**Effortful Swallow**

- Baseline (~50uV)
- Effortful (~100uV)

**Mendelsohn Maneuver**

**Indications/Rationale**
- Reduced hyolaryngeal motion
- Reduced laryngeal vestibular closure
- Reduced PES Opening
  - Facilitates and sustains laryngeal closure and PES opening
  - Cook et al., 1989; Jacob et al., 1989
  - Facilitates and sustains contraction of oropharyngeal muscles
  - Kahrilas et al., 1991

- Tongue base pressure
- Eustachian pressure and duration
- Pre-opening UES pressure (less resistance)
- Post-closure UES pressure (prevents reflux)
- UES Nadir relaxation pressure
- UES relaxation duration
- Hoffman et al., 2012

**Shaker (Head Lift) Exercise**

- Developed by Shaker et al. (1997)
- Strengthen suprahyoid musculature which improves PESO
- 2 exercises
  - 3 sustained head raising for one minute in supine position
  - 30 consecutive head lifts in supine position
- Contraindications
  - Excessive fatigue
  - Cervical/neck injury

**Falsetto Exercise**

- Glide up in pitch as high as possible and hold note for several seconds with as much effort as possible
  - Elevates larynx
  - Pharyngeal squeeze
- Pharyngeal squeeze: forceful “ee” at highest pitch
- Effortful pitch glide: combination of falsetto and pharyngeal squeeze

**Chin Tuck Against Resistance (CTAR) Exercise**

- Chin tuck and hold position (isometric)
- Repetitive chin tucks (isotonic)
- Can use ISO-CTAR device, CTAR ball, or towel
- Can combine with effortful swallow
- Can also use jaw opening

**Mendelsohn Maneuver Training & Monitoring**

- 2 exercises
  - 3 sustained head raising for one minute in supine position
  - 30 consecutive head lifts in supine position
- Contraindications
  - Excessive fatigue
  - Cervical/neck injury

**Falsetto Exercise**

- Glide up in pitch as high as possible and hold note for several seconds with as much effort as possible
  - Elevates larynx
  - Pharyngeal squeeze
- Pharyngeal squeeze: forceful “ee” at highest pitch
- Effortful pitch glide: combination of falsetto and pharyngeal squeeze
Outcomes: Falsetto Exercise

Pre-Tx
Post-Tx

Tongue Hold Maneuver

*Hold tongue between teeth/lips/gauze and swallow*

Indications/Rationale
- Decreased pharyngeal stripping wave
  - Increases contraction of superior pharyngeal constrictor (Fuji et al., 1996)
  - Anterior tongue movement pulls pharyngeal wall forward (Ong and others, 2006)

Expiratory Muscle Strength Training Program (EMST)

- Expiratory pressure threshold training
  - Not resistance training (physiological load calibrated and imposed)
  - Target muscles: expiratory (abdominals) and supralaryngeal
- Device: EMST150
  - Pressure-threshold device
  - Calibrated one-way spring valve
- Protocol
  - 4-5 week program (5 days/week)
  - 5 sets of exercises (5 exercises/set)
  - Device load set at 75% maximum expiratory pressure (MEP)

Neuromuscular Electrical Stimulation (NMES)

- Traditionally used in physical therapy
- Premise: voluntary contraction + electrical stimulation = better movement
- In dysphagia, electrodes are placed on surface of head and neck
  - Low voltage electrical currents causing contraction of muscle fibers
- 2 electrodes types:
  - Anode and cathode (positive and negative charge)
  - Current arcs between electrodes
  - Tissues activated from superficial to deep
Neuromuscular Electrical Stimulation (NMES)

- Neuromuscular response influenced by...
  - Characteristics of electrical current
  - Continuous or intermittent stimulation
  - Placement of electrodes
  - Length of treatment session (i.e., dose)
  - Isolation or used during functional task
  - Frequency of treatment

Considerations
- Type/intensity (motor, sensory only)
- When (at rest, during swallowing)
- Type of dysphagia
- Cognitive status
- Muscle group(s) of interest
- Medical diagnosis, time since onset, and patient severity
- Location of damage (muscle, nerve, motoneuron, cortex)
- Patient interest
- Overall measurement of change (physiological, oral intake, penetration/aspiration, weight gain, etc.)

Kate’s professional opinion:
- Get proper training – achieve competency
- Do not use in isolation
- Be weary of methodological quality of studies
- Be weary of underlying medical condition
- Don’t hop on bandwagons just because other people are doing it!

