How to Integrate Cough Evaluation and Cough Skill Training into Dysphagia Management

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Laboratory for the Study of Upper Airway Dysfunction
TEACHERS COLLEGE, COLUMBIA UNIVERSITY

Disclosures

- James Borders

  Salary: Teachers College, Columbia University
- Emilie Lowell

  Fellowship: Teachers College, Columbia University
- Katya Villareal

  Fellowship: Teachers College, Columbia University
- Michelle Troche

  Salary: Teachers College, Columbia University
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Laboratory for the Study of Upper Airway Dysfunction

Research aimed at improving health outcomes and quality of life associated with disorders of swallowing, cough, and speech production.

Learning Objectives

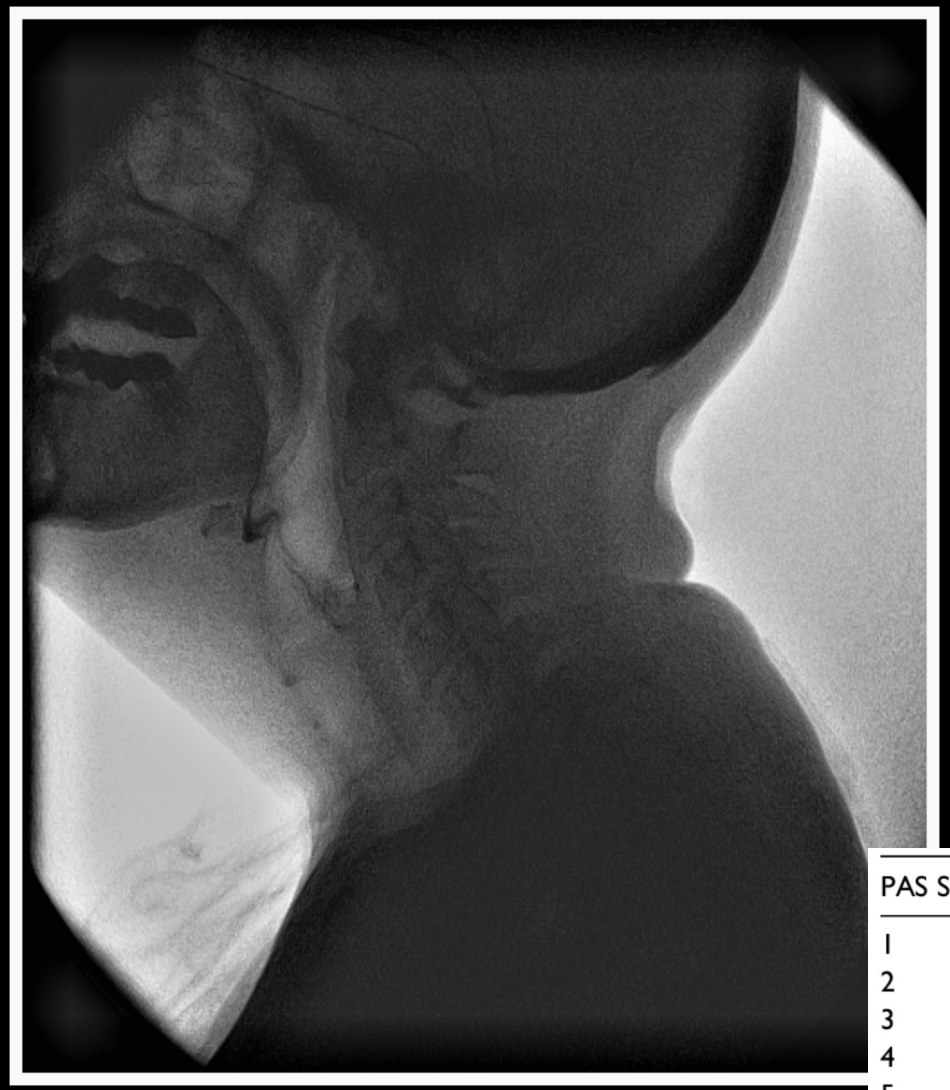
- Describe the theoretical underpinnings and rationale for cough as an important airway protective behavior
- Provide practical approaches to evaluate sensory and motor aspects of cough in clinical practice
- Illustrate the clinical implementation evaluation and treatment of cough skill training in case presentations

Have you or someone (SLP) you know ever….

- Asked a patient to cough during a cranial nerve exam.
- Made an assumption based on a cough (or absence of cough) on a clinical swallowing evaluation.
- Used the penetration-aspiration scale.
- Prescribed a ‘cough’ during meals or after liquids.

Why do we care about these things?

We care about whether our patient can protect their airway



PAS Score	Description
1	Material does not enter the airway
2	Material enters the airway, remains above the vocal folds, and is ejected from the airway
3	Material enters the airway, remains above the vocal folds, and is not ejected from the airway
4	Material enters the airway, contacts the vocal folds, and is ejected from the airway
5	Material enters the airway, contacts the vocal folds, and is not ejected from the airway
6	Material enters the airway, passes below the vocal folds, and is ejected into the larynx or out of the airway
7	Material enters the airway, passes below the vocal folds, and is not ejected from the trachea despite effort
8	Material enters the airway, passes below the vocal folds, and no effort is made to eject

Without knowing we KNOW that swallowing and cough disorders co-exist

Dysphagia (2016) 31:757–764
DOI 10.1007/s00455-016-9734-6

ORIGINAL PAPER

Reflex Cough and Disease Duration as Predictors of Swallowing Dysfunction in Parkinson's Disease

Michelle S. Troche[1] · Beate Schumann[2] · Alexandra E. Brandimore[1] ·

The Laryngoscope

RESEARCH ARTICLE

Sensorimotor Cough Dysfunction Is Prevalent and Pervasive in Progressive Supranuclear Palsy

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Voluntary Cough Airflow Differentiates Safe Versus Unsafe Swallowing in Amyotrophic Lateral Sclerosis

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Received: 28 August 2017 / Accepted: 31 July 2018

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And we know that (an effective) cough is good for clearing the airway - and important for preventing aspiration pneumonia

Research letter

Higher cough flow is associated with lower risk of pneumonia in acute stroke FREE

PDF

PDF + Supplementary Material

Stefan T Kulnik [1], Surinder S Birring [2], John Hodsoll [3], John Moxham [2], Gerrard F Rafferty [2], Lalit Kalra [4]

Correspondence to Dr Stefan T Kulnik, Faculty of Health, Social Care and Education, St George's, University of London, Cranmer Terrace, London SW17 0RE, UK; stefan.kulnik@nhs.net

Morbidity in Patients with Dysphagia

Bianchi, Carlo MD; Baiardi, Paola PhD; Khirani, Sonia PhD; Cantarella, Giovanna MD

Author Information

American Journal of Physical Medicine & Rehabilitation 91(9):p 783-788, September 2012. | *DOI:* 10.1097/PHM.0b013e3182556701

Metrics

Translational Stroke Research (2019) 10:36–43
https://doi.org/10.1007/s12975-018-0625-z

ORIGINAL ARTICLE

CrossMark

The Dysphagia in Stroke Protocol Reduces Aspiration Pneumonia in Patients with Dysphagia Following Acute Stroke: a Clinical Audit

Sarah E. Perry[1,2] · Anna Miles[3] · John N. Fink[4] · Maggie-Lee Huckabee[1]

Received: 10 January 2018 / Revised: 7 February 2018 / Accepted:

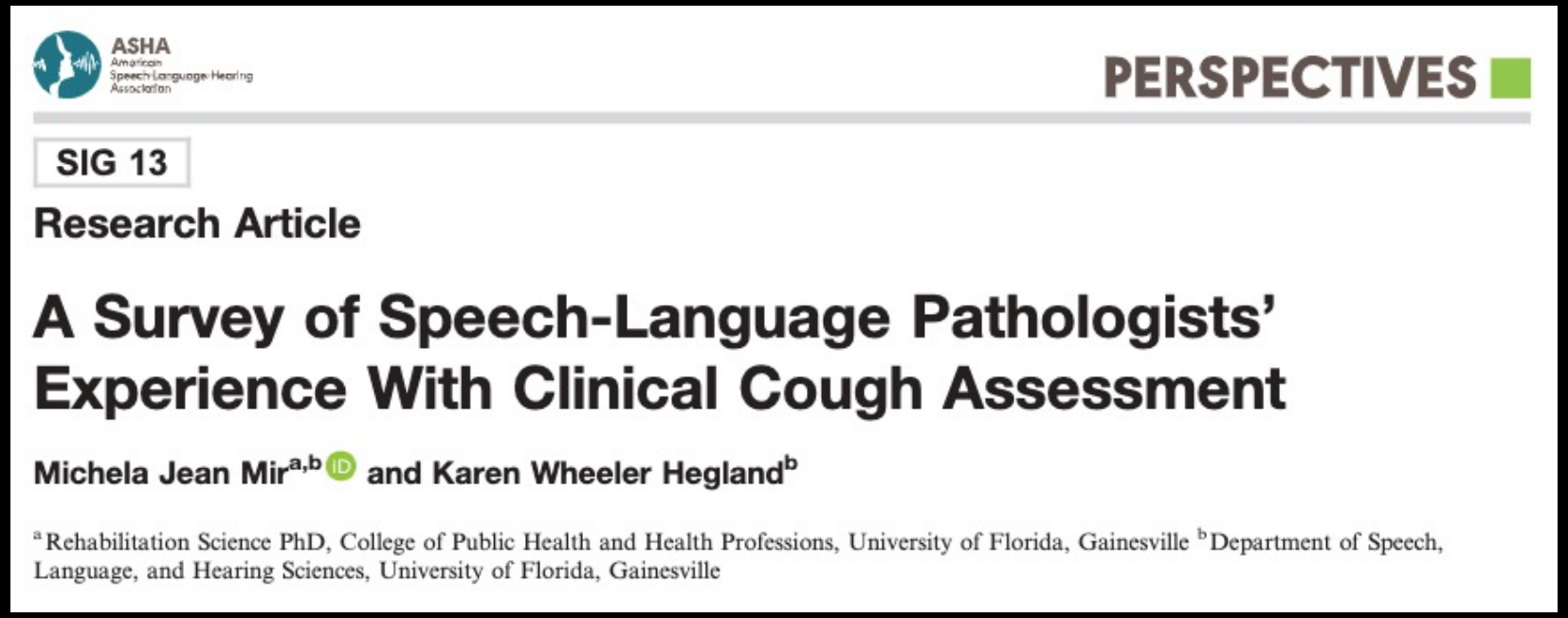
Cough Strength Is an Indicator of Aspiration Risk When Restarting Food Intake in Elderly Subjects With Community-Acquired Pneumonia

Yasunari Sakai, Masayoshi Ohira, and Yoshiharu Yokokawa

So if we know all of this….

How can we do better?

- Many clinicians who treat individuals with dysphagia report limited education related to cough
- Over 97% SLPs in a recent survey reported an interest in learning more about cough assessment.



ASHA American Speech-Language-Hearing Association

PERSPECTIVES

SIG 13

Research Article

A Survey of Speech-Language Pathologists' Experience With Clinical Cough Assessment

Michela Jean Mir[a,b] and Karen Wheeler Hegland[b]

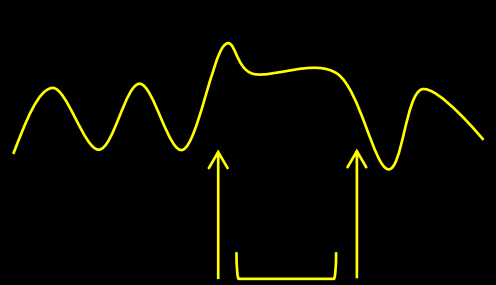
[a] Rehabilitation Science PhD, College of Public Health and Health Professions, University of Florida, Gainesville [b] Department of Speech, Language, and Hearing Sciences, University of Florida, Gainesville

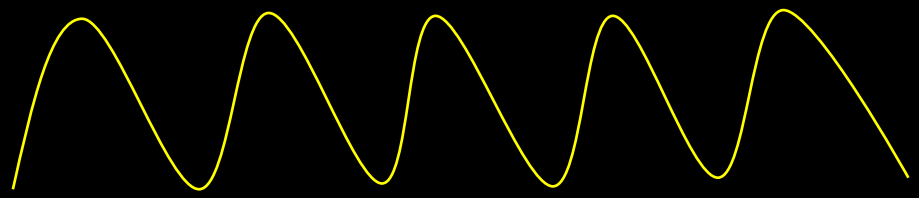
Let the Cough 101 course begin….

