Dysphagia Following Stroke

Third Edition

Clinical Dysphagia

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Stephanie K. Daniels, PhD
Maggie-Lee Huckabee, PhD
Kristin Gozdzikowska, PhD

Plural Publishing Inc.

PLURAL PUBLISHING
INC.

5521 Ruffin Road
San Diego, CA 92123

e-mail: information@pluralpublishing.com
Website: http://www.pluralpublishing.com

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Foreword

When asked to write a foreword for the new edition of *Dysphagia Following Stroke* from the perspectives of patient and caregiver, it made sense. My husband, Adan, suffered a brainstem CVA during a coronary angioplasty procedure in 2012. Dysphagia has been part our family's daily life for six years. We began this journey late one Wednesday night. The stubborn man had been complaining of a chest cold for a couple of days, and he finally agreed to go to the hospital when he realized that the pain in his shoulder might be something heart related. When the ER staff told us that they suspected a blockage and might need to put in a stent, we never thought of potential complications. We would never have imagined a brainstem stroke. The next year, filled with physical therapy, occupational therapy, and speech therapy, was so busy that we did not register that swallowing was an issue until after he came home.

In terms of rehabilitation hospital statistics, Adan counted as a positive outcome. He was admitted after a brainstem stroke, NPO, and with a PEG tube inserted. At discharge, he was fully dependent on oral feeding. Modified barium swallow (videofluoroscopy) testing showed minor penetration with nectar-thick liquids, but no aspiration. His volitional cough was gone for the most part, but his reflexive cough was strong. With a modified diet, he would be safe to return home.

Adan's outpatient experience shows what can happen when that team is no longer in place. When he switched providers, a different speech pathologist—who may not have had full access to his medical records—tried having him practice effortful swallows for two or three months. The harder my husband tried to follow the directions, the less success he experienced. (A later chapter in this book hints at why this may have been the case.) I also made major mistakes with his diet. I provided Adan with prepackaged dysphagia food and drink but failed to consider that he had a hearty appetite. A year after his stroke, his cardiologist discovered that his triglycerides were sky-high and he had gained 40 pounds. As a runner and cyclist who was no longer as active, his caloric requirements were much lower than before. His appetite was not reduced, and unlike some patients with dysphagia, he had enthusiasm and energy to eat even when it was a challenge. If a team including a speech pathologist and nutritionist, informed by data of his lesion location and the results of his swallowing assessments, had been monitoring his status, he would not have had to unlearn the effortful swallows or work hard to lose weight.

In reflecting on the differences between his inpatient and outpatient experiences, I realize that the dysphagia rehabilitation system did not fail Adan. The goal was to prevent him from aspirating, and to keep him safe. In the five and a half years since the stroke, he has never had aspiration pneumonia, but he has significant dysphagia. He is grateful to have progressed beyond the PEG tube he remembers from the hospital. But with little improvement in his ability to swallow, approximately a year and a half after the stroke, treatment for Adan's dysphagia was discontinued. He was 49 years old. Adan comes from a long-lived family. He is discouraged by the notion of spending the next 30 or 40 years of life drinking nectar-thick liquids and eating pureed foods.

Managing meals and drinks has become a blur of thickener and blender. We learned tricks from the speech therapists, from books, and from more mistakes than I care to admit. Gluten is the devil for purees. Packaged gravy has a billion calories and too much salt. Rice will blend, but it works better if it is overcooked a bit. Cream of rice is better. Baby food pouches are great for travel. Over the past five and a half years, we have collected quite a list of lessons. The most important is this: *Dysphagia is relentless*. It invades every meal and infuses every drink.

A perfect illustration comes from a recent weekend trip to a fishing cottage near the coast in South Texas. Our plan was to drive the six hours to meet Adan's parents and siblings for a celebration of his father's 94th birthday. Having traveled before, I knew to pack food and drink for Adan. We brought yogurt, milk, baby food fruit and veggie squeeze pouches, baby cereal, bananas, and plenty of powdered (low-cal) sports drinks and bottles of water to keep him hydrated. I always have thickener in his backpack for travel, a small chopper to puree, and a cover up in case of spills. A normal road trip in the U.S. means grabbing a quick meal at a fast food restaurant along the road. With dysphagia, a meal means squeeze pouches in the parking lot or stares from curious customers who wonder why the adult is eating baby food.