Strength Training and Skill Training

Connected concepts – impairment in both present but may not be equally distributed:

Skill | Strength | Skill | Strength

Huckabee & Macrae, 2014

Strength Training and Skill Training

- Traditional rehab approaches focus on peripheral muscle strength training (e.g., effortful swallow) and duration (e.g., Mendelsohn).
- Our bias towards “weakness” is imposed by:
  - Our limited understanding of the capacity for cortical modulation of pharyngeal response
  - Our instrumental techniques that visualize biomechanics reasonably well but not underlying pathophysiology

Sella (2012) suggests:
“dysphagia is not always due to a deficit in muscle strength, but can rather be attributed to limited precision and timing of muscular activation, thus, a limitation of swallowing skill, rather than strength.”
Not everyone is weak!
Swallowing depends on precision and speed of movement and does not require maximal muscle contraction
Potential adverse effects of improper strength training:
- fatigue (Moldover & Borg-Stein, 1994)
- increased muscle tone (June, 2010)
- detraining (Parks et al., 2009; Baker, Doorey, & Eppein, 2005)

Strength training may not be wrong...
but also may not be right

Strength Training ➔ Skill Training: Desired Target

SKILL TRAINING

• Flexibility and adaptability are key features of the swallow system (Han, 2005; Suzuki, 2003; Miller, 2008; Humbert, 2013)
• Motor learning and motor control foster skill acquisition and adaptability.
  - May be the basis of swallowing rehabilitation?
• Motor adaptation reliant on error based learning (Bastian, 2008; Mischke, 2004; Shadmehr, 2010; Matori, 2013)
• Motor refinement may be hierarchically organized-increased motor unit recruitment occurs first ➔ then strength gains

Skill Training

Specificity of Practice

- Current research suggests superior outcomes for task-oriented skill training over strength training alone programs (Huckabee & Macrae, 2014)
- Specific motor skills developed through non-contextualized practice do not generalize across tasks
- Skill based training must replicate the desired task – task specificity
- Incorporate the exercise into the context of functional swallowing
- Feedback (biofeedback and intrinsic feedback)

Specificity and Feedback

- Swallowing produces no clear external movement patterns and intrinsic feedback systems are likely impaired in the presence of dysphagia (Huckabee & Macrae, 2014)
- Improved performance is heavily influenced by the presence of guidance and feedback (Gulak, Lobato, & Miller, 2009)
Device Facilitated Biofeedback

Maximizes rehabilitation & improves outcomes

Azola et al., 2016
Martin-Harris et al., 2015
Macrae et al., 2014
Humbert & Joel, 2012
Crary et al. 2004
Kahrilas et al. 1993

Modalities
- Fluoroscopy
- Electromyography
- Endoscopy
- Manometry
- Plethysmography

Paradigm shift from strength to skill training

Athukorala et al., 2014
Huckabee et al., 2013

Treatment Using Biofeedback

• Education and shaping of desired response
  - Educate the patient regarding the nature of their swallowing disorder
  - Dependent on cognitive ability

• Targeted intervention training
  - Demonstrate and train targeted treatment
  - Goal is patient understanding of exercises and strategies

Biofeedback Application

- Adjunct tool for proprioceptive biofeedback
  - Not a stand-alone therapy
  - Utilize with traditional and/or novel therapies

- Evaluate efficacy of intervention
- Monitor adherence and progress
- Documentation of improvement – quantitative, objective data

Candidacy for Biofeedback

- Observable phenomenon
  - Electromyography: Some degree of observable extrinsic muscle activity
  - Endoscopy: Defects related to glottic closure, bolus transit abnormalities (premature spillage or stasis), pharyngeal contraction, penetration or aspiration
  - Manometry: Some degree of observable pharyngeal contractility

- Good visual acuity
- Intact cognition
- Ability to place/pass device:
  - Electromyography: radiation fibrosis, “woody neck” – poor candidate
  - Endoscopy: patient nasal passage for endoscope
  - Manometry: patient nasal passage and absence of stricture/severe kyphosis for catheter

Surface Electromyography (sEMG)

• Uses surface electrodes to detect muscle activity
• Common placement sites
  - Oribularis oris
  - Submental group (suprahypoids)
  - Masseter
  - Infrahypoid group

Feedback is immediate
• Duration of laryngeal elevation (Mendelsohn Maneuver)
• Amount of electrical activity in submandibular muscles (Effortful Swallow)

sEMG: Suprahypoid Musculature

Mendelsohn Maneuver
Effortful Swallow
Stevi et al., 2012
sEMG Considerations

- Placement of electrodes
- Distance between electrodes
- Size of electrodes

Pharyngolaryngoscopy


"Videoendoscopic biofeedback significantly increased the chance of therapeutic success, shortening the period of functional rehabilitation in comparison to conventional swallowing therapy."


"Visual biofeedback provided by FEES was successful for both patient and family education and to investigate individualized therapeutic strategies that, if successful, can be implemented immediately."


"The median length of time to acquire SGS was 1.5 days in the biofeedback group and 3.5 days in the non-biofeedback group (P=0.04)."

