



**MSHA**  
MICHIGAN SPEECH LANGUAGE HEARING  
ASSOCIATION

2021 MSHA Annual Conference • March 18-20, 2021 • VIRTUAL CONFERENCE  
*Propelling the Professions into the Future: Connecting Research & Clinical Practice*

**Current and Future Directions in Swallowing Assessment and Treatment: Standardized Protocols and Cross-System Approaches**

**PART II**


**Bonnie Martin-Harris, Ph.D., CCC-SLP, BCS-S**  
Alice Gabrielle Twight Professor, Roxelyn and Richard Pepper Department of Communication Sciences Disorders, Associate Dean for Academic Affairs, School of Communication




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**Support & Disclosures**


- Principal Investigator, VA RR&D, 1I01RX002352-01A1, Clinical Impact of Respiratory Swallow Training on Refractory Dysphagia in OP HNC, 2018-2022
- Principal Investigator, NIH/NIDCD, 2K24DC12801-07, Data Science Applications in Communication and Swallowing Disorders, 2020-2024
- Co-Investigator (Principal Investigator: Shuai Xu, MD) NIH/STTR, R41AG062023-01, A Therapeutic Wearable Sensor for Dysphagia, 2018-2022
- Co-Investigator (Principal Investigator: Heather Bonilha, PhD), NIH/NIDDK R01DK122975-01, Excess Radiation Exposure in Infants and Children from Videofluoroscopic Swallow Studies
- Machine Vision Fellowship Grant, Bracco Diagnostics, Inc., 2019-2021
- Copyright royalties from Northern Speech Services through agreement with Medical University of South Carolina
- U.S. provisional patent; Feb 16, 2018: US 62/710,324. Inventors: Shuai Xu, Kun Lee, Angela Roberts, Bonnie Martin-Harris, John Rogers.
- Salary from Northwestern University
- Salary from Edward Hines, Jr. VA Hospital




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**Afternoon Session Agenda**

- 12:30 – 1:45 Grand Rounds: Integration of Best Practice in Standardized Assessment and Swallowing Treatment
- 1:45 – 2:00 BREAK
- 2:00 – 3:00 Fundamentals of Respiratory-Swallowing Coordination: Impact on Swallowing Function and Impairment
- 3:00 – 3:30 Enhancing the Reliability of Swallowing Measures: Big Data, AI, Machine Vision and Wearable Sensors
- 3:30 – 3:45 Final Remarks, Questions and Discussion



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**Grand Rounds: Integration of Best Practice in Standardized Assessment and Swallowing Treatment**

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**History of Present Illness**

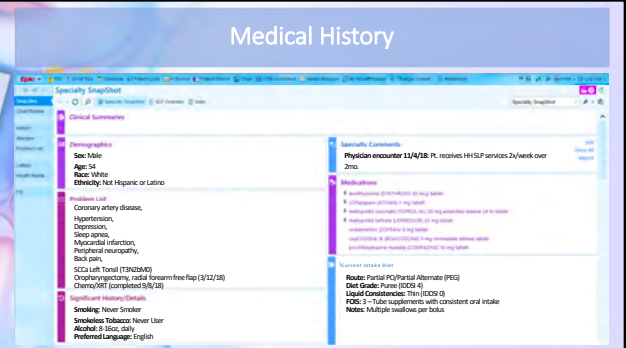
For Modified Barium Swallow Study Date: 11/4/2018

**Rx** The patient is a 54yo male referred with dysphagia following to recent resection of left tonsil SCCa with reconstruction. He reports limited PO intake of "baby food" and uses PEG to maintain nutrition. He reports coughing and choking with PO intake and the need for multiple swallows for each bite. No recent PNA. Receives home health SLP services. Please perform MBSS and provide rees.

Dr. Victor Bolus  
Substitution Permitted Dispense as Written  
DEA No. BC0025631689

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**Medical History**



**Specialty Snapshot**

**Demographics**  
Sex: Male  
Age: 54  
Race: White  
Ethnicity: Not Hispanic or Latino

**Medications List**  
Coronary artery disease  
Hypertension  
Depression  
Sleep apnea  
Myocardial infarction  
Periparturient neuropathy  
Back pain  
Sicca (left tonsil (T3N2M0))  
Oropharyngectomy, radical forearm free flap (3/12/18)  
Chemotherapy (completed 9/2/19)

**Significant History Details**  
Smoking: Never Smoker  
Smoking: Tobacco: Never User  
Alcohol: 8 16oz. daily  
Preferred Language: English

**Physician encounter 11/4/18** Pt. receives 145LP-panicles 2x/week over 21mo.

**Medications**  
• Ondansetron 4mg tablets 10 mg tablet  
• Ceftriaxone 500mg 1 mg tablet  
• Metoprolol succinate (TOPROL XL) 50 mg extended release (1x to twice)  
• Metoprolol succinate (TOPROL XL) 50 mg tablet  
• Lisinopril 20 (LISINAP) 4 mg tablet  
• Aspirin 81 (ASA) 81mg immediate release tablet  
• Propofol 1% (DIPRIVAL) 100 mg vial  
• Propofol 1% (DIPRIVAL) 100 mg vial

**Current intake diet**  
Route: Partial PO/Partial Alternate (PEG)  
Diet Grade: Pure (ECS 4)  
Liquid Consistencies: Thin (ECS 3)  
FDS: 1 - Thin supplements with consistent oral intake  
Notes: Multiple swallows per bolus

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### MBSImp Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	1 Escape to interlabial space.
2 Tongue Control/Bolus Hold	(0-3)	3 Posterior escape of greater than half of bolus
3 Bolus Prep/Mastication	(0-3)	NA Solid not presented secondary to pharyngeal clearance concerns
4 Bolus Transport/Lingual Motion	(0-4)	2 Slowed tongue motion
5 Oral Residue	(0-4)	2 Collection of residue remaining.
6 Initiation of Pharyngeal Swallow	(0-4)	3 Occurred when the bolus head was in the pyriform sinuses.
7 Soft Palate Elevation	(0-4)	0 No bolus between soft palate and posterior pharyngeal wall
8 Laryngeal Elevation	(0-3)	1 Partial superior movement of thyroid cartilage/partial approximation of arytenoids to epiglottic petiole.
9 Anterior Hyoid Excursion	(0-2)	2 Absent.
10 Epiglottic Movement	(0-2)	2 No inversion
11 Laryngeal Vestibular Closure	(0-2)	1 Incomplete; narrow column air/contrast in laryngeal vestibule
12 Pharyngeal Stripping Wave	(0-2)	1 Partial
13 Pharyngeal Contraction	(0-3)	3 Bilateral bulging
14 Pharyngoesophageal Segment Opening	(0-3)	1 Partial distension/partial duration; partial obstruction of flow
15 Tongue Base Retraction	(0-4)	3 Wide column of contrast or air between tongue base and posterior pharyngeal wall
16 Pharyngeal Residue	(0-4)	4 Minimal to no pharyngeal clearance
17 Esophageal Clearance (upright)	(0-4)	2 Esophageal retention with retrograde flow.

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### MBSImp Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	1 Escape to interlabial space.
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### PAS Results

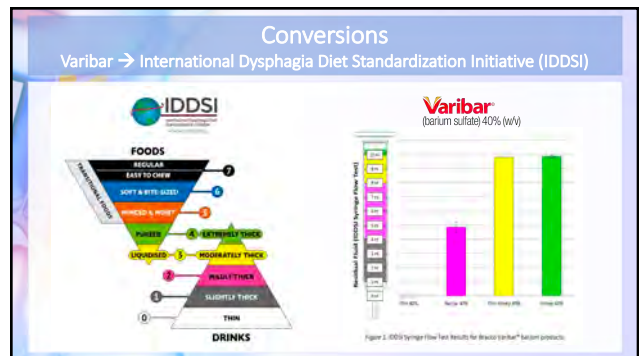
Varibar Task	IDDS Level	CURRENT Score and Descriptor
Sml Thin trial 1	0 - Thin	1 Contrast did not enter the airway
Sml Thin trial 2	0 - Thin	7 Contrast entered the airway, passed below the vocal folds, and was not ejected despite effort
Cup Sip (20mL) Thin	0 - Thin	3 Contrast entered the airway, remained above the vocal folds, and was not ejected from the airway.
Sequential (40mL) Thin	0 - Thin	3 Contrast entered the airway, remained above the vocal folds, and was not ejected from the airway.
Sml Nectar	2 - Mildly Thick	3 Contrast entered the airway, remained above the vocal folds, and was not ejected from the airway.
Cup Sip (20mL) Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
Sequential (40mL) Nectar	2 - Mildly Thick	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sml Thin Honey	3 - Moderately Thick	1 Contrast did not enter the airway
Sml Pudding	4 - Puree	1 Contrast did not enter the airway
1/2 Shortbread Cookie (1/2x1/2x1/2)	5-7 - Transitional Foods	NA Contrast did not enter the airway

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### PAS Results

Varibar Task	IDDS Level	CURRENT Score and Descriptor
Sml Thin trial 1	0 - Thin	1 Contrast did not enter the airway
Sml Thin trial 2	0 - Thin	7 Contrast entered the airway, passed below the vocal folds, and was not ejected despite effort
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1/2 Shortbread Cookie (1/2x1/2x1/2)	5-7 - Transitional Foods	NA Contrast did not enter the airway

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### Targeted Intervention Plan

<p><b>INTAKE RECOMMENDATIONS</b></p> <ul style="list-style-type: none"> <li>Route: Partial PO/PEG</li> <li>Food Grade: IDDSI 3 - Liquidized</li> <li>Liquid Grade: IDDSI 2 - Mildly Thick</li> </ul> <p><b>COMPENSATIONS</b></p> <ul style="list-style-type: none"> <li>Super-supraglottic swallow</li> <li>Head rotation</li> <li>Effortful swallow</li> </ul> <p><b>RETRAINING</b></p> <ul style="list-style-type: none"> <li>McNeil Dysphagia Therapy Program</li> </ul>	<p><b>PHYSIOLOGIC TARGETS</b></p> <ul style="list-style-type: none"> <li>Component 2: Tongue Control/Bolus Hold</li> <li>Component 6: Initiation of Pharyngeal Swallow</li> <li>Component 9: Anterior Hyoid Excursion</li> <li>Component 11: Laryngeal Vestibular Closure</li> <li>Component 13: Pharyngeal Contraction</li> <li>Component 15: Tongue Base Retraction</li> </ul> <p><b>TIME FRAME</b></p> <ul style="list-style-type: none"> <li>Total Duration: 3 weeks</li> <li>Structured Sessions: 1 hr, 5x per week</li> </ul> <p><b>DEVICES/BIOFEEDBACK</b></p> <ul style="list-style-type: none"> <li>None</li> </ul>
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### McNeill Dysphagia Therapy Program (MDTP)

- Systematic and intensive program based on exercise principles.
  - Error based learning → individualized on perturbation → intense, repetitive swallowing
- Uses food hierarchy to advance patient towards more "normal" eating behaviors – advancing safe, oral intake.
- Validated clinical and instrumental assessments to monitor patient performance and inform clinical decisions.
- Effective with long standing, severe swallowing problems.



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Volume 91, Number 12, December 2010

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### Targeted Intervention Plan

<p><b>INTAKE RECOMMENDATIONS</b></p> <ul style="list-style-type: none"> <li>Route: Partial PO/PEG</li> <li>Food Grade: IDDSI 3 - Liquidized</li> <li>Liquid Grade: IDDSI 2 - Mildly Thick</li> </ul> <p><b>COMPENSATIONS</b></p> <ul style="list-style-type: none"> <li>Super-supraglottic swallow</li> <li>Head rotation</li> <li>Effortful swallow</li> </ul> <p><b>RETRAINING</b></p> <ul style="list-style-type: none"> <li>McNeil Dysphagia Therapy Program</li> </ul>	<p><b>PHYSIOLOGIC TARGETS</b></p> <ul style="list-style-type: none"> <li>Component 2: Tongue Control/Bolus Hold</li> <li>Component 6: Initiation of Pharyngeal Swallow</li> <li>Component 9: Anterior Hyoid Excursion</li> <li>Component 11: Laryngeal Vestibular Closure</li> <li>Component 13: Pharyngeal Contraction</li> <li>Component 15: Tongue Base Retraction</li> </ul> <p><b>TIME FRAME</b></p> <ul style="list-style-type: none"> <li>Total Duration: 3 weeks</li> <li>Structured Sessions: 1 hr, 5x per week</li> </ul> <p><b>DEVICES/BIOFEEDBACK</b></p> <ul style="list-style-type: none"> <li>None</li> </ul>
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### Targeted Intervention Plan

**Long-Term Goal:**  
The patient will meet nutritional needs by mouth with a puree diet (IDDSI 4) and thin liquids (IDDSI 0) without the use of compensatory strategies with improved pharyngeal clearance (MBSImP Component 5 scores ≤2) and airway protection (PAS scores ≤2) on MBS following 6 weeks of treatment.

**Short-Term Goals (Retraining):**

- The patient will maintain a tongue to palatal seal during bolus hold to prevent anterior spillage of food and liquids prior to productive bolus transport.
- The patient will achieve timely initiation of the pharyngeal swallow with the head of the bolus at the angle of the ramus at the time of first brisk hyoid movement to prevent penetration of liquids and foods.
- The patient will achieve complete laryngeal vestibular closure to improve airway protection
- The patient will increase PES opening and duration to facilitate bolus passage into the esophagus.
- The patient will increase pharyngeal stripping wave, tongue base retraction and pharyngeal contraction to improve pressure generation along the tail of the bolus for complete pharyngeal clearance.

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### Targeted Intervention Plan

**Short-Term Goals (Compensation):**

- The patient will implement a super-supraglottic swallow to achieve laryngeal vestibular closure prior to the swallow and efficiently expectorate residue remaining in the laryngeal vestibule post-swallow.
- The patient will effectively utilize head rotation with head flexion to increase pharyngeal pressures facilitating pharyngeal clearance.
- The patient will effectively utilize an effortful swallow to increase the extent and duration of pharyngeal pressures to improve pharyngeal clearance of liquids and foods.

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### Targeted Intervention Plan

**MDTP Treatment Objectives:**  
The patient will swallow 5mL of nectar thick liquid (IDDSI 2) without clinical indicators of aspiration or need to expectorate on 8 out of 10 attempts with moderate cues.

**Swallow Technique:**

- Place the bolus mouth, close mouth, breathe through nose, swallow hard and fast with a single attempt
- Keep mouth closed, inhale gently via the nose, and clear throat
- Repeat until bolus is swallowed or expectorated

**Preset Food Hierarchy**

- Range: Ice chips → foods of patient's preference
- Begin with highest level that did not cause aspiration or expectoration on VFSS
- Increase volume first, then viscosity

**Successful Swallow**

- Absence of food expectoration or clinical indicators of aspiration on 8 of 10 attempts
- If patient demonstrates clinical indicators of aspiration on 3/5 swallows, revert to next-lower level on hierarchy.

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### History of Present Illness

For **Modified Barium Swallow Study** Date **1/13/2018**

**Rx** Pt. is a 65 year-old male with metastatic thymic carcinoma, stage IV. He is undergoing palliative radiation. He reports dysphagia to liquids. He describes his swallowing problem as coughing and choking with thin liquids. This is worse when rate of ingestion is increased. No difficulty with solids. No recent PNA. Please eval and tx.