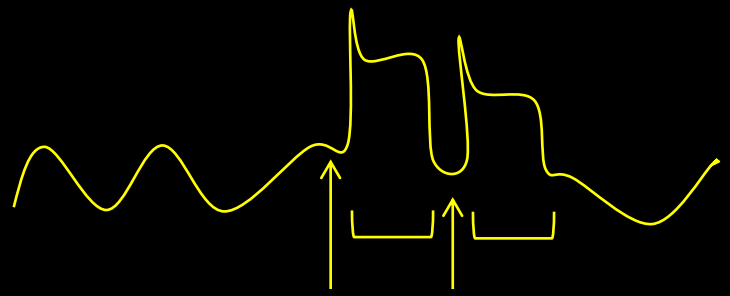
Airway Protection: A Continuum of Behaviors

Swallowing | Glottal stop/ LAR | Exp reflex | Exp effort | Throat clear | Cough

Prevention — Ejection

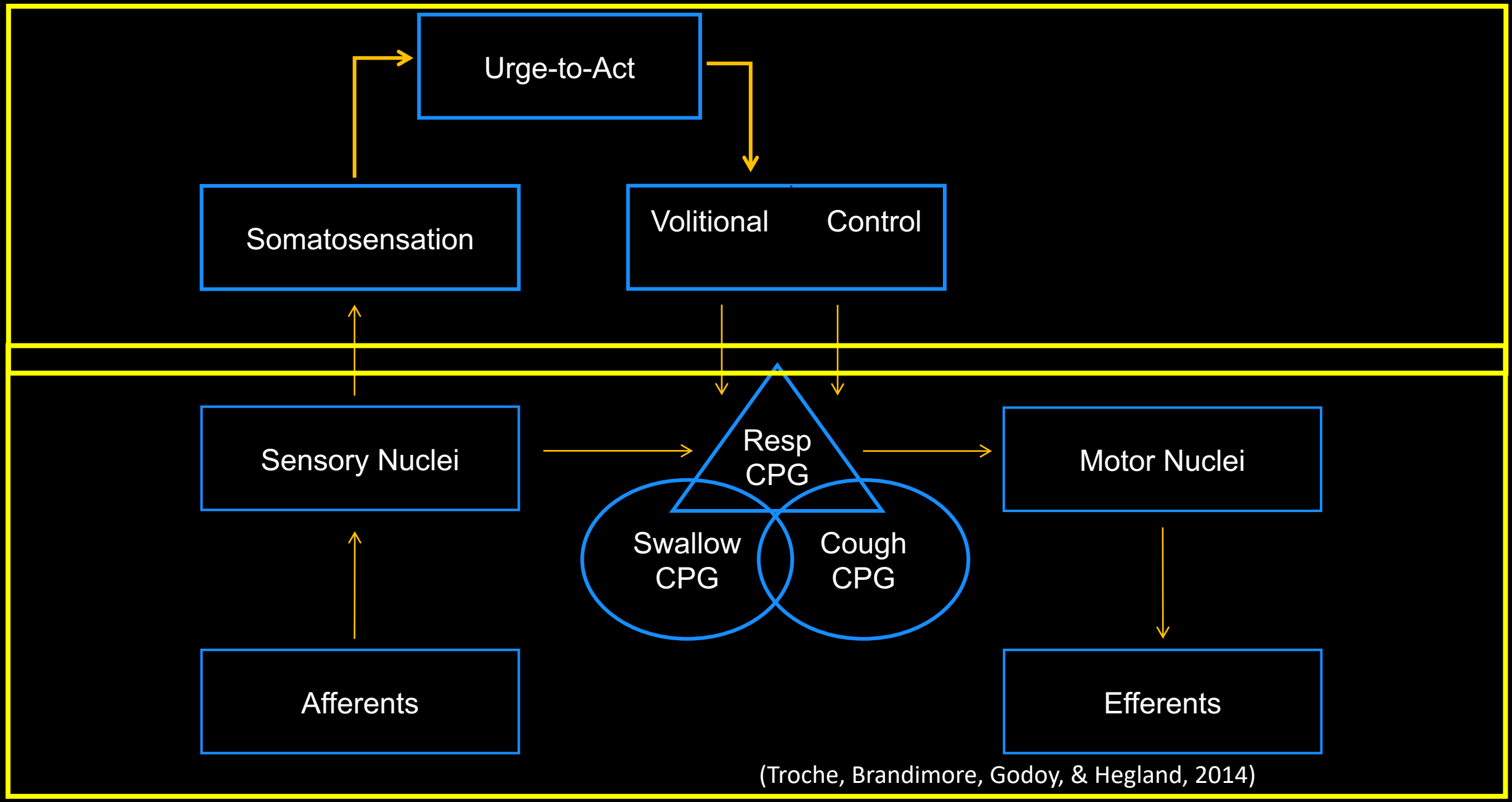






(Troche, Brandimore, Godoy, & Hegland, 2014)

A Framework to Understand Airway Protection



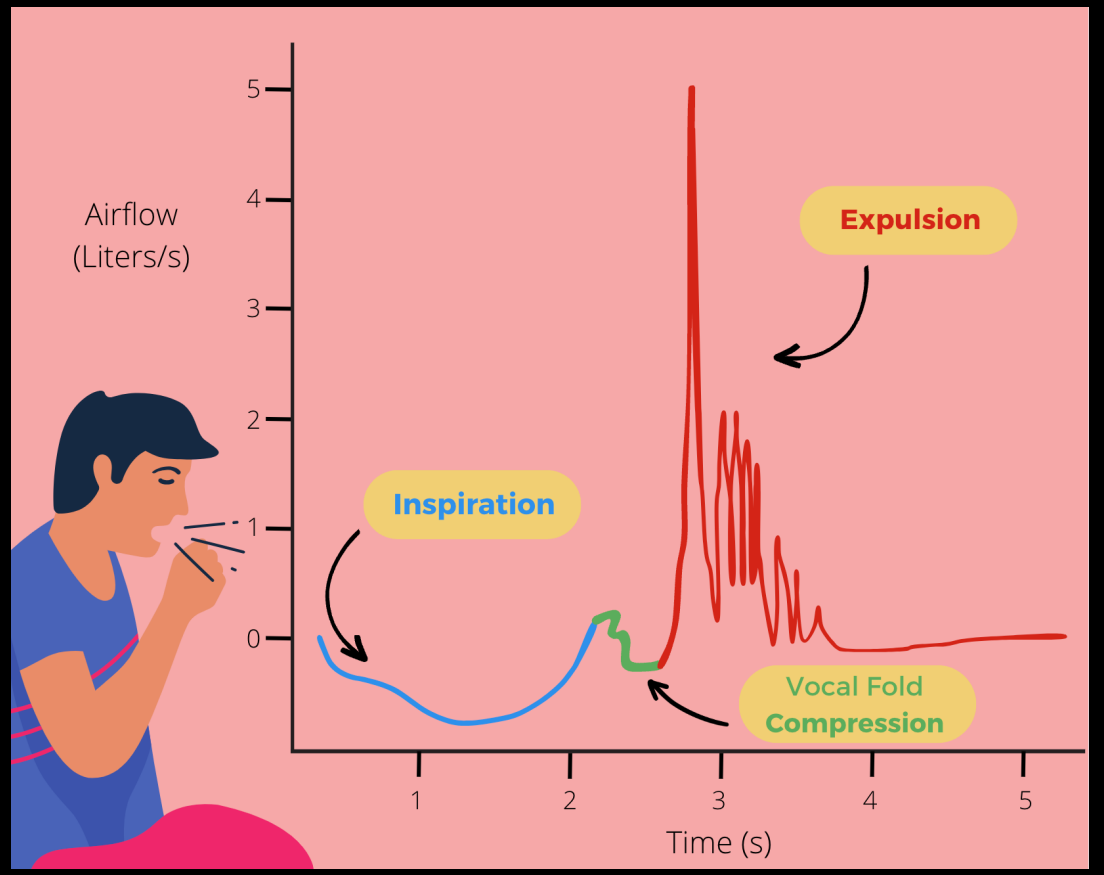
(Troche, Brandimore, Godoy, & Hegland, 2014)

Cough is....

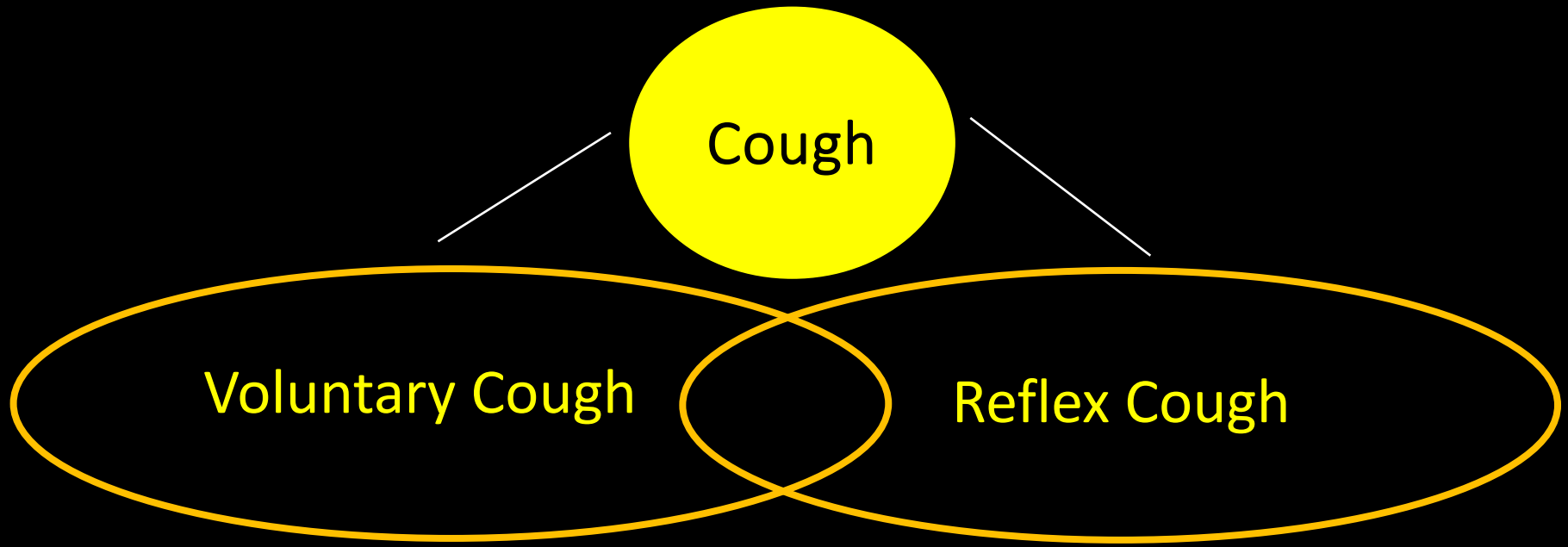
- A mechanism of airway protection
- A sensorimotor behavior which serves to protect the pulmonary system by generating expiratory airflows that create ‘scrubbing’ action, removing material from the airway
- Forced expiratory maneuver, usually against a closed glottis, associated with a characteristic sound

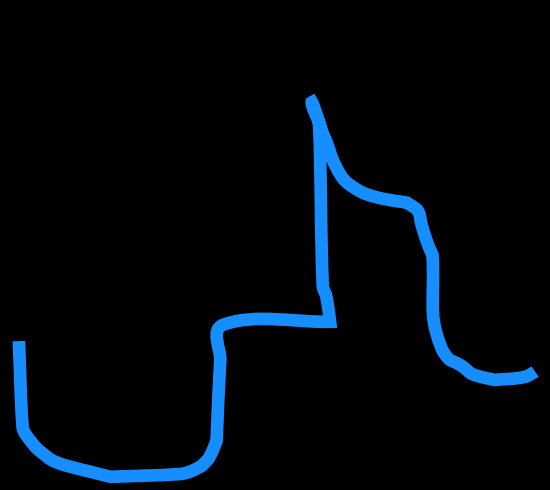
In order to generate high airflow velocities during cough you need four things:

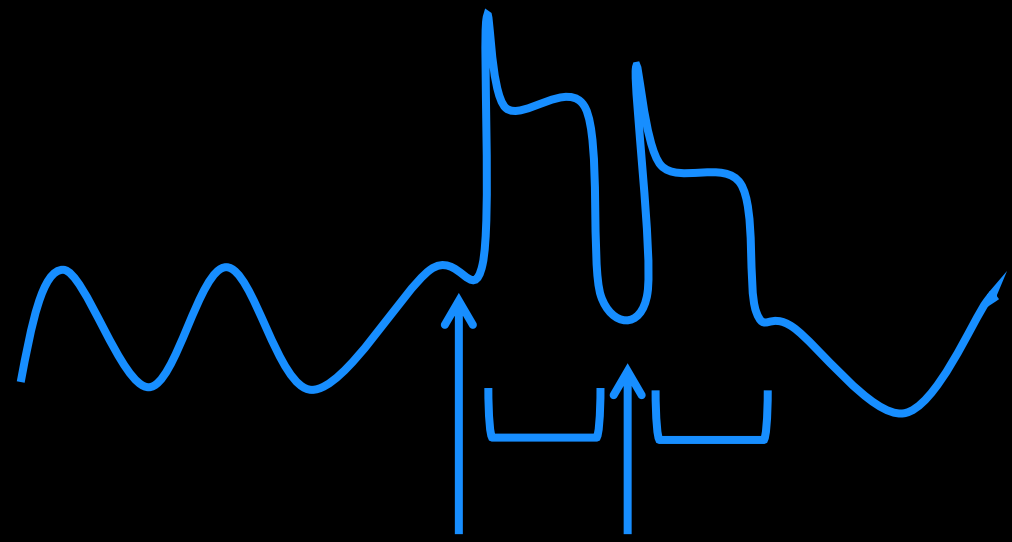
- Inspiration
- Adduction of vocal folds/closure of the laryngeal vestibule
- Rapid opening of the vocal folds and larynx
- Forced expiration

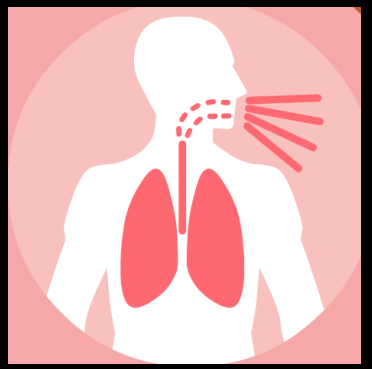


Types of cough (and their unique importance)









How might DYSTUSSIA manifest in my patients?

