

# Needle EMG of important muscles

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## Goals

- Basic issues with needle EMG
  - Contraindications
- Be able to choose suitable muscles for EDX
- Examine difficult muscles

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## Outline 45 min

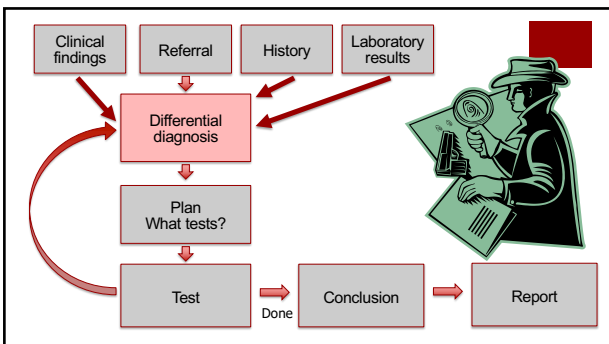
- EMG electrodes
- How to handle electrodes
- Contraindications and cautions
- **What muscles to study**
- **Special tricks and techniques**

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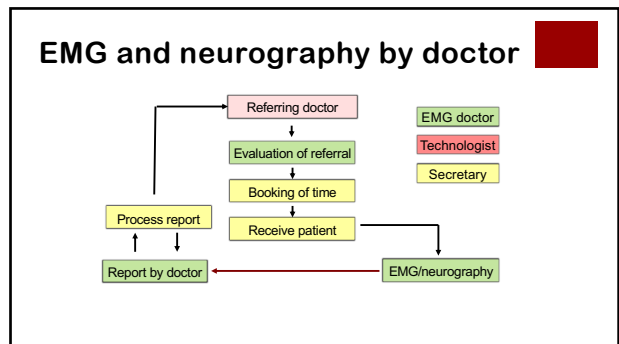
## Goal of diagnostic EMG

- 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.....)

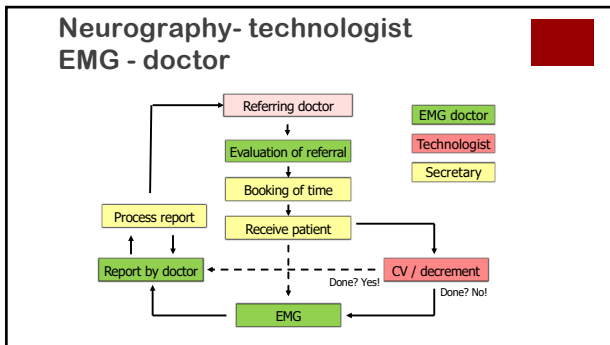
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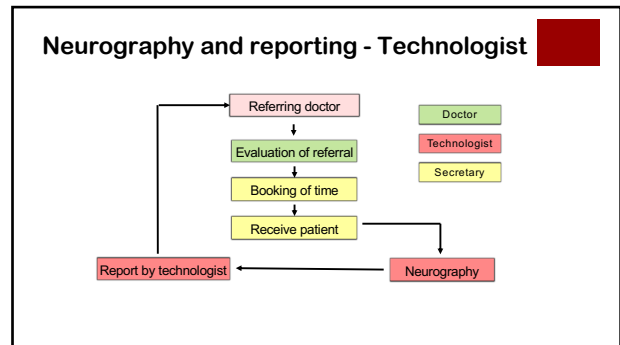
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**Physical Medicine and Rehabilitation 2013;5:S3-**

**Electrodiagnostics Supplement**

**Electromyography and Anticoagulation**

J. T. Gerlken, MD, Atul T. Patel, MD, Andrea J. Boon, MD

**Abstract:** Needle electromyography (EMG) is a common and safe diagnostic procedure. Although there are no absolute contraindications to performing an EMG, medically induced coagulopathy represents a relative contraindication. The purpose of this article is to discuss EMG safety for patients taking anticoagulants and antiplatelet agents, and to review the current literature regarding bleeding risks. Safety measures used to avoid serious bleeding complications are also discussed.

PM R 2013;5:S3-S7

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### 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

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### 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

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### Cardiac pace-makers

- Modern cardiac pace-makers are not a contraindication

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## Endocarditis prophylaxis

- Antibiotics are not indicated for prophylaxis of endocarditis

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## 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

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## 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

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## Examination table

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



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## Patient comfortable



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## Electrodes

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### Bronk's electrode 1929

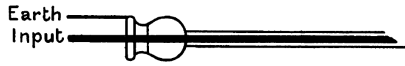


Fig. 13. Concentric needle electrode.

