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Neuromuscular Electrical Stimulation: What it is and different devices

Tiffani Wallace, MA, CCC-SLP, BCS-S

Moderated by:
Amy Hansen, MA, CCC-SLP, Managing Editor, SpeechPathology.com

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NEUROMUSCULAR ELECTRICAL STIMULATION: WHAT IT IS AND DIFFERENT DEVICES

TIFFANI WALLACE, MA, CCC-SLP, BCS-S

LEARNING OBJECTIVES

After this course, participants will be able to:

- List muscles that may be stimulated by NMES.
- Identify NMES devices specifically designed for dysphagia rehabilitation.
- Describe current research related to NMES.

8

WHAT IS NMES?

- **Neuromuscular Electrical Stimulation or NMES** uses a device that sends electrical impulses to nerves. This input causes muscles to contract. The electrical stimulation can increase strength and range of motion, and offset the effects of disuse. It is often used to "re-train" or "re-educate" a muscle to function and to build strength after a surgery or period of disuse.
- https://www.cincinnatichildrens.org/service/o/ot-pt/electrical-stiumulation

9

NMES

- Cleared by the FDA in 2002 for use on the anterior neck.
- NMES is an adjunct modality.
- Billed under 92526

10

REVIEW OF ANATOMY AND PHYSIOLOGY

- Cranial Nerves
  - Trigeminal Nerve (V)
  - Facial Nerve (VII)
  - Glossopharyngeal Nerve (IX)
  - Vagus Nerve (X)
  - Spinal Accessory Nerve (XI)
  - Hypoglossal Nerve (XII)

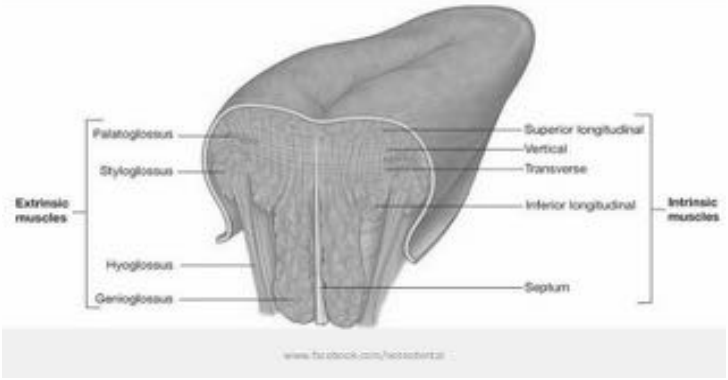
11

REVIEW OF ANATOMY AND PHYSIOLOGY

- Intrinsic Lingual Muscles
  - Transverse (XII)-Narrows and elongates the tongue.
  - Vertical (XII)-Flattens and broadens the tongue.
  - Superior Longitudinal (XII)-anterior-posterior pattern.
  - Inferior Longitudinal (XII)-Widens, shortens tongue; creates convex dorsum, depresses teeth.