Breakfast in South Texas brings breakfast tacos with homemade salsa. All of those things are not on my husband's diet. He can clear carefully scrambled eggs on a good day when the wind is blowing from the right direction, but eggs mixed with chorizo sausage and chopped onion is a no-go situation. Baby cereal was his option on our visit. He likes oatmeal baby cereal when traveling. It is easy, tastes good, and travels well.

The afternoon meal was a grill-centric affair. The portable chopper enabled Adan to eat some grilled chicken and rice. Nevertheless, he coughed one hard cough—the type that triggers vasovagal syncope for him. Adan's mom is becoming accustomed to the momentary dips in consciousness; she no longer prays aloud when his head slumps to the right.

For those who are relatively young and fortunate enough to return home, dysphagia after stroke joins the family like an unwanted guest. You know that things could be worse, but it is inconvenient and annoying and gets in the way of your social life. If only it would leave.

When asked to share our thoughts as patient and caregiver, I asked if I might read the book. I expected to learn more about the latest research in dysphagia and stroke. I was surprised by the number of times I found myself saying, "Yes!" to something the authors described or recommended. From the value of a team approach, to the importance of nutrition and oral hygiene, to the central role of medical history and data, and even the observation that one should not assume that patients who do not perform a task cannot perform the task (Adan hated one physician in ICU, so pretended he was asleep when that doctor rounded), this book speaks to our experience as patient and caregiver. That said, we find the final chapters about the future of the field profoundly exciting. They give us new directions to explore and new horizons to watch. It is an exciting time.

Karen French Montoya

Preface

This text is geared toward clinicians working with patients with stroke-related dysphagia in all settings: hospitals, rehabilitation centers, outpatients, and long-term care. However, it may also be useful as an entry level textbook, supplemented by other etiologic-specific readings, for students in professional training programs. It is intended as a practical sourcebook. In addition to a thorough overview of dysphagia diagnosis and management, this book focuses heavily on evaluation and management of stroke. The clinician will want to refer to other texts for coverage of specific issues or techniques related to other etiologies. We recognize that survivors of stroke can present as patients with complex needs. The full range of clinical encounters cannot be addressed; thus, we focus specifically on the effects of stroke and not the potential complicating features of the critically or chronically ill patient.

In this third edition, chapters on assessment have been expanded to include new and emerging instrumental technologies, including high resolution manometry, impedance, and ultrasound. For the chapters on management, we have included description of the newly described International Dysphagia Diet Standardization Initiative but have also included new research that emphasizes caution in diet modification. We have provided a significantly expanded framework for rehabilitation, reflecting our shift from peripherally focused rehabilitation to neuromodulation of cortical swallowing control. All chapters have been updated with the latest research and trends in clinical practice.

Acknowledgments

The third edition was more challenging than anticipated. This is a reflection of the rate at which our research and practice patterns in dysphagia diagnosis and management change. Kristin (Lamvik) Gozdzikowska moved from assistant to author in this edition and was welcomed warmly. It was great to have another perspective, particularly from someone who is part of the next generation of clinicians-researchers.

There are many, many people who have contributed to our clinical and research practice; however, there are two in particular to whom we would like to give a shout out: Jay Rosenbek and Art Miller. Both Jay and Art have inspired us through the quality of their seminal work, their generosity with their time in mentoring, and their overall kindness. They continually make us want to do more and better, and we feel privileged that they are our friends.

As clinicians at heart, we give tribute to our patients. The inherent idiosyncrasies of dysphagia following stroke make writing a book on this topic a challenging task. But it is through those who live with this condition that we all learn to be critical of what we think we know, impatient with our failures to know more, and driven to develop better clinical practices. Many thanks to Karen and Adan for contributing their thoughts to this book.

The first edition of this book followed on the footsteps of Hurricane Katrina and the levee breaches in New Orleans. The second edition followed on the footsteps of the Christchurch earthquakes. These two events affected us personally and professionally. The writing "home" for this third edition is the bruised, battered, and nonetheless resilient Kaikoura, New Zealand following the 2016 earthquake. It is no surprise that *Dysphagia Following Stroke* has an increasing emphasis on rehabilitation! We three believe strongly in the capacity for recovery and regeneration at many levels.

