmässä käyrässä, joka on rekisteröity selektiivisellä neutroelektrodilla, näkyy hierottavia potentiaaleja. Keskellä käyriä samaan joko tahdonalaisesti tai spontaanisti aktivoituneen yksikön tuottamia yhden, kahden tai kolmen potentiaalin ryhmiä. Käyrän lopussa hyvin suurtaajuinen faskikulaatio- ja -sarja. Alemmassa käyrässä, joka on rekisteröity samanaikaisesti epäselektiivisellä pinnaelektrodilla, näkyy lukuisien motoristen yksiköiden tuottama runsas spontaaniaktiiviteetti. Kalibraatio 200 µV, 100 ms.

103

Neuromyotonic discharges

Arimura K, et al. Isaacs syndrome as a potassium channelopathy of the nerve. *Muscle Nerve* 2002;25(suppl11):S55-58.

104

Neuromyotonic discharges

A. R. Gantenbein et al. Focal neuromyotonia: do I love you? *J Neurol* (2010) 257:1727-1729

105

Neuromyotonia – afterdischarges following electrical stimulation

106

Neuromyotonia

- Muscle fiber activity manifested as continuous muscle stiffness
- The accompanying electric activity continuous
- Terms used to describe related clinical syndromes
 - Isaac's syndrome, Isaac-Merton syndrome

107

Differences myokymia/neuromyotonia?

- Myokymia/neuromyotonia related with increased axon excitability
- Voltage gated potassium channels abnormal
- Acquired (Isaac's syndrome)
- Genetic (Episodic ataxia with myokymia)
- Probably not meaningful to differentiate the two phenomena

108

Neuromyotonia Isacs syndrome

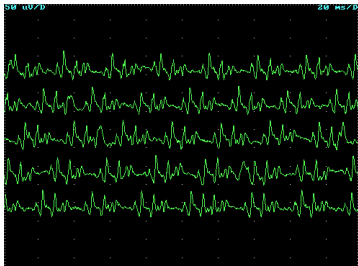
- Antibodies against K⁺ channels
- May be a paraneoplastic phenomenon
- Generated in the axons
- Respond to Na⁺ channel blockers
 - Phenytoin or carbamazapine

109

Complex repetitive discharges CRD

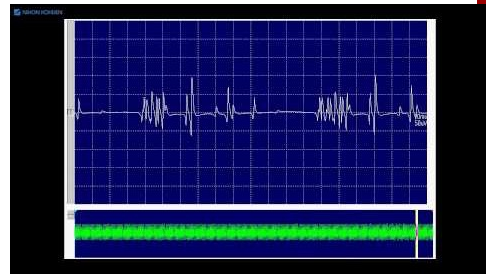
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Complex repetitive discharges



111

Complex repetitive discharges



<https://www.youtube.com/watch?v=pG7WjCjHpw&t=14s>

112

Complex repetitive discharges

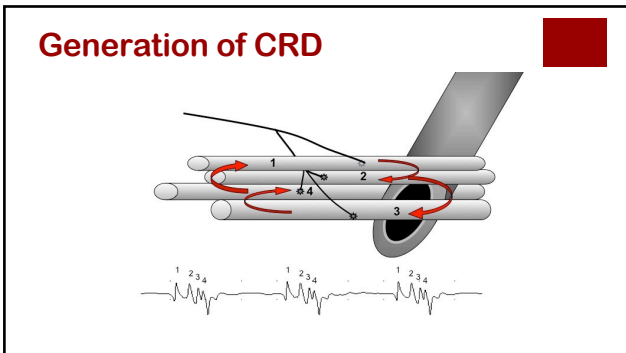
- Polyphasic action potentials
- Start spontaneously or after a needle movement
- Abrupt onset and cessation
- Uniform frequency, shape
- Amplitude 100-1000 μ V
- Frequency 5-100 Hz

113

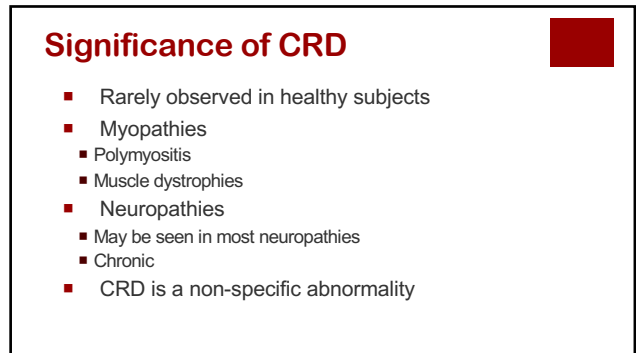
CRD - not recommended terms

- Pseudomyotonic discharge
- Bizarre high frequency discharge
- Bizarre repetitive discharge
- Bizarre repetitive potential
- Near constant frequency trains