Dr. \_\_\_\_\_ Substitution Permitted \_\_\_\_\_ Dispense as Written  
 Dr. **Emma DeGuttive**  
 DEA No: **BC00285691**

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### Medical History

Specialty Snapshot

**Clinical Summaries**

**Demographics**  
 Sex: Male  
 Age: 65  
 Race: White  
 Ethnicity: Not Hispanic or Latino

**Medication List**  
 Metastatic thymic carcinoma  
 Hypertension  
 Asthma  
 Lumbar spinal fusion (2/23/2002)

**Significant History (Details)**  
 Smoking: Former Smoker (Quit Date: 6/17/1987)  
 Smoking: Tobacco: Never Use  
 Alcohol: 0.6 - 1.2 oz of alcohol/week  
 Preferred Language: English

**Specialty Comments**

**Medications**  
 • Pantoprazole (PANTOPROZOL) 40 mg tablet  
 • Lidocaine (LIDOCAINE) 1 mg tablet  
 • Metoprolol succinate (TOPROL XL) 50 mg controlled-release (24 hr tablet)  
 • Hydrocodone bitartrate (HYDROCODONE) 5 mg tablet  
 • Insulin (INSULIN) 4 mg tablet  
 • Reproductive health (ORAL CONTRACEPTION) 0.01 mg tablet

**Current intake diet**  
 Route: PO  
 Diet grade: Regular (ICD9: 7)  
 Liquid Consistency: Thin (ICD9: 0)  
 FODS: - Typical oral intake with no restrictions  
 Notes: N/A

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### Modified Barium Swallow Study

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	<b>1</b> Resulted in interlabial escape, without progression to the anterior lip.
2 Tongue Control/Bolus Hold	(0-3)	<b>2</b> Resulted in posterior escape of less than half of the bolus.
3 Bolus Prep/Mastication	(0-3)	<b>0</b> Resulted in timely and efficient chewing and mashing.
4 Bolus Transport/Lingual Motion	(0-4)	<b>3</b> Was with repetitive/disorganized motion of the tongue.
5 Oral Residue	(0-4)	<b>1</b> Was a trace, being oral structures.
6 Initiation of Pharyngeal Swallow	(0-4)	<b>3</b> Occurred when the bolus head was in the pyriform sinuses.
7 Soft Palate Elevation	(0-4)	<b>1</b> Allowed a trace column of contrast or air between the soft palate and the pharyngeal wall.
8 Laryngeal Elevation	(0-3)	<b>1</b> Partial superior movement of thyroid cartilage/partial approximation of arytenoids to epiglottic petiole.
9 Anterior Hyoid Excursion	(0-2)	<b>1</b> Demonstrated partial anterior movement.
10 Epiglottic Movement	(0-2)	<b>0</b> Resulted in complete inversion.
11 Laryngeal Vestibular Closure	(0-2)	<b>0</b> Complete, as indicated by no air or contrast within the laryngeal vestibule at the height of the swallow.
12 Pharyngeal Stripping Wave	(0-2)	<b>1</b> Was present, but diminished.
13 Pharyngeal Contraction	(0-3)	<b>0</b> Was complete.
14 Pharyngoesophageal Segment Opening	(0-3)	<b>1</b> Demonstrated partial distension/partial duration, with partial obstruction of bolus flow.
15 Tongue Base Retraction	(0-4)	<b>2</b> Narrow column of contrast or air between the retracted tongue base and the posterior pharyngeal wall.
16 Pharyngeal Residue	(0-4)	<b>2</b> Was a collection of residue within or on pharyngeal structures.
17 Esophageal Clearance (upright)	(0-4)	<b>0</b> Was complete, with only a coating of contrast, if any.

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	<b>1</b> Resulted in interlabial escape, without progression to the anterior lip.
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15 Tongue Base Retraction	(0-4)	<b>2</b> Narrow column of contrast or air between the retracted tongue base and the posterior pharyngeal wall.
16 Pharyngeal Residue	(0-4)	<b>2</b> Was a collection of residue within or on pharyngeal structures.
17 Esophageal Clearance (upright)	(0-4)	<b>0</b> Was complete, with only a coating of contrast, if any.

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### PAS Results

Variflow Task	ICD9 Level	CURRENT Score and Descriptor
5mL Thin trial 1	0 - Thin	<b>2</b> Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
5mL Thin trial 2	0 - Thin	<b>1</b> Contrast did not enter the airway.
Cup Sip (20mL) Thin	0 - Thin	<b>2</b> Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sequential (40mL) Thin	0 - Thin	<b>2</b> Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
5mL Nectar	2 - Mildly Thick	<b>1</b> Contrast did not enter the airway.
Cup Sip (20mL) Nectar	2 - Mildly Thick	<b>1</b> Contrast did not enter the airway.
Sequential (40mL) Nectar	2 - Mildly Thick	<b>1</b> Contrast did not enter the airway.
5mL Thin Honey	3 - Moderately Thick	<b>1</b> Contrast did not enter the airway.
5mL Pudding	4 - Puree	<b>1</b> Contrast did not enter the airway.
% Shortbread Cookie ("VXZP")	5-7 - Transitional Foods	<b>1</b> Contrast did not enter the airway.

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### PAS Results

Verbal Task	IDDSI Level	CURRENT Score and Descriptor
Sml Thin trial 1	0 - Thin	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sml Thin trial 2	0 - Thin	1 Contrast did not enter the airway
Cup Sip (20mL) Thin	0 - Thin	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sequential (40mL) Thin	0 - Thin	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sml Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
Cup Sip (20mL) Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
Sequential (40mL) Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
Sml Thin Honey	3 - Moderately Thick	1 Contrast did not enter the airway
Sml Pudding	4 - Puree	1 Contrast did not enter the airway
1/2 Shortbread Cookie (1"x1"x2")	5-7 - Transitional Foods	1 Contrast did not enter the airway

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### Targeted Intervention Plan

<b>INTAKE RECOMMENDATIONS</b> <ul style="list-style-type: none"> <li>Route: PO</li> <li>Food Grade: IDDSI 7 - Regular</li> <li>Liquid Grade: IDDSI 0 - Thin</li> </ul>	<b>PHYSIOLOGIC TARGETS</b> <ul style="list-style-type: none"> <li>Component 6: Initiation of the Pharyngeal Swallow</li> </ul>
<b>COMPENSATIONS</b> <ul style="list-style-type: none"> <li>N/A</li> </ul>	<b>TIME FRAME</b> <ul style="list-style-type: none"> <li>Total Duration: 3 weeks</li> <li>Structured Sessions: 1 hr, 1x per week</li> <li>Independent Practice: All swallow tasks</li> </ul>
<b>RETRAINING</b> <ul style="list-style-type: none"> <li>Skill training</li> </ul>	<b>DEVICES/BIOFEEDBACK</b> <ul style="list-style-type: none"> <li>Endoscopy</li> <li>Simulated models</li> </ul>

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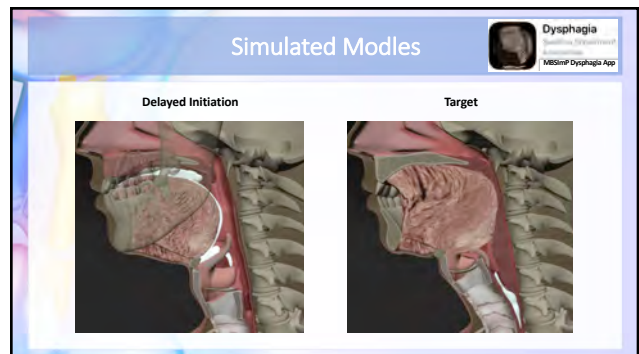
### Targeted Intervention Plan

**Long-Term Goal:**  
*The patient will meet nutritional needs by mouth with a regular diet (IDDSI 7) and thin liquids (IDDSI 0) without coughing and choking within 6 weeks of treatment.*

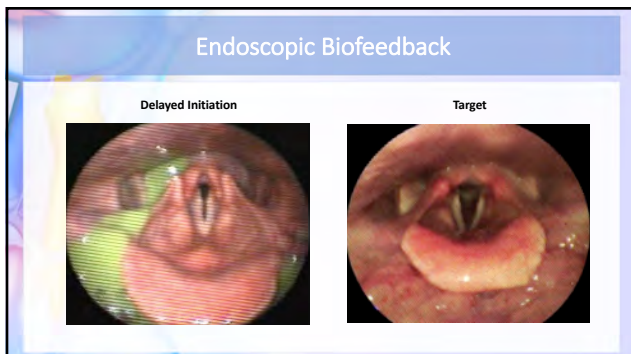
**Short-Term Goal:**  
*The patient will achieve timely initiation of the pharyngeal swallow, indicated by no advancement of the leading edge of the bolus beyond the valleculae on endoscopy.*

**Treatment Objective:**  
*The patient will initiate a pharyngeal swallow prior to the leading edge of the bolus advancing beyond the valleculae during endoscopic biofeedback on 8 out of 10 trials with moderate cues.*

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### History of Present Illness

7/4/18	72 yo AAF s/p kidney transplant in 2/11 2° end stage renal disease due to hypertension. Post-operative course complicated by ICU admission for septic shock and left lower lobe PNA requiring intubation. Re-admitted to the hospital with increased lethargy, decreased PO intake, weight loss, disorientation, confusion, and aphonia. Found to have recurrent left lower lobe PNA and left true vocal fold paralysis of unknown etiology. Failed RN BS swallow screen. SLP consulted for BS swallow eval at which time the pt was deemed appropriate for MBS.	LING WALL, MD 6-3455
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### Medical History

**Specialty Snapshot**

**Clinical Summaries**

**Demographics**  
 Sex: Female  
 Age: 72  
 Race: African American  
 Ethnicity: Not Hispanic or Latino

**Current Medications**  
 PT encounter 6/24/18: Pt. lives in a rehab facility. ADLs completed with min assistance.

**Medications**  
 • Aspirin  
 • Enalapril (40)  
 • Iron supplement  
 • Lisinopril (10 mg twice daily)  
 • Sodium bicarbonate  
 • Vitamin D

**Recent Tests**  
 Route: PO  
 Diet Grade: IDDSI 6 - Soft and Bite Sized  
 Liquid Consistency: IDDSI 2 - Mildly Thick  
 FOS: 5. Total oral intake of multiple consistencies requiring special preparation  
 Note: NPO following clinical swallow eval pending MBS

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### Baseline Laryngeal Videostroboscopy

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### Baseline Modified Barium Swallow Study

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	<b>4</b> Profuse escape through open lips
2 Tongue Control/Bolus Hold	(0-3)	<b>1</b> Escape to lateral cavity and/or floor of mouth
3 Bolus Prep/Mastication	(0-3)	<b>NA</b> Solid not given secondary to safety concerns related to pharyngeal clearance
4 Bolus Transport/Lingual Motion	(0-4)	<b>3</b> Was with repetitive/disorganized motion of the tongue.
5 Oral Residue	(0-4)	<b>4</b> Minimal to no clearance
6 Initiation of Pharyngeal Swallow	(0-4)	<b>2</b> Occurred when the leading edge of the bolus was at the laryngeal surface of the epiglottis
7 Soft Palate Elevation	(0-4)	<b>3</b> Escape to nasal cavity
8 Laryngeal Elevation	(0-3)	<b>2</b> Minimal superior movement of thyroid cartilage, min approximation of arytenoids to epiglottic petiole
9 Anterior Hyoid Excursion	(0-2)	<b>1</b> Partial
10 Epiglottic Movement	(0-2)	<b>2</b> No inversion
11 Laryngeal Vestibular Closure	(0-2)	<b>2</b> None, as indicated by wide column of air/contrast in the laryngeal vestibule at the height of the swallow.
12 Pharyngeal Stripping Wave	(0-2)	<b>2</b> Absent
13 Pharyngeal Contraction	(0-3)	<b>NA</b> AP view not obtained
14 Pharyngoesophageal Segment Opening	(0-3)	<b>3</b> No distension with total obstruction of bolus flow.
15 Tongue Base Retraction	(0-4)	<b>3</b> Wide column of contrast or air between the retracted tongue base and the posterior pharyngeal wall.
16 Pharyngeal Residue	(0-4)	<b>4</b> Minimal to no pharyngeal clearance
17 Esophageal Clearance (upright)	(0-4)	<b>NA</b> AP view not obtained

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	<b>4</b> Profuse escape through open lips
2 Tongue Control/Bolus Hold	(0-3)	<b>1</b> Escape to lateral cavity and/or floor of mouth
3 Bolus Prep/Mastication	(0-3)	<b>NA</b> Solid not given secondary to safety concerns related to pharyngeal clearance
4 Bolus Transport/Lingual Motion	(0-4)	<b>3</b> Was with repetitive/disorganized motion of the tongue.
5 Oral Residue	(0-4)	<b>4</b> Minimal to no clearance
6 Initiation of Pharyngeal Swallow	(0-4)	<b>2</b> Occurred when the leading edge of the bolus was at the laryngeal surface of the epiglottis
7 Soft Palate Elevation	(0-4)	<b>3</b> Escape to nasal cavity
8 Laryngeal Elevation	(0-3)	<b>2</b> Minimal superior movement of thyroid cartilage, min approximation of arytenoids to epiglottic petiole
9 Anterior Hyoid Excursion	(0-2)	<b>1</b> Partial
10 Epiglottic Movement	(0-2)	<b>2</b> No inversion
11 Laryngeal Vestibular Closure	(0-2)	<b>2</b> None, as indicated by wide column of air/contrast in the laryngeal vestibule at the height of the swallow.
12 Pharyngeal Stripping Wave	(0-2)	<b>2</b> Absent
13 Pharyngeal Contraction	(0-3)	<b>NA</b> AP view not obtained
14 Pharyngoesophageal Segment Opening	(0-3)	<b>3</b> No distension with total obstruction of bolus flow.
15 Tongue Base Retraction	(0-4)	<b>3</b> Wide column of contrast or air between the retracted tongue base and the posterior pharyngeal wall.
16 Pharyngeal Residue	(0-4)	<b>4</b> Minimal to no pharyngeal clearance
17 Esophageal Clearance (upright)	(0-4)	<b>NA</b> AP view not obtained

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### PAS Results

Variflow Task	IDDSI Level	CURRENT Score and Descriptor
S/mL Thin trial 1	0 - Thin	<b>7</b> Contrast entered the airway, passed below the vocal folds, and was not ejected despite effort
S/mL Thin trial 2	0 - Thin	<b>NA</b> Not presented
Cup Slip (20mL) Thin	0 - Thin	<b>NA</b> Not presented
Sequential (40mL) Thin	0 - Thin	<b>NA</b> Not presented
S/mL Nectar	2 - Mildly Thick	<b>7</b> Contrast entered the airway, passed below the vocal folds, and was not ejected despite effort
Cup Slip (20mL) Nectar	2 - Mildly Thick	<b>NA</b> Not presented
Sequential (40mL) Nectar	2 - Mildly Thick	<b>NA</b> Not presented
S/mL Thin Honey	3 - Moderately Thick	<b>7</b> Contrast entered the airway, passed below the vocal folds, and was not ejected despite effort
S/mL Pudding	4 - Puree	<b>7</b> Contrast entered the airway, passed below the vocal folds, and was not ejected despite effort
1/2 Shortbread Cookie ("VIXZ")	5-7 - Transitional Foods	<b>NA</b> Not presented

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### PAS Results

Verbal Task	IDDS Level	CURRENT Score and Descriptor
5mL Thin trial 1	0 - Thin	<b>7</b> Contrast entered the airway, passed below the vocal folds, and was not ejected despite effort
5mL Thin trial 2	0 - Thin	<b>NA</b> Not presented
Cup Sip (20mL) Thin	0 - Thin	<b>NA</b> Not presented
Sequential (40mL) Thin	0 - Thin	<b>NA</b> Not presented
5mL Nectar	2 - Mildly Thick	<b>7</b> Contrast entered the airway, passed below the vocal folds, and was not ejected despite effort
Cup Sip (20mL) Nectar	2 - Mildly Thick	<b>NA</b> Not presented
Sequential (40mL) Nectar	2 - Mildly Thick	<b>NA</b> Not presented
5mL Thin Honey	3 - Moderately Thick	<b>7</b> Contrast entered the airway, passed below the vocal folds, and was not ejected despite effort
5mL Pudding	4 - Puree	<b>7</b> Contrast entered the airway, passed below the vocal folds, and was not ejected despite effort
1/2 Shortbread Cookie (1"x1"x2")	5-7 - Transitional Foods	<b>NA</b> Not presented

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### Targeted Intervention Plan

<b>INTAKE RECOMMENDATIONS</b> <ul style="list-style-type: none"> <li>Route: NPO/PEG</li> <li>Food Grade: NA</li> <li>Liquid Grade: NA</li> </ul>	<b>PHYSIOLOGIC TARGETS</b> <ul style="list-style-type: none"> <li>Component 8: Laryngeal Elevation</li> <li>Component 11: Laryngeal Vestibular Closure</li> <li>Component 12: Pharyngeal Stripping Wave</li> <li>Component 14: PES Opening</li> <li>Component 15: Tongue Base Retraction</li> </ul>
<b>RETRAINING</b> <ul style="list-style-type: none"> <li>Masako</li> <li>Effortful swallow</li> <li>Mendelsohn maneuver</li> <li>PhoRTE</li> </ul>	<b>TIME FRAME</b> <ul style="list-style-type: none"> <li>Total Duration: 12 weeks, 3x/week IP; 1x/week OP</li> <li>Structured Sessions: 30 mins IP; 1 hr OP</li> <li>Independent Practice: 5x each/5x daily</li> </ul>
<b>SURGICAL</b> <ul style="list-style-type: none"> <li>Suspension microlaryngoscopy with Radiesse injection into the vocal folds bilaterally</li> </ul>	<b>DEVICES/BIOFEEDBACK</b> <ul style="list-style-type: none"> <li>sEMG</li> </ul>

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### Targeted Intervention Plan

**Long-Term Goal:**

*The patient will meet nutritional needs by mouth with a puree diet (IDDSI 4) and thin liquids (IDDSI 0) with the use of an effortful and super-supraglottic swallow with improved pharyngeal clearance (MBSimP Component 5 scores ≤2) and airway protection (PAS scores ≤2) on MBSS following 12 weeks of treatment.*

**Short-Term Goals:**

- The patient will achieve complete laryngeal elevation and laryngeal vestibular closure to improve airway protection
- The patient will increase PES opening and duration to facilitate bolus passage into the esophagus.
- The patient will increase pharyngeal stripping wave and tongue base retraction to improve pressure generation along the tail of the bolus for complete pharyngeal clearance and prevention of retrograde flow into the nasal cavity.
- The patient will increase laryngeal elevation and tongue base retraction to facilitate complete epiglottic inversion.