12

Muscles of Tongue

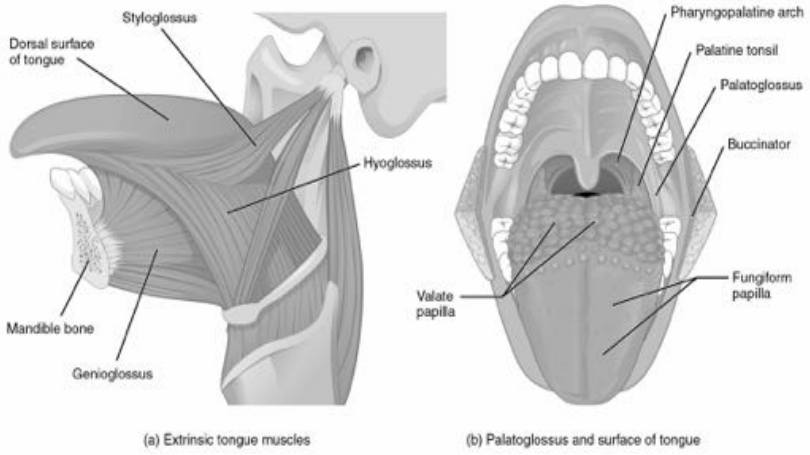


13

REVIEW OF ANATOMY AND PHYSIOLOGY

- Extrinsic Muscles of the Tongue
  - Styloglossus (XII)-Elevates the rear of the tongue, retracts protruded tongue during mastication.
  - Genioglossus (XII)-Inferior fibers help the tongue protrude, middle fibers depress the tongue, superior fibers draw the tongue tip back and down.
  - Hyoglossus (XII)-Depresses and retracts the tongue.
  - Palatoglossus (V)-Raises posterior part of the tongue.

14

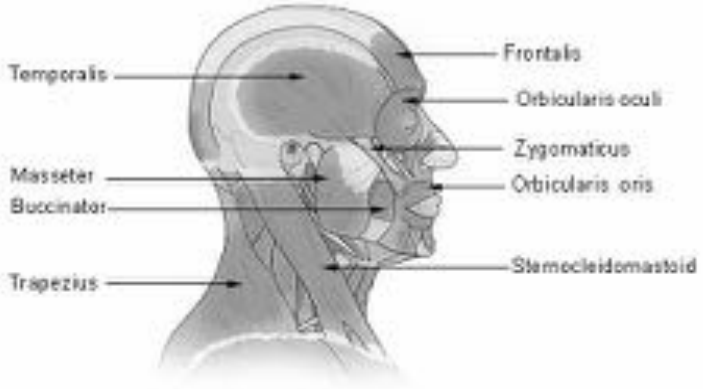


15

REVIEW OF ANATOMY AND PHYSIOLOGY

- Muscles of Facial Expression
  - Quadratus Labii Superior (VII)-elevates the upper lip
  - Zygomatic Major (VII)-draws corner of the mouth up and back
  - Zygomatic Minor (VII)-elevates portion of the upper lip
  - Risorius (VII)-retracts corner of the mouth
  - Depressor Anguli Oris (VII)-depresses angle of the mouth
  - Levator Anguli Oris (VII)-elevates the mouth (smile)

16



17

REVIEW OF ANATOMY AND PHYSIOLOGY

- Muscles of facial expression continued:
  - Quadratus Labii Inferior (VII)-depresses and retracts lower lip
  - Mental (VII)-raises and protrudes lower lip
  - Orbicular Oris (VII)-closes mouth and puckers lip
  - Buccinator (VII)-flattens cheek
  - Platysma (VII)-depresses mandible, aids in pouting reaction, depresses corner of mouth

18

REVIEW OF ANATOMY AND PHYSIOLOGY

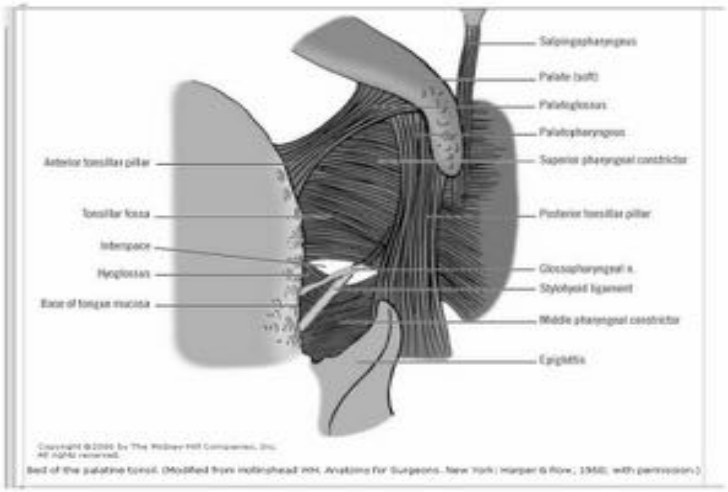
- Muscles of Mastication
  - Temporalis (V)-raises and retracts the mandible
  - Masseter (V)-raises the mandible against the maxilla, protraction of mandible (closing mouth)
  - Internal Pterygoid (V)-elevates mandible, closes jaw, help lateral pterygoids in moving the jaw from side to side
  - External Pterygoid (V)-depresses mandible and draws mandible forward and sideways

19

REVIEW OF ANATOMY AND PHYSIOLOGY

- Soft Palate
  - Levator Veli Palatine (X)-Raises soft palate to meet posterior pharyngeal wall.
  - Tensor Veli Palatine (V)-Tenses the soft palate.
  - Palatine Uvula (X)-Raises and shortens the uvula.