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**Adrian, E.D., Bronk, D.W., 1929. The discharge of impulses in motor nerve fibres: Part II. The frequency of discharge in reflex and voluntary contractions. J. Physiol. (Lond.) 67, 119-151.**

- First recording of unitary single motor units in humans
- Activity in the triceps brachii muscle (Adrian) with an intramuscular electrode
- They called it concentric needle electrode
- The electrode consisted of an insulated copper wire (diameter 0.193 mm) inserted in the lumen of a hypodermic needle and held in position by a plug.
- The tip of the wire was bared and acted as one electrode and the barrel of the needle provided the other electrode
- With a loudspeaker, the sounds of the recording were added
- It was useful to follow slight differences in sound intensity and quality

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### Edgar Adrian 1889-1977

- Trinity College, Cambridge 1911
- Bartholomew's Hospital, London 1919
- Cambridge, MD 1919
- Professor of physiology, Cambridge 1937-51
- Nobel price in Medicine 1932
  - Together with Charles Sherrington
  - For discoveries regarding the functions of neurons
- Studies on EEG



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### Detlev Bronk [1879-1975]1

- PhD in physics and physiology at University of Pennsylvania, 1926
- Cambridge University, 1928, fellow
- Professor of medical physics at University of Pennsylvania, 1929 to 1940
- Professor of physiology and biophysics at Cornell Medical School, 1940-1949
- President of John Hopkins University, 1948
- Rockefeller university, 1953



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### First intramuscular EMG in man

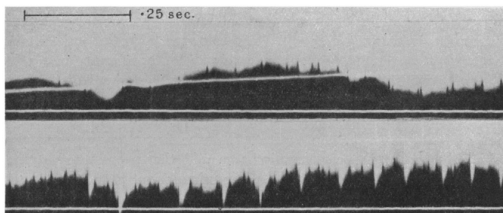


Fig. 15. Voluntary contraction of triceps (E. D. A.). Concentric needle electrodes. Pull recorded by rising line on record (connected with spring balance).

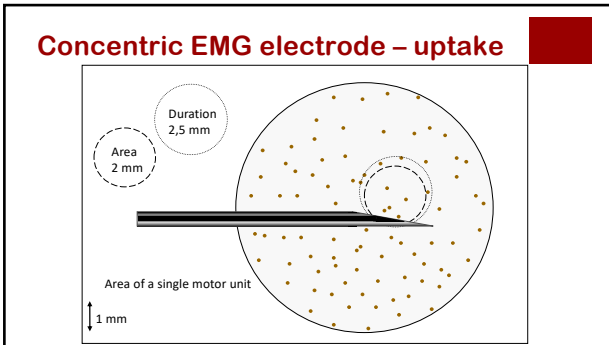
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### Concentric EMG electrode



- Introduced by Adrian and Bronk 1929
- Initially devised to record motor unit firing pattern
- Electrode 150 x 580 um elliptical shape
- Area of recording surface 0.07 mm<sup>2</sup>

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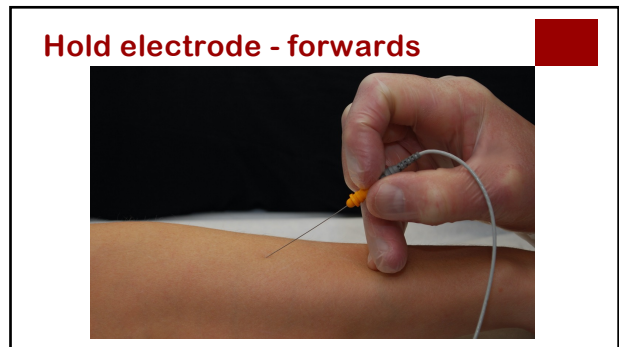
### Electrodes

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

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### Handling electrodes

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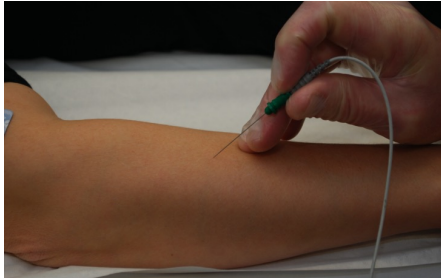


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- ### Hold the electrode
- Stable grip, like a pen
  - Mostly "forwards" away from the hand
  - Sometimes "backwards" toward the hand

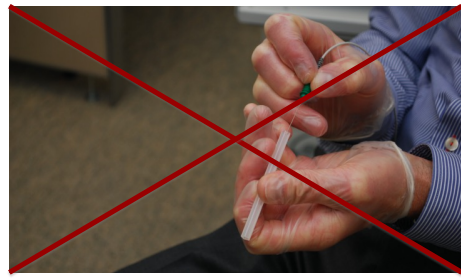
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**Not like this! Middle finger!!**



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**Do not recap the electrode**



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**Handling electrodes**

- Keep the cap covering the electrode on until you use it
- **Do not reinsert the electrode into the cap!!!!**
- Always wear gloves
- 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

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**Moving the needle smoothly**



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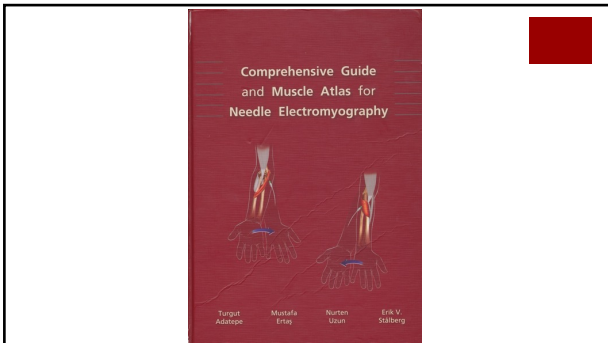
**Study sequence of muscles**