Dystussia is….

- Disordered or pathologic cough
- Related terms
  - Eutussia – Normal cough
  - Hypertussia – Too much cough
  - Hypotussia – Too little cough
  - Atussia – absent cough

How does DYStussia manifest in people with dysphagia?

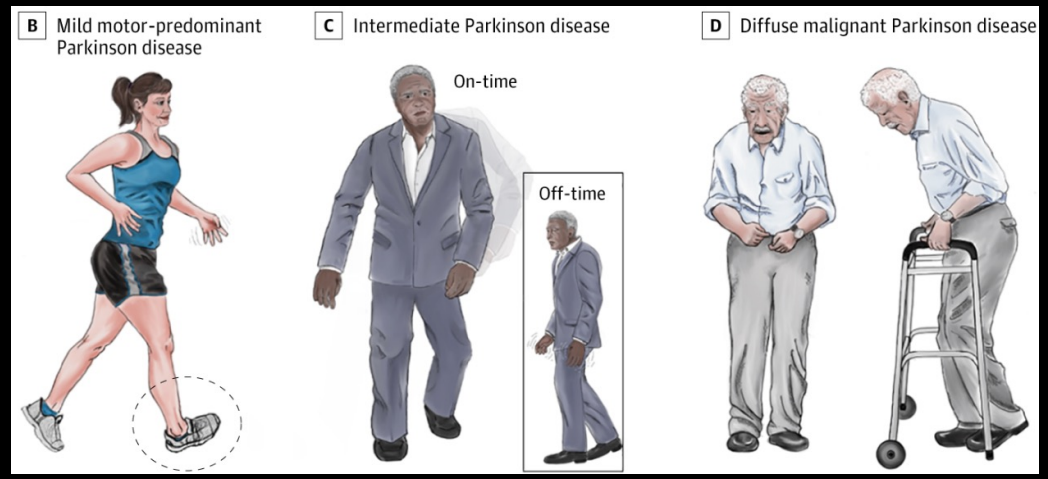
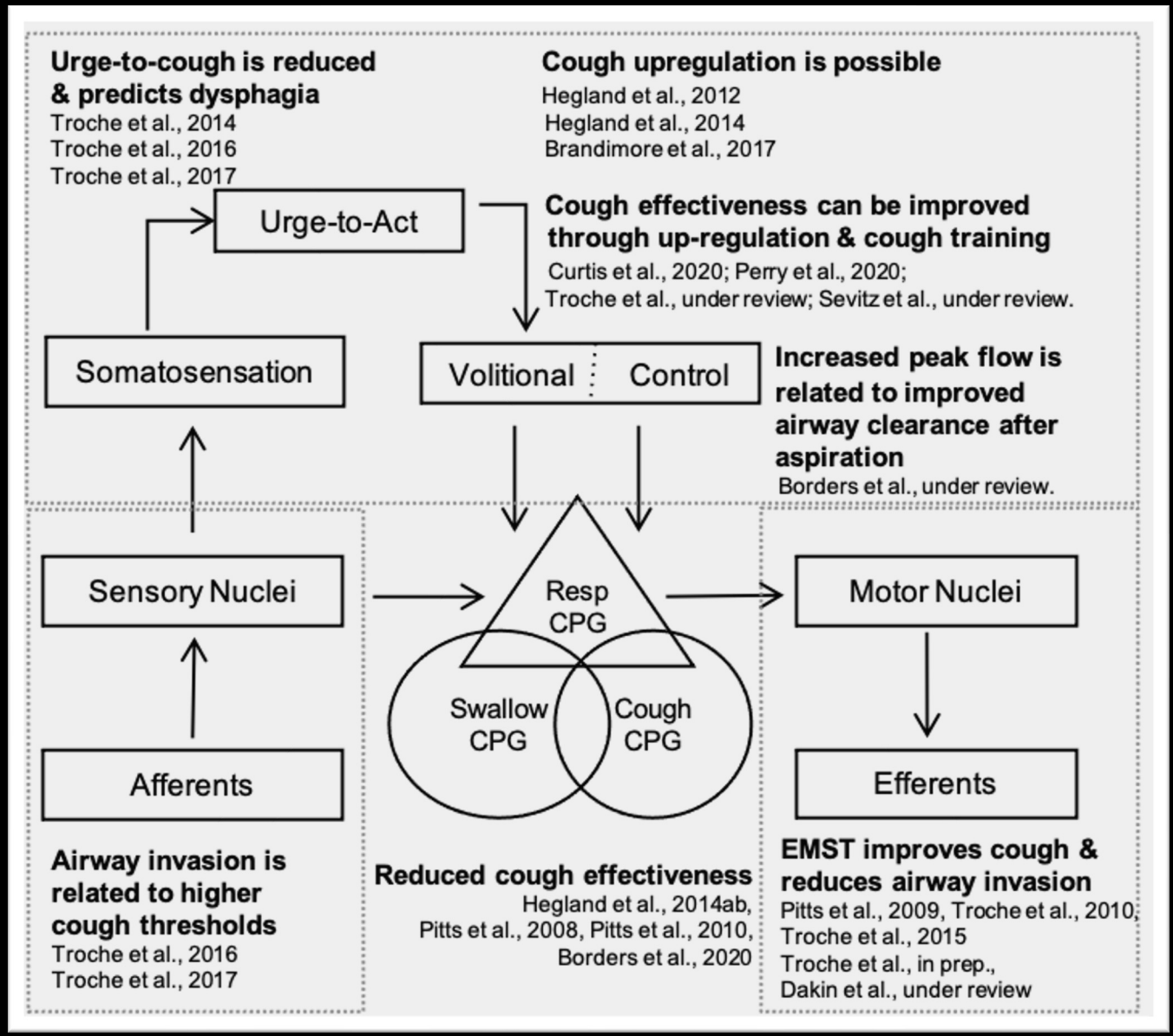


Figure from Armstrong & Okun 2020

- Higher cough thresholds
- Blunted urge-to-cough
- Disorganized/reduced voluntary control of cough
- Reduced peripheral strength
- Increased variability in cough performance



Framework from: Troche et al, 2014

Dysphagia and Dystussia commonly ~~(always?)~~ co-exists!

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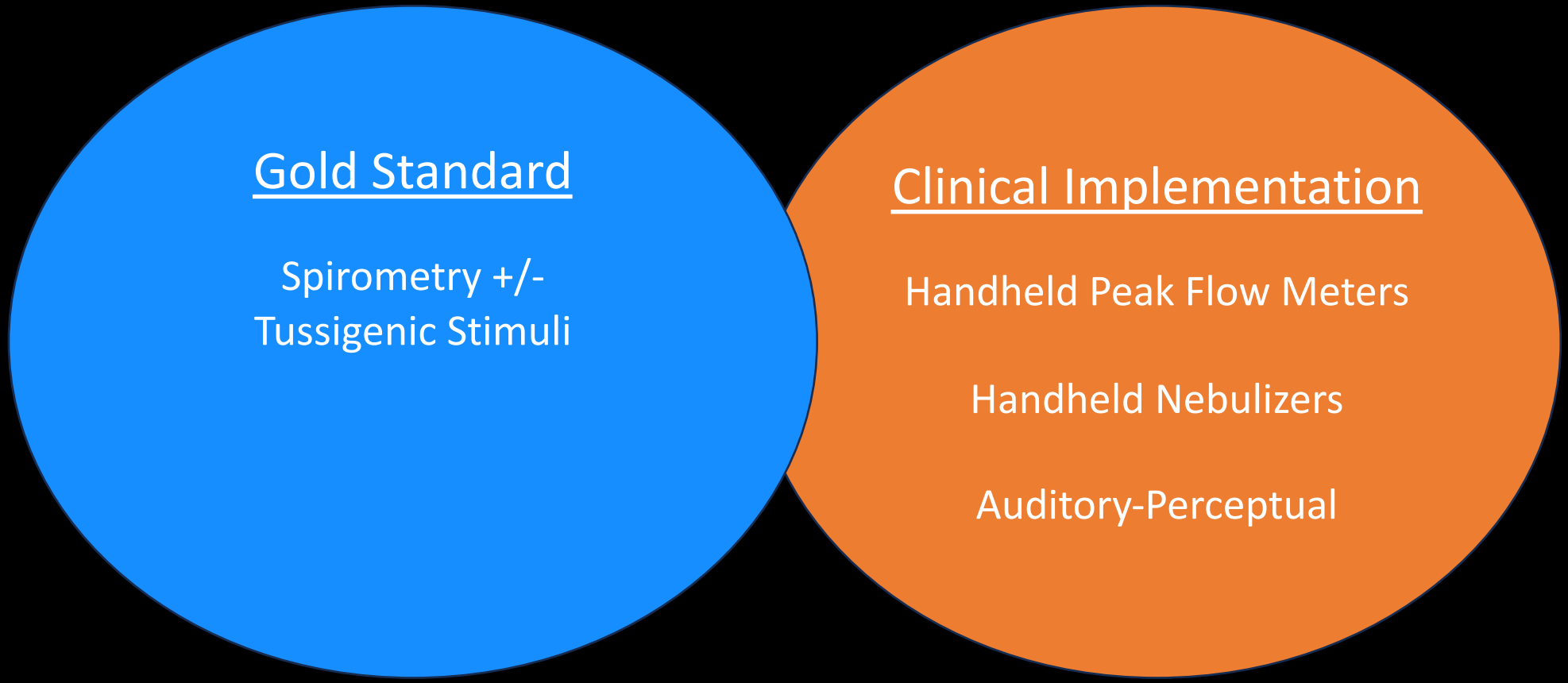
Cough Evaluation: A Step-by-Step Tutorial



Spirometry: the Gold Standard

Equipment

- Pneumotachograph coupled with a facemask
  - Connected to a computer to visualize airflow during breathing and coughing

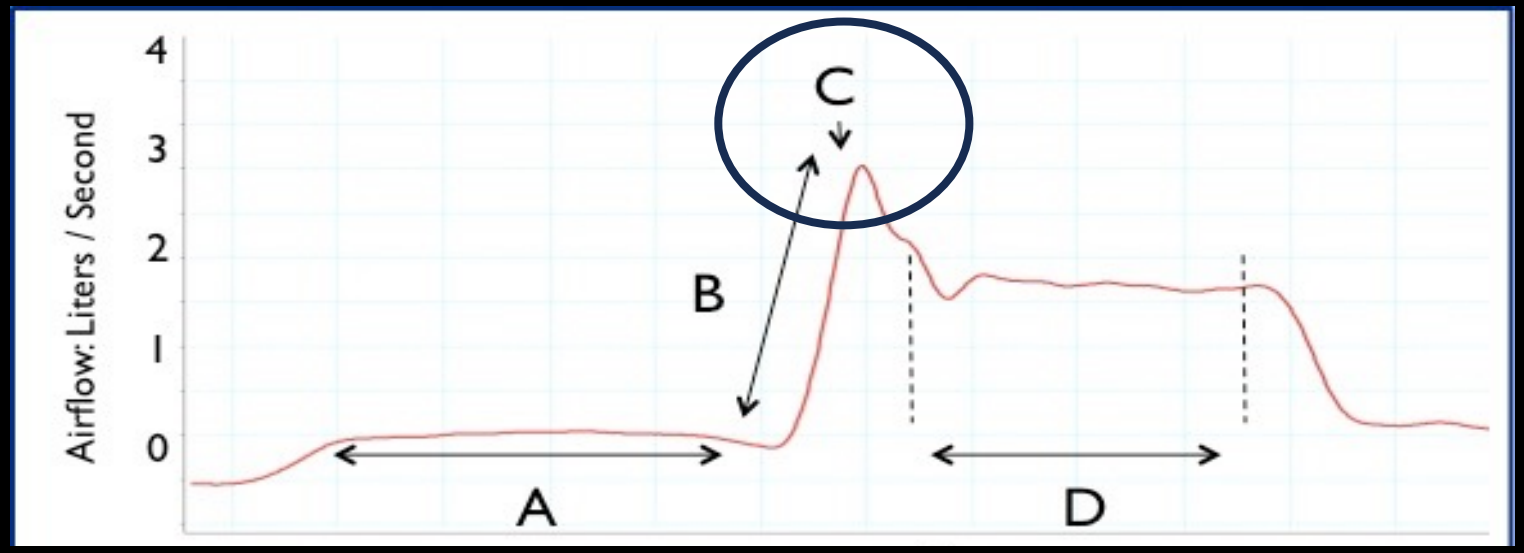
Pneumotachograph

Facemask

Filter

Full setup

Cough Measurement with Spirometry



Cough Inspired Volume (CIV)
Amount of air inspired before coughing

Compression Phase Duration (CPD)
Time from end of inspiration to beginning of expiratory phase

Peak Expiratory Flow Rate (PEFR)
Peak airflow during the expiratory phase of the cough

What can PEFR predict?