Abbreviations

AHA/ASA = American Heart Association/American Stroke Association

AIS = acute ischemic stroke

A-P = anterior-posterior

BA = Brodmann's area

BOT = base of tongue

CAD = coronary artery disease

CDS = Clinical Dysphagia Scale

CEA = carotid endarterectomy

CIMT = constraint-induced motor therapy

CN = cranial nerve

CNS = central nervous system

CP = cricopharyngeus

CPG = central pattern generator

CRT = cough reflex test

CSA = cross-sectional area

CSE = clinical swallowing examination

CT = computed tomography

CTAR = chin tuck against resistance

DiSP = dysphagia in stroke protocol

DOSS = Dysphagia Outcome and Severity Scale

DWI = diffusion-weighted imaging

EAT-10 = Eating Assessment Tool

ED = emergency department

E-E = expiration-expiration

E-I = expiration-inspiration

EMG = electromyography

EMST = expiratory muscle strength training

FDS = Functional Dysphagia Scale

FIM = functional independence measure

fMRI = functional magnetic resonance imaging

HLC = hyolaryngeal complex

HRM = high resolution manometry

I-E = inspiration-expiration

I-I = inspiration-inspiration

ICC = intraclass correlation coefficient

IDDSI = International Dysphagia Diet Standardization Initiative

IOPI = Iowa Oral Pressure Instrument

LES = lower esophageal sphincter

LHD = left hemisphere damage

LMN = lower motor neuron

LMS = lateral medullary syndrome

LOC = level of consciousness

MASA = Mann Assessment of Swallowing Ability

MBSImP = Modified Barium Swallow Impairment Profile

MDTP = McNeil Dysphagia Treatment Program

MEP = motor evoked potential

mL = milliliter

MRI = magnetic resonance imaging

NA = nucleus ambiguous

NGT = nasogastric tube

NIH-SSS = National Institutes of Health-Swallowing Safety Scale

NMES = neuromuscular electrical stimulation

NPO/NBM = nil per os/nothing by mouth

NPV = negative predictive value

NTS = nucleus tractus solitarius

OTT = oral transit time

P-A = penetration-aspiration

PEG = percutaneous endoscopic gastrostomy

PES = pharyngeal electrical stimulation

PPS = pulses per second

PPV = positive predictive value

PPW = posterior pharyngeal wall

PTT = pharyngeal transit time

PVWM = periventricular white matter

PWI = perfusion-weighted imaging

QoL = quality of life

RHD = right hemisphere damage

RIG = radiologically inserted gastrostomy

rTMS = repetitive transcranial magnetic stimulation

SA = swallowing apnea

SAD = swallowing apnea duration

sEMG = submental electromyography

SMA = supplementary motor area

SPM = swallows per minute

SST = swallowing screening tool

STD = stage transit duration

SWAL-QoL = Swallowing Quality of Life

SWI = swallow risk index

tDCS = transcranial direct current stimulation

TOMASS = Test of Masticating and Swallowing Solids

TTA = thermal-tactile application

TVF = true vocal fold

TWST = Timed Water Swallowing Test

UES = upper esophageal sphincter

UMN = upper motor neuron

VDS = Videofluoroscopic Dysphagia Scale

VEES = videoendoscopic evaluation of swallowing

VFSS = videofluoroscopic swallowing study

VPMpc = parvocellular component of the ventroposterior medial nucleus

WST = water swallowing test

Online Resources

The following videos and clinical forms are accessible on the PluralPlus companion website (instructions are included on the inside front cover of this book):

Chapter 6. The Clinical Swallowing Examination: The Evaluation of the Oral Mechanism

Dysphagia in Stroke Protocol (DiSP) Form

Cough Reflex Test—Video Example

Chapter 7. The Clinical Swallowing Examination: Assessment of Oral Intake

Sample of a Clinical Swallowing Examination (CSE) Form

CSE—Video Example

Chapter 9. Adjuncts to the Clinical Swallowing Examination

Timed Water Swallowing Test—Video Example

Test of Mastication and Swallowing Solids—Video Example

Chapter 10. Videofluoroscopic Swallowing Study

Sample of a Videofluoroscopic Swallowing Study (VFSS) Evaluation Form

VFSS—Video Example of a Normal Swallow

VFSS—Video Example of Delayed Onset of the Pharyngeal Swallow with Pre-Swallow Pyriform Sinus Pooling and Aspiration During the Swallow