20



21

REVIEW OF ANATOMY AND PHYSIOLOGY

- Muscles of the Pharynx
  - Palatopharyngeus (X) (XI)-Pulls pharynx and larynx.
  - Superior Constrictor (X)-Contracts pharynx, aids movement of food bolus toward the esophagus.
  - Middle Constrictor (X)-Contracts pharynx, aids movement of food bolus toward esophagus.
  - Inferior Constrictor (X)-Contracts pharynx, aids movement of food bolus.

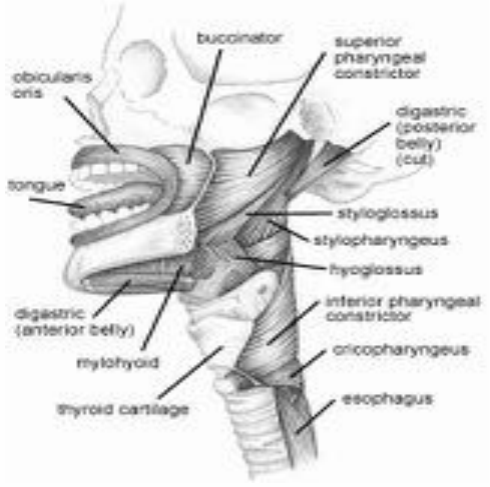
22

REVIEW OF ANATOMY AND PHYSIOLOGY

Muscles of the Pharynx (cont)

- Cricopharyngeus (X)-Contracts pharynx.
- Stylopharyngeus (IX)-Elevates the larynx, elevates the pharynx.
- Salpingopharyngeus (X)-Elevates pharynx.

23



24

REVIEW OF ANATOMY AND PHYSIOLOGY

- Suprahyoid
  - Stylohyoid (VII)-elevates and draws hyoid bone backward
  - Digastric (V Anterior Belly) (VII Posterior Belly)-elevates hyoid, depresses mandible
  - Mylohyoid (V)-raises and projects hyoid bone and tongue
  - Geniohyoid (VII)-draws tongue and hyoid bone forward.

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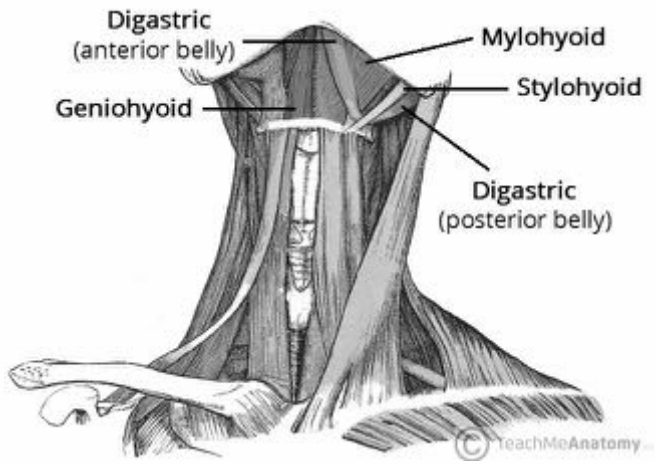
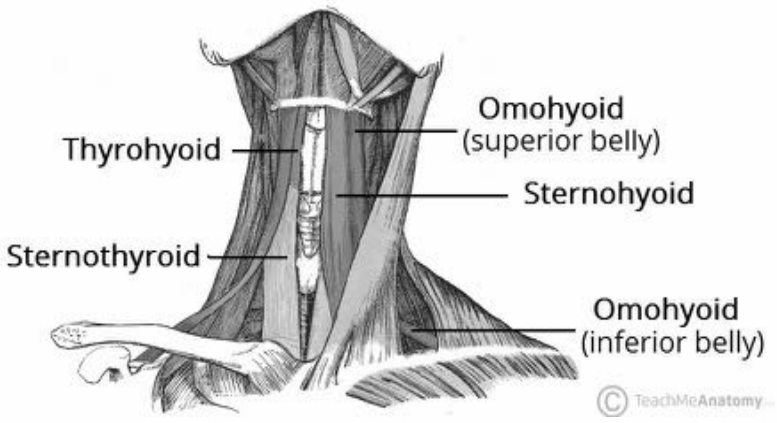