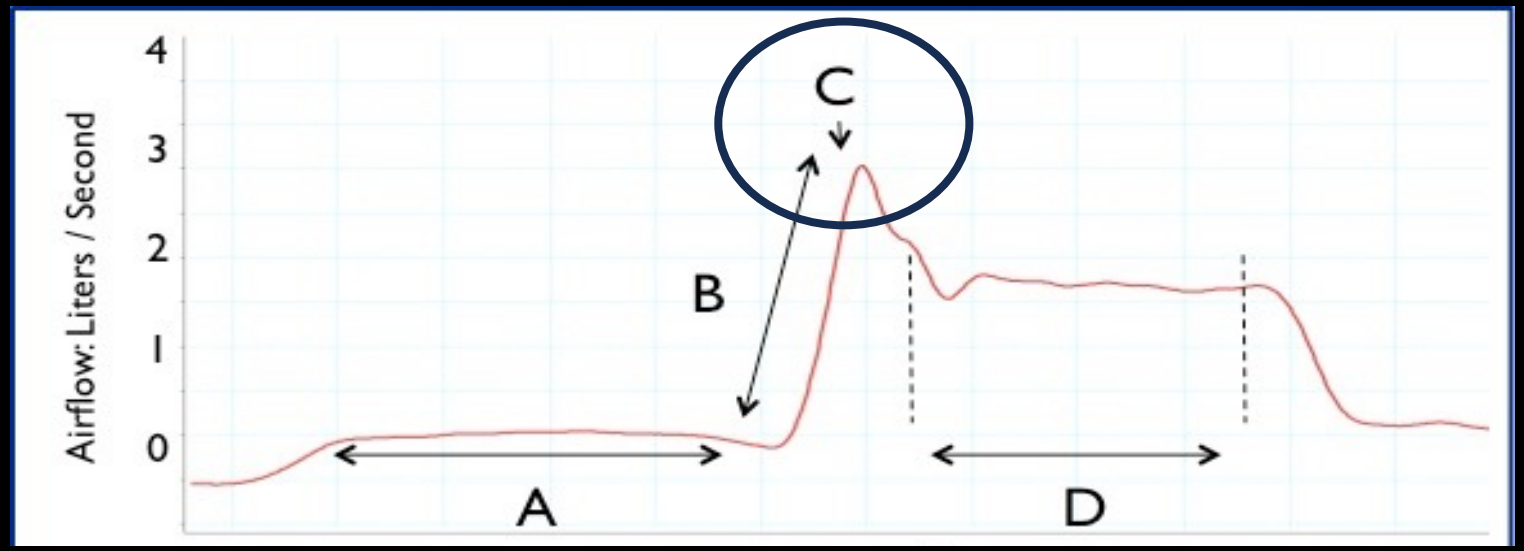
Swallowing safety deficits in people with dysphagia

- PEFR < 5.24 L/s had 100% specificity to detect aspiration on instrumental swallowing evaluation (Pitts et al., 2010)

Ability to clear the airway on an instrumental swallowing evaluation

- PEFR of 5 L/s predicted 80% of aspiration expelled from subglottis (Borders et al., 2021)

Cough Measurement



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Peak Expiratory Flow Rate (PEFR)
Peak airflow during the expiratory phase of the cough

Please rate your urge-to-cough	
0	None at all
1	Very slight
2	Slight
3	Moderate
4	Somewhat severe
5	Severe (heavy)
6	
7	Very, very severe
8	
9	
10	Very, very, very severe (almost maximal)

Voluntary Cough Testing

Step-by-Step Guide

- Hold the facemask tightly against face
- Provide instructions with a model

"Cough hard one time"

- Maintain tight seal with facemask during coughing
- Hold in place for 1 -2 seconds after coughing
- Remove facemask

Spirometry

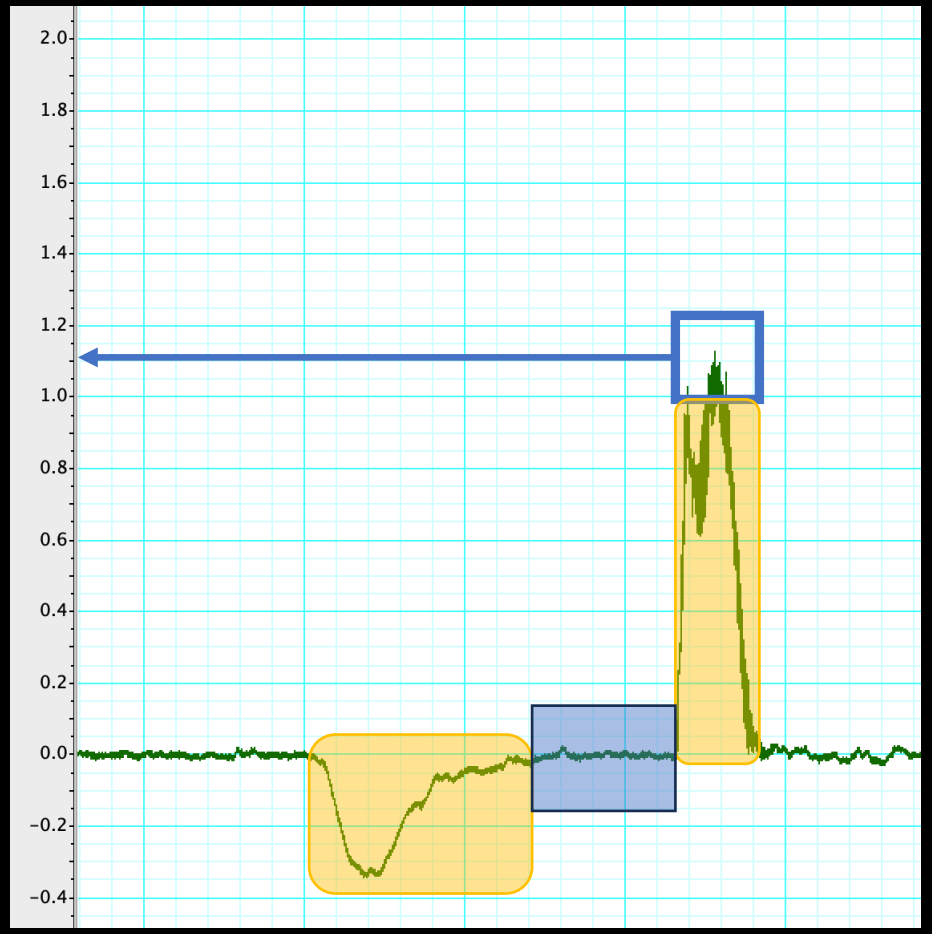
"Cough hard one time"

Instructions

- Single Voluntary Cough
  - Elicits one strong cough
  - Ideal for clearing material from the *upper* airway
  - Can be a stronger cough than sequential

Voluntary Cough Testing: Interpretation

Single



Peak Flow: 1.12 L/s

Cough Inspired Volume: -0.10 L

Cough Expired Volume: 0.16 L

Compression Phase Duration: 0.45 s

Clinical Takeaways

High likelihood of airway invasion on instrumental swallowing evaluation

Poor airway clearance of aspiration

Pitts et al. (2010); Borders & Troche (2021)

Spirometry

"Cough like something went down the wrong tube"

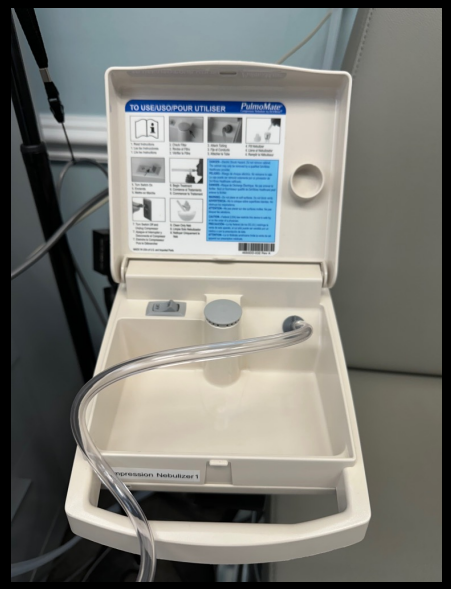
Instructions

- Sequential Voluntary Cough
  - Imitates cough response to aspiration
  - Elicits multiple coughs
  - Clear material from the *lower* airway

Hegland et al. (2014)

Moving onto… Reflex Cough Testing

Delivery of sensory stimulus on inhalation

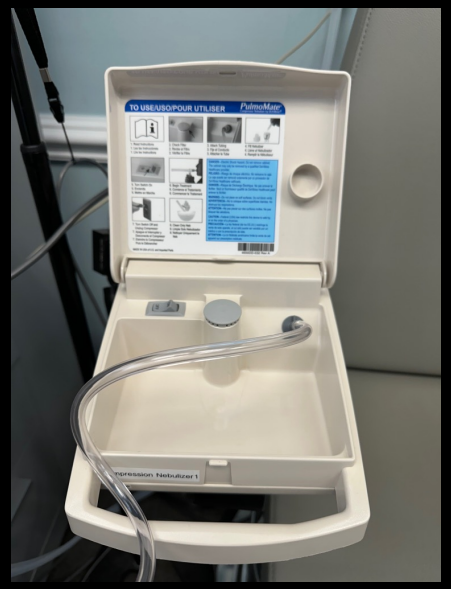


Nebulizer

+

Dosimeter

Continuous delivery of sensory stimulus



Nebulizer

e.g., Miles et al. (2013)

- Protocol improves predictive value of swallowing screens and reduces pneumonia and mortality rates.

Considerations

- Unable to randomize dosages
- Difficult to assess urge-to-cough

Reflex Cough Testing

	Capsaicin	Citric Acid	Distilled Water
Sensory receptors	Stimulates airway receptors that mediate coughing to prolonged irritation	Stimulates laryngeal receptors involved in coughing to aspiration	Poorly defined
Reproducibility after repeated exposure	Good	Poor	Poor
Clinical implementation	Difficult	Easy	Easiest
Potential adverse effects	Allergy	Tachyphylaxis	Bronchoconstriction

e.g., Wallace et al. (2019, 2022); Ohno et al. (2022); Hegland et al. (2016); Mazzone et al. (2011); Dicpinigaitis & Alva (2005)

Reflex Cough Testing

Step-by-Step Guide

- Confirm no allergy to capsaicin

- Randomize order of different amounts of capsaicin
  - 0 µM, 50 µM, 100 µM, 200 µM

