Dysphagia Following Stroke

Fourth Edition

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Foreword

When the first edition of *Dysphagia Following Stroke* was published in 2008, Maggie-Lee Huckabee and I told our colleague, mentor, and friend Jay Rosenbek, "Never again." Of course, we didn't quite keep that promise and went on to complete two additional editions, with the third published in 2019. When it came time to begin a fourth edition, I finally followed through on that original promise to Jay. Fortunately for the field, Maggie-Lee did not. Instead, she joined forces with Sebastian Doeltgen and Janina Wilmskoetter, forming a crackerjack team of clinical scientists deeply committed to advancing our understanding of neurogenic dysphagia.

What is immediately evident in this edition is not only the depth of their expertise but also their care for the readers they serve. They have continued the tradition of presenting evidence-based clinical practice in a way that is approachable and meaningful for students, early-career clinicians, and seasoned professionals alike. As I read through the chapters, I appreciated the many "nuggets" of insight woven throughout as well as the thoughtful integration of new and evolving research. The addition of new chapters and the comprehensive updating of existing ones reflect both the growth of the field and the authors' commitment to keeping this text current and relevant. Their collective experiences also bring a rich international perspective to the evaluation and management of dysphagia.

Having been through this process myself, I know that updating a book of this scope is no small task. It requires an extraordinary level of time, effort, and persistence, which is every bit as demanding as writing a first edition. Maggie-Lee, Sebastian, and Janina have taken on this challenge with impressive dedication, and they are to be warmly commended for it. I am confident that readers will find this edition to be an invaluable and lasting contribution to the dysphagia literature.

Stephanie K. Daniels, PhD, CCC-SL
University of Houston, Texas

Preface

This book is intended to offer a practical, user-friendly reference guide that will accompany dysphagia clinicians[1] across their careers, from novice learners to experienced practitioners. Given the depth of coverage of swallowing fundamentals, including anatomy, neurology, biomechanics, and pathology, it may serve well as an introductory text when paired with additional readings focused on specific etiologies. In this way, it can support students in professional training programs as they merge into clinical practice while also serving practicing clinicians who provide care to individuals with stroke across all settings, including acute hospitals, inpatient rehabilitation, outpatient services, and long-term care.

Although this book includes a comprehensive overview of dysphagia assessment and management, the primary emphasis is on evaluating and managing swallowing disorders in the context of stroke. Clinicians should consult other resources for detailed discussions of conditions or techniques related to non-stroke causes of dysphagia. We acknowledge that stroke survivors often present with complex clinical profiles. Because it is not possible to cover the full spectrum of clinical scenarios, this text concentrates on the consequences of stroke itself rather than the added complications seen in patients who are critically or chronically ill.

In this fourth edition, chapters on assessment have been expanded to encompass the ever-broadening evidence base supporting new instrumental technologies, including high resolution manometry, impedance, and ultrasound. We have also reordered the appearance of content for better flow and easier navigation. For the chapters on management, we have provided a significantly expanded framework for rehabilitation, reflecting our shift from peripherally focused rehabilitation to neuromodulation of cortical swallowing control. All

[1]The term dysphagia clinician is used throughout this book to reflect international variation in professional roles, recognizing that although speech-language pathologists often lead dysphagia care, this is not universal across all countries.