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

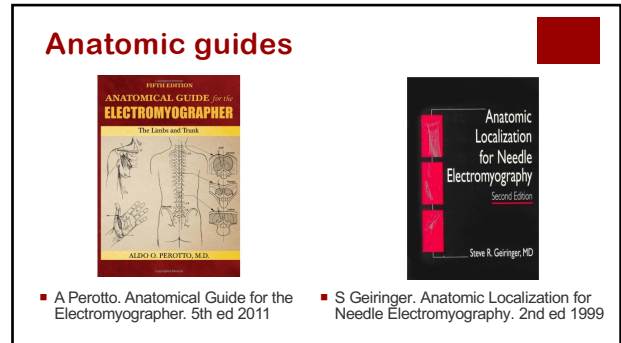
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**Muscles**

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**Upper extremity – most studied**

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

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**M. deltoideus**

Innervation: n. axillaris  
Spinal innervation: C5 and C6 (60%/40%)  
Action: Upper arm abduction

Utility

- C5 radiculopathy
- N. Axillaris
- Truncus superior

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**M. Infraspinatus  
M. supraspinatus**

m. supraspinatus

m. infraspinatus

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

Utility

- Lesions of n. suprascapularis
- C5 radiculopathy
- Truncus superior

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**M. biceps brachii**

Innervation: n. musculocutaneus  
Spinal innervation: C5 and C6 (50%-50%)  
Action: Elbow flexion and forearm supination

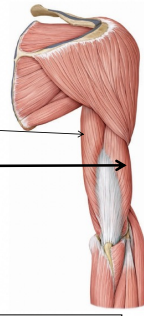
Utility

- Lesions of n. musculocutaneus
- C5 and C6 radiculopathy
- Truncus superior

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### M.triceps brachii




Caput longum

Caput laterale

Innervation: n.radialis  
Spinal innervation: C7  
Action: Elbow extension

**Utility**

- Normal in Saturday palsy
- **C7 radiculopathy**

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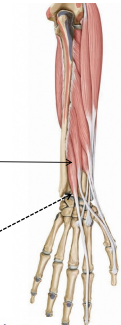
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### M.triceps brachii caput laterale



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### 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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### M.pronator teres



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

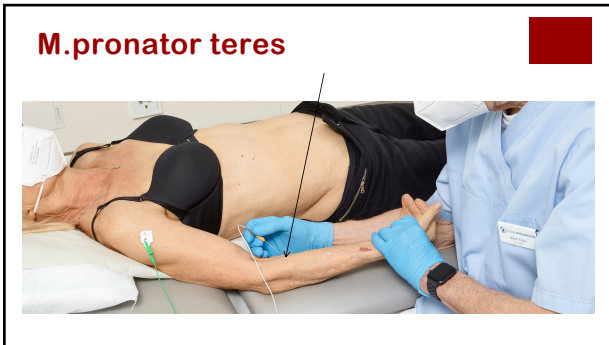
**Utility**

- Good C6 muscle

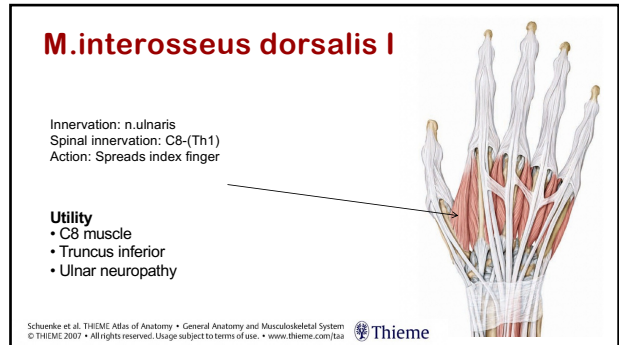
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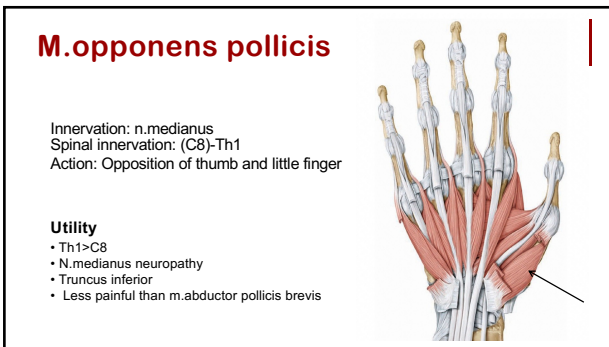