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### Targeted Intervention Plan

**Treatment Objectives:**

Components 8: Laryngeal Elevation, 11: Laryngeal Vestibular Closure, 14: Pharyngeoesophageal Segment Opening

- The patient will achieve complete laryngeal elevation, laryngeal vestibular closure, and PES opening while performing the Mendelsohn maneuver as indirectly measured via sustained infrahyoid sEMG readings of >50uV for 5 seconds on 8 out of 10 trials with moderate cues.

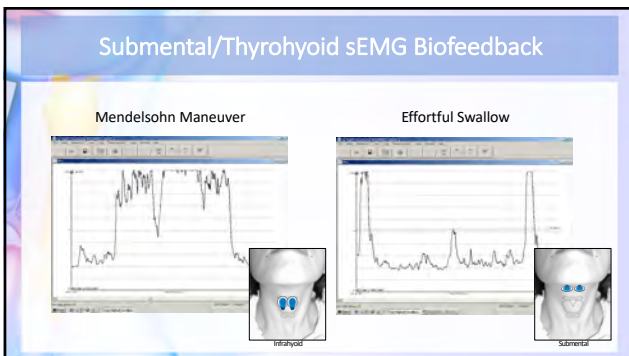
Component 12: Pharyngeal Stripping Wave

- The patient will recruit and increase contraction of the posterior pharyngeal wall while performing the Masako maneuver on 8 out of 10 trials with minimal cues.

Component 15: Tongue Base Retraction

- The patient will increase tongue base pressures while performing the effortful swallow as indirectly measured via submental sEMG readings of >50uV on 8 out of 10 trials with minimal cues.

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	Pre	Post-treatment Score and Descriptor
1 Lip Closure	(D-4)	4	3 Interlabial escape, no progression to anterior lip
2 Tongue Control/Bolus Hold	(D-3)	1	1 Escape to lateral cavity and/or floor of mouth
3 Bolus Prep/Mastication	(D-3)	NA	NA Solid not given secondary to safety concerns related to pharyngeal clearance
4 Bolus Transport/Lingual Motion	(D-4)	1	2 Slowed tongue motion
5 Oral Residue	(D-4)	4	2 Residue collection on oral structures
6 Initiation of Pharyngeal Swallow	(D-4)	2	1 Occurred when the leading edge of the bolus was in the valleculae
7 Soft Palate Elevation	(D-4)	3	0 Complete
8 Laryngeal Elevation	(D-3)	2	1 Partial superior movement of thyroid cartilage, partial approx of arytenoids to epiglottic petiole
9 Anterior Hyoid Excursion	(D-2)	1	1 Partial excursion
10 Epiglottic Movement	(D-2)	2	1 Partial inversion
11 Laryngeal Vestibular Closure	(D-2)	2	1 Incomplete, narrow column of air/contrast in the laryngeal vestibule at the height of the swallow
12 Pharyngeal Stripping Wave	(D-2)	2	1 Diminished
13 Pharyngeal Contraction	(D-3)	NA	3 Bilateral bulging
14 Pharyngoesophageal Segment Opening	(D-3)	3	1 Partial distension, partial duration, with partial obstruction of bolus flow
15 Tongue Base Retraction	(D-4)	3	2 Narrow column of contrast between the retracted tongue base and the posterior pharyngeal wall
16 Pharyngeal Residue	(D-4)	4	2 Collection of residue on pharyngeal structures
17 Esophageal Clearance (upright)	(D-4)	NA	1 Esophageal retention

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	Pre	Post-treatment Score and Descriptor
1 Lip Closure	(D-4)	4	1 Interlabial escape, no progression to anterior lip
2 Tongue Control/Bolus Hold	(D-3)	1	1 Escape to lateral cavity and/or floor of mouth
3 Bolus Prep/Mastication	(D-3)	NA	NA Solid not given secondary to safety concerns related to pharyngeal clearance
4 Bolus Transport/Lingual Motion	(D-4)	3	2 Slowed tongue motion
5 Oral Residue	(D-4)	4	2 Residue collection on oral structures
6 Initiation of Pharyngeal Swallow	(D-4)	2	1 Occurred when the leading edge of the bolus was in the valleculae
7 Soft Palate Elevation	(D-4)	3	0 Complete
8 Laryngeal Elevation	(D-3)	2	1 Partial superior movement of thyroid cartilage, partial approx of arytenoids to epiglottic petiole
9 Anterior Hyoid Excursion	(D-2)	1	1 Partial excursion
10 Epiglottic Movement	(D-2)	2	1 Partial inversion
11 Laryngeal Vestibular Closure	(D-2)	2	1 Incomplete, narrow column of air/contrast in the laryngeal vestibule at the height of the swallow
12 Pharyngeal Stripping Wave	(D-2)	2	1 Diminished
13 Pharyngeal Contraction	(D-3)	NA	3 Bilateral bulging
14 Pharyngoesophageal Segment Opening	(D-3)	3	1 Partial distension, partial duration, with partial obstruction of bolus flow
15 Tongue Base Retraction	(D-4)	3	2 Narrow column of contrast between the retracted tongue base and the posterior pharyngeal wall
16 Pharyngeal Residue	(D-4)	4	2 Collection of residue on pharyngeal structures
17 Esophageal Clearance (upright)	(D-4)	NA	1 Esophageal retention

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### PAS Results

Variable/Task	IDDSI Level	Current Score and Descriptor
Sml Thin trial 1	0 - Thin	7 1 Contrast did not enter the airway
Sml Thin trial 2	0 - Thin	NA 1 Contrast did not enter the airway
Cup Sip (20mL) Thin	0 - Thin	NA 6 Contrast entered the airway, passed below the vocal folds, and was ejected
Sequential (40mL) Thin	0 - Thin	NA NA Not presented
Sml Nectar	2 - Mildly Thick	7 1 Contrast did not enter the airway
Cup Sip (20mL) Nectar	2 - Mildly Thick	NA 1 Contrast did not enter the airway
Sequential (40mL) Nectar	2 - Mildly Thick	NA NA Not presented
Sml Thin Honey	3 - Moderately Thick	7 1 Contrast did not enter the airway
Sml Pudding	4 - Puree	7 1 Contrast did not enter the airway
1/2 Shortbread Cookie (1.5x1.5x1.5)	5-7 - Transitional Foods	NA NA Not presented

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### PAS Results

Variable/Task	IDDSI Level	Pre	Post-treatment Score and Descriptor
Sml Thin trial 1	0 - Thin	7	1 Contrast did not enter the airway
Sml Thin trial 2	0 - Thin	NA	1 Contrast did not enter the airway
Cup Sip (20mL) Thin	0 - Thin	NA	6 Contrast entered the airway, passed below the vocal folds, and was ejected
Sequential (40mL) Thin	0 - Thin	NA	NA Not presented
Sml Nectar	2 - Mildly Thick	7	1 Contrast did not enter the airway
Cup Sip (20mL) Nectar	2 - Mildly Thick	NA	1 Contrast did not enter the airway
Sequential (40mL) Nectar	2 - Mildly Thick	NA	NA Not presented
Sml Thin Honey	3 - Moderately Thick	7	1 Contrast did not enter the airway
Sml Pudding	4 - Puree	7	1 Contrast did not enter the airway
1/2 Shortbread Cookie (1.5x1.5x1.5)	5-7 - Transitional Foods	NA	NA Not presented

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### Targeted Intervention Plan

<p><b>INTAKE RECOMMENDATIONS</b></p> <ul style="list-style-type: none"> <li>Route: PO, PEG supplement per RD recs</li> <li>Food Grade: Pureed (IDDSI 4)</li> <li>Liquid Grade: Thin (IDDSI 0)</li> </ul>	<p><b>PHYSIOLOGIC TARGETS</b></p> <ul style="list-style-type: none"> <li>Component 8: Laryngeal Elevation</li> <li>Component 11: Laryngeal Vestibular Closure</li> <li>Component 12: Pharyngeal Stripping Wave</li> <li>Component 14: PES Opening</li> <li>Component 15: Tongue Base Retraction</li> </ul>
<p><b>RETRAINING</b></p> <ul style="list-style-type: none"> <li>Masako</li> <li>Effortful swallow</li> <li>Mendelsohn maneuver</li> </ul>	<p><b>TIME FRAME</b></p> <ul style="list-style-type: none"> <li>Independent Practice: 10x each/3x daily</li> </ul>
<p><b>COMPENSATION</b></p> <ul style="list-style-type: none"> <li>Effortful swallow</li> <li>Super-supraglottic swallow</li> </ul>	<p><b>SURGICAL</b></p> <ul style="list-style-type: none"> <li>Consultation and monitoring with RD for PEG weaning and removal.</li> </ul>

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### History of Present Illness

For **Modified Barium Swallow Study** Date **8/1/2019**

**Rx** The patient is a 64yo m with a hx of PD (Stage 2). S/p excision of right vallecular cyst last year. Hx of reflux, currently taking Omeprazole 40 mg BID. Reports the sensation of "food getting stuck" and describes what may be nasal regurgitation when drinking large volumes of liquid. Pt. is edentulous and refuses dentures. Currently tolerating soft foods (e.g. mashed potatoes, smashed noodles). Please perform VFSS.

Dr. **Val Eculac**  
 Substitution Permitted Dispense as Written  
 DEA No: **BC00678911**

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### Medical History

Specialty Snapshot

**Clinical Summaries**

**Demographics**  
 Sex: Male  
 Age: 64  
 Race: Black or African American  
 Ethnicity: Not Hispanic or Latino

**Medication List**  
 Protonix (Stage 2)  
 Obstructive sleep apnea  
 COPD  
 Right vallecular benign cyst excision (1/23/2018)

**Specialty Comments**  
 OTO encounter (3/14/19) Mild dysarthria and wet vocal quality. Vocal fold atrophy observed on videostroboscopy. Referral to speech for CVT/LOU.

**Medications**  
 Protonix (Esomeprazole) 40 mg tablet  
 Omeprazole (Esomeprazole) 40 mg tablet  
 Omeprazole (Esomeprazole) 40 mg tablet  
 Omeprazole (Esomeprazole) 40 mg tablet  
 Omeprazole (Esomeprazole) 40 mg tablet

**Current Status**  
 Route: PO  
 Diet Grade: EGG 4 - Puree  
 Liquid Consistency: EGG 0 - Thin  
 FOS: 1 - Trial and error of multiple consistencies requiring special preparation  
 Notes: N/A

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### Modified Barium Swallow Study

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	1 Resulted in interlabial escape, without progression to the anterior lip.
2 Tongue Control/Bolus Hold	(0-3)	1 Escape to lateral buccal cavity/floor of mouth.
3 Bolus Prep/Mastication	(0-3)	1 Patient refusal
4 Bolus Transport/Lingual Motion	(0-4)	2 Slowed tongue motion.
5 Oral Residue	(0-4)	2 Residue collection on oral structures.
6 Initiation of Pharyngeal Swallow	(0-4)	3 Occurred when the bolus head was in the pyriform sinuses.
7 Soft Palate Elevation	(0-4)	3 Escape to nasal cavity
8 Laryngeal Elevation	(0-3)	1 Partial superior movement of thyroid cartilage/partial approximation of arytenoids to epiglottic petiole.
9 Anterior Hyoid Excursion	(0-2)	1 Demonstrated partial anterior movement.
10 Epiglottic Movement	(0-2)	1 Resulted in partial inversion.
11 Laryngeal Vestibular Closure	(0-2)	1 Incomplete; narrow column air/contrast in laryngeal vestibule
12 Pharyngeal Stripping Wave	(0-2)	1 Was present, but diminished.
13 Pharyngeal Contraction	(0-3)	1 Was incomplete with bilateral bulging.
14 Pharyngoesophageal Segment Opening	(0-3)	1 Demonstrated partial distension/partial duration, with partial obstruction of bolus flow.
15 Tongue Base Retraction	(0-4)	2 Narrow column of contrast or air between the retracted tongue base and the posterior pharyngeal wall.
16 Pharyngeal Residue	(0-4)	2 Was a collection of residue within or on pharyngeal structures.
17 Esophageal Clearance (upright)	(0-4)	1 Esophageal retention

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	1 Resulted in interlabial escape, without progression to the anterior lip.
2 Tongue Control/Bolus Hold	(0-3)	1 Escape to lateral buccal cavity/floor of mouth.
3 Bolus Prep/Mastication	(0-3)	1 Patient refusal
4 Bolus Transport/Lingual Motion	(0-4)	2 Slowed tongue motion.
5 Oral Residue	(0-4)	2 Residue collection on oral structures.
6 Initiation of Pharyngeal Swallow	(0-4)	3 Occurred when the bolus head was in the pyriform sinuses.
7 Soft Palate Elevation	(0-4)	3 Escape to nasal cavity
8 Laryngeal Elevation	(0-3)	1 Partial superior movement of thyroid cartilage/partial approximation of arytenoids to epiglottic petiole.
9 Anterior Hyoid Excursion	(0-2)	1 Demonstrated partial anterior movement.
10 Epiglottic Movement	(0-2)	1 Resulted in partial inversion.
11 Laryngeal Vestibular Closure	(0-2)	1 Incomplete; narrow column air/contrast in laryngeal vestibule
12 Pharyngeal Stripping Wave	(0-2)	1 Was present, but diminished.
13 Pharyngeal Contraction	(0-3)	1 Was incomplete with bilateral bulging.
14 Pharyngoesophageal Segment Opening	(0-3)	1 Demonstrated partial distension/partial duration, with partial obstruction of bolus flow.
15 Tongue Base Retraction	(0-4)	2 Narrow column of contrast or air between the retracted tongue base and the posterior pharyngeal wall.
16 Pharyngeal Residue	(0-4)	2 Was a collection of residue within or on pharyngeal structures.
17 Esophageal Clearance (upright)	(0-4)	1 Esophageal retention

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### PAS Results

Variflow Task	IDDSI Level	CURRENT Score and Descriptor
5mL Thin trial 1	0 - Thin	1 Contrast did not enter the airway
5mL Thin trial 2	0 - Thin	1 Contrast did not enter the airway
Cup Sip (20mL) Thin	0 - Thin	1 Contrast did not enter the airway
Sequential (40mL) Thin	0 - Thin	5 Contrast entered the airway, contacted the vocal folds, and was not ejected from the airway.
5mL Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
Cup Sip (20mL) Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
Sequential (40mL) Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
5mL Thin Honey	3 - Moderately Thick	1 Contrast did not enter the airway
5mL Pudding	4 - Puree	1 Contrast did not enter the airway
% Shortbread Cookie (1"x1"x2")	5-7 - Transitional Foods	NA

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### PAS Results

Verbal Task	IDDSI Level	CURRENT Score and Descriptor
5mL Thin trial 1	0 - Thin	1 Contrast did not enter the airway
5mL Thin trial 2	0 - Thin	1 Contrast did not enter the airway
Cup Sip (20mL) Thin	0 - Thin	1 Contrast did not enter the airway
Sequential (40mL) Thin	0 - Thin	5 Contrast entered the airway, contacted the vocal folds, and was not ejected from the airway.
5mL Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
Cup Sip (20mL) Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
Sequential (40mL) Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
5mL Thin Honey	3 - Moderately Thick	1 Contrast did not enter the airway
5mL Pudding	4 - Puree	1 Contrast did not enter the airway
1/2 Shortbread Cookie (1"x1"x2")	5-7 - Transitional Foods	NA

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### Targeted Intervention Plan

<b>INTAKE RECOMMENDATIONS</b> <ul style="list-style-type: none"> <li>Route: PO</li> <li>Food Grade: IDDSI 5 - Minced &amp; Moist</li> <li>Liquid Grade: IDDSI 0 - Thin</li> </ul>	<b>PHYSIOLOGIC TARGETS</b> <ul style="list-style-type: none"> <li>Component 2: Bolus Transport Lingual Motion</li> <li>Component 12: Pharyngeal Stripping Wave</li> <li>Component 13: Pharyngeal Contraction</li> <li>Component 15: Tongue Base Retraction</li> </ul>
<b>COMPENSATIONS</b> <ul style="list-style-type: none"> <li>Control rate for thin (no sequential swallows)</li> <li>Effortful swallow</li> </ul>	<b>TIME FRAME</b> <ul style="list-style-type: none"> <li>Total Duration: 6 weeks, maintenance thereafter</li> <li>Structured Sessions: 1hr, 2x per week</li> <li>Independent Practice: 30 min, 2x per day</li> </ul>
<b>RETRAINING</b> <ul style="list-style-type: none"> <li>Effortful swallow</li> <li>Lingual strength training</li> </ul>	<b>DEVICES/BIOFEEDBACK</b> <ul style="list-style-type: none"> <li>Manometry</li> <li>TongueOmeter</li> </ul>

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### Targeted Intervention Plan

**Long-Term Goal:**  
*The patient will meet nutritional needs by mouth with a minced and moist diet (IDDSI 5) and thin liquids (IDDSI 0) without the use of dentures, achieving complete pharyngeal clearance and adequate airway protection during sequential drinking tasks (PAS ≤ 2) during repeat MBSS within 6 weeks of treatment.*

**Short-Term Goals:**

- 1) The patient will increase lingual strength and use integrated lingual movements to effectively break down a minced and moist bolus without the use of a dental appliance for safe and efficient transport through the oropharynx.
- 2) The patient will increase pharyngeal stripping, pharyngeal contraction and tongue base retraction to improve pressure generation along the tail of the bolus for complete pharyngeal clearance.