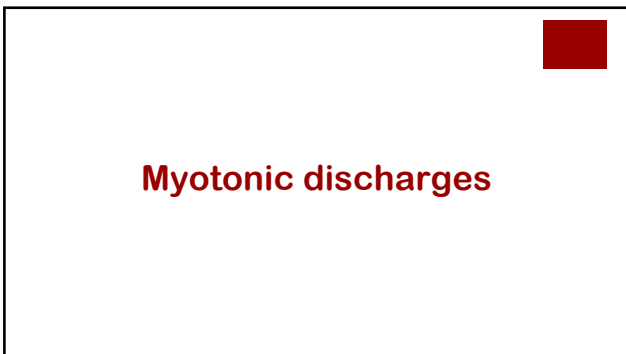
114



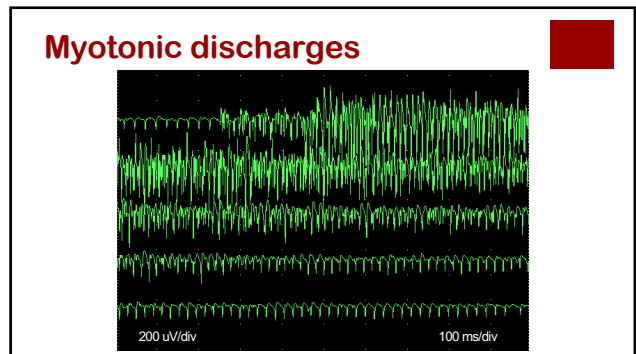
115



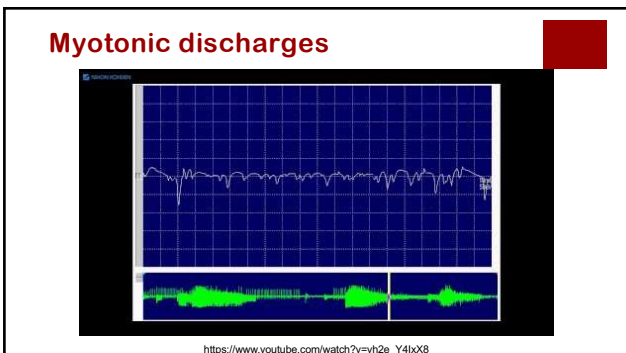
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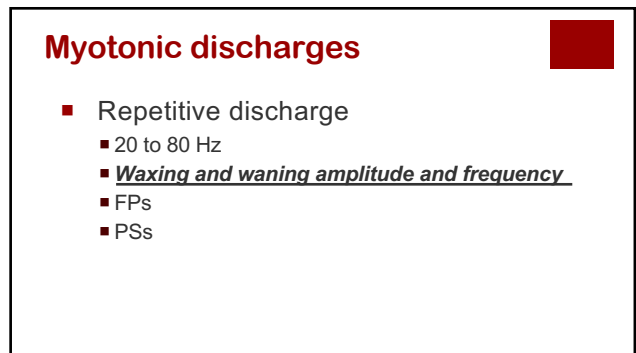
117



118



119



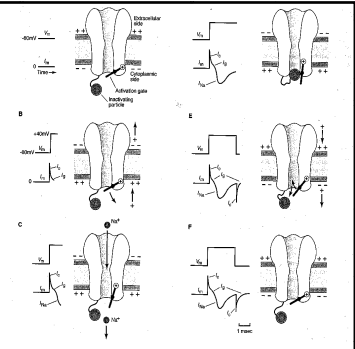
120

Myotonic discharges

- Repetitive discharges of single muscle fibers
- Recorded after
 - Needle insertion
 - Voluntary muscle contraction
- Amplitude and frequency **must both wax and wane**
- Sounds like "starting a motorcycle"

121

Na+ channel function in mytonia



122

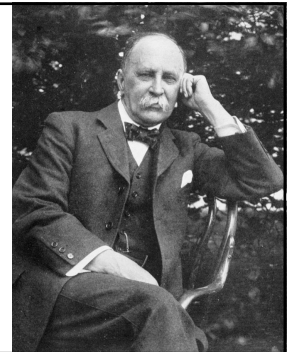
Myotonic disorders

- Progressive myopathy and myotonia
 - Myotonic dystrophy type 1 and type 2
- Main symptom myotonia
 - Myotonia congenita, Myotonia fluctuans
- Other myotonias
 - Paramyotonia congenita
 - Paraneoplastic myotonia
- Periodic paralysis
 - Hyperkalemic periodic paralysis

123

William Osler 1849-1919

"The practice of medicine is an art, not a trade; a calling, not a business; a calling in which your heart will be exercised equally with your head."



124



Goretzki - Georgia

125