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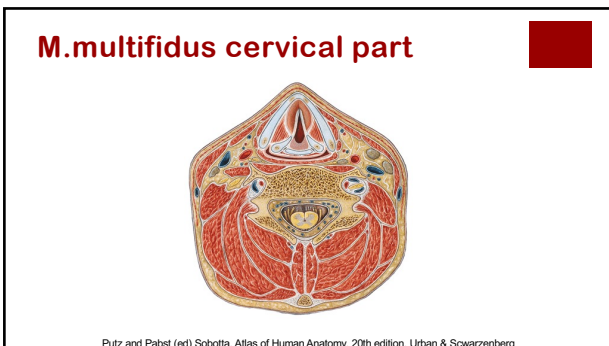
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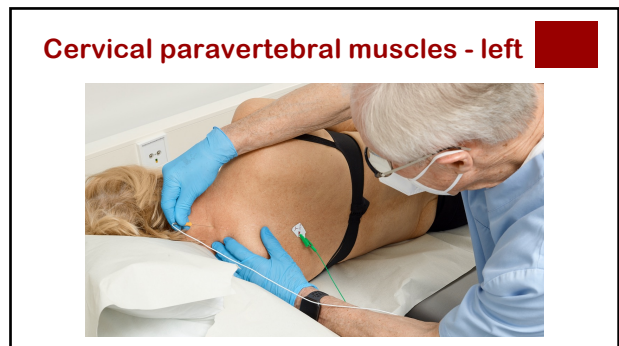
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**Upper extremity – sometimes studied**

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

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**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

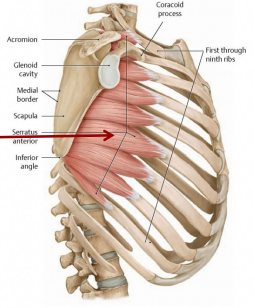
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**M.serratus anterior**

Innervation: N.thoracicus longus  
Myotomes: C5-7

**Utility:**

- Scapular winging
- N.thoracicus longus neuropathy



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**M.serratus anterior**



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**M.serratus anterior - activation**



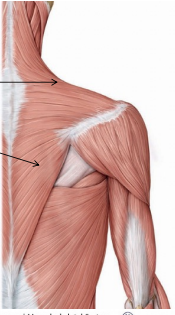
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**M.trapezius**

Innervation: n.accessorius  
Spinal level: C3-4

**Utility**


- N.accessorius neuropathy
- Cranial nerve in ALS
- Evaluation of m.diaphragma



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**M.extensor digitorum communis**



Innervation: n. radialis  
Spinal innervation: C7-C8

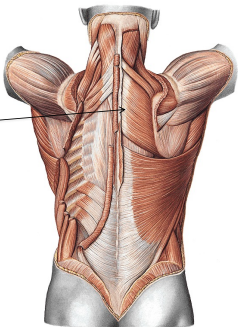
Utility

- Saturday night palsy
- N. interosseus posterior neuropathy

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**M. rhomboideus major**



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

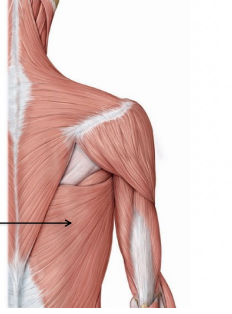
Utility

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

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

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**M. latissimus dorsi**



Innervation: N. thoracodorsalis  
Spinal innervation: (C6)-C7-(C8)

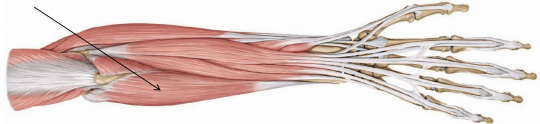
Utility

- Good C7 muscle

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**M. extensor carpi radialis longus**



Innervation: n. radialis  
above branching of the deep motor branch  
Spinal innervation: (C6) C7 (C8)


**NOTE!**

- Innervated above the arcade of Frohse (branching of the sensory and motor branches)

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**M. flexor digitorum profundus**



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


Utility:

- Anterior interosseus neuropathy

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**M. flexor pollicis longus**