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### Targeted Intervention Plan

**Treatment Objectives:**

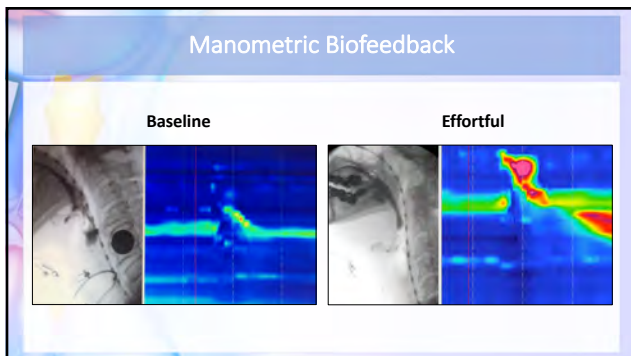
Component 2: Bolus Transport/Lingual Motion

- The patient will generate 60kpa with the tongue for 10 seconds using the TongueOmeter on 8 out of 10 trials with moderate cues.

Components 12: Pharyngeal Stripping Wave, 13: Pharyngeal Contraction, 15: Tongue Base Retraction

- The patient will generate pharyngeal contractile integral (PhCI) pressures above 300mmHg\*cm\*s during performance of an effortful swallow using a viscous bolus on 8 out of 10 trials with moderate cues.

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### History of Present Illness

For **Modified Barium Swallow Study** Date **6/19/2019**

**Rx** The patient is an 83yo f. Concern for aspiration. Chronic cough with recurrent lung infections over the past year. She endorses 28lb weight loss and poor appetite. She states that swallowing has become increasingly difficult/effortful and she has had to modify her diet to include milkshakes, soup and liquid only. She endorses a nonproductive cough that is exacerbated following meals. Please perform MBSS.

Dr. \_\_\_\_\_ Substitution Permitted \_\_\_\_\_ Dr. **Esoph McClearence**  
 Dispense as Written

DEA No: **BC0037248756**

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### Medical History

Specialty Snapshot

**Clinical Summaries**

**Demographics**  
 Sex: Female  
 Age: 83  
 Race: Native Hawaiian or Other Specific Islander  
 Ethnicity: Not Hispanic or Latino

**Medication List**  
 Sinus and collapse  
 Hypertension  
 Hypertension  
 Cognitive heart failure  
 Coronary artery disease  
 Blurred vision  
 Chronic rhinitis  
 Hysterectomy (1/23/2018)  
 Cardiac defibrillator placement (10/11/2006)

**Significant History/Details**  
 Smoking: Never Smoker  
 Smoking: Tobacco: Never User  
 Alcohol: None  
 Preferred Language: English

**Specialty Comments**  
 Admin note (6/22/19): difficult to understand pt. on phone when scheduling appt.

**Medications**  
 Multiple (see specialty snapshot)  
 pantoprazole (PRILLOSEC) 35 MG delayed release capsule  
 pantoprazole (PRILLOSEC) 35 MG delayed release capsule  
 warfarin (COUMADIN) 1 MG tablet

**Current State Diet**  
 Route: PO  
 Diet grade: Liquidized (E09 3)  
 Liquid Consistency: Thin (E09 0)  
 FOD: 4 - Typical oral intake of a single consistency  
 Notes: N/A

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### Modified Barium Swallow Study

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	0 No labial escape.
2 Tongue Control/Bolus Hold	(0-3)	3 Posterior escape of greater than half of bolus
3 Bolus Prep/Mastication	(0-3)	2 Disorganized chewing/mashing with solid pieces of bolus unchewed
4 Bolus Transport/Lingual Motion	(0-4)	3 Disorganized/disorganized tongue motion
5 Oral Residue	(0-4)	3 Majority of bolus remaining.
6 Initiation of Pharyngeal Swallow	(0-4)	3 Occurred when the bolus head was in the pyriform sinuses.
7 Soft Palate Elevation	(0-4)	0 No bolus between soft palate and posterior pharyngeal wall
8 Laryngeal Elevation	(0-3)	1 Partial superior movement of thyroid cartilage/partial approximation of arytenoids to epiglottic petiole.
9 Anterior Hyoid Excursion	(0-2)	1 Demonstrated partial anterior movement.
10 Epiglottic Movement	(0-2)	2 No inversion
11 Laryngeal Vestibular Closure	(0-2)	1 Incomplete; narrow column air/contrast in laryngeal vestibule
12 Pharyngeal Stripping Wave	(0-2)	2 Absent
13 Pharyngeal Contraction	(0-3)	3 Bilateral bulging
14 Pharyngoesophageal Segment Opening	(0-3)	2 Minimal distension/minimal duration; marked obstruction of flow
15 Tongue Base Retraction	(0-4)	3 Wide column of contrast or air between tongue base and posterior pharyngeal wall
16 Pharyngeal Residue	(0-4)	4 Minimal to no pharyngeal clearance
17 Esophageal Clearance (upright)	(0-4)	1 Esophageal retention

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	0 No labial escape.
2 Tongue Control/Bolus Hold	(0-3)	3 Posterior escape of greater than half of bolus
3 Bolus Prep/Mastication	(0-3)	2 Disorganized chewing/mashing with solid pieces of bolus unchewed
4 Bolus Transport/Lingual Motion	(0-4)	3 Repetitive/disorganized tongue motion
5 Oral Residue	(0-4)	3 Majority of bolus remaining.
6 Initiation of Pharyngeal Swallow	(0-4)	3 Occurred when the bolus head was in the pyriform sinuses.
7 Soft Palate Elevation	(0-4)	0 No bolus between soft palate and posterior pharyngeal wall
8 Laryngeal Elevation	(0-3)	1 Partial superior movement of thyroid cartilage/partial approximation of arytenoids to epiglottic petiole.
9 Anterior Hyoid Excursion	(0-2)	1 Demonstrated partial anterior movement.
10 Epiglottic Movement	(0-2)	2 No inversion
11 Laryngeal Vestibular Closure	(0-2)	1 Incomplete; narrow column air/contrast in laryngeal vestibule
12 Pharyngeal Stripping Wave	(0-2)	2 Absent
13 Pharyngeal Contraction	(0-3)	3 Bilateral bulging
14 Pharyngoesophageal Segment Opening	(0-3)	2 Minimal distension/minimal duration; marked obstruction of flow
15 Tongue Base Retraction	(0-4)	3 Wide column of contrast or air between tongue base and posterior pharyngeal wall
16 Pharyngeal Residue	(0-4)	4 Minimal to no pharyngeal clearance
17 Esophageal Clearance (upright)	(0-4)	1 Esophageal retention

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### PAS Results

Varibar Task	IDDS Level	CURRENT Score and Descriptor
Sml, Thin trial 1	0 - Thin	1 Contrast did not enter the airway
Sml, Thin trial 2	0 - Thin	1 Contrast did not enter the airway
Cup Ssp (20ml) Thin	0 - Thin	1 Contrast did not enter the airway, passed below the vocal folds, no attempt to eject.
Sequential (40ml) Thin	0 - Thin	NA
Sml, Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
Cup Ssp (20ml) Nectar	2 - Mildly Thick	3 Contrast entered the airway, remained above the vocal folds, and was not ejected from the airway.
Sequential (40ml) Nectar	2 - Mildly Thick	NA
Sml, Thin Honey	3 - Moderately Thick	1 Contrast did not enter the airway
Sml, Pudding	4 - Puree	8 Contrast entered the airway, passed below the vocal folds, no attempt to eject.
% Shortbread Cookie (1 1/4 x 1 1/2)	5-7 - Transitional Foods	6 Contrast entered the airway, passed below the vocal folds, and was ejected into the airway.

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### PAS Results

Verbal Task	IDDSI Level	CURRENT Score and Descriptor
Sml. Thin trial 1	0 - Thin	1 Contrast did not enter the airway
Sml. Thin trial 2	0 - Thin	1 Contrast did not enter the airway
Cup Sip (20ml) Thin	0 - Thin	1 Contrast entered the airway, passed below the vocal folds, no attempt to eject.
Sequential (40ml) Thin	0 - Thin	1
Sml. Nectar	2 - Mildly Thick	1 Contrast did not enter the airway
Cup Sip (20ml) Nectar	2 - Mildly Thick	3 Contrast entered the airway, remained above the vocal folds, and was not ejected from the airway.
Sequential (40ml) Nectar	2 - Mildly Thick	NA
Sml. Thin Honey	3 - Moderately Thick	1 Contrast did not enter the airway
Sml. Pudding	4 - Puree	1 Contrast entered the airway, passed below the vocal folds, and was not ejected.
ix Shortbread Cookie (1/4" x 1/4")	5-7 - Transitional Foods	6 Contrast entered the airway, passed below the vocal folds, and was ejected into the airway.

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### Targeted Intervention Plan

**REFERRAL**

- Neurology
- Movement Disorders Clinic, ongoing assessment

**INTAKE RECOMMENDATIONS**

- Route: PEG
- Food Grade: IDDSI 3 - Liquidized
- Liquid Grade: IDDSI 0 - Thin

**COMPENSATIONS**

- Reclined position
- Super-supraglottic swallow
- Effortful swallow

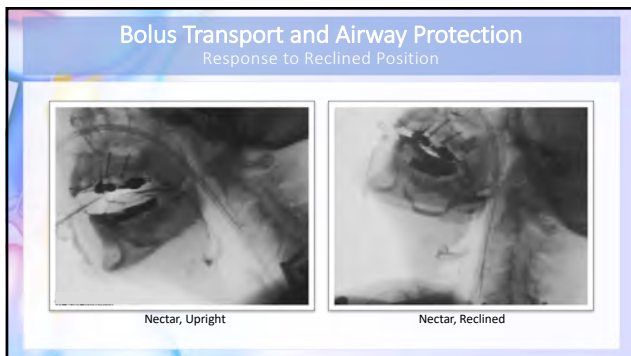
Dysphagia

**Dysphagia in Progressive Supranuclear Palsy: Radiologic Features**

*Thomas A. Lavinelli MD and Nelson T. Kugel MD*

**Abstract:** Progressive supranuclear palsy (PSP) is a neurodegenerative tauopathy characterized by axial rigidity, falls, and supranuclear vertical gaze palsy. The pathologic hallmark is the presence of tau pathology in the brainstem and the striatum. The radiologic features of PSP are characterized by the presence of a "beak sign" on axial CT scans, which is a hyperdense area in the posterior horn of the lateral ventricle. This sign is thought to be due to the presence of calcification in the globus pallidus. Other radiologic features include enlargement of the lateral ventricle, atrophy of the cerebellum, and enlargement of the sylvian fissure. The radiologic features of PSP are highly specific and can be used to aid in the diagnosis of this condition.

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### History of Present Illness

Date	Event	Diagnosis/Action/Prescription	ICD9	ICD10
12/6/17	46 yo M involved in MVC	MRI revealed traumatic SAH, SDH, and multiple facial fractures		
	Developed hospital acquired PNA resulting in respiratory failure, tracheostomy and intubation for 8 days	Meeting nutritional needs via NGT and SLP consulted		
	S/S aspiration noted at BS and MBS ordered	Severe dysphonia noted, ENT referral for videostrob		

Pres B. Phonia, MD | G-2385

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### Medical History

**Specialty Snapshot**

**Clinical Summaries**

**Demographics**  
 Sex: Male  
 Age: 46  
 Race: Native Hawaiian or Other Specific Islander  
 Ethnicity: Not Hispanic or Latino

**Problems List**  
 Hypertension  
 Tracheostomy (12/2016)  
 Depression  
 SAH  
 SDH  
 Facial fractures (facial, zygomatic)  
 PNA  
 Respiratory failure (intubation, tracheostomy, NGT)

**Significant History/Details**  
 Smoking: Never Smoker  
 Smokeless Tobacco: Never User  
 Alcohol: None  
 Preferred Language: English

**Specialty Comments**  
 Respiratory Therapy (12/3/17): Pt. decannulated

**Medications**  
 Adderall  
 Fluoxetine  
 Amitriptyline  
 Metoprolol  
 Vitamin D

**Current Issue List**  
 Route: NPO/NGT  
 Diet Grade: NA  
 Liquid Consistencies: NA  
 FOSG: N-Topical (in use)  
 Notes: NGT placed at time of intubation. Pt. has been NPO since extubation/decanulation.

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	<b>1</b> Interlabial escape.
2 Tongue Control/Bolus Hold	(0-3)	<b>0</b> Cohesive bolus between tongue to palatal seal
3 Bolus Prep/Mastication	(0-3)	<b>NA</b> Cookie not given secondary to pharyngeal safety concerns (bolus clearance)
4 Bolus Transport/Lingual Motion	(0-4)	<b>0</b> Break tongue motion
5 Oral Residue	(0-4)	<b>2</b> Collection on oral structures
6 Initiation of Pharyngeal Swallow	(0-4)	<b>3</b> Occurred when the bolus head was in the pyriform sinuses.
7 Soft Palate Elevation	(0-4)	<b>2</b> Escape to nasopharynx
8 Laryngeal Elevation	(0-3)	<b>1</b> Partial superior movement of thyroid cartilage/partial approximation of arytenoids to epiglottic petiole.
9 Anterior Hyoid Excursion	(0-2)	<b>1</b> Demonstrated partial anterior movement.
10 Epiglottic Movement	(0-2)	<b>2</b> No inversion
11 Laryngeal Vestibular Closure	(0-2)	<b>1</b> Incomplete; narrow column air/contrast in laryngeal vestibule
12 Pharyngeal Stripping Wave	(0-2)	<b>2</b> Absent
13 Pharyngeal Contraction	(0-3)	<b>2</b> Unilateral bulging (right)
14 Pharyngoesophageal Segment Opening	(0-3)	<b>2</b> No distension with total obstruction to bolus flow
15 Tongue Base Retraction	(0-4)	<b>3</b> Wide column of contrast or air between tongue base and posterior pharyngeal wall
16 Pharyngeal Residue	(0-4)	<b>4</b> Minimal to no pharyngeal clearance
17 Esophageal Clearance (upright)	(0-4)	<b>2</b> Esophageal retention with retrograde flow below the level of the PES