26

REVIEW OF ANATOMY AND PHYSIOLOGY

- Infrahyoid Muscles
  - Sternohyoid C1-C3 (XII)-Depresses hyoid bone.
  - Sternothyroid C1-C3 (XII)-Depresses the thyroid cartilage.
  - Thyrohyoid (XII)-Depresses hyoid bone or elevates the larynx.
  - Omohyoid C1 (XII)-Depresses and retracts the hyoid bone.

27

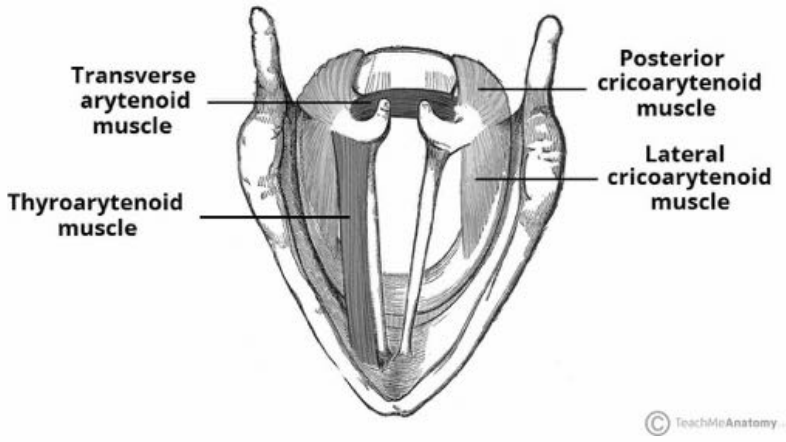


28

REVIEW OF ANATOMY AND PHYSIOLOGY

- Intrinsic Muscles of the Larynx
  - Cricothyroid (X)-Tension and elongation of the vocal folds.
  - Cricoarytenoids Lateral (X)-Draws arytenoids forward, aids in rotating arytenoids, tenses and adducts vocal folds.
  - Interarytenoids Transverse (X)-Draws together arytenoid cartilages, adducts vocal folds.
  - Oblique (X)-Draws arytenoid cartilages together.
  - Thyroarytenoid (X)-Draws arytenoids forward, shortens and relaxes vocal folds.
  - Vocalis (X)-Differentially tenses vocal folds.

29



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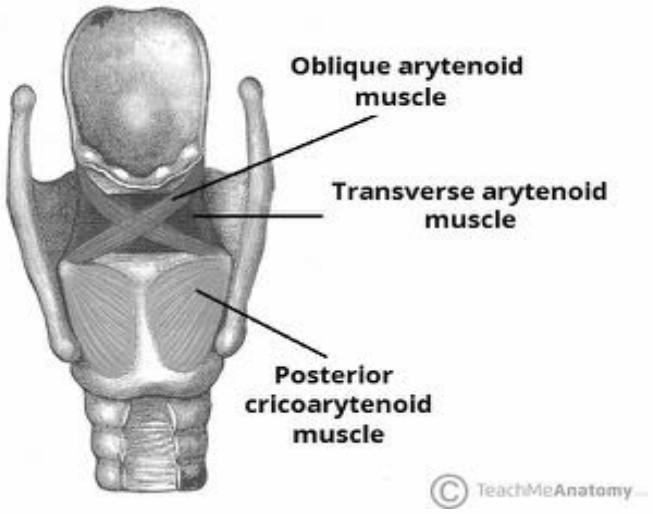