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

Utility

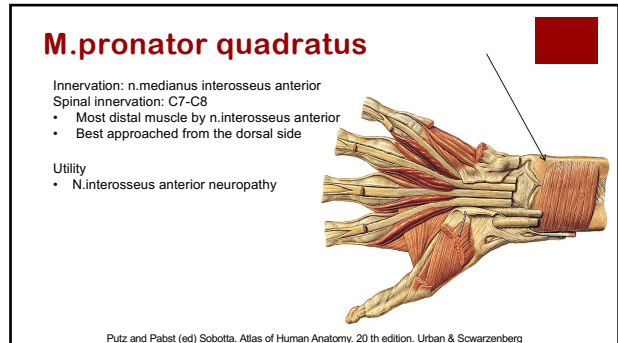
- N. anterior interosseus neuropathy

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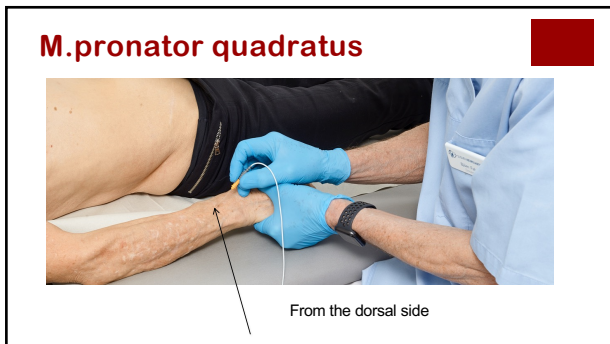
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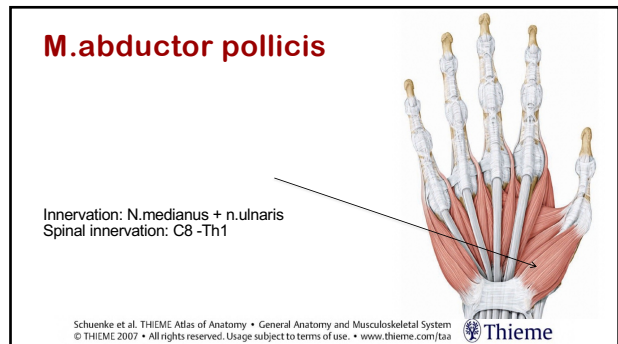
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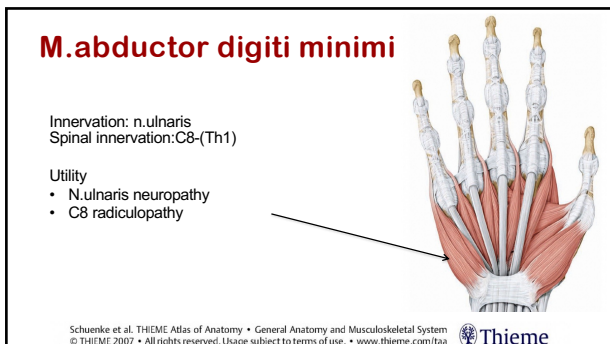
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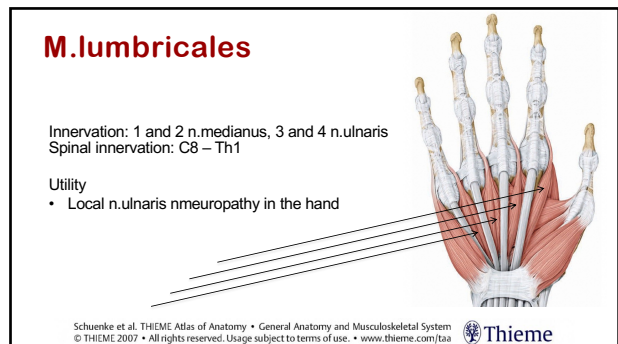
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### Lower extremity – Important muscles

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


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### M.tensor fascial latae

Innervation: n.gluteus superior  
Spinal innervation: L5

Utility

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

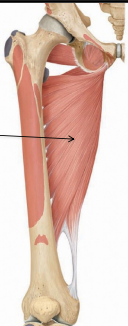
- L2 (L3-4) muscle
- N.femoralis
- Lumbar plexus



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### M.adductor magnus



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

Utility

- L3 muscle

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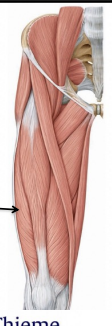
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### M.vastus lateralis

Innervation: n.femoralis  
Spinal innervation: L2-L3-L4  
Action: Extension of knee

Utility

- L4 muscle
- N.femoralis neuropathy
- Lumbar plexus



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### M.vastus lateralis -activation

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### M.tibialis anterior

Innervation: n.peroneus profundus  
 Spinal innervation: L4-L5  
 Action: Dorsiflexion of ankle

Utility:

- Peroneal nerve lesion
- Differentiation L3 and L4

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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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### M.peroneus longus

Innervation: N.peroneus superficialis  
 Spinal innervation: L5-(S1)  
 Action: eversion of ankle, plantar flexion of foot

Utility

- N.peroneus superficialis lesions
- Lesions of n.peroneus communis

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### 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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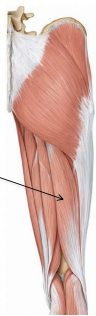
**M.gastrocnemius -activation**



Bend knee and extend ankle


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**M.biceps femoris c.longum**



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

Utility  
 • S1 radiculopathy

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**Lower extremity – helpful muscles**

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


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**M.gluteus maximus**



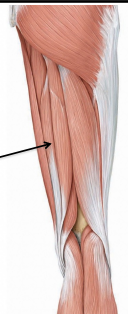
Innervation: n.gluteus inferior  
 Spinal innervation: S1 (S2)  
 Action: Extension of thigh

Utility  
 • S1 radiculopathy

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**M.semimembranosus**



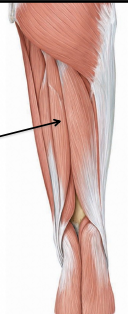
Innervation: n.ischiadicus  
 Spinal innervation: L5 (S1)  
 Action: Flexion of knee

Utility  
 • L5 radiculopathy

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**M.semitendinosus**



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

Utility  
 • L5 radiculopathy

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### M.flexor digitorum longus