VFSS—Video Example of Decreased Base of Tongue to Posterior Pharyngeal Wall Contact with Valleculae Residue

22 Central Rehabilitation for Oropharyngeal Dysphagia

Behavioral Adaptation[1]

Behavioral interventions for swallowing impairment have traditionally focused on restoring safe and effective swallowing through functional modification of biomechanics in the peripheral structures—the muscles (Chapter 20). Most literature suggests that this approach changes muscle, with little effect on central mechanisms. As we are learning, swallowing may not require maximal muscle contraction; in some patients, strengthening may be the wrong approach. Neuromodulatory approaches (Chapter 21) have gone a long way to encourage a rethinking of our rehabilitation targets. These techniques focus on changes not at the periphery through muscle strengthening, but through lasting modulation of the neuronal circuitries involved in swallowing motor control. They change the brain first, with the intent of altered functional swallowing as a consequence. However, they are non-specific to swallowing biomechanics. This leads to a question: Can we develop approaches that first target specific swallowing biomechanics, but then encode those changes in the brain?

This chapter addresses the advent of behavioral adaptation to change the neural swallowing system in dysphagia rehabilitation. Skill-based training represents a category of emerging approaches to specifically target cortical modulation of swallowing in a task-specific manner. These approaches are considered to maintain the biomechanical specificity of muscle strengthening by focusing on specific features of impaired swallowing, while also capturing the longer-lasting change associated with neural adaptation.

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[1]Portions of this section have been reprinted with permission of RightsLink/Springer Nature: Huckabee, M. L., and Lamvik-Gozdzikowska, K. (2018). Reconsidering rehabilitation for neurogenic dysphagia: Strengthening skill in swallowing. *Current Physical Medicine and Rehabilitation Reports*, *6*(3), 186–191.

SKILL-BASED TRAINING PARADIGMS: DYSPHAGIA AS A MOTOR PLANNING DISORDER

A central theme in this text has been the need for diagnostic specificity and how our current techniques allow us clear evaluation of biomechanics but little insight into the underlying pathophysiology that causes impaired movement. This leaves us to base our intervention, quite inadequately, on assumptions. Whereas strengthening approaches appear to be predicated on an assumption of weakness underlying swallowing impairment, it could be argued that skill-based training is predicated on an assumption of impaired motor planning and execution.

In one of the very first publications on management of dysphagia nearly 40 years ago, George Larsen recognized that "rehabilitation of this disorder depends on careful assessment of spared and damaged processes responsible for swallowing" (Larsen, 1972, p. 189). When commenting on rehabilitation, he proffered that rehabilitation should maximize "use of assets, capitalizing on intelligence to support reflex behavior" (p. 191). This theme was reflected again nearly 20 years later by Stevenson and Allaire (1991). In an article on development of swallowing in pediatrics, they commented that swallowing is reflexive at birth; however, the ability to modify developmental swallowing behavior is linked to a process of encephalization. This suggests that the "skill" component of ingestive swallowing is acquired through cortical expansion and modulation of the primitive brainstem-driven swallowing response. In the face of injury or disease, relearning or modifying the complex sequence of events involved in swallowing poses a much greater challenge. However, skill-based paradigms essentially are targeted toward recruiting cortical control mechanisms to alter the impaired response—an essential expansion of cortical modulation of swallowing that is well documented in the literature.

Skill-based training may be simply defined as the acquisition of skill through functional repetition and refinement of movement patterns (Huckabee & Macrae, 2014; Plautz, Milliken, & Nudo, 2000). As with most rehabilitation approaches, we have bolstered our development of skill-based training paradigms from research in other areas of rehabilitation medicine. And as with other approaches, translation to swallowing cannot necessarily be assured due to the differences in composition and neural processes (Chhabra & Sapienza, 2007). In the physical therapy domain, skill-based training has been shown to induce cortical reorganization of motor networks (Lefebvre et al., 2015) and has been investigated as an approach for motor recovery (Kitago & Krakauer, 2013; Krakauer, 2006; Matthews, Johansen-Berg, & Reddy, 2004). The principles of neural plasticity (Kleim & Jones, 2008) outlined in Chapter 19 are critically relevant in discussions of skill-based training, particularly the concepts of specificity of practice (plasticity is experience specific), task challenge (use it and improve it), and feedback (salience).