31

MUSCLE TYPES

- Type I Muscles
- Type I muscles: slow twitch, slow-oxidative fibers, fatigue-resistant, increased endurance (lingual lateralizers, jaw closers and in anterior tongue along with Type IIa).
  - Jaw Closers (Temporal, Masseter, Internal and External Pterygoid
  - Levator Veli Palatini
  - Inner layer of the lower portion of the infernal pharyngeal constrictor

32

MUSCLE TYPES

- Type II muscles: to propel and move bolus, fast twitch, larger, generate more force, easily fatigued. (tongue base, pharyngeal constrictors). No resistance=no need for type II muscles.
  - Type IIa-fast oxidative/glycolytic.
  - Type IIb-greatest capacity for force, easily fatigued, uses glycogen.

33

MUSCLE TYPES

- Type II muscles
  - intrinsic tongue muscles
  - supra/infra hyoids
  - digastric
  - medial pharyngeal constrictor
  - pharyngeal muscles

34

PRECAUTIONS

- Dementia
- Significant reflux
- Drug toxicity
- Seizures

35

CONTRAINDICATIONS

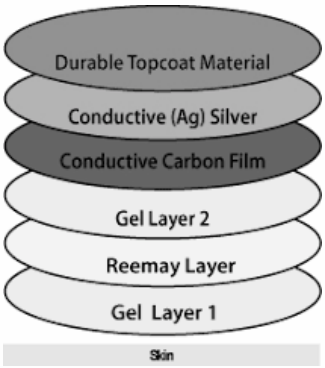
- Carotids
- Active neoplasm
- Active infection
- Pacemaker/implanted device

- *Long-term effects of e-stim are unknown at this time.

36

ELECTRODES

- Anatomy of an electrode:
  - Topcoat
  - Conductive Silver
  - Conductive Carbon Film
  - Gel Layer 2
  - Reemay Layer
  - Gel Layer 1



37

NMES

- Intensity-current flow measured in milliamperes (mA). Also known as amplitude.
- Frequency-Pulses per second measured in Hertz (Hz). 30-50 represents a good muscle contraction while 50-100 Hz is more fatiguing.
- Phase Duration-+ or – phase of the pulse measured in microseconds (higher=deeper penetration which may cause increased pain). Traditional is 200-400.
- Ramp Up-Length of time for output to reach maximum strength.
- Ramp Down-Length of time for intensity to drop back to 0.

38

NMES

- Duty Cycle-Determine time on/off of current. 1:1 (10:10 sec) more fatiguing while 1:5 (4:20 sec) less fatiguing.
- Waveform-shape, direction, amplitude, duration of a frequency channel. Symmetrical or asymmetrical.

39

NMES MACHINE

- VitalStim-VitalStim, VitalStim Plus, Experia




40

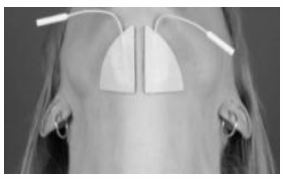
VITALSTIM

- 2 channels with 2 electrodes each (4 electrodes)
- Flows in 1 direction in a pulsed form
- Phase is 300 microseconds long
- 2 phases (biphasic pulse)
- Frequency 30-80 hz
- Amplitude (mA) 0-25

41

NMES MACHINES

- Ampcare-Effective Swallowing Protocol (ESP)




42

AMPCARE

- 2 channels with 2 electrodes (4 total)
- Offers 3 setting levels
- Frequency 5-50 HZ (adjustable)
- Phase Duration 50-250 (can be adjustable)
- Ramp Up 1 (fixed)
- Ramp Down 0 (fixed)

43

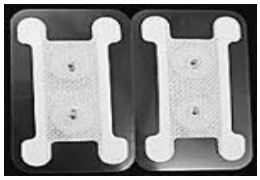
AMPCARE

- Cycle On 5 (fixed)
- Cycle Off 15-25
- Program Duration 30-50 minutes
- Intensity 0—20 (adjustable)