Innervation: n.tibialis  
 Spinal innervation: L5 (S1)  
 Action: Plantar flexion of toes

Utility

- Normal in n.peroneus neuropathies
- L5 radiculopathy



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### M.flexor hallucis longus

Innervation: n.tibialis  
 Spinal innervation: L5 (S1)  
 Action: Plantar flexion of great toe

Utility

- L5 radiculopathy



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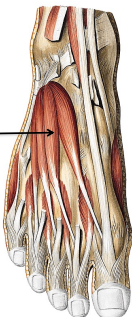
94

### 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



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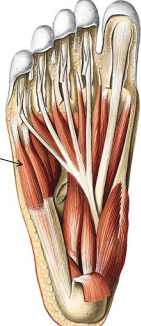
95

### M.abductor digiti minimi

Innervation: n.plataris lateralis  
 Spinal innervation: S1 (S2)

**NOTE!**

- Abnormalities common in healthy subjects

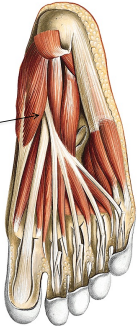


Putz and Pabst (ed) Sobotta. Atlas of Human Anatomy, 20th edition. Urban & Swarzenberg

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### M.abductor hallucis

Innervation: N.plataris medialis  
 Spinal innervation: S1 (S2)




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

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### Trunk – Important muscles

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

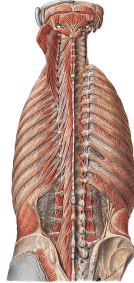


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**M.multifidus**

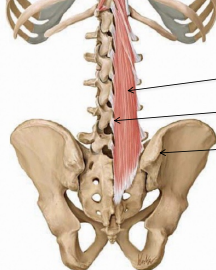
Innervation: Innervated by dorsal branch of spinal nerve of the spinous process the multifidus fibers are attached to.



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

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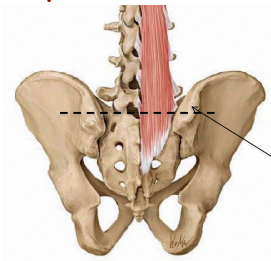
**M.multifidus lumbar part**



M.multifidus  
Processus spinae  
Spina iliaca posterior

100

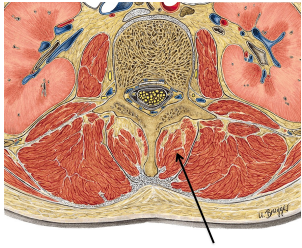
**Paraspinal level L5/S1**



Spina iliaca posterior

101

**M.multifidus lumbar part**




Insertion 2-3 cm lateral to the spinous process  
Insertion downwards and towards the midline

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**Examination of paraspinal muscles**

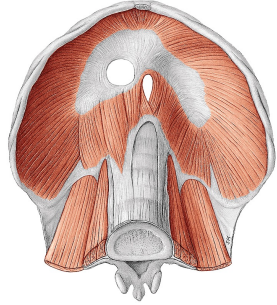


For relaxation:  
"Lift hips 2-3 cm with your knees"

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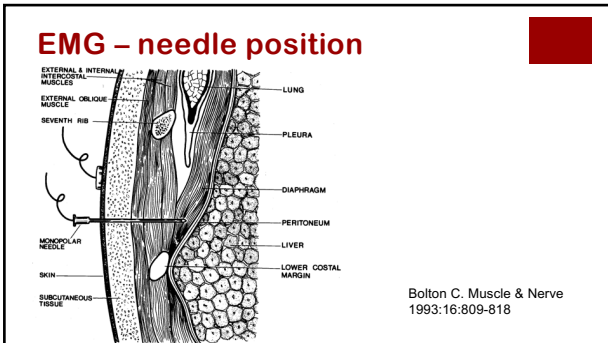
**M.diaphragma**

Innervation: N.phrenicus  
Spinal innervation: C3-4

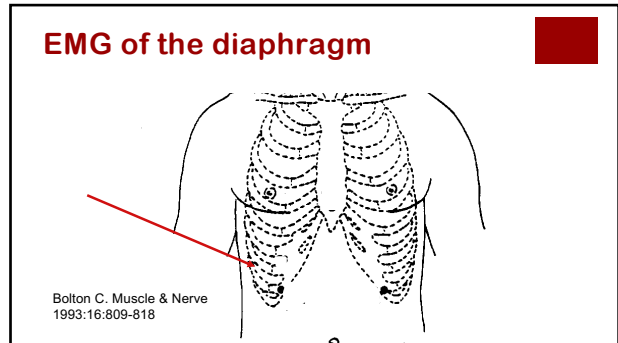


Putz and Pabst (ed) Sobotta, Atlas of Human Anatomy, 20 th edition, Urban & Swarzenberg c