Barnett, Ross, Schmidt, and Todd (1973) proposed that specific motor skills are developed and stored through practice, and that these motor skills do not generalize across tasks. Thus, specificity of practice is crucial to encouraging skill acquisition. There is evidence of this in the literature relative to corticobulbar function. A series of studies have reported that a tongue protrusion exercise resulted in increased size of cortical representation of the tongue (Sessle et al., 2007, 2005; Svensson, Romaniello, Arendt-Nielsen, & Sessle, 2003; Svensson, Romaniello, Wang, Arendt-Nielsen, & Sessle, 2006) and increased excitability (Svensson et al., 2003, 2006) of corticobulbar projections (see Sessle et al., 2007, for review). Despite these increases in the tongue motor cortex, the authors report that no increase was seen in representation of the "cortical masticatory area/swallow cortex" (Sessle et al., 2005, pp. 111–112), suggesting a lack of generalization from one repetitive task to a structurally related function. This research emphasizes the importance of task specificity, the need for exercise that replicates the desired task—that of swallowing—in skill-based training. Historically, strategies such as effortful swallowing, Mendelsohn maneuver, or Masako maneuver have been applied using maximal contraction in a strength-training approach. However, by adapting functional swallowing for recruitment of greater strength or duration, there is a suggestion that some strengthening exercises may have a skill-based training component that would not be apparent in exercises that are not executed within a functional context, such as the head lift. Interestingly, limb-based skill training has been documented to influence strength gains to a greater extent than strength training alone, despite training at submaximal levels of muscle contraction (Liu-Ambrose, Taunton, MacIntyre, McConkey, & Khan, 2003). This phenomenon has been attributed to improved movement coordination and neural adaptation due to proprioceptive facilitation in skill-based training. Task-oriented training programs inherently incorporate proprioceptive facilitation (Borsa, Sauers, & Lephart, 1999). Adler, Beckers, and Buck (2008), therefore, suggest that skill-based paradigms are recommended for motor deficits with underlying impairments in both coordination and muscle strength. The importance of task-oriented exercise training has been documented in many physical therapy research studies and is considered crucial to foster optimal motor learning (see Rensink, Schuurmans, Lindeman, & Hafsteinsdottir, 2009 for an in-depth review).

However, repetition of motor activity alone is not thought to result in functional recovery, particularly in the context of rehabilitation where impaired motor performance is then repeated. Another key component of skill-based training, and a principle of neural plasticity, is that of task challenge, the "use it and improve it" principle. Encouraging "practice" of dysphagic swallowing with no adaptation or adjustment, although preventing against disuse, is unlikely to produce a more functional swallowing response and may encourage maladaptive behaviors. Skill-based training involves the introduction of a challenge component, requiring an individual to evaluate and adjust the movement with each repetition, rather than memorizing and replaying the same sequence of muscle contractions (Krakauer, 2006). Task challenge extends neural activation to different brain circuits than those associated with previously acquired movements (Luft & Buitrago, 2005). This extension induces neural and behavioral changes associated with learning. Motor learning, rather than motor repetition, is required for functional cortical reorganization (Plautz et al., 2000). Translated to clinical routines, ingestion of a safely tolerated diet may facilitate pulmonary safety but may also be considered "practicing" impaired swallowing unless ongoing feedback and adjustments are made to swallowing behavior. Eating may be important to maintain existing neural pathways but is unlikely to have therapeutic benefits. However, systematically challenging the system in a controlled therapeutic environment may facilitate recovery. This appears to be one of the tenets of the McNeill Dysphagia Therapy Program (MDTP) (Crary, Carnaby, LaGorio, & Carvajal, 2012), constituting a type of skill-based training.