Reflex Cough Testing

Step-by-Step Guide

- Hold the facemask tightly against face
- Provide instructions

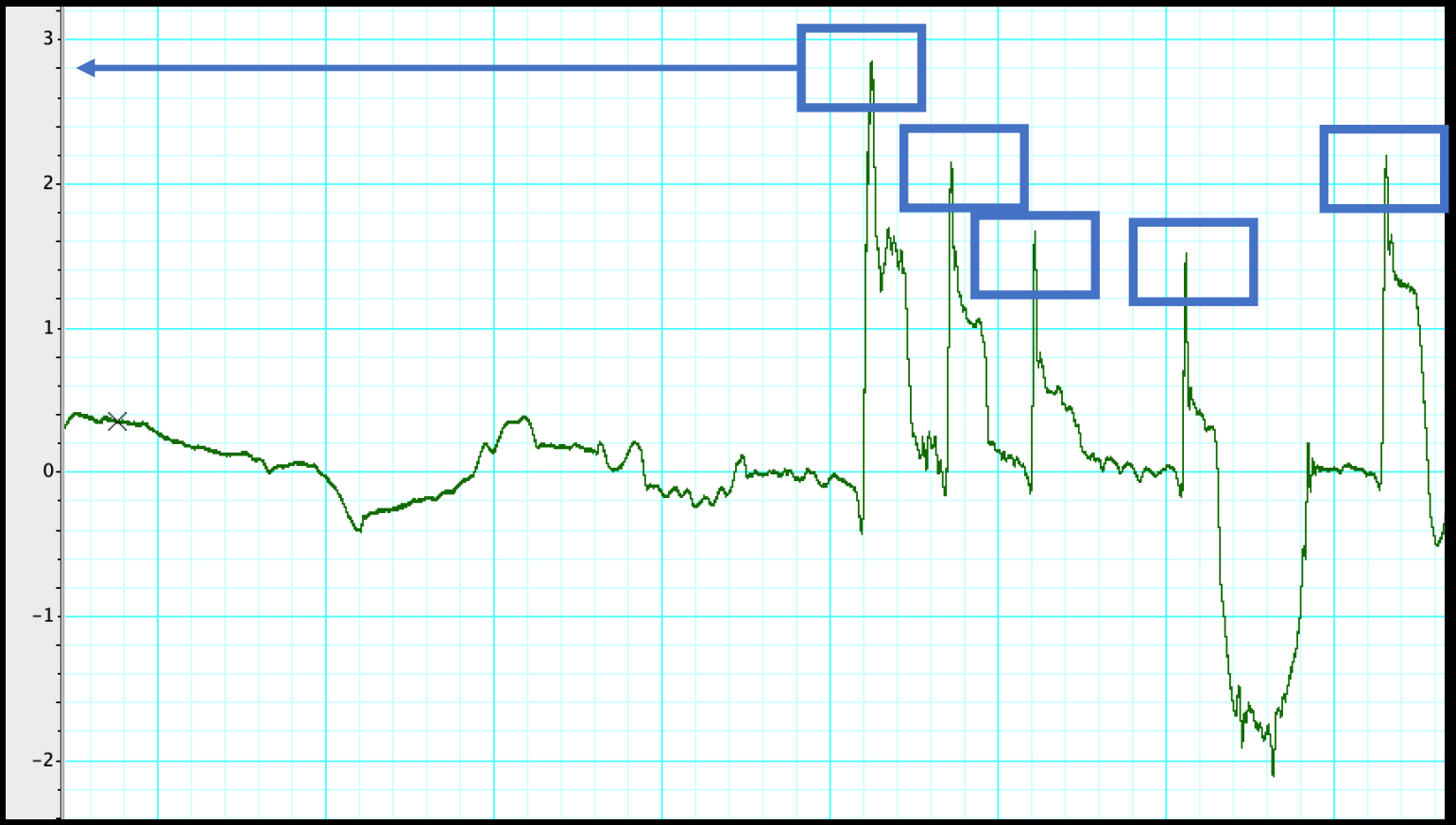
"Relax with the facemask in place and cough if you need to"

- Hold facemask in place after presentation of stimulus and remove facemask
- Wait at least 30 seconds if no immediate cough response
- Ask to rate urge-to-cough and take a sip of water

Please rate your urge-to-cough	
0	None at all
1	Very slight
2	Slight
3	Moderate
4	Somewhat severe
5	Severe (heavy)
6	
7	Very, very severe
8	
9	
10	Very, very, very severe
	(almost maximal)

Reflex Cough Testing: Interpretation

200µM Capsaicin



Produced 5 reflexive coughs with a peak flow of 2.85 L/s

Clinical Takeaways

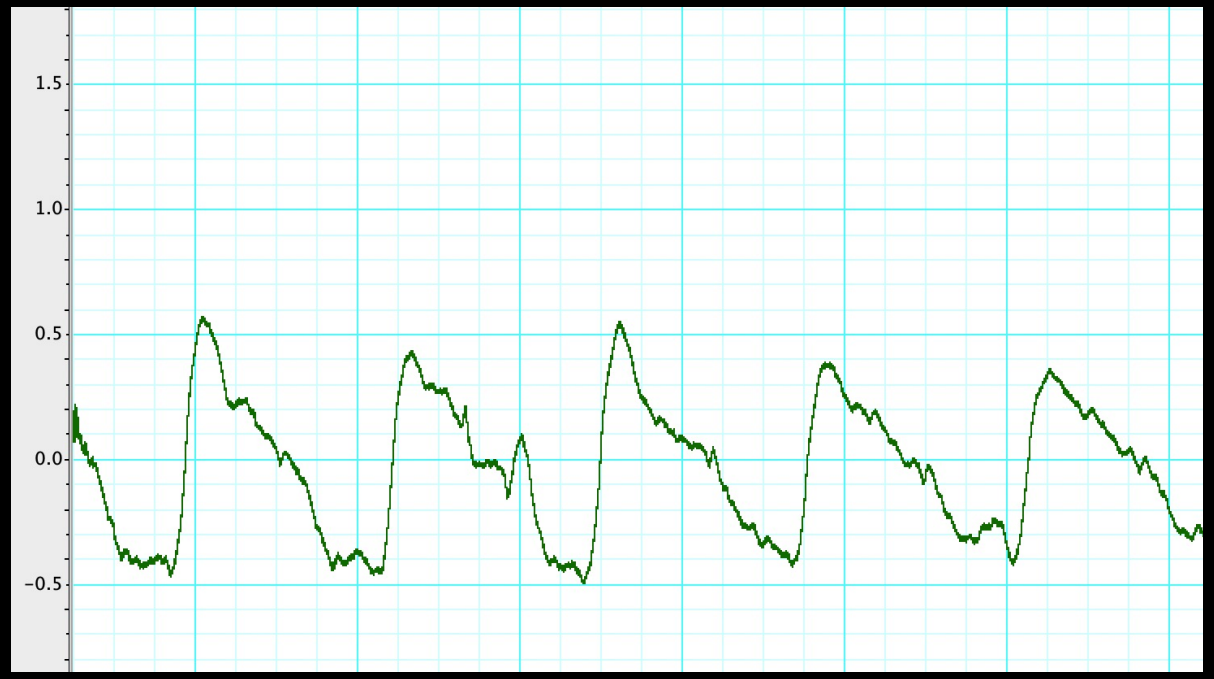
Adequate cough response to capsaicin

Urge-to-cough rating of 9

Reduced cough strength

Reflex Cough Testing: Interpretation

200µM Capsaicin



Tidal breathing

No reflexive cough response to a high dose of capsaicin

Clinical Takeaways

No cough motor response to high dose of capsaicin

Urge-to-cough rating was low

May indicate inability to detect and cough in response to airway invasion

Spirometry: the Gold Standard

Benefits

- High precision and validity
- Measure timing, volume, and strength of cough

Drawbacks

- High cost
- Lack of portability

What can I use to evaluate cough **today**?

Handheld Devices

Voluntary Cough Testing

Sequential

"Cough like something went down the wrong tube"

Single

"Cough hard one time"

Analog

- Number of coughs
- Cough strength

Digital

- Number of coughs
- Cough strength
- Cough expired volume

Silverman et al. (2014); Tabor-Gray et al. (2019)

Handheld Devices

Voluntary Cough Testing

Sequential

"Cough like something went down the wrong tube"

Single

"Cough hard one time"

Analog

Digital

Device	Pros	Cons
Analog	• Affordable (~ $20) • Multi-use with filter and facemask	• Only measures cough strength
Digital	• Monitors adherence • Measures CEV • Multi-use with filter and facemask	• Expensive ($50) • Requires software program

Handheld Devices

Reflex Cough Testing

- Handheld nebulizer
  - Measures presence and number of coughs to sensory stimulus
  - Affordable (~ $30)

Instructions

"Relax with the device in your mouth. Cough if you need to."

- Keep device in place for 1 minute or until patient produces two coughs.
- Rate urge-to-cough

Hegland et al., 2016

Handheld Devices

Reflex Cough Testing

- Handheld nebulizer

Clinical Takeaways

- Absent motor response to sensory stimuli
- No urge-to-cough

Hegland et al., 2016

Handheld Devices

Reflex Cough Testing

- Handheld nebulizer

Setup with Handheld Peak Flow

Curtis et al. (2020)

- Connect handheld peak flow meter with a t-tube to facemask and handheld nebulizer
- Allows for additional measurement of cough strength

Auditory-Perceptual Cough Assessment

- Most SLPs include auditory-perceptual assessments of cough in clinical swallowing evaluations

- Emerging evidence…
  - Raters can be reliable with training
  - Unknown validity
    - Some evidence that perceptual characteristics are associated with objective cough outcomes

Table 1: Definitions of Cough Descriptors

Descriptors	Definitions
Quality	
Strength	Perceived force and loudness of expired airflow, taking into consideration distance from the sound source
Crispness	Perception of an abrupt (as opposed to gradual) and distinct pop of expired airflow at the onset of the expulsive cough phase
Voicing	Perception of vocal fold vibration during the expulsive cough phase
Strain	Perception of excessive vocal effort (hyperfunction), when voicing is present
Duration	Length of time of the expiratory phase of cough
Effectiveness	Perceived effectiveness at clearing material from the airway
Normality	How normal (as opposed to abnormal) the expiratory maneuver sounds
Coordination	How coordinated (as opposed to discoordinated) the expiratory maneuver sounds

Curtis et al. (2023); Laciuga et al. (2016)

Auditory-Perceptual Cough Assessment

- Number and type of coughs
  - Cough
  - Throat clear
  - Huff
- Quality of the cough
  - Crispness

Rated from 0-100

Normal

Mild-to-Moderate

Severe

Curtis et al. (2023)

Auditory-Perceptual Cough Assessment

- Number and type of coughs
  - Cough
  - Throat clear
  - Huff
- Quality of the cough
  - Crispness
  - Duration