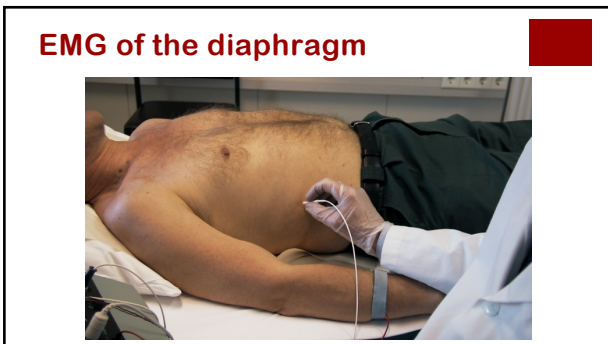
104



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### EMG of the diaphragm

- Start with m.trapezius (C3-4 myotome)
- In m.diaphragma
  - Bursts of activity during inspiration
  - MUP amplitudes 200-500  $\mu$ V
  - Individual MUPs may be difficult to identify
  - In partial old neuropathies large MUPs
  - Reduced amplitude in myopathies
  - Fibrillation potentials

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### Complications

- **Pneumothorax !!**
- 2/1000 in a survey by Bolton (1996)
  - COPD patients in particular
- In outpatients follow the patient for at least six hours
  - Examine patient in the morning
  - Chest X-ray in the afternoon
  - Check patient personally before going home
  - Instructions to contact the hospital if shortness of breath

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### M.rectus abdominis

**NOTE!**

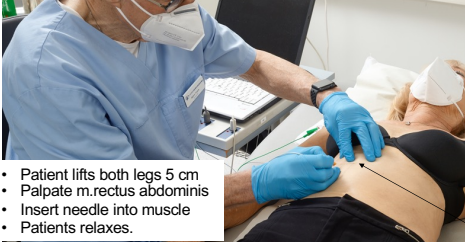
- The upper segment can easily be examined also in obese subjects
- Very good trunk muscle in ALS, much better than paraspinals

Spinal innervation: Th5-Th12

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### M.rectus abdominis



- Patient lifts both legs 5 cm
- Palpate m.rectus abdominis
- Insert needle into muscle
- Patients relaxes.

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### M.rectus abdominis -activation



- Lift both legs

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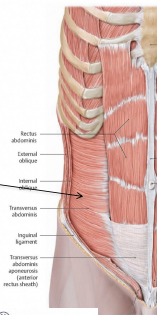
### M.transversus abdominis

**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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### M.transversus abdominis



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### Ilioypogastric nerve lesion



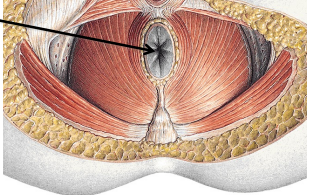
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### M.sphincter anii

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 & Sowaerzenberg

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

**SHORT REPORT**

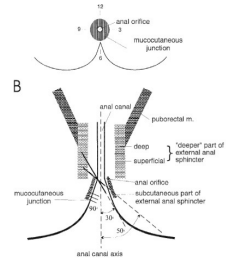
**ABSTRACT:** The external anal sphincter (EAS) anatomy is complex, and no exact technique of needle electrode insertion into it for electromyography (EMG) has been described. To define optimal positions for needle electrode insertions, EAS muscle topography was studied by concentric needle EMG. Fifteen women without uro-neurological 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 (in 5) or 10 mm (in 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**

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ADOLF LUKANOVIĆ MD, MSc,<sup>2</sup> BOJAN TRŠINAR, MD, DSc,<sup>2</sup> and  
DAVID B. VODUŠEK, MD, DSc<sup>1</sup>

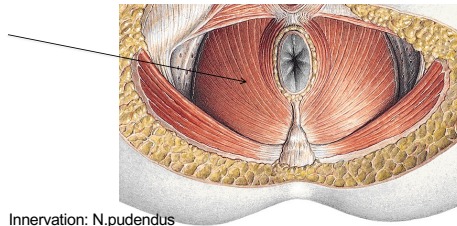
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**M.sphincter anii**



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**M.levator anii (m.puborectalis)**



Innervation: N.pudendus  
Spinal innervation: S2-S4

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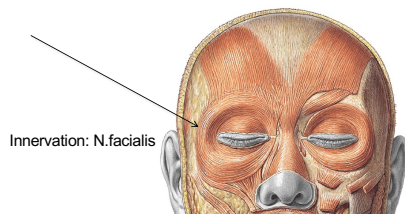
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**Cranial muscles - important**

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

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**M.orbicularis oculi**

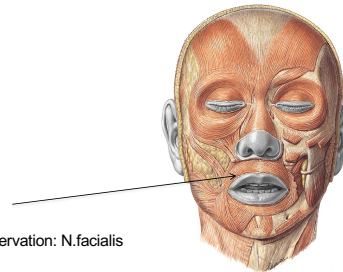


Innervation: N.facialis

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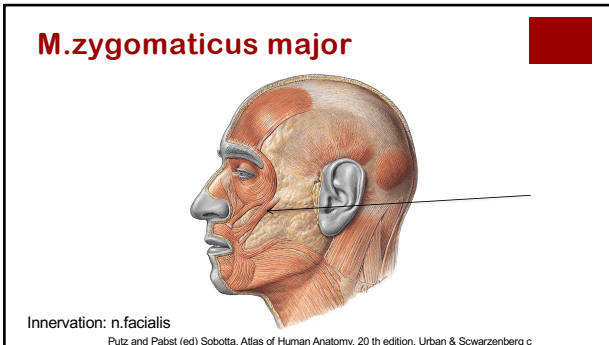
**M.oribicularis oris**