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	CURRENT Score and Descriptor
1 Lip Closure	(0-4)	<b>1</b> Interlabial escape.
2 Tongue Control/Bolus Hold	(0-3)	<b>0</b> Cohesive bolus between tongue to palatal seal
3 Bolus Prep/Mastication	(0-3)	<b>NA</b> Cookie not given secondary to pharyngeal safety concerns (bolus clearance)
4 Bolus Transport/Lingual Motion	(0-4)	<b>0</b> Break tongue motion
5 Oral Residue	(0-4)	<b>2</b> Collection on oral structures
6 Initiation of Pharyngeal Swallow	(0-4)	<b>3</b> Occurred when the bolus head was in the pyriform sinuses.
7 Soft Palate Elevation	(0-4)	<b>2</b> Escape to nasopharynx
8 Laryngeal Elevation	(0-3)	<b>1</b> Partial superior movement of thyroid cartilage/partial approximation of arytenoids to epiglottic petiole.
9 Anterior Hyoid Excursion	(0-2)	<b>1</b> Demonstrated partial anterior movement.
10 Epiglottic Movement	(0-2)	<b>2</b> No inversion
11 Laryngeal Vestibular Closure	(0-2)	<b>1</b> Incomplete; narrow column air/contrast in laryngeal vestibule
12 Pharyngeal Stripping Wave	(0-2)	<b>2</b> Absent
13 Pharyngeal Contraction	(0-3)	<b>2</b> Unilateral bulging (right)
14 Pharyngoesophageal Segment Opening	(0-3)	<b>2</b> No distension with total obstruction to bolus flow
15 Tongue Base Retraction	(0-4)	<b>3</b> Wide column of contrast or air between tongue base and posterior pharyngeal wall
16 Pharyngeal Residue	(0-4)	<b>4</b> Minimal to no pharyngeal clearance
17 Esophageal Clearance (upright)	(0-4)	<b>2</b> Esophageal retention with retrograde flow below the level of the PES

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### PAS Results

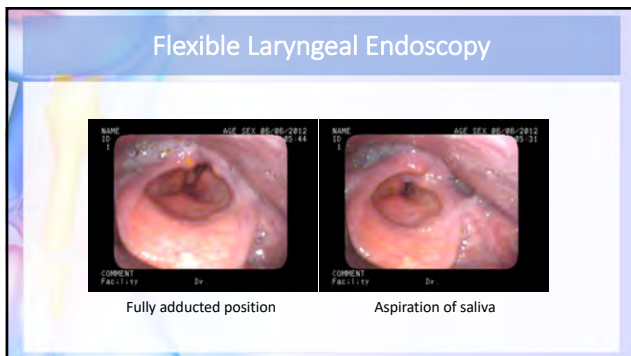
Varibar Task	IDDSI Level	CURRENT Score and Descriptor
Sml Thin trial 1	0 - Thin	<b>4</b> Materials enter the airway, contacts the vocal folds, and is ejected from the airway
Sml Thin trial 2 - CHIN TUCK	0 - Thin	<b>3</b> Contrast entered the airway, passed below the vocal folds, no attempt to eject.
Cup Sip (20mL) Thin	0 - Thin	<b>3</b> Contrast entered the airway, passed below the vocal folds, no attempt to eject.
Sequential (40mL) Thin	0 - Thin	<b>NA</b> Not given, safety concerns
Sml Nectar	2 - Mildly Thick	<b>3</b> Contrast entered the airway, remained above the vocal folds, and was not ejected from the airway.
Cup Sip (20mL) Nectar	2 - Mildly Thick	<b>2</b> Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sequential (40mL) Nectar	2 - Mildly Thick	<b>NA</b> Not given, safety concerns
Sml Thin Honey	3 - Moderately Thick	<b>2</b> Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sml Pudding - HEAD TURN	4 - Puree	<b>NA</b> Head turn obstructs view
Shortbread Cookie - HEAD TURN	5-7 - Transitional Foods	<b>NA</b> Head turn obstructs view

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### PAS Results

Varibar Task	IDDSI Level	CURRENT Score and Descriptor
Sml Thin trial 1	0 - Thin	<b>4</b> Materials enter the airway, contacts the vocal folds, and is ejected from the airway
Sml Thin trial 2 - CHIN TUCK	0 - Thin	<b>3</b> Contrast entered the airway, passed below the vocal folds, no attempt to eject.
Cup Sip (20mL) Thin	0 - Thin	<b>3</b> Contrast entered the airway, passed below the vocal folds, no attempt to eject.
Sequential (40mL) Thin	0 - Thin	<b>NA</b> Not given, safety concerns
Sml Nectar	2 - Mildly Thick	<b>3</b> Contrast entered the airway, remained above the vocal folds, and was not ejected from the airway.
Cup Sip (20mL) Nectar	2 - Mildly Thick	<b>2</b> Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sequential (40mL) Nectar	2 - Mildly Thick	<b>NA</b> Not given, safety concerns
Sml Thin Honey	3 - Moderately Thick	<b>2</b> Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sml Pudding - HEAD TURN	4 - Puree	<b>NA</b> Head turn obstructs view
Shortbread Cookie - HEAD TURN	5-7 - Transitional Foods	<b>NA</b> Head turn obstructs view

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### Targeted Intervention Plan

<h4>INTAKE RECOMMENDATIONS</h4> <ul style="list-style-type: none"> <li>Route: Cont. NPO, NGT</li> <li>Food Grade: NA</li> <li>Liquid Grade: NA</li> </ul>	<h4>PHYSIOLOGIC TARGETS</h4> <ul style="list-style-type: none"> <li>Component 8: Laryngeal Elevation</li> <li>Component 11: Laryngeal Vestibular Closure</li> <li>Component 12: Pharyngeal Stripping Wave</li> <li>Component 13: Pharyngeal Contraction</li> <li>Component 14: PES Opening</li> <li>Component 15: Tongue Base Retraction</li> </ul>
<h4>RETRAINING</h4> <ul style="list-style-type: none"> <li>Masako</li> <li>Effortful swallow</li> <li>Mendelsohn maneuver</li> <li>Chin tuck against resistance (ISO-CTAR Device)</li> <li>PO Trials (all consistencies)</li> <li>Vocal Function Exercises (VFE)</li> </ul>	<h4>TIME FRAME</h4> <ul style="list-style-type: none"> <li>Total Duration: 2-4x/week, ongoing assessment</li> <li>Structured Sessions: 30 mins</li> <li>Independent Practice: 5x each/5x daily</li> </ul>
<h4>COMPENSATION</h4> <ul style="list-style-type: none"> <li>Head Turn Right</li> <li>Super-supraglottic swallow</li> </ul>	<h4>SURGICAL</h4> <ul style="list-style-type: none"> <li>Medialization procedure</li> </ul>

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### Targeted Intervention Plan

**Long-Term Goal:**  
*The patient will meet nutritional needs by mouth with a minced & moist diet (IDDSI 5) and thin liquids (IDDSI 0) with the use of a head turn right and super-supraglottic swallow with improved pharyngeal clearance (MBSImP Component 5 scores >2) and airway protection (PAS scores >2) on MBSS following 12 weeks of treatment.*

**Short-Term Goals:**

- 1) The patient will achieve complete laryngeal elevation and laryngeal vestibular closure to improve airway protection
- 2) The patient will increase PES opening and duration to facilitate bolus passage into the esophagus.
- 3) The patient will increase pharyngeal stripping wave and tongue base retraction to improve pressure generation along the tail of the bolus for complete pharyngeal clearance and prevention of retrograde flow into the nasal cavity.

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### Targeted Intervention Plan

**Treatment Objectives:**

Component 8 Laryngeal Elevation, 11: Laryngeal Vestibular Closure

- The patient will sustain laryngeal vestibular closure for 5 seconds while performing the Mendelsohn maneuver as evidenced by laryngeal elevation on 8 out of 10 trials with moderate cues.

Component 12: Pharyngeal Stripping Wave

- The patient will recruit and increase contraction of the posterior pharyngeal wall while performing the Masako maneuver on 8 out of 10 trials with minimal cues.

Component 13: Pharyngeal Contraction; Component 15: Tongue Base Retraction

- The patient will increase tongue base and pharyngeal pressures pressures while performing the effortful swallow on 8 out of 10 trials with minimal cues.

Component 14: Pharyngoesophageal Segment Opening

- The patient will perform 5 sets of 30 chin tucks against resistance using the ISO-CTAR device with minimal cues.

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### Treatment Course

Participated in 22 IP exercise based swallowing therapy sessions over the course of 3 months in the ICU and TCU

↓

PEG placed at 2 weeks (repeat MBSS, minimal improvement) when patient was transitioned to TCU

↓

ENT performed vocal fold medialization procedure at month 1 (repeat videofluoroscopy, minimal improvement)

↓

Discharged at month 3 (repeat MBSS, moderate improvement), puree diet/thin liquids, home exercise program

↓

Returned at month 4 for repeat MBSS, reporting he had been "eating hamburger patties and drinking beer"

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### Modified Barium Swallow Study

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	Pre-treatment Score and Descriptor	Post-treatment Score and Descriptor
1 Lip Closure	(0-4)	1	1 Interlabial escape.
2 Tongue Control/Bolus Hold	(0-3)	0	0 Cohesive bolus between tongue to palatal seal
3 Bolus Prep/Mastication	(0-3)	NA	0 Timely and efficient chewing and mashing
4 Bolus Transport/Ungual Motion	(0-4)	0	0 Bolus tongue motion
5 Oral Residue	(0-4)	2	2 Collection on oral structures.
6 Initiation of Pharyngeal Swallow	(0-4)	3	3 Occurred when the bolus head was in the pyriform sinuses.
7 Soft Palate Elevation	(0-4)	2	1 Trace column of contrast or air between soft palate and posterior pharyngeal wall
8 Laryngeal Elevation	(0-3)	1	1 Partial superior movement of thyroid cartilage/partial approx of arytenoids to epiglottic petiole.
9 Anterior Hyoid Excursion	(0-2)	1	1 Demonstrated partial anterior movement.
10 Epiglottic Movement	(0-2)	2	1 Partial inversion
11 Laryngeal Vestibular Closure	(0-2)	1	1 Complete closure
12 Pharyngeal Stripping Wave	(0-2)	2	1 Diminished
13 Pharyngeal Contraction	(0-3)	2	2 Unilateral bulging (right, improved)
14 Pharyngoesophageal Segment Opening	(0-3)	2	1 Partial distension, partial duration, partial obstruction to bolus flow
15 Tongue Base Retraction	(0-4)	3	2 Narrow column of contrast or air between tongue base and posterior pharyngeal wall
16 Pharyngeal Residue	(0-4)	4	3 Majority of bolus remaining (solid, otherwise (2))
17 Esophageal Clearance (upright)	(0-4)	2	0 Complete clearance (partial view)

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### MBSImP Results

COMPONENT Number and Descriptor	Scale	Pre-treatment Score and Descriptor	Post-treatment Score and Descriptor
1 Lip Closure	(0-4)	1	1 Interlabial escape.
2 Tongue Control/Bolus Hold	(0-3)	0	0 Cohesive bolus between tongue to palatal seal
3 Bolus Prep/Mastication	(0-3)	NA	0 Timely and efficient chewing and mashing
4 Bolus Transport/Ungual Motion	(0-4)	0	0 Bolus tongue motion
5 Oral Residue	(0-4)	2	2 Collection on oral structures.
6 Initiation of Pharyngeal Swallow	(0-4)	3	3 Occurred when the bolus head was in the pyriform sinuses.
7 Soft Palate Elevation	(0-4)	2	1 Trace column of contrast or air between soft palate and posterior pharyngeal wall
8 Laryngeal Elevation	(0-3)	1	1 Partial superior movement of thyroid cartilage/partial approx of arytenoids to epiglottic petiole.
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10 Epiglottic Movement	(0-2)	2	1 Partial inversion
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16 Pharyngeal Residue	(0-4)	4	3 Majority of bolus remaining (solid, otherwise (2))
17 Esophageal Clearance (upright)	(0-4)	2	0 Complete clearance (partial view)

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### PAS Results

Var/Bar Task	IDDSI Level	Pre	Post-treatment Score and Descriptor
Sml. Thin trial 1	0 - Thin	4	1 Contrast did not enter the airway
Sml. Thin trial 2	0 - Thin	8	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Cup Sip (20ml) Thin	0 - Thin	8	1 Contrast did not enter the airway
Sequential (40ml) Thin	0 - Thin	NA	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sml. Nectar	2 - Mildly Thick	3	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Cup Sip (20ml) Nectar	2 - Mildly Thick	2	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sequential (40ml) Nectar	2 - Mildly Thick	NA	1 Contrast did not enter the airway
Sml. Thin Honey	3 - Moderately Thick	2	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sml. Pudding <b>HEAD TURN</b>	4 - Puree	NA	NA Head turn obstructs view
Shortbread Cookie <b>HEAD TURN</b>	5-7 - Transitional Foods	NA	NA Head turn obstructs view

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### PAS Results

Var/Bar Task	IDDSI Level	Pre	Post-treatment Score and Descriptor
Sml. Thin trial 1	0 - Thin	4	1 Contrast did not enter the airway
Sml. Thin trial 2	0 - Thin	8	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Cup Sip (20ml) Thin	0 - Thin	8	1 Contrast did not enter the airway
Sequential (40ml) Thin	0 - Thin	NA	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sml. Nectar	2 - Mildly Thick	3	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Cup Sip (20ml) Nectar	2 - Mildly Thick	2	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sequential (40ml) Nectar	2 - Mildly Thick	NA	1 Contrast did not enter the airway
Sml. Thin Honey	3 - Moderately Thick	2	2 Contrast entered the airway, remained above the vocal folds, and was ejected from the airway.
Sml. Pudding <b>HEAD TURN</b>	4 - Puree	NA	NA Head turn obstructs view
Shortbread Cookie <b>HEAD TURN</b>	5-7 - Transitional Foods	NA	NA Head turn obstructs view

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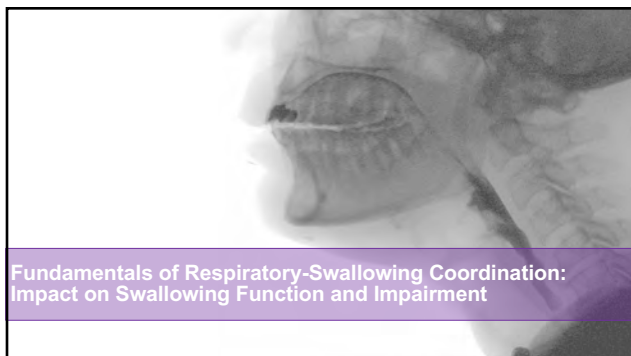
### Targeted Intervention Plan

INTAKE RECOMMENDATIONS	PHYSIOLOGIC TARGETS
<ul style="list-style-type: none"> <li>Route: PO, PEG supplement per RD recs</li> <li>Food Grade: Minced &amp; Moist (IDDSI - 5)</li> <li>Liquid Grade: Thins (IDDSI - 0)</li> </ul>	<ul style="list-style-type: none"> <li>Component 8: Laryngeal Elevation</li> <li>Component 11: Laryngeal Vestibular Closure</li> <li>Component 12: Pharyngeal Stripping Wave</li> <li>Component 13: Pharyngeal Contraction</li> <li>Component 14: PES Opening</li> <li>Component 15: Tongue Base Retraction</li> </ul>
RETRAINING	TIME FRAME
<ul style="list-style-type: none"> <li>Masako</li> <li>Effortful swallow</li> <li>Mendelsohn maneuver</li> <li>Chin tuck against resistance (ISO-CTAR Device)</li> </ul>	<ul style="list-style-type: none"> <li>Independent Practice: 10x each/3x daily</li> </ul>
COMPENSATION	SURGICAL
<ul style="list-style-type: none"> <li>Head Turn Right</li> <li>Super-supraglottic swallow</li> </ul>	<ul style="list-style-type: none"> <li>Consultation and monitoring with RD for PEG weaning and removal.</li> </ul>

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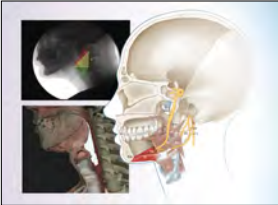



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### Physiology of Deglutition is Synergistic, Complex and Coordinated with Respiration

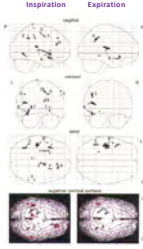
Northwestern
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### Respiratory System

**Looks simple but it is NOT**

- Complex system
- Complex acquisition and measurement
- Difficult to interpret
  - Significant errors can lead to erroneous interpretations of experimental data particularly within a research context.

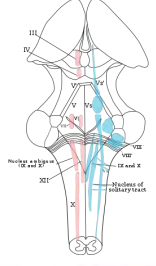


Northwestern Evans et al., 1999

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### Neural Control of Swallowing

- Olfactory I
- Trigeminal V
- Facial VII
- Glossopharyngeal IX
- Vagus X
- Hypoglossal XII
- Ansa Cervicalis (C1-C2)



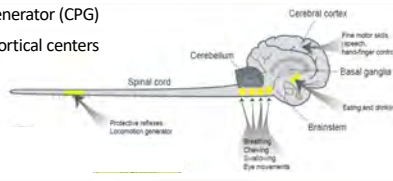
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### Neural Control of Swallowing

Involves multiple levels of the nervous system

- Sensory afferents
- Central Pattern Generator (CPG)
- Cortical and sub-cortical centers

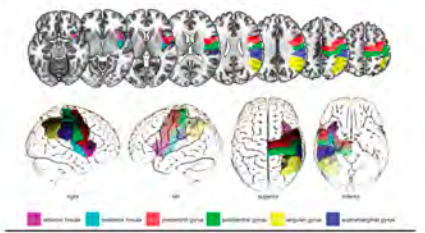


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### Cortical and Subcortical Control

Figure 2. Commonly identified cortical brain regions critical for swallowing after stroke. For visualization purposes, brain regions are shown only in the right hemisphere and not in both hemispheres. Colors were chosen arbitrarily.