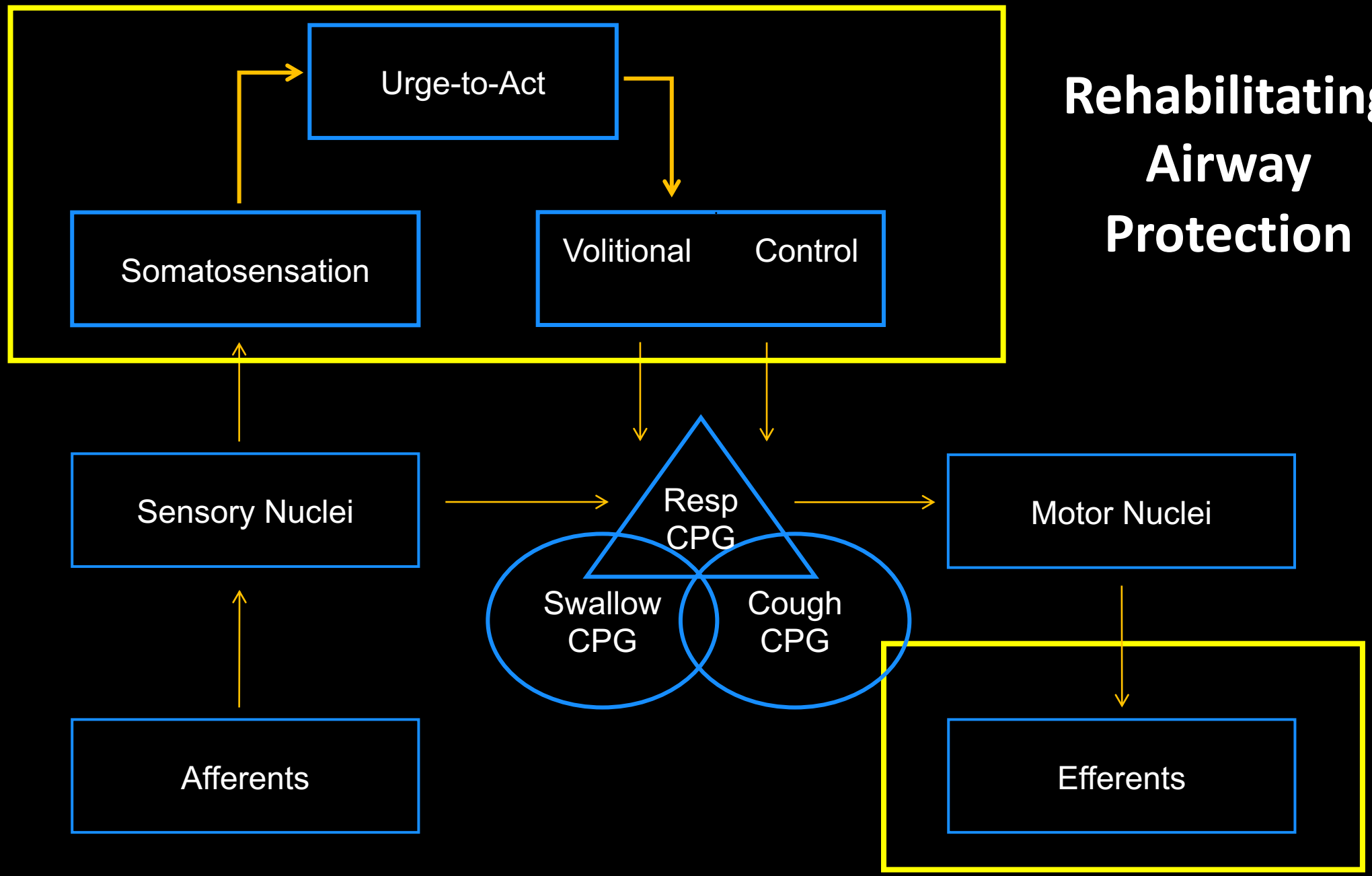
Rated from 0-100

Short

Long

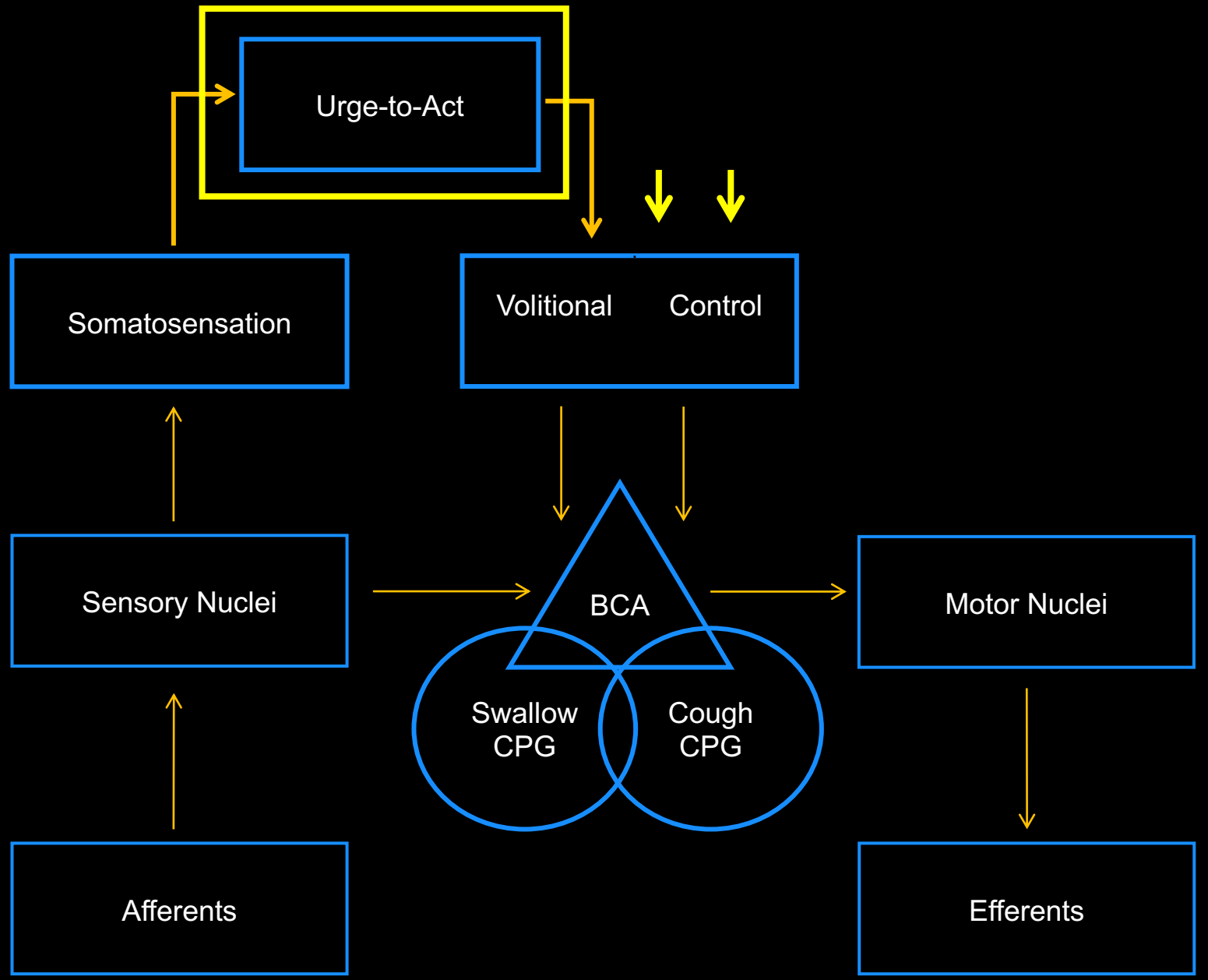
Curtis et al. (2023)

Rehabilitating Airway Protection



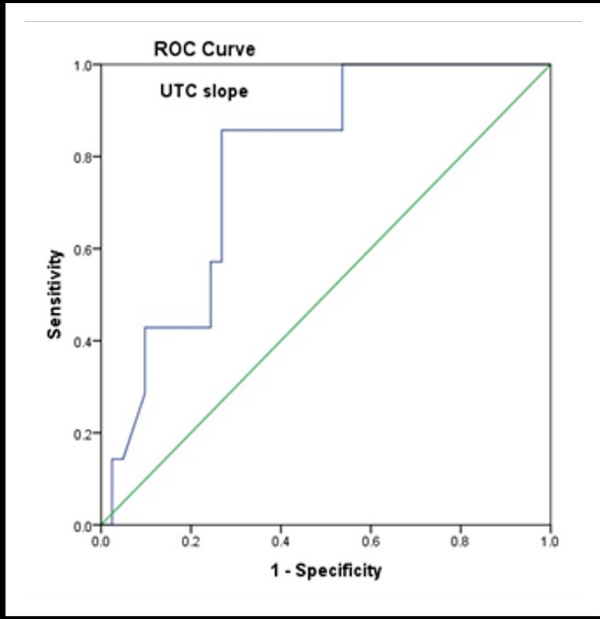
(Troche, Brandimore, Godoy, & Hegland, 2014)

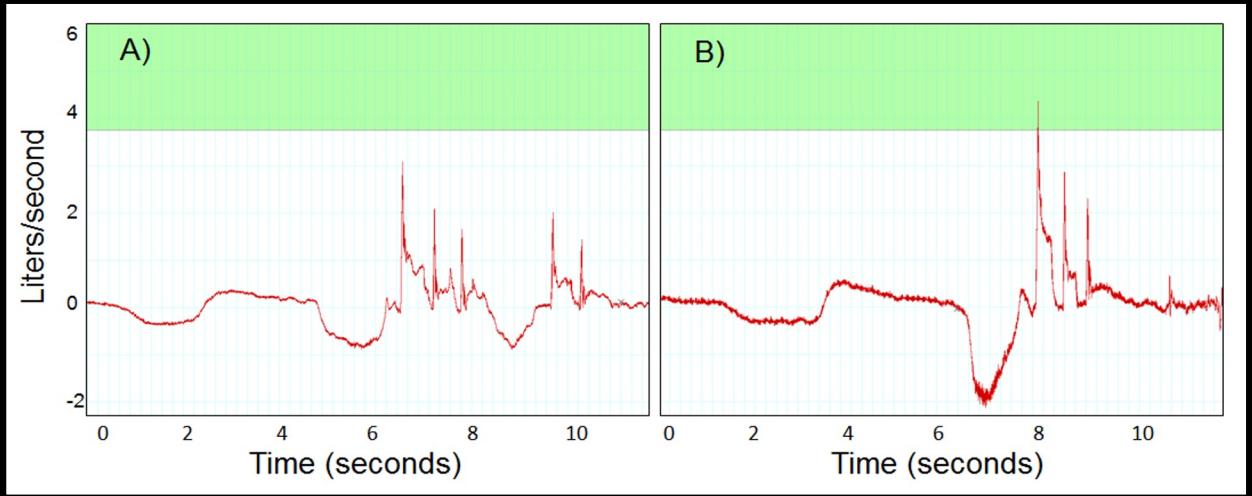
A Framework to Understand Airway Protection

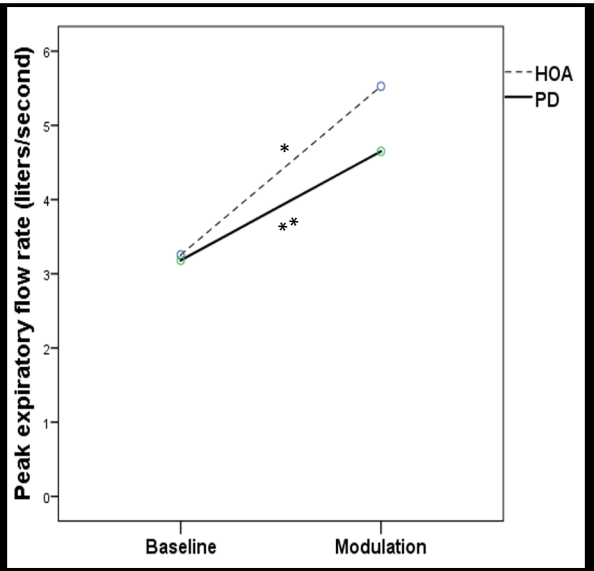


(Troche, Brandimore, Godoy, & Hegland, 2014)

People with dysphagia can up-regulate voluntary and reflex cough function despite a blunted perception of cough-inducing stimuli



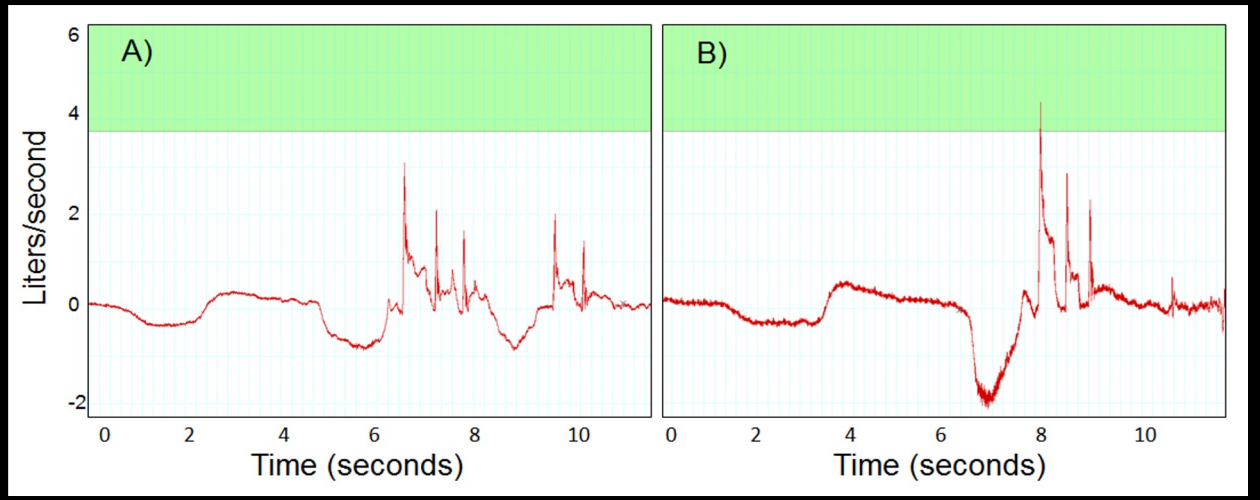




(Brandimore et al., 2017; Hegland et al., 2012; Troche et al., 2014)

Treatments: Sensorimotor Training for Airway Protection (smTAP)

Sensorimotor Skill-based Paradigm



Key features:

- Salient context for cough execution
  - Emphasis on urge-to-cough
- Salient verbal cue: *"cough hard"*
- Salient visual cues for cough airflow:
  - Target set at 25% above baseline cough PEFR
  - Real-time biofeedback of cough PEFR

(Brandimore et al., 2017; Hegland et al., 2012; Troche et al., 2014; Troche et al., 2022)

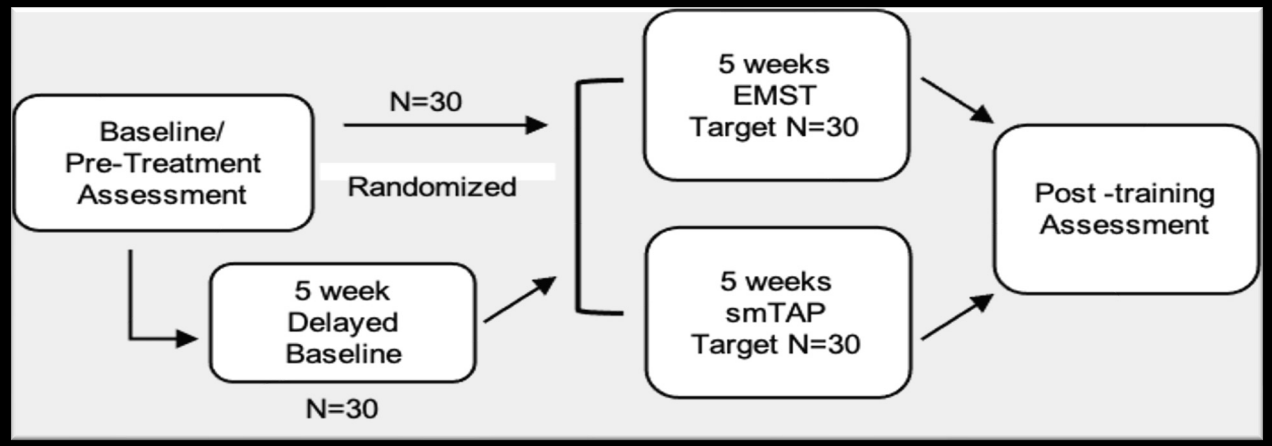
Home Training Program:
Sensorimotor Training in Airway Protection (smTAP)

Day 1	Day 2	Day 3	Day 4	Day 5	
					x 5 weeks
1 hour	25 coughs	25 coughs	25 coughs	25 coughs	

RESEARCH ARTICLE

Rehabilitating Cough Dysfunction in Parkinson's Disease: A Randomized Controlled Trial