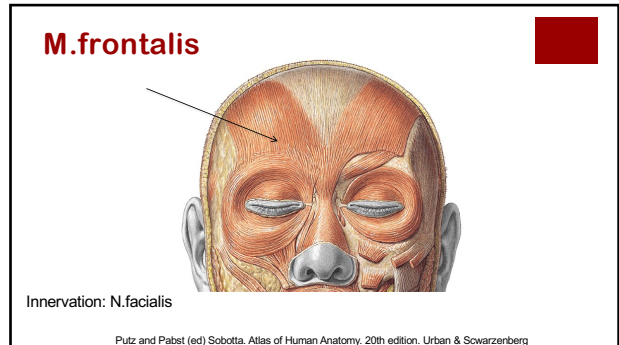
Innervation: N.facialis

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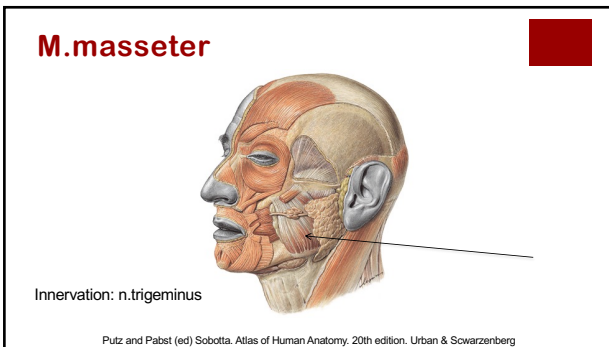
122



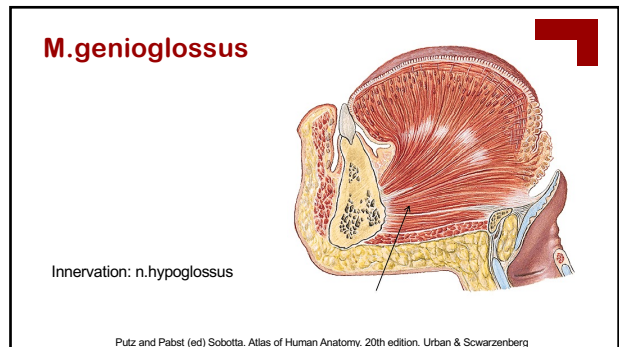
123



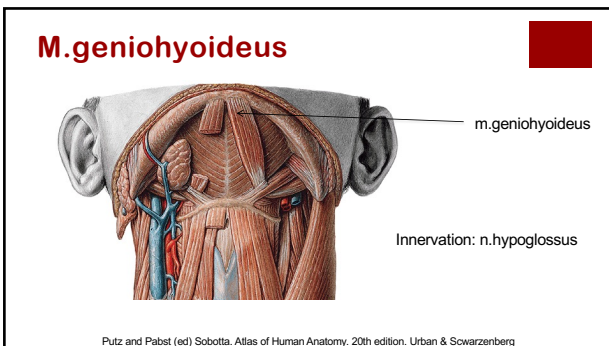
124



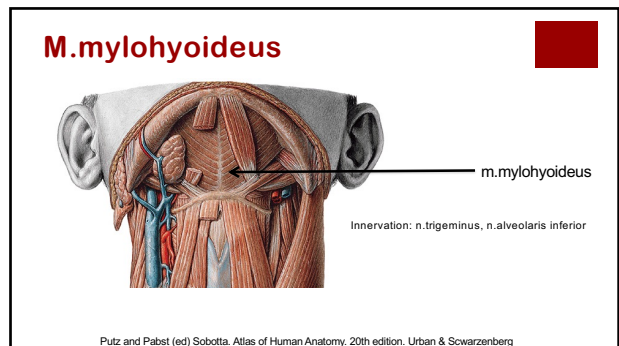
125



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### M.sternocleidomastoideus

Sternal head  
Clavicular head

Innervation: n.accessorius

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### M.trapezius

In scapular winging important to study the lower part of the trapezius

Innervation: n.accessorius

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### M.cricothyroideus

Innervation: N.laryngeus superior (N.vagus)

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### M.cricothyroideus

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

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### 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

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### M.cricoaerytenoideus lateralis

Innervation: N.recurrens

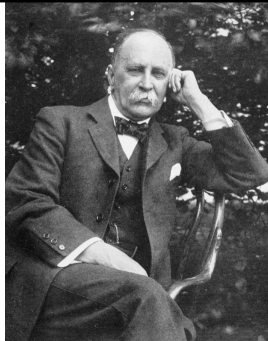
- Needle in midline between cricoid and thyroid cartilage
- LCA: 40° up and 40° lateral
- Vocalization

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

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**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."*



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