Northwestern Wilmkoetter, Daniels & Miller, 2019

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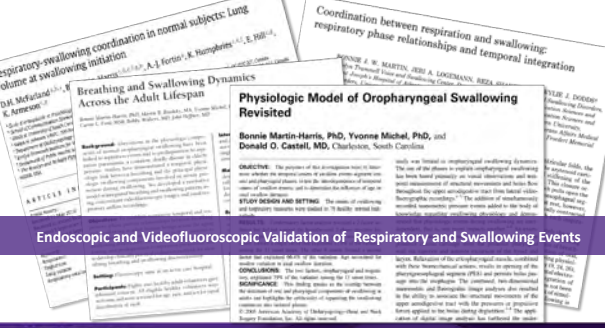
### Endoscopic and Videofluoroscopic Validation of Respiratory and Swallowing Events

Coordination between respiration and swallowing: respiratory phase relationships and temporal integration

Respiratory-swallowing coordination in normal subjects: Lung volume at swallowing initiation

Breathing and Swallowing Dynamics Across the Adult Lifespan


Physiologic Model of Oropharyngeal Swallowing Revisited



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### Respiratory Phase Control

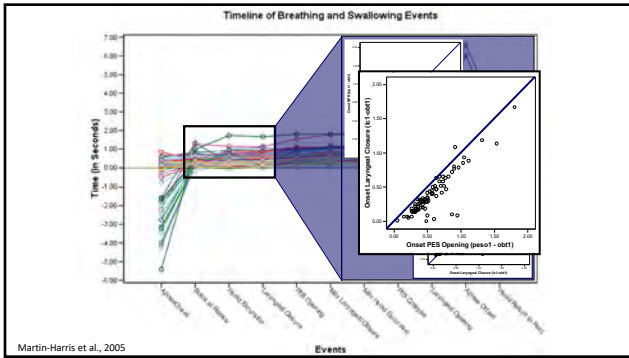


Example of simultaneous videofluoroscopy (A) and respiratory trace data (B) as seen on the Kay Digital Swallowing Workstation (model 7100, Kay Elemetrics, Lincoln Park, MI). The green portion of the tracing represents expiration and the red portion represents inspiration. The black portion of the line along the abscissa indicates no air movement or apnea.

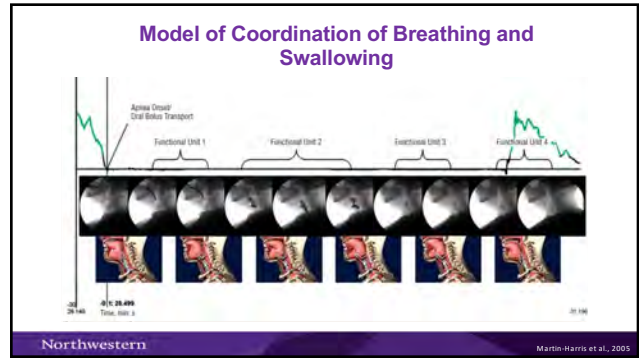
Northwestern Martin-Harris et al., 2005

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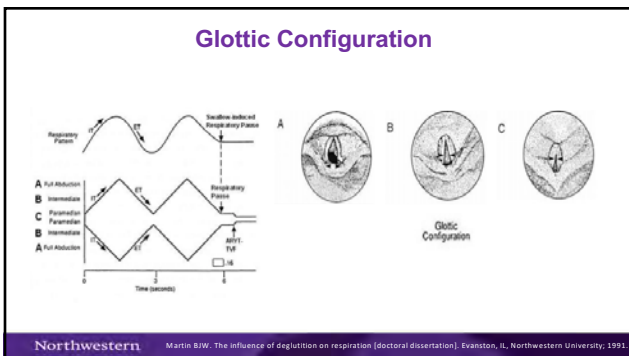




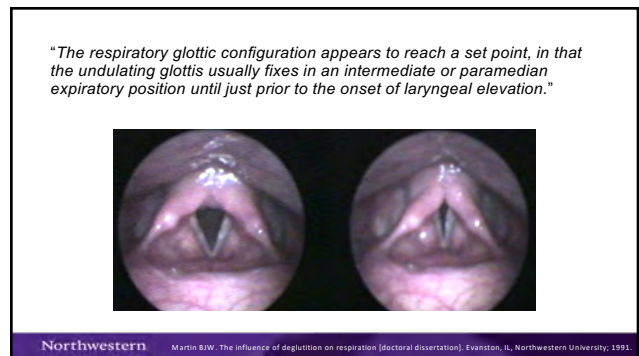
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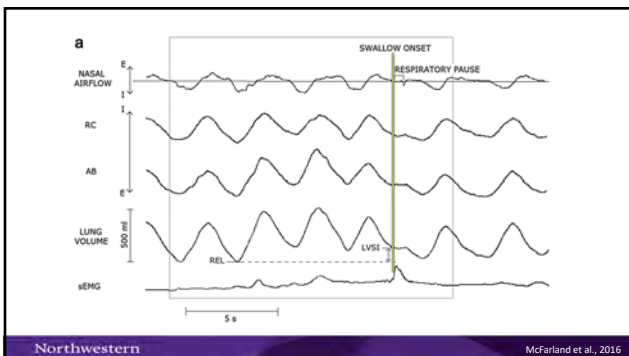
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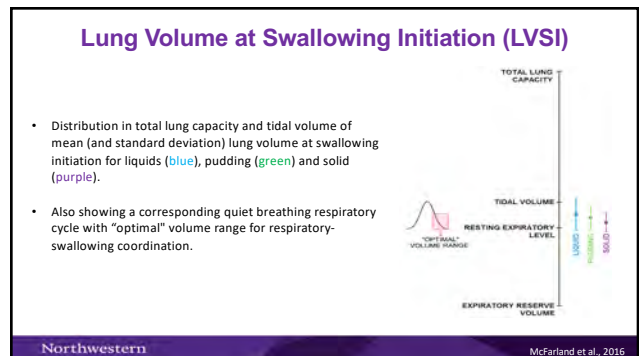
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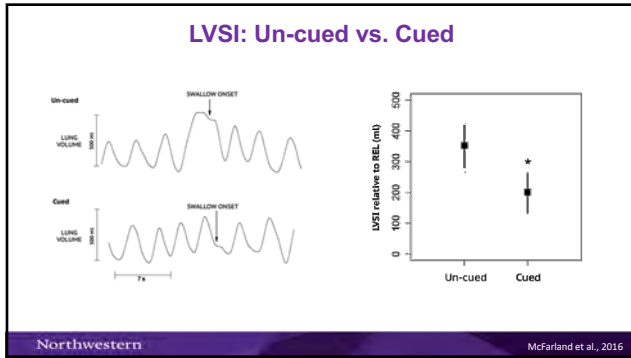
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### Why this range of expiratory lung volumes?

We have suggested previously (McFarland et al., 1994; Martin et al., 1991, 1995, 2005) and continue to refine, (Martin, McFarland et al., 2015, 2018) that swallowing in this range of quiet breathing lung volumes imparts potentially *significant airway protection and mechanical benefits* to swallowing.

The slide includes a diagram of the human respiratory system and a small graph showing a bell-shaped curve representing lung volume over time.

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### Mechanical advantages of optimal respiratory-swallowing coordination

- The contraction of the diaphragm (inspiration) exerts a downward pull on the trachea and larynx (Agostoni & Mead, 1964; Andrew, 1955; Mitchinson and Yoffey, 1947).
- 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), pharyngo-esophageal sphincter opening (PESO), esophageal clearance.
- We suggest that this range is optimal for airway protection and swallowing mechanics.

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### Mechanical advantages of Swallowing Initiation During Expiratory Phase of Respiration

**Inspiration:** The tongue moves forward, pharynx widens, larynx descends  
 \*Placing counterproductive traction on the structures involved in airway protection and bolus clearance.

**Expiration:** Posterior positioning of tongue, narrowing of pharynx, superior position of the larynx and inward posturing of the arytenoid-true vocal fold complex.  
 \*Creates efficient set point for swallowing movements necessary to safely close the airway and transfer the bolus.

The slide features two diagrams of airway cross-sections labeled '1a' (Inspiration) and '1b' (Expiration), showing the relative positions of the tongue, pharynx, and larynx. Below these is a graph of lung volume over time with a star marking the 'Initiation of Swallowing During Expiration' at a mid-to-low lung volume.

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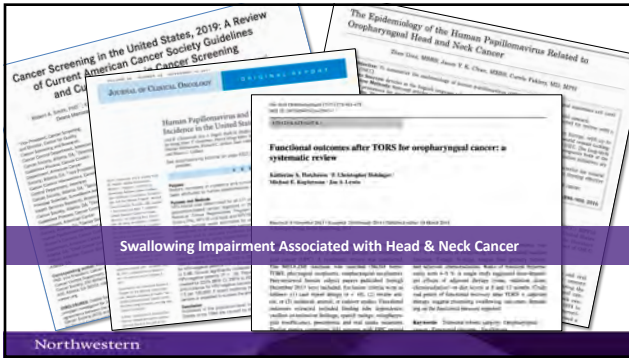
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### Summary

- We have seen that swallows are typically initiated in mid to low quiet breathing lung volumes.
- This normal coordinative relationship is perturbed in some patient populations.

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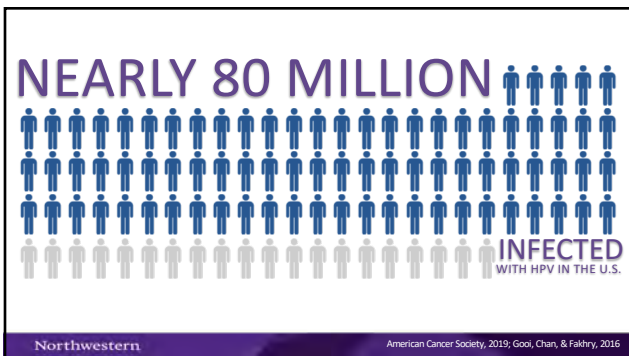


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### Oropharyngeal (OP) Cancer

- Worldwide, 350,000-400,000 people are diagnosed with OP HNC each year – nearly 10% in the US alone.
- Incidence of HPV+ OPHNC has nearly doubled
- Good treatment response
  - Acute, persistent, late effects on swallowing
- Swallowing impairment represents the **highest functional morbidity** in OP HNC treated with surgical approaches followed by radiation or combined chemotherapy and radiation.

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### OP Cancer Treatment: Components of Impairment

Tumor Site(s), Size, Treatment

- Sensory receptive fields** oropharynx and larynx
  - Initiation of pharyngeal swallow
  - Laryngeal closure
- Base of tongue**
  - Airway protection, pharyngeal clearance
  - Epiglottic inversion
- Pharyngeal wall**
  - Constriction and shortening->
  - Laryngeal elevation and laryngeal vestibular closure
  - PES Opening

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### OP Cancer Treatment: Components of Impairment

**Oropharyngeal Head and Neck Cancer Treatment Impacts Critical Sensory and Motor Components of Swallowing and Respiratory Swallowing Coordination**

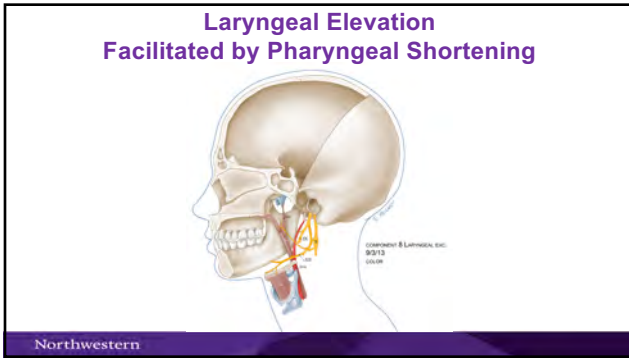
- Lip Closure
- Tongue Control
- Bolus Preparation/Mastication
- Bolus Transport/Lingual Motion
- Oral Residue
- Initiation of Pharyngeal Response
- Soft Palate Elevation
- Laryngeal Elevation
- Anterior Hyoid Excursion
- Epiglottic Movement
- Laryngeal Vestibular Closure
- Pharyngeal Stripping Wave
- Pharyngeal Contraction
- Pharyngoesophageal Segment Opening
- Tongue Base Retraction
- Pharyngeal Residue
- Esophageal Clearance

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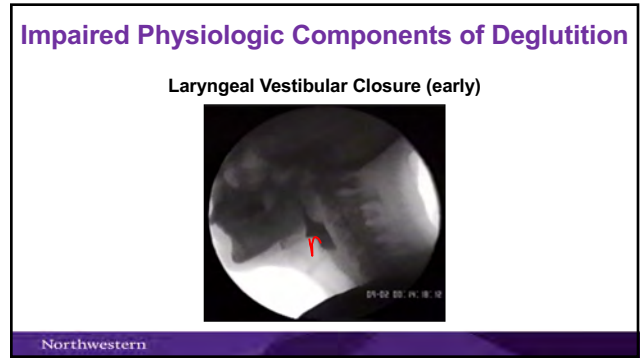
### Impaired Physiologic Components of Deglutition

#### Laryngeal Elevation (Component 18)

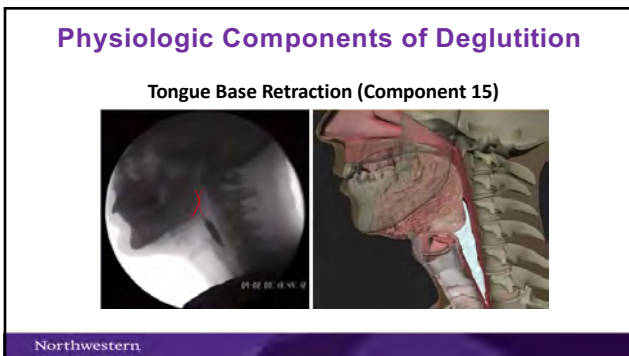
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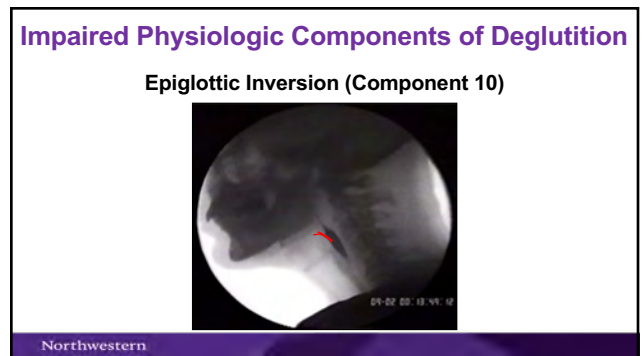
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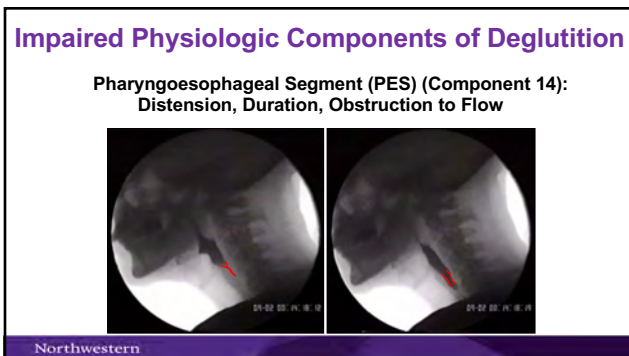
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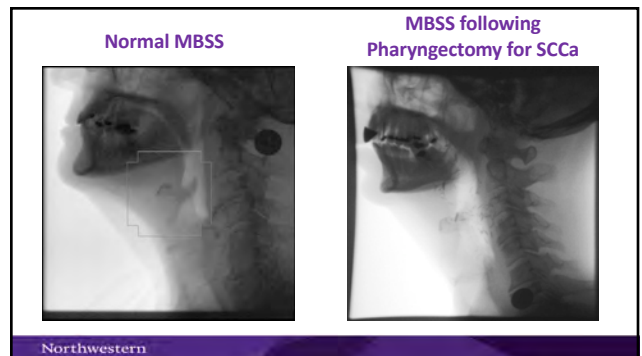
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### Traditional Swallow Therapy Following OP HNC Treatments

- Current therapies extremely limited and include:
  - dietary modifications
  - compensatory strategies (e.g. postural changes)
  - therapeutic approaches directed toward improving strength, range and skill of movement
- **Do not** include standardized protocols
- **Do not** result in substantive or durable improvements
- **Do not** consider contribution of respiratory-swallow phase patterning to airway protection and swallowing efficiency.