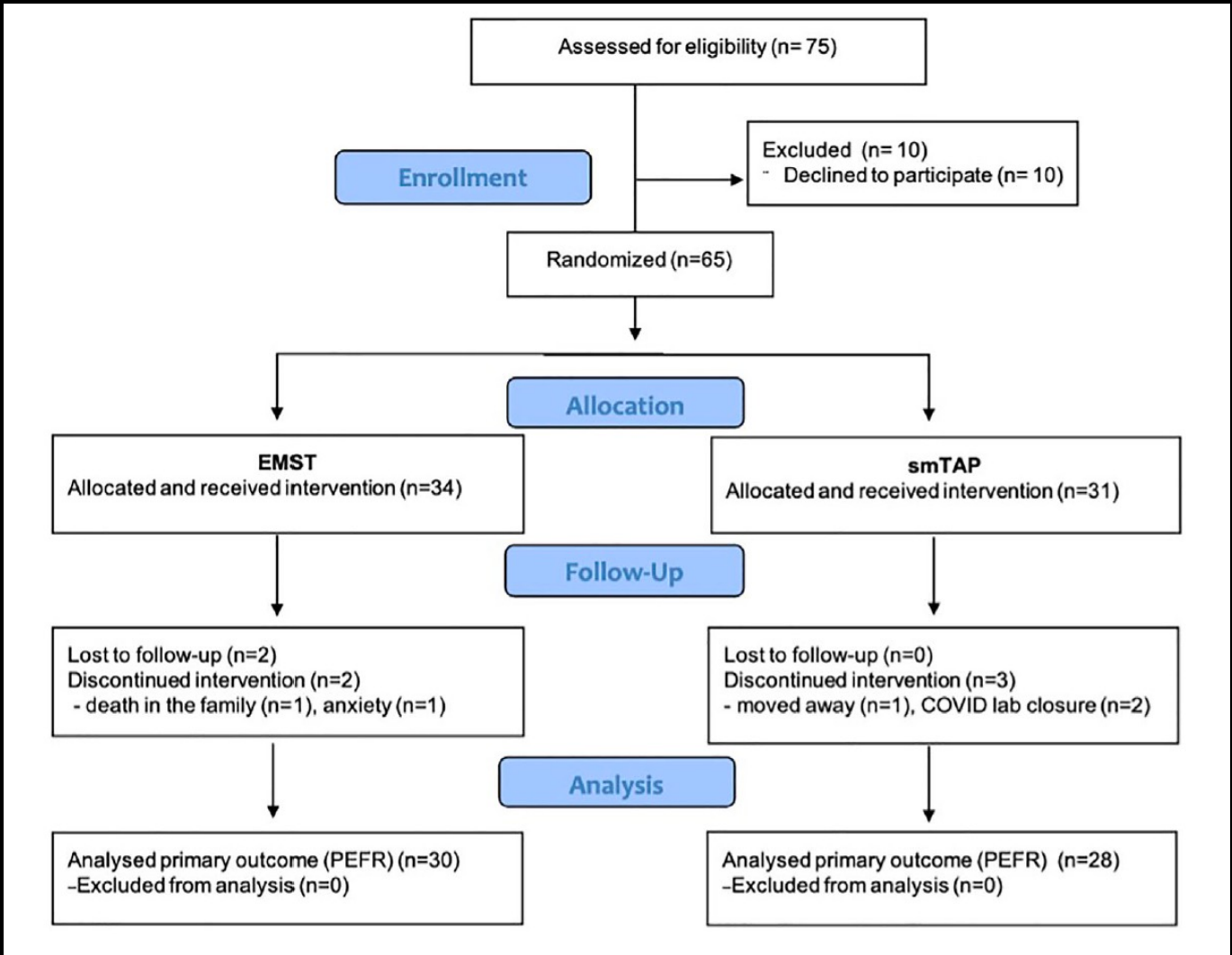
Michelle S. Troche, PhD, CCC-SLP,[1,2*] James A. Curtis, PhD, CCC-SLP,[1] Jordanna S. Sevitz, MS, CCC-SLP,[1] Avery E. Dakin, MS, CCC-SLP,[1] Sarah E. Perry, PhD, CCC-SLP,[3,4,5] James C. Borders, MS, CCC-SLP,[1] Alessandro A. Grande, MPhil,[6] Yuhan Mou, MA, CCC-SLP,[7] Nora Vanegas-Arroyave, MD,[8] and Karen W. Hegland, PhD, CCC-SLP[7,9]



THE MICHAEL J. FOX FOUNDATION
FOR PARKINSON'S RESEARCH

(Troche et al., 2022)

Results: Participants



There were no adverse events reported throughout the study

(Troche et al., 2022; Doruk et al., 2023)

Measure	EMST (n = 34)	smTAP (n = 31)
Age (y)[a]	70.5 (53.0, 87.0)	69.1 (53.0, 81.0)
Disease duration (y)[a]	8.0 (1.3, 21.8)	7.6 (0.2, 24.7)
Missing	1	0
Hoehn & Yahr[b]		
1	0 (0%)	2 (6.5%)
2	26 (79%)	20 (65%)
2.5	1 (3.0%)	1 (3.2%)
3	4 (12%)	5 (16%)
4	2 (6.1%)	3 (9.7%)
Missing	1	0
Location[b]		
Teachers College	28 (82%)	26 (84%)
University of Florida	6 (18%)	5 (16%)
Sex[b]		
Female	13 (38%)	9 (29%)
Male	21 (62%)	22 (71%)

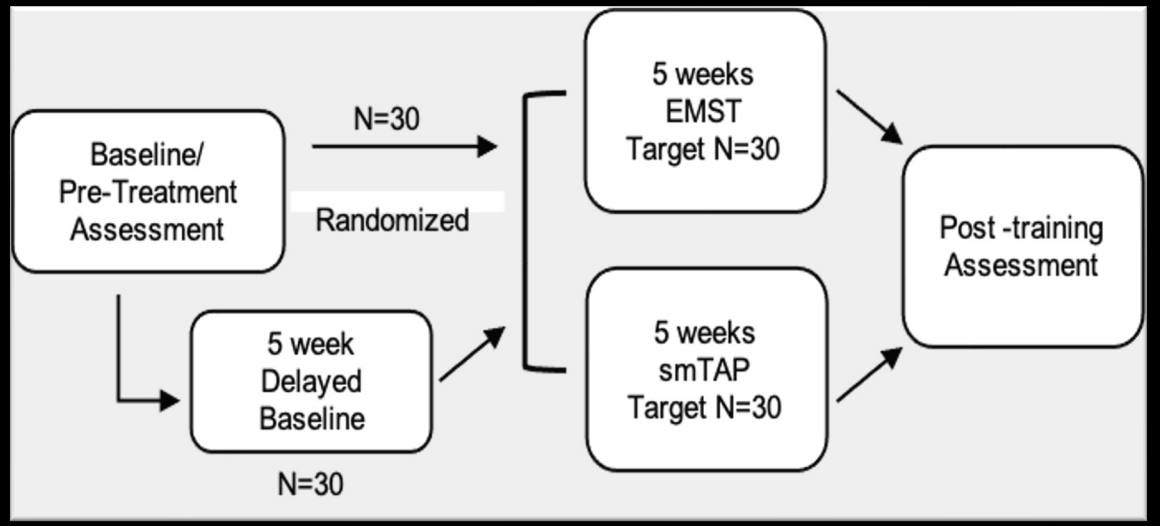
Results: Delayed Baseline

Peak Expiratory Flow Rate (Voluntary Cough PEFR)

- Voluntary cough PEFR decreased between baseline 1 and the 5-week delayed baseline, by an average of 0.09 L/s or ~3% of baseline PEFR ($p < .001$) when controlling for the number of coughs.

Maximum Expiratory Pressure (MEP)

- No significant main effect of time.



Results: Summary of treatment findings

OUTCOME	EMST	smTAP
Penetration-Aspiration Score	Improved	Improved
MEP	Improved by 22 cm H20*	Improved by 8 cm H20
Voluntary Cough PEFR	Improved by 0.17 L/s	Improved by 0.51 L/s
Reflex Cough PEFR	Decreased by 0.23 L/s	Improved by 0.53 L/s
Urge-to-Cough	No change	Improved
FOIS	No change	No change
SWAL-QOL	No change	No change

- Confirmed the efficacy of smTAP for the improvement of both motor AND sensory aspects of voluntary and reflex cough function, above and beyond the changes seen with EMST, the current gold standard for airway protection treatment in PD

Discussion: Clinical Significance

- Changes in cough effectiveness are of clinical significance for airway protection
- Voluntary PEFR for participants with severe DIGEST safety profiles went from 2.83 (SD = 0.81) to 3.36 (SD = 1.06)
- Reflex PEFR for participants with severe DIGEST safety profiles went from 2.60 (SD = 0.63) to 2.88 (SD = 0.63).

ASHA American Speech-Language-Hearing Association
JSLHR

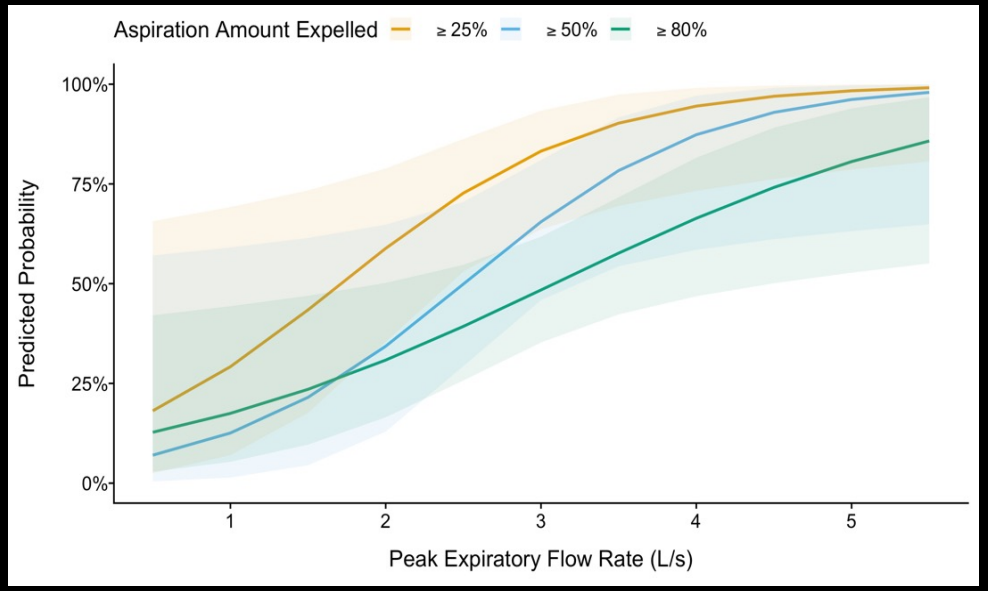
Research Article

Voluntary Cough Effectiveness and Airway Clearance in Neurodegenerative Disease

James C. Borders[a] and Michelle S. Troche[a]

[a] Laboratory for the Study of Upper Airway Dysfunction, Department of Biobehavioral Sciences, Teachers College, Columbia University, New York, NY

Voluntary cough PEFR values of 3.41 L/s differentiate between "effective" and "ineffective" airway clearance for ≥ 80% of subglottic residue (aspirate material)



(Borders et al., 2022)