44

NMES MACHINE

- eSwallow



45

ESWALLOW

- Dual channels, isolated between channels
- Waveform-symmetric
- Intensity 0-25 mA
- Pulse Rate 80 Hz (fixed)
- Pulse width-Fixed 300 microseconds
- Treatment Time 60 minutes
- Ramp Down ½ second, every 60 seconds
- Ramp Up 5 seconds

46

NMES MACHINE

- Guardian-Aspire 2-The Guardian Way

47

GUARDIAN

- Max Amplitude 60 mA
- Wave Form Assymetrical, biphasic with 0 DC current
- Pulse Duration Adjustable 50-450 microseconds
- Frequency Adjustable 5-100 HZ
- Work and Rest Time Adjustable on/off 1-100 seconds
- Ramp Up 0-50 seconds

48

GUARDIAN

- Ramp Down 0-50 seconds
- Total Therapy Time 30 minutes
- Electrode Placement 2 electrodes on the submental

49

ARGUMENT FOR NMES

- Exercise without NMES typically involves Type I muscle.
- With NMES, greater elicitation of Type II muscles than with exercise alone.

- Carter, J. (2011). Point/Counterpoint: Electrical stimulation for dysphagia: The argument for electrical stimulation for dysphagia. *Perspectives on Swallowing and Swallowing Disorders (Dysphagia)*, *20*(4), 96-101.

50

ARGUMENT AGAINST NMES

- Unclear clinical use of E-Stim.
- Lack of Evidence Based support.
- Insufficient training in physiology.

- Humbert, I. A. (2011). Point/Counterpoint: Electrical stimulation for dysphagia: The argument against electrical stimulation for dysphagia. *Perspectives on Swallowing and Swallowing Disorders (Dysphagia)*, *20*(4), 102-108.

51

WHAT DOES THE RESEARCH TELL US?

- Laryngeal and hyoid descent occurred with stimulation at rest.
- During the swallow, there was significant reduction in laryngeal and hyoid elevation.
- Stimulation was at a level there was tugging.
- Electrode placement targeted submental and laryngeal areas.

- Humbert, I. A., Poletto, C. J., Saxon, K. G., Kearney, P. R., Crujido, L., Wright-Harp, W., ... & Ludlow, C. L. (2006). The effect of surface electrical stimulation on hyolaryngeal movement in normal individuals at rest and during swallowing. *Journal of Applied Physiology*, *101*(6), 1657-1663.

52

WHAT DOES THE RESEARCH TELL US

- VitalStim
- Top electrodes horizontal in the submental region
- Bottom electrodes over the thyroid cartilage
- Chronic dysphagia
- All but 2 participants had hyoid depression during stimulation
- Limited anterior-posterior movement in the hyoid
- No change in aspiration
- Ludlow, C. L., Humbert, I., Saxon, K., Poletto, C., Sonies, B., & Crujido, L. (2007). Effects of surface electrical stimulation both at rest and during swallowing in chronic pharyngeal dysphagia. *Dysphagia*, *22*(1), 1-10.

53

WHAT DOES THE RESEARCH TELL US

- 7 of 8 patients showed no myoelectrical activity change in the submental muscles.

- Suiter, D. M., Leder, S. B., & Ruark, J. L. (2006). Effects of neuromuscular electrical stimulation on submental muscle activity. *Dysphagia*, *21*(1), 56-60.

54

WHAT DOES THE RESEARCH TELL US

- 170 Head and Neck cancer patients
- After 12 weeks of treatment, NMES group had significantly worse penetration and aspiration.
- Both reported better quality of life and diet.

- Langmore, S. E., McCulloch, T. M., Krisciunas, G. P., Lazarus, C. L., Daele, D. J., Pauloski, B. R., ... & Doros, G. (2016). Efficacy of electrical stimulation and exercise for dysphagia in patients with head and neck cancer: a randomized clinical trial. *Head & neck*, *38*(S1).

55

CONCLUSIONS

- Use your best clinical judgment to determine if NMES might be right for your patient.
- If it is an option, watch the effects of NMES under fluoroscopy.
- Stay current with the literature regarding NMES.

56

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62