Northwestern Langmore 1995; Murphy & Gilbert, 2009; Martin-Harris & McFarland, 2013


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### Impact of HNC Treatment on Respiratory-Swallow Coordination



Treatments for Head and Neck Cancer (Surgical, Radiation, Chemotherapy)

➔



Decrease Frequency of Initiating Swallowing During Expiration

Northwestern Hopkins-Rossabi, Armeson, Zecker, Martin-Harris 2011

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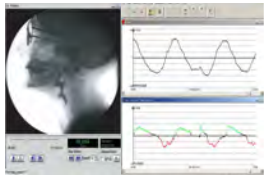


Respiratory-Swallow Phase Patterns and Swallowing Impairment in HNC

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### Synchronized Respiratory and MBS Recording



**Respiratory Flow**

**Chest Kinematics**

**MBS**

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### Respiratory-Swallow Patterns in HNC

- N = 40
- HNC: 20
- Control group: 20
- 5-ml liquid

	Age, y (SD; range)	Stage	
		I or II	III or IV
Age-matched controls	60.2 (13.5; 42-79)		
Patients with cancer	59.4 (9.5; 44-78)	N = 11	N = 9
SURG-XRT	61.3 (8.0; 49-74)	n = 7	n = 4
CHEMO-XRT	57.1 (11.1; 44-78)	n = 4	n = 5

Abbreviations: SURG-XRT, patients previously treated with surgery and radiation therapy; CHEMO-XRT, patients previously treated with chemotherapy and radiation therapy.

Northwestern Brodsky et al., 2009

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### Respiratory-Swallow Patterns in HNC

	No. of patients (%)			
	E-E	E-I	I-E	I-I
Age-matched controls	29 (72.5%)	2 (5.0%)	8 (20%)	1 (2.5%)
Patients with cancer	15 (37.5%)	4 (10.0%)	20 (50%)	1 (2.5%)
SURG-XRT	8 (38.4%)	3 (13.6%)	11 (50%)	0 (0.0%)
CHEMO-XRT	7 (38.9%)	1 (5.6%)	9 (50%)	1 (5.6%)

Abbreviations: E-E, swallows immediately preceded by and followed by expiratory flow; E-I, swallows immediately preceded by expiratory flow and followed by inspiratory flow; I-E, swallows immediately preceded by inspiratory flow and followed by expiratory flow; I-I, swallows immediately preceded by and followed by inspiratory flow; SURG-XRT, patients previously treated with surgery and radiation therapy; CHEMO-XRT, patients previously treated with chemotherapy and radiation therapy.

Northwestern Brodsky et al., 2009

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### Respiratory-Swallow Patterns in HNC

**Table 5.** Summary of respiratory-swallow phase patterns for both 5-mL trials collapsed across trials.

	Respiratory phase pattern	
	E-E	Not E-E
Age-matched controls	72.5%	27.5%
Patients with cancer	37.5%	62.5%
SURG-XRT	36.4%	63.6%
CHEMO-XRT	38.9%	61.1%

Abbreviations: E-E, swallows immediately preceded by and followed by expiratory flow; SURG-XRT, patients previously treated with surgery and radiation therapy; CHEMO-XRT, patients previously treated with chemotherapy and radiation therapy.

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Brodsky et al., 2009

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### System Overlap: Cross System Interactions

- HNC patients had altered phase patterning, including inconsistent or unstable patterns ("non-optimal")
- HNC patients had significantly increased severity of penetration/aspiration (PAS) and swallowing impairment (MBSImP)

**Table 6.** Respiratory-swallow phase patterns and MBSImP scores across trials

Phase pattern	MBSImP <sub>1</sub>	MBSImP <sub>2</sub>
Consistent E-E (25%)	7.80	7.20
Mean	7.80	7.20
SD	3.130	2.693
Inconsistent E-E (20%)	16.73	16.00
Mean	16.73	16.00
SD	3.867	4.243
Consistent Not E-E (25%)	9.43	9.86
Mean	9.43	9.86
SD	4.805	4.337
Inconsistent Not E-E (15%)	10.00	11.33
Mean	10.00	11.33
SD	5.568	5.774

Abbreviation: MBSImP<sub>1</sub>, Modified Dysphagia Swallowing Impairment Profile 23; and/or MBSImP<sub>2</sub>, MBSImP score. E-E, swallow immediately preceded by and followed by expiratory flow. Note: One participant had not provided to the analysis because of aspiration data (1 = 5).

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Brodsky et al., 2009

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### Reversal in Respiratory Swallow Pattern

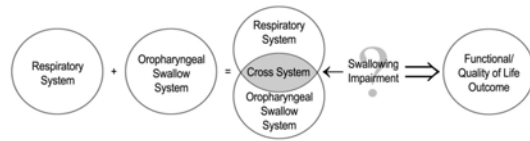
	Respiratory Phase Pattern	
	EX/EX	Not EX/EX
Age-matched controls	75%	25%
Cancer patients	35%	65%
SURG-XRT	36%	64%
CHEMO-XRT	33%	67%

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Brodsky et al., 2009

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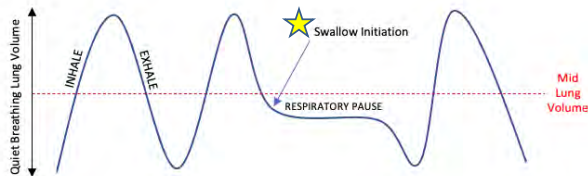
### Directly Target Respiratory-Swallowing Impairment



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### Respiratory-Swallow Training (RST)



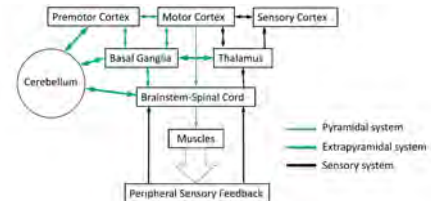
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### Question:

How might training to initiate swallowing during mid-expiration improve swallowing function and risk of aspiration?

### Swallowing ↔ Breathing



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Paydarfar, 2018, CSC

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**Which cortical sites might be necessary to learn to initiate swallowing near the mid-expiratory phase of respiration?**

- (1) Swallow initiation
- (2) Expiratory effort

**Theoretical Hypothesis:**  
 Performing the task will result in cortico-cortical mediated enhancement of swallowing function. As the task is learned the motor enhancement is embedded within cortico-basal ganglionic and cerebellar circuits that are shared between the swallowing and respiratory control systems.

Northwestern Paydarfar, 2018, CSC

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**Respiratory-Swallow Training in Patients with OP HNC**

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**Respiratory-Swallow Training**

**What is RST changing about the swallow to drive these findings?**

**TIMING**

- ✓ Increase in frequency of swallows initiated during expiration
- ✓ Improved tongue base retraction
- ✓ Improved closure of laryngeal vestibule
- ✓ Decrease in Penetration-Aspiration Scale scores
- ✓ Decrease in pharyngeal residue

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**Primary Study Aim**

- Test novel therapeutic regimen
  - Train optimal respiratory-swallow pattern in patients with HNC
  - Detraining effect
- Primary outcome measures (Pre/Post/1m post)
  - MBSImP™ scores
  - PAS scores
  - MDADI scores

Northwestern Martin-Harris et al., 2015

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**Study Entry Criteria**

- Volunteers recruited from head and neck cancer clinics at MUSC and Ralph H. Johnson VAMC
- Oropharyngeal Head and Neck Cancer (≥ 6 months post treatment)
- Persistent dysphagia
- Passing score on Cognistat (2010)
- Could not have severe COPD
- Could not be currently smoking

Northwestern Martin-Harris et al., 2015

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**Synchronized Respiratory and MBS Recording**


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## Methods

### MBS Protocol (limited)

- Liquids only (thin, nectar, honey)
  - 5-mL teaspoon (tsp)
  - 15-mL cup
  - Patient-controlled volume from cup
- 2 trials for each consistency and volume
  - maximum: 18 trials



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## Intervention MBSS Inclusion Criteria

- MBSImP™ (scores total  $\geq 5$ )
- PAS scores  $\geq 3$  on 10% of trial swallows
- Non-optimal or inconsistent (E-I, I-E, or I-I) respiratory phase pattern on trial swallows

E-I: Expiration-Inspiration; I-E: Inspiration-Expiration; I-I: Inspiration-Inspiration

Northwestern Martin-Harris et al., 2015

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## Respiratory-Swallow Training

Intervention phase divided into 3 learning modules (total of 24 goals) using traditional hierarchical motor learning approach:

- 1) Identification
- 2) Acquisition/Performance
- 3) Mastery

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Module	Weeks	Goals
Identification Module Critical event 80%	Week 1	Session 1: Goal 1 a,b - Identification of respiratory phase pattern (inspiration, expiration); Goal 1c - Identification of swallow event (respiratory cessation/pause); Goal 1d - Identification of swallow event at mid to low lung volume. Simulated tracings (cards) of breathing and swallowing events
	Week 2	Session 2: Goal 2 a,b - Identification of respiratory phase pattern (inspiration, expiration); Goal 1c - Identification of swallow event (respiratory cessation/pause); Goal 2d - Identification of swallow event at mid to low lung volume. Recorded tracing of respiratory/swallow events
Acquisition Module Critical event 80%	Week 3	Session 3: Goal 3a (thin liquids) - Cued swallow initiation during expiratory phase; Goal 3b- Cued swallow initiation during expiratory phase at mid-to-low lung volume; Goal 3c (nectar thick liquids) - Cued swallow initiation during expiratory phase; Goal 3d- Cued swallow initiation during expiratory phase at mid-to-low lung volume; Goal 3e (honey thick liquids) - Cued swallow initiation during expiratory phase; Goal 3f- Cued swallow initiation during expiratory phase at mid-to-low lung volume. Visually-assisted feedback during swallowing of 5mL cup sips
	Week 4	Session 4: Goal 4a (thin liquids) - Swallow (no cues) initiation during expiratory phase at mid-to-low lung volume; Goal 4b (nectar thick liquids) - Swallow (no cues) initiation during expiratory phase at mid-to-low lung volume; Goal 4c- (honey thick liquids) - Swallow (no cues) initiation during expiratory phase at mid-to-low lung volume. Visually-assisted feedback during swallowing of 5mL cup sips
Mastery Module Critical event 80%	Week 5	Session 5: Goal 5a (thin liquids) - Swallow initiation during expiratory phase at mid-to-low lung volume; Goal 5b (nectar thick liquids) - Swallow initiation during expiratory phase at mid-to-low lung volume; Goal 5c- (honey thick liquids) - Swallow initiation during expiratory phase at mid-to-low lung volume. NO cues or Visually-assisted feedback during swallowing of 5mL cup sips
	Week 6	Session 6: Goal 6a (thin liquids) - Swallow initiation during expiratory phase at mid-to-low lung volume; Goal 6b (nectar thick liquids) - Swallow initiation during expiratory phase at mid-to-low lung volume; Goal 6c- (honey thick liquids) - Swallow initiation during expiratory phase at mid-to-low lung volume. NO cues or Visually-assisted feedback during swallowing of 5mL cup sips

Martin-Harris et al., 2015

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## Swallow Initiation in Optimal Respiratory Phase and Lung Volume Range

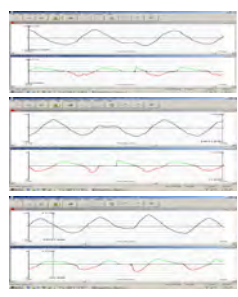


Northwestern Martin-Harris et al., 2015

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## Identification

- Identification of respiratory phase
- Identification of respiratory pause at high, mid, and low lung volumes during swallowing.



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### Acquisition

- Initiation of swallow during expiratory phase at mid-to-low lung volume—**with visually assisted biofeedback**

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Martin-Harris et al., 2015

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### Mastery

- The patient will demonstrate proficiency (90% criteria) in optimal swallowing pattern across textures **without visually assisted biofeedback**

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Martin-Harris et al., 2015

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### Sample

**Table 2** Study patient demographics and clinical characteristics

Variable	Academy Hospital (n = 16)	VMC (n = 22)	Total (n = 38)
<b>Age (y)</b>			
Mean ± SD	60.11	64.11	62.11
Range	27–78	39–74	27–78
<b>Sex</b>			
Male	17 (88)	14 (64)	31 (82)
Female	1 (6)	1 (5)	2 (5)
<b>Respiratory</b>			
Nonrestrictive	12 (80)	18 (82)	30 (78)
Restrictive	4 (25)	4 (18)	8 (21)
<b>Other</b>			
Obesity	1 (6)	1 (5)	2 (5)
Neurological	1 (6)	1 (5)	2 (5)
Cardiovascular	1 (6)	1 (5)	2 (5)
Pharyngeal	1 (6)	1 (5)	2 (5)
Other/unspecified	6 (38)	1 (5)	7 (18)
<b>Stage</b>			
I	1 (6)	1 (5)	2 (5)
II	4 (25)	4 (18)	8 (21)
III	1 (6)	1 (5)	2 (5)
IV	1 (6)	1 (5)	2 (5)
<b>Respiratory support</b>			
None	1 (6)	1 (5)	2 (5)
CPAP	1 (6)	1 (5)	2 (5)
BiPAP	1 (6)	1 (5)	2 (5)
Other	1 (6)	1 (5)	2 (5)
<b>Other</b>			
Stroke	1 (6)	1 (5)	2 (5)
Head and neck	1 (6)	1 (5)	2 (5)
Neurological	1 (6)	1 (5)	2 (5)
Cardiovascular	1 (6)	1 (5)	2 (5)
Pharyngeal	1 (6)	1 (5)	2 (5)
Other/unspecified	6 (38)	1 (5)	7 (18)

NOTE: Obesity (BMI ≥ 30) presented when otherwise specified. Some percentages may not total 100 because of rounding. Lung function determined by GOLD criteria for obstructive lung disease criteria.

- N = 30
- 26 males, 4 females
- Mean age: 61 +/- 10.3 years
- Range: 22 – 78
- Lung function (PFT results)
- 12 normal, 2 restrictive, 16 obstructive

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Martin-Harris et al., 2015

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### Results

- Training time = 6.5 sessions (SD: 1.4; Range: 4-8)
- Significant increase in optimal respiratory-swallowing pattern (p <.0001)

**Table 5** Optimal swallow pattern rates by bolus viscosity and volume for all study patients

Viscosity	Volume	Preintervention	Postintervention	P
Thin liquid	5mL	53.3	93.3	<.0001
	15mL	18.6	78.3	<.0001
	Cup sip	27.1	86.7	<.0001
Nectar	5mL	51.7	90.0	.0001
	15mL	43.1	80.0	.0009
	Cup sip	41.7	89.7	<.0001
Honey	5mL	56.0	86.7	.0013
	15mL	53.4	86.4	.0018
	Cup sip	48.3	84.5	.001

NOTE: Values are percent unless otherwise specified.

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Martin-Harris et al., 2015

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### Scored Physiologic Components

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Martin-Harris et al., 2015

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### Results

**Table 4** Preintervention, postintervention, and 1-month follow-up rates (respiratory-swallow phase, PAS, and MBSImP) and average MDADI scores for VMC patients only (n=15)

Outcome Measure	Preintervention	Postintervention	1-mo Follow-Up	P (preintervention vs 1mo follow-up)	P (postintervention vs 1mo follow-up)
Optimal respiratory-swallow phase	49.1	88.4	88.1	<.0001	.95
PAS score ≥3	74.8	41.0	42.2	<.0001	.84
Lip closure ≥2	3.9	8.5	2.8	.56	.03
Tongue control during bolus hold	55.5	55.6	59.2	.52	.47
Bolus transport/lingual motion	40.5	55.6	41.5	.92	.25
Oral residue ≥2	77.2	78.3	71.1	.16	.05
Initiation of pharyngeal swallow	91.0	89.5	91.1	.95	.70
Soft palate elevation	14.3	27.3	15.6	.82	.14
Laryngeal elevation	70.3	71.5	63.3	.49	.36
Anterior hyoid excursion	92.9	92.9	93.3	.91	.42
Epiglottic movement	63.9	59.9	55.6	.07	.33
Laryngeal vestibular closure	79.7	62.2	62.2	.01	>.99
Pharyngeal stripping wave	48.5	62.8	60.7	.36	.86
Pharyngoesophageal segment opening	76.7	77.1	70.0	.51	.29
Tongue base retraction ≥2	93.9	82.4	80.7	.003	.81
Pharyngeal residue ≥2	95.9	81.6	83.0	.006	.75
MDADI (mean ± SD)	63.3±13.1	68.9±17.1	74.1±17.7	.0014	.12

NOTE: Percent presented unless otherwise specified. MBSImP component score ≥1 unless otherwise specified.