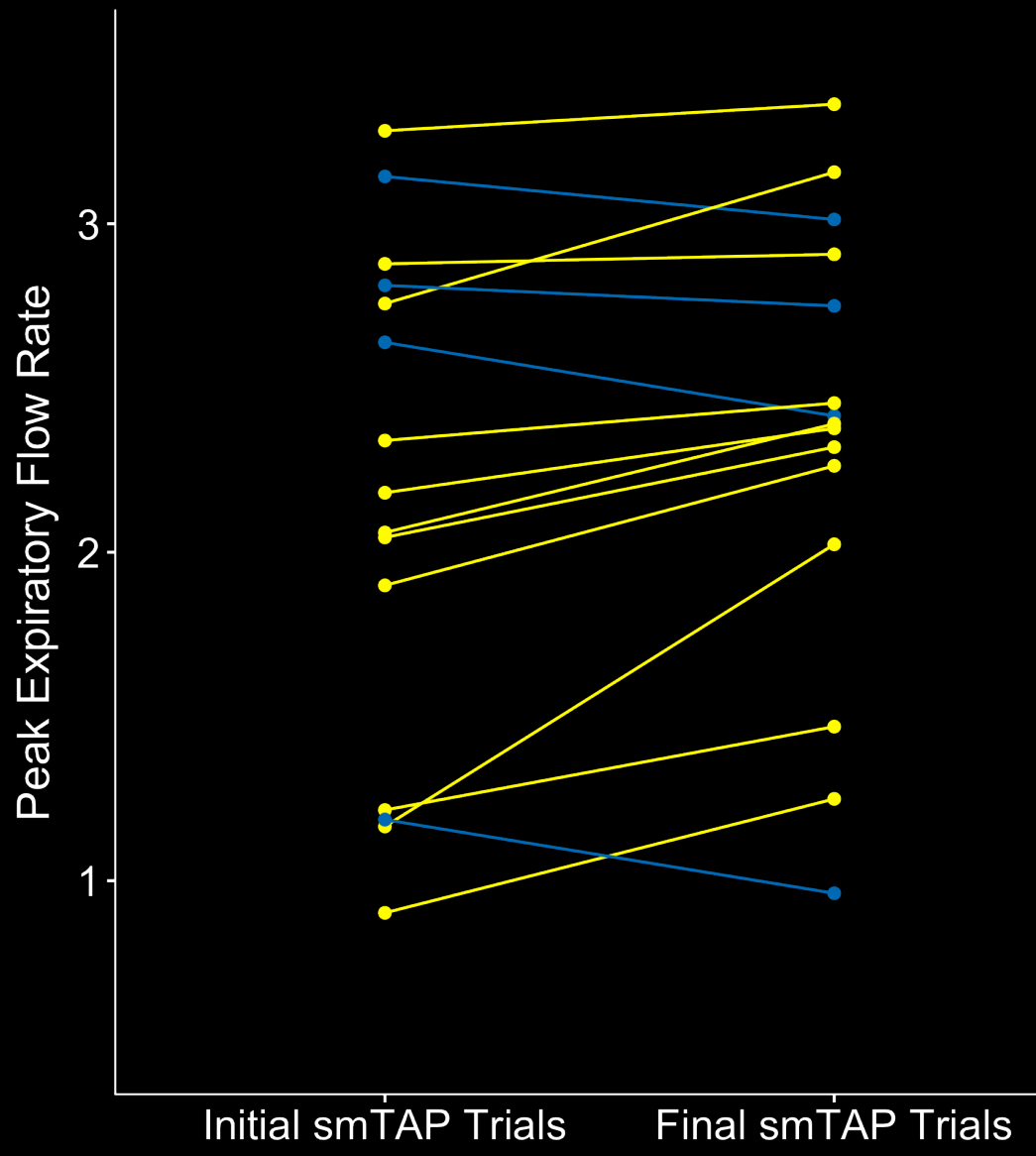
Dysphagia
https://doi.org/10.1007/s00455-021-10251-1

ORIGINAL ARTICLE

Immediate Effects of Sensorimotor Training in Airway Protection (smTAP) on Cough Outcomes in Progressive Supranuclear Palsy: A Feasibility Study

James C. Borders[1] · James A. Curtis[1] · Jordanna S. Sevitz[1] · Nora Vanegas-Arroyave[2] · Michelle S. Troche[1]

- Improvements in peak expiratory airflow ($p < .001$) and airflow variability for PEFR and CEV ($p = .01$) were appreciated during smTAP



(Borders, Curtis, Sevitz, Vanegas-Arroyave & Troche, 2021)

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UNLOCKING THE SECRETS OF BRAIN DISEASE®

What if I do not have access to all of that equipment….

Clinical Translation:
Voluntary Cough Skill Training

Day 1 | Day 2 | Day 3 | Day 4 | Day 5

x 5 weeks

1 hour | 25 coughs | 25 coughs | 25 coughs | 25 coughs

Lung (2022) 200:49–57
https://doi.org/10.1007/s00408-022-00509-2

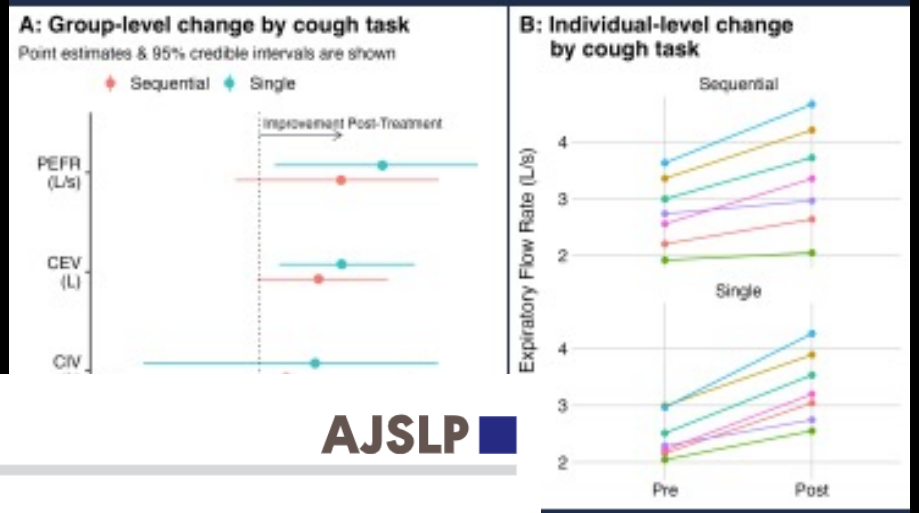
COUGH

Effects of Cough Training and Inspiratory Muscle Training on Cough Strength in Older Adults: A Randomized Controlled Trial

Hideo Kaneko[1] · Akari Suzuki[1] · Jun Horie[2]

Received: 23 September 2021 / Accepted: 24 December 2021 / Published online: 20 January 2022

Individuals with spinocerebellar ataxia can upregulate cough outcomes after one session of cough skill training



AJSLP

JSLHR

Research Article

Respiratory–Swallow Coordination Training and Voluntary Cough Skill Training: A Single-Subject Treatment
With Park

James A. Curtis,[a] Avery

ASHA American Speech-Language-Hearing Association

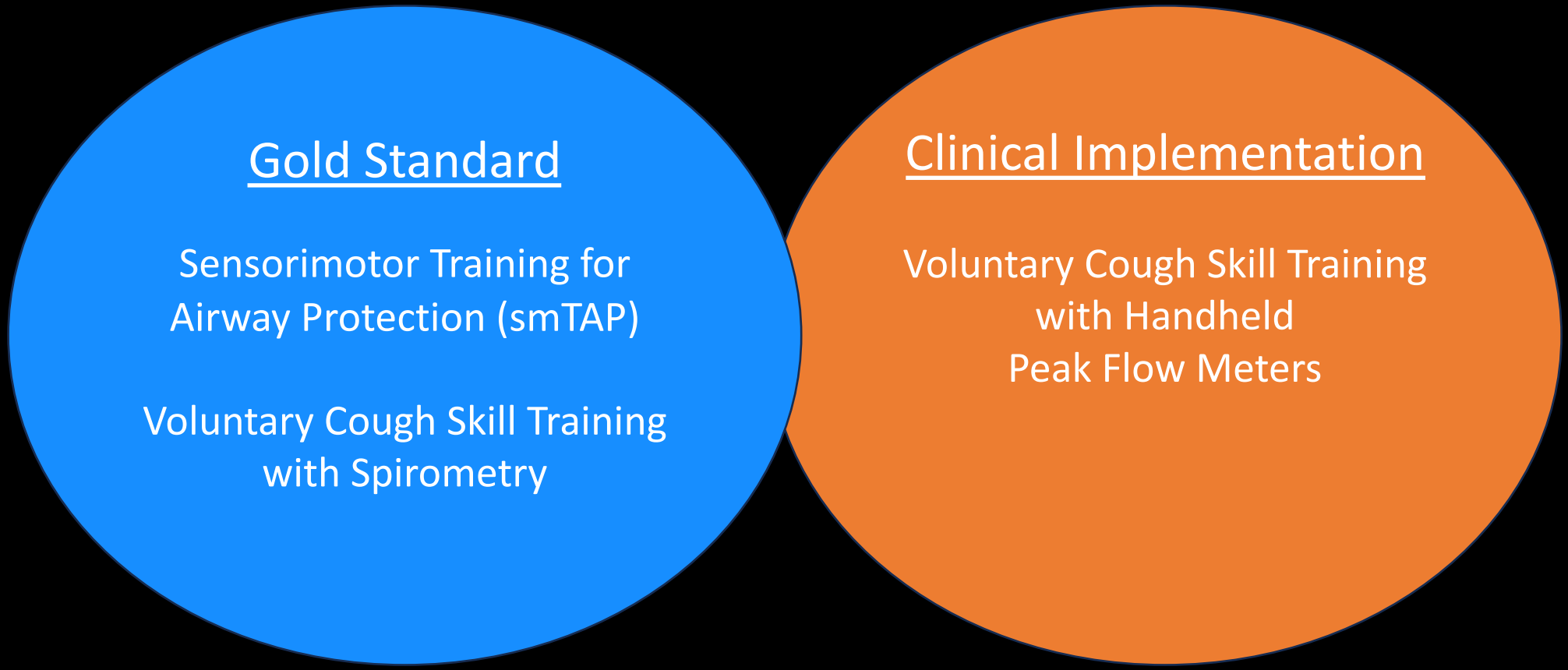
Research Article

Rehabilitation of Airway Protection in Individuals With Movement Disorders: A Telehealth Feasibility Study

Jordanna S. Sevitz,[a] James C. Borders,[a] Avery E. Dakin,[a] Brianna R. Kiefer,[b] Roy N. Alcalay,[c,d] Sheng-Han Kuo,[c] and Michelle S. Troche[a,c]

[a]Laboratory for the Study of Upper Airway Dysfunction, Department of Biobehavioral Sciences, Teachers College, Columbia University, New York, NY [b]Department of Speech, Language, and Hearing Sciences, Purdue University, West Lafayette, IN [c]Department of Neurology, Columbia University Irving Medical Center, New York, NY [d]Department of Neurology, Tel Aviv Sourasky Medical Center, Israel

Cough Skill Training: A Step-by-Step Tutorial

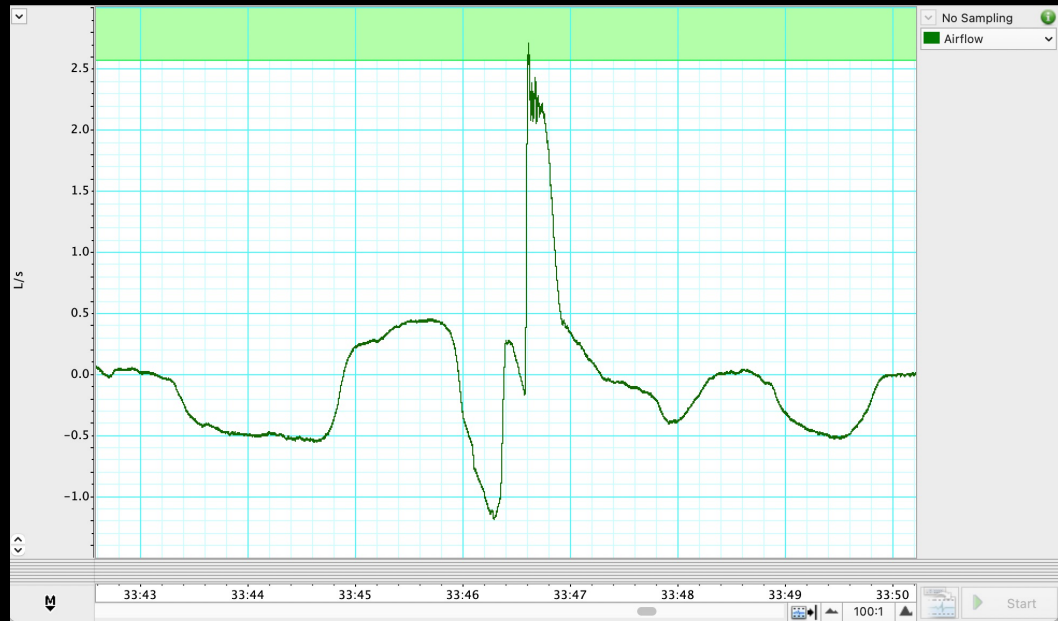


Spirometry: Voluntary Cough Skill Training

Step-by-step guide

- Set target line 25% above maximum peak flow from voluntary cough testing
- Participant sits in front of computer screen
- Provide instructions with goal to exceed the target line
- Provide feedback based on performance
- Complete 25 repetitions (5 sets of 5 repetitions)

"Cough hard one time."



How can we translate this to clinical practice?

- Provide patient with handheld peak flow meter
- Set visual treatment target on the device
- Provide instructions
- Note the number and strength of their cough from handheld peak flow meter
- Provide feedback on performance

"Cough like something went down the wrong tube."

Voluntary Cough Skill Training

Handheld Peak Flow Meter

Troubleshooting

- Lip seal
- Proper hand placement
- Reset dial before next trial
- Follow principles of motor learning related to feedback
- Avoid over-cueing

A useful resource

Current Otorhinolaryngology Reports
https://doi.org/10.1007/s40136-023-00446-5

LARYNGOLOGY: UPDATE ON DYSPHAGIA (H STARMER AND A RAMEAU, SECTION EDITORS)

Check for updates

A Primer on Hypotussic Cough: Mechanisms and Assessment

Emilie R. Lowell[1] · James C. Borders[1] · Jordanna S. Sevitz[1] · Avery E. Dakin[1] · Danielle Brates[2] · Michelle S. Troche[1]

Accepted: 27 January 2023

Thank you!

Laboratory for the Study of
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