BioFEESback

- Swallowing deficits & consequences
- Show that techniques improve swallowing
- Penetration or Aspiration
- Glottic Closure
- Stasis or Residue
- Show efficacy of strategies (e.g. liquid wash)

Benefits of Endoscopic Biofeedback

HRPM Landmarks

A) Velopharynx Region
   - Soft palate
   - Superior pharyngeal constrictors

B) Mesopharyngeal Region
   - Tongue base
   - Inferior pharyngeal constrictors
   - Middle pharyngeal constrictors

C) Hypopharynx Region
   - Inferior pharyngeal constrictors

D) UES Region
   - Pharyngoesophageal segment
HRPM Intervention Applications

- Maneuver/strategy planning
- Exercise training & monitoring
- Temporal coordination
- PES relaxation & duration
- Swallow mapping (pattern recognition)
- Dosing & adherence

RESULTS:

- Seven of ten patients (70%) showed improvement in HPRM parameters
- Average PhCI increase of 87.1 mmHg - cm
- EAT-10 scores 25.7 → 21.6
- DHI total scores 64.2 → 57.1
- MBSImP Scores: greatest = LVC, PR
- 70% showed improvement in PAS
- No adverse events.

AIM: Identify changes in pharyngeal pressures and quality of life parameters in patients undergoing HRPM biofeedback dysphagia therapy.

Mechanical Advantages:

- Optimal respiratory-swallowing coordination

  - The contraction of the diaphragm (inspiration) exerts a downward pull on the trachea and larynx (larynx & head, limbic, limbic).

  - At mid to low quiet breathing lung volumes, the laryngeal elevators are working against the least resistance.

  - Facilitates timing, extent and duration of laryngeal elevation and laryngeal vestibular closure (LVC), pharyngoesophageal sphincter opening (PESO), esophageal clearance.

Respiratory–Swallow Coordination

- Disruption of respiratory-swallow coordination has been documented in healthy aging, neurologic disease, COPD, and HNC

Respiratory-Swallow Training (RST) Program

- Disruption of respiratory-swallow coordination has been documented in healthy aging, neurologic disease, COPD, and HNC
How might training to initiate swallowing during mid-expiration improve swallowing function and risk of aspiration?

Respiratory–Swallow Training (RST) Program

Training occurs across 3 modules:
- Identification: ID of respiratory phase; ID of respiratory phase at high, mid, and low lung volumes
- Acquisition: ID swallow during respiratory phase at mid- to low lung volume with and without feedback
- Mastery: demonstrate optimal respiratory-swallow pattern across textures without feedback

Results
- Significant increase in optimal respiratory-swallow pattern
- Significant improvement in MBSImP scores:
  - laryngeal vestibular closure,
  - tongue base retraction, and
  - pharyngeal residue
- Significant increase in MDADI scores
- Significant decrease in PAS scores

Conclusions:
- Respiratory-swallow coordination can be trained without adverse events or effects
- Swallowing during expiration at mid- to low lung volumes improves aspects of airway protection and bolus propulsion

Respiratory–Swallow Training (RST) Program

Iowa Oral Performance Instrument (IOPI)

- Isometric exercise (lip, tongue, cheek)
- Air-filled tongue bulb
- Biofeedback for strength training or endurance exercises
- Measurement of pressure (kPa)
- Target value = Max pressure x (Effort/100)
- Endurance: time to maintain 50% of max
**IOPI Standardized Training**

- "Press your tongue against the bulb as hard as possible"
- One repetition maximum (1 RM): highest value achieved one time only
- 2 sets of 3 repetitions
- 80% RM improves strength
- Wk 1: 60% of RM
- Wks 2 – 8: 80% of RM
- 10 reps/set; 3 sets/day; 3 days/wk for 8 weeks

**IOPI Instructional Video**

**COMBINED INTERVENTIONS**

- Systematic and intensive program based on exercise principles.
- Uses swallowing as the exercise!
- Uses hierarchy to advance patient towards more "normal" eating behaviors.
- Focus on eliminating maladaptive eating and swallowing behaviors.
- Requires training for certification.

(Carnaby-Mann & Crary, 2010)

**AIM:** To investigate functional and physiological changes in swallowing performance of adults with chronic dysphagia after an exercise-based dysphagia therapy.

**Results:** Clinical and functional swallowing performance improved significantly and were maintained at a 3-month follow up. 4 of 7 patients who were feeding tube dependent progressed to total oral intake after 3 weeks of intervention.

(Crary, Carnaby, Crary, & Carvajal, 2013)
Intensive Dysphagia Rehabilitation Approach (IDR)

Comprehensive, personalized, intensive 4-week treatment approach that incorporates 3 components:
1) evidence-based oropharyngeal training increasing gradually in intensity based on exercise physiology guidelines,
2) targeted swallowing practice increasing gradually in complexity following principles of experience-dependent brain plasticity, and
3) adherence-inducing features

AIM: To examine the effects of the IDR approach on physiological and functional swallowing outcomes in adults with neurogenic dysphagia.

RESULTS: Effective in improving PAS scores and level of oral intake. Of 5 patients who were NPO, 2 progressed to total oral diet and 2 to partial oral nutrition. QOL significantly improved at 4-week follow-up. No adverse events.

CASE STUDIES
Protected Health Information Removed From Handout