The final key element in motor learning is the necessity for feedback regarding task performance, related to the principle of neural plasticity of "salience" (Rose & Robert, 2006; Schmidt & Lee, 1999). Execution of motor tasks requires movement awareness to be paired with kinesthetic intrinsic feedback from joint receptors, muscle spindles, and Golgi tendon organs and consequently transferred to the central nervous system (Schmidt & Lee, 1999). If a mismatch between the projected motor plan and the actual performance occurs, correction of the motor plan ensues during subsequent trials. Guidance and integrated feedback are critical for improved performance (Salmoni, Schmidt, & Walter, 1984). Rehabilitation of swallowing poses significantly greater challenges than the limb in this regard. No clear external movement patterns are observed in swallowing, and intrinsic feedback systems are likely to be impaired in neurological disorders. Thus, learning through repetition is less likely to occur. Particularly in swallowing skill-based training, exteroceptive feedback is likely necessary to provide a salient means for conveying cues regarding movement accuracy, thus allowing improvement in swallowing motor function.

Development of Skill-Based Training Paradigms for Swallowing

The ultimate goal in swallowing skill-based training, very simply put, is for a patient to return to oral ingestive swallowing that is safe, pleasurable, and sufficient for sustaining nutrition and hydration. In a higher-level therapeutic sense, one might define the goal of skill-based training as to acquire skill in execution of specific aspects of swallowing biomechanics that are encoded at a central level. Several approaches for translating the construct of skill-based training to the practice of dysphagia rehabilitation have emerged. The MDTP is a systematic exercise framework that is predicated on components of strength training (Crary et al., 2012). An additional key component of this approach appears to be the systematic and hierarchical presentation of oral intake. This emphasizes task specificity in that the treatment is focused on swallowing repetition, although it is not specific to individual pathophysiologic features of swallowing. Task challenge is met through the hierarchical presentation of food, with the purveyors of this approach advocating that assessment of task performance for advancement on the hierarchy is based on clinical presentation of bolus tolerance. The researchers have documented positive outcomes of the MDTP in subsequent studies (Crary et al., 2012; Lan, Ohkubo, Berretin-Felix, Carnaby-Mann, & Crary, 2012; Sia, Carvajal, Lacy, Carnaby, & Crary, 2015). However, as the approach fundamentally is focused on repetition of a type of effortful swallowing task, the "active treatment" is unclear.

Stepp, Britton, Chang, Merati, and Matsuoka (2014) evaluated the feasibility of skill-based therapy for dysphagia rehabilitation by utilizing surface electromyography (sEMG) biofeedback. Electrodes were placed bilaterally on the anterior neck, overlying the thyrohyoid, sternohyoid, and omohyoid muscles. Six healthy participants and one patient with severe oropharyngeal dysphagia following brainstem stroke received real-time visual feedback of muscle activity on a computer screen placed in front of them. Surface EMG data were presented in video-game format, with the leading edge of the waveform represented as a large fish that moves vertically on the screen based on the magnitude of sEMG output. The game involved using the muscles in an organized manner such that the larger fish "caught" a smaller fish (target) that moved at a constant speed across the horizontal (time) axis but with a variable amplitude across the vertical axis. In the baseline session, healthy volunteers "caught" significantly more fish than the single patient participant. Throughout five subsequent sessions, the patient significantly increased target accuracy and reported improved secretion management. As is evident, this study utilized biofeedback to increase task performance and provided significant challenge to facilitate motor learning. However, physiologic swallowing was not required to complete the task, thus task specificity was not optimized.

Athukorala, Jones, Sella, and Huckabee (2014) addressed the limitation in task specificity in the above study with a similar approach. Using submental electrode placement to detect timing and magnitude of the anterior belly of the digastric, mylohyoid, and geniohyoid muscles, 10 patients with dysphagia secondary to Parkinson's disease completed a 2-week, daily treatment protocol. The task, executed with specialized software, required the patient to control the timing and degree of muscle activation during swallowing such that the peak of the time-by-amplitude waveform "hit" a target box that was placed randomly on the visualized computer screen. All targets were calibrated to fall within 2 and 25 sec of a 30-sec screen sweep and between 20% and 80% of maximal sEMG amplitude during five effortful swallows, thus avoiding the confound of effortful-type swallowing. Task challenge was provided by a decrease in the size of the target by 10% following three successive "hits," and, conversely, an increase of 10%