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Martin-Harris et al., 2015

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### Results

Significant improvement in several MBSImP™ component scores at post-treatment with stability at one-month follow-up:

- Laryngeal vestibular closure ( $p = 0.0001$ )
- Tongue base retraction ( $p < .0001$ )
- Pharyngeal residue ( $p = 0.017$ )

Northwestern Martin-Harris et al., 2015

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### Results

Significant decrease in PAS scores

Measure	Pre-	Post-	p-value
PAS >2 (%)	77.2	35.5	<0.0001

PAS Score	1	2	3	4+
Pre-	100 (20%)	17 (3%)	294 (57%)	102 (20%)
Post-	197 (39%)	132 (26%)	99 (19%)	82 (16%)

Northwestern Martin-Harris et al., 2015

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### Results

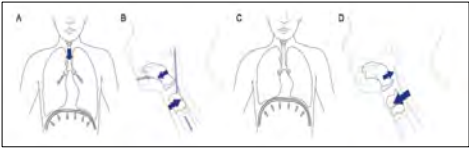
- Significant increase in MDADI scores ( $p = .001$ )
- 30% had a *clinically significant improvement* in MDADI score (>10 points)

	Pre-	Post-
MDADI Score Mean (SD)	60.0 (5.5)	65.3 (6.1)

Northwestern Martin-Harris et al., 2015

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### Mechanisms Underlying Improvement

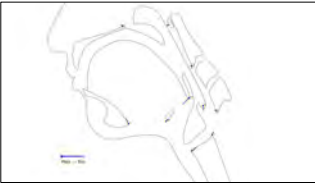


Traction on the trachea and larynx associated with respiratory inspiration shown in (A). Forces acting on the larynx during inspiration (B) are shown in light blue with the resulting negative impact on swallowing mechanics during inspiration shown in dark blue. The absence of traction on the trachea and larynx associated with respiratory expiration shown in (C). Facilitation of swallow mechanics resulting from swallowing at mid-to-low volume expiration shown in dark blue (D).

Northwestern Pearson et al., 2017

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### Mechanisms Underlying Improvement



Vectors characterizing mean position of coordinates from pre- to post-RST indicating **repositioning of the hyoid and larynx, increased tongue base retraction, pharyngeal shortening,** and increased head and neck flexion after RST in a single participant from previous clinical trial.

Northwestern Tran et al., 2018

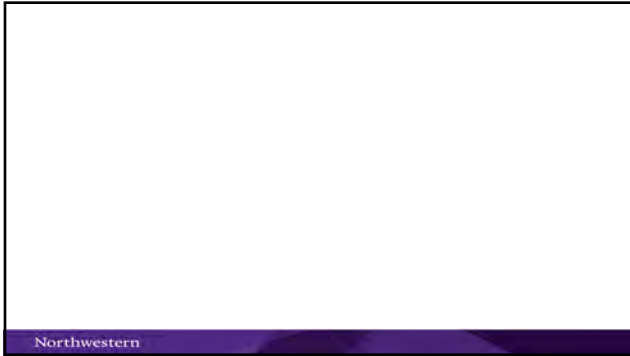
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### Preliminary Findings Support

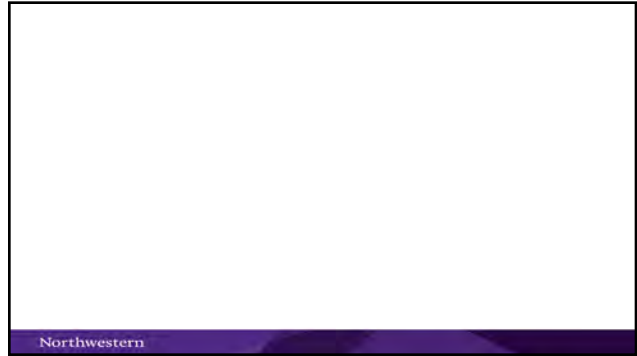
- RST is a skill-based therapy that recalibrates respiratory coordination
- Performance improved with practice (motor learning)
- RST results in improvement in mechanical and airway protective mechanisms in patients treated for persistent dysphagic following oropharyngeal head and neck cancer treatment

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### Establishing Clinical Efficacy

VA RR&D, 1I01RX002352-01A1,  
Respiratory Phase Training in Dysphagic Veterans with Oropharyngeal Cancer,  
Martin-Harris (PI), 2018-2022

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### Training Refinements

*RST Algorithm*  
Real-time performance feedback

Northwestern Rossabi, 2018

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### Training Refinements

Northwestern Rossabi, T. (2018)

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### Toward Clinical Translation

NIH/STTR, R41AG062023-01,  
A Therapeutic Wearable Sensor for Dysphagia  
Xu (PI), Martin-Harris (Co-I), 2018-2021

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**FUTURE: RST in acute phases of HNC recovery, other patient populations, and in combination with other treatments**

Hutcheson, Barrow, Plowman et al., *Laryngoscope*, 2017

O'Rourke, A., Davidson, K., *AJSLP*, 2020

Giselle D. Carnaby-Mann MPH, PhD, Michael A. Crary, PhD  
 McNeill Dysphagia Therapy Program: A Case-Control Study

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**Enhancing the Reliability of Swallowing Measures: Big Data, Artificial Intelligence, Machine Vision and Wearable Sensors**

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**Standardized Assessment of Swallowing Impairment**

NIH/NIDCD K23DC005764, 2003-2010  
 NIH/NIDCD K24 2013-2018  
 2K24DC012801 2019-2024

Method of Training  
 Administration Protocol  
 Assessment Tool  
 Vernacular  
 Analysis and Reporting Methods

→

**TRANSPARENCY**  
**RIGOR**  
 (design, data capture, analysis, interpretation)  
**REPRODUCIBILITY**

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**Modified Barium Swallow Impairment Profile (MBSImp™)**

1. Lip Closure
2. Tongue Control
3. Bolus Preparation/Mastication
4. Bolus Transport/Lingual Motion
5. Oral Residue
6. Initiation of Pharyngeal Response
7. Soft Palate Elevation
8. Laryngeal Elevation
9. Anterior Hyoid Excursion
10. Epiglottic Movement
11. Laryngeal Vestibular Closure
12. Pharyngeal Stripping Wave
13. Pharyngeal Contraction
14. PES Opening
15. Tongue Base Retraction
16. Pharyngeal Residue
17. Esophageal Clearance

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**Standardized and Validated Protocol**

Viscosity, Volume, Dose, Method

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### Operational Definitions

**The MODIFIED BARIUM SWALLOW IMPAIRMENT PROFILE (MBSImP™) Components, Scores, and Scale Definitions**

**ORAL Impairment**

**PHARYNGEAL Impairment**

**Component 6 – Initiation of Pharyngeal Swallow**

- 0 = Bolus head at posterior angle of ramus (first hyoid excursion)
- 1 = Bolus head in valleculae
- 2 = Bolus head at posterior laryngeal surface of epiglottis
- 3 = Bolus head in pyriformis
- 4 = No visible initiation at any location

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NIH/NIDCD K23DC005764, Standardized assessment of swallowing impairment, 2003-2010

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### Dissemination

February 2021  
**MBSImP™**  
Modified Barium Swallow Impairment Profile

**27 Countries**

**MBSImP™ By The Numbers**

- 5,500** NIH grant recipients worldwide who have completed the MBSImP™ (International Training and Integrity Testing)
- 60,000** International patients who have completed the MBSImP™ (International Training and Integrity Testing)
- 65,000** International patients who have completed the MBSImP™ (International Training and Integrity Testing)
- 185** International centers who have completed the MBSImP™ (International Training and Integrity Testing)

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### Reliability Training & Testing

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NIH/NIDCD K23DC005764, Standardized assessment of swallowing impairment, 2003-2010

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### Standardized Analysis and Reporting

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### MBSImP Patient Query Function

Database and Dysphagia Registry (65,000 entries)

Outcome Tracking • Clinical Research • Big Data Warehouse

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### BIG DATA

<b>N=</b>	52,787*			
<b>Sex</b>	Male	27,317		
	Female	23,853		
<b>Age</b>	18-30	1,211	<b>Ethnicity</b>	
	31-40	1,580		
	41-50	3,050		
	51-60	6,002		
	61-70	11,251		
	71-80	12,614		
	81-90	9,820		
91+	4,118	<b>Race</b>		
			Unknown/Not-Reported	13,410
			Hispanic/Latino	4,028
			Not Hispanic/Latino	35,349
			White	35,894
			Asian	1,057
			Black/African American	6,248
		Native Hawaiian/Pacific Islander	149	
		American Indian/Alaskan Native	286	
		More than one race	290	
		Unknown/Other/Not Reported	7,900	

HNC = Head and Neck Cancer, COPD = Chronic Obstructive Pulmonary Disease, PD = Parkinson's Disease  
 \*Demographic information not reported for all categories for all subjects

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### Data Science Applications in CSD

**Aim 1** Refine swallowing phenotypes for five specific diagnoses commonly known to be at high risk for nutritional and health complications related to swallowing impairment including: 1) Stroke, 2) Parkinson's Disease, 3) Head and Neck Cancer, 4) Dementia and 5) COPD

**Aim 2** Predict swallowing impairment severity classifications based on Modified Barium Swallowing Impairment (MBSImP) overall impression (OI) component scores in each of the five diagnoses using both supervised and unsupervised statistical learning algorithms.

**Aim 3** Develop a computerized scoring algorithm using computer vision and machine learning techniques toward minimization of subjectivity, human error and further enhanced reproducibility of swallowing metrics.

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### Impairment Severity

Research Article

#### Classification of Physiologic Swallowing Impairment Severity: A Latent Class Analysis of Modified Barium Swallow Impairment Profile Scores

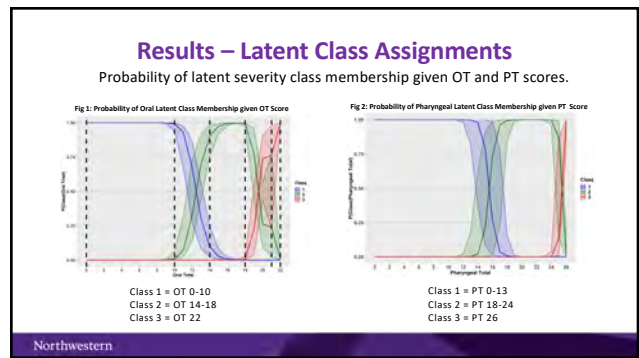
Jonathan Basik,<sup>1</sup> Elizabeth G. Hill,<sup>2</sup> Kent Arneson,<sup>3</sup> Kandrea L. Fochigand,<sup>4</sup> Kelly Humphrey Davidson,<sup>5</sup> and Barbra Martin-Harris<sup>6</sup>

**Background:** Our objectives were to identify oral and pharyngeal physiologic swallowing impairment severity classes based on clinical video analysis (CVA) of the Modified Barium Swallow Impairment Profile (MBSImP) swallow task scores and to identify the probability of severity class membership given composite MBSImP scores. Methods: MBSImP scores were obtained from a national database of 213 consecutive modified barium swallow studies. Because of missing swallow task scores, CVA was performed using 25 multiple impacted video frames. CVA revealed a three class structure for oral and pharyngeal swallows, the oral-pharyngeal (OP) and pharyngeal (P) classes. Results: MBSImP scores were derived following latent class assignment.

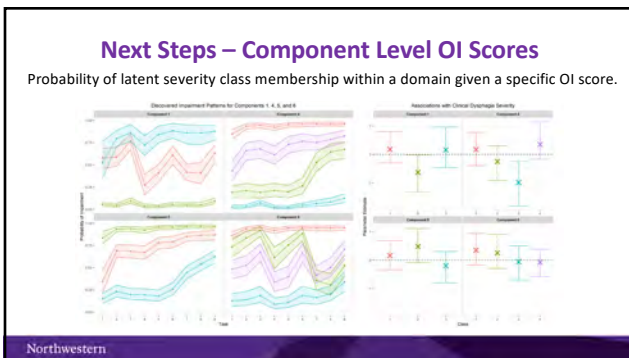
**Conclusions:** CVA of MBSImP data revealed significant underlying oral and pharyngeal and/or oropharyngeal impairments, severity gradients of physiologic swallow impairment. Clinical meaning of OP and P class targets were derived following latent class assignment.

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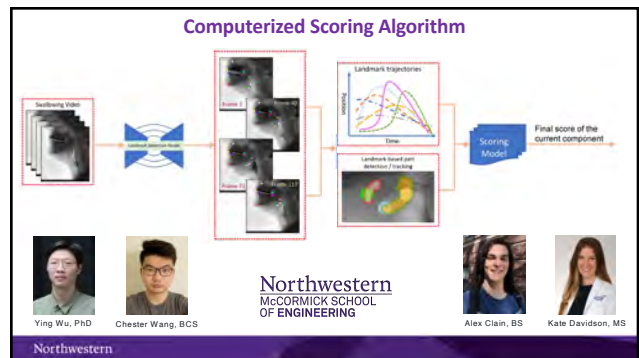
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### Wearable Sensor Technology Respiratory-Swallow Detection

A) Synchronized Video/Fluoroscopy; B) Respiratory signal from the wearable sensor; C) Swallow signal from the wearable sensor

John Rogers, PhD  
  
Steve Xu, PhD  
  
Abby Nellis, MS  
  
Caglia Kantarcigil, PhD

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### Big Data Informs Clinical Decision Making

Standardized, validated swallowing metrics  
recorded during standard of care MBSS by like-trained clinicians...

↓

...uncover new hypotheses,  
refine existing theories,  
apply new discoveries to swallowing assessments and interventions.

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### Swallow Cross-Systems Collaborative Lab Members

 Bonnie Martin-Harris, PhD Lab Executive Director	 Kate Davidson, MS, CCC-SLP Lab Assistant Director	 Abigail Nellis, MS, CCC-SLP Lab Manager
 Caglia Kantarcigil, PhD Post-Doctoral Fellow	 Brittany Kreckeler, PhD Post-Doctoral Fellow	 Alex Clain, BS Doctoral Candidate
 Munirah Alkhuwair, MS Doctoral Candidate	 Rabab Rangwala, MS Doctoral Candidate	 Raneh Saadi, MS Doctoral Candidate

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### Internal Collaborators

 Rick McGee, PhD Medical Education	 Sumitrajit Dhar, PhD CSD Dept Chair CSD	 Leslie DeChurch, PhD Communication Studies	 Sandeep Samant, MD Otolaryngology	 Bharat Mittal, MD Radiation Oncology	 Brandon Grill Director IT
 Kristin Lorenz, MS Speech Pathology	 Sharon Wei, MS Speech Pathology	 Laura Cumbly, MS Speech Pathology	 CC Chiu, MS Speech Pathology	 Laura Vignata, MS Speech Pathology	 Zoe Pakis, MS Speech Pathology
 Brittni Carnes, MS Speech Pathology					

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### Internal Collaborators

 Ying Wu, PhD Electrical Engineering and Computer Science	 Darren Geigle, PhD Communication Studies and Dept of Electrical Engineering and Computer Science	 Nash Contractor, PhD Industrial Engineering and Management Science	 Jim Elliot, PhD Physical Therapy
 John Rogers, PhD Professor of Materials Science and Engineering	 Shuai (Steve) Xu, MD Center of Bio-Integrated Electronics	 Lutfiyya Muhammad, PhD Preventive Medicine (Biostatistics)	 Jungwha Lee, PhD, MPH Preventive Medicine (Biostatistics)
 Chester Wang, BCS Electrical Engineering and Computer Science			

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### External Collaborators

 Ashi O'Rourke, MD	 Elizabeth G. Hill, PhD	 Kent Armeson, MS	 Bill Pearson, Jr., PhD	 Maureen Lefton-Greif, PhD	 David McFarland, PhD
 Heather S. Bonilha, PhD, CCC-SLP	 Terry Rossabi, PhD, BCS-S	 Jordan Hazelwood, PhD, CCC-SLP, BCS-S, CBR	 Julie Blair, MA, CCC-SLP, BCS-S	 Janina Wilmskoetter, PhD	 Kendrea L. Focht, PhD, CScD, CCC-SLP, CBIS, BCS-S

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