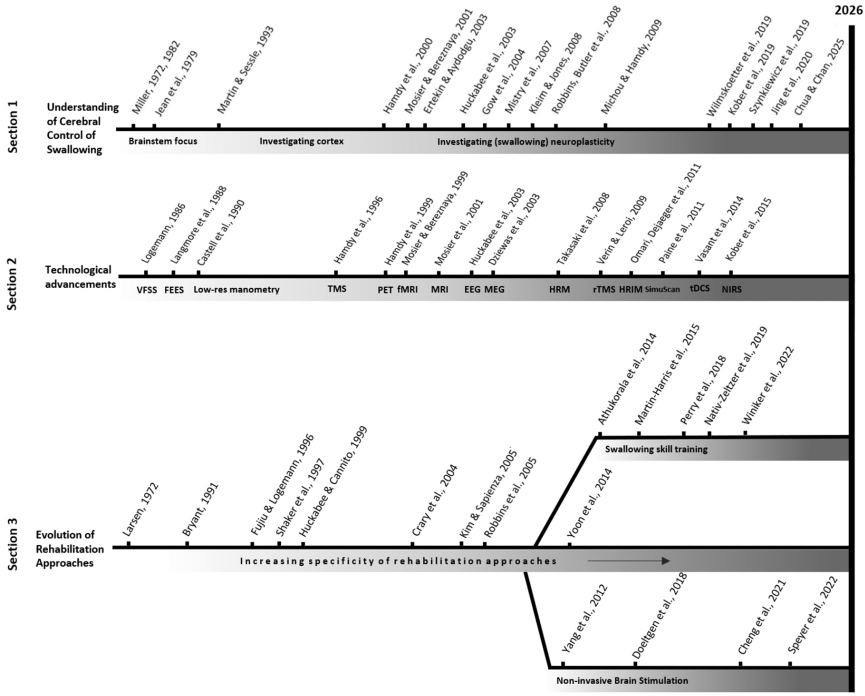

Figure P1–1. Historical Review. Adapted from Huckabee et al. (2023). Copyright © Springer Nature. Reproduced with permission.

chapters have been updated with the latest research and trends in clinical practice.

To create continuity across the book, we have adopted a clearly signposted structure, which presents this book in three distinct but interrelated sections: 1. Background Knowledge, 2. Identification of Swallowing Impairment, and 3. Dysphagia Management.

In each section, we provide a brief narrative tracing the major historical developments that have shaped our understanding of swallowing control. This includes the evolution from early models centered largely on brainstem reflexes, through the expanding recognition of cortical and subcortical networks, to more recent insights into biomechanical complexity and neuroplastic adaptation after neurological injury. By weaving these historical and scientific advances through each section, we aim to highlight how innovations in neuroscience, biomechanics, and clinical research have progressively informed, and

transformed, our contemporary approach to understanding swallowing and to managing dysphagia after stroke. The reader is referred to Figure P–1 for a visual representation of the parallel advancements in these three areas. Together, these sections are designed to guide the reader from essential, contemporary foundational knowledge through to clinical decision-making and into evidence-based intervention, thereby helping them to develop a coherent understanding of dysphagia that links scientific principles with practical, real-world application.

The addition of **Key Points** boxes for each chapter is intended to provide a quick reference and succinct summary of essential context. The new **Deep Dive** sections provide opportunities for the interested reader to advance their introductory knowledge on a selection of key topics.

STATEMENT ON AI USE

Generative artificial intelligence tools were used in a limited and responsible manner during the development of this book to support the organization, synthesis, and clarity of written material. This use was confined to assistive functions and did not replace author expertise, clinical reasoning, or scholarly judgment.

All clinical content, interpretations, and recommendations were authored, critically reviewed, and verified by the author in accordance with current evidence, professional standards, and accepted principles of good clinical practice. The authors retain full responsibility for the accuracy and integrity of the work.

About the Authors

Maggie-Lee Huckabee, PhD, is the founder of the University of Canterbury Rose Centre for Stroke Recovery and Research and Distinguished Professor in the Department of Psychology, Speech and Hearing in Christchurch, New Zealand. Professor Huckabee is committed to translational science to move research discoveries into routine clinical practice and is the founder of Swallowing Technologies Ltd., a commercial enterprise to translate laboratory-developed technology to clinical care. She is well known as a clinical teacher and is an invited speaker by health systems worldwide to provide clinical training, particularly in rehabilitation practices.

Sebastian Doeltgen, PhD, SFHEA, is the lead of the Swallowing Neurorehabilitation Research Laboratory at Flinders University in Adelaide, Australia, and internationally recognized for his research into the biomechanical, neurological, and socio-economical characteristics of dysphagia. When not in the research lab or lecture theater, Professor Doeltgen enjoys spending time with his family exploring Australia's unique outdoors.

Janina Wilmskoetter, PhD, CCC-SLP, BCS-S, is an Associate Professor at the Medical University of South Carolina, where she teaches graduate students, works clinically in acute care and neurological specialty clinics, and conducts research focusing on post-stroke dysphagia and aphasia. Dr. Wilmskoetter has a soft spot for dessert, particularly anything chocolate, and is committed to advancing care so that individuals with swallowing disorders can continue to enjoy their favorite foods.

Section 1

Background Knowledge

It is critical for clinicians at all levels and in all settings of clinical practice to have a thorough understanding of the basic prevalence of dysphagia following stroke, swallowing neural control, and swallowing biomechanics. The confluent understanding of these topics facilitates well-informed, patient-specific, and evidence-based diagnostic reasoning. The swallowing-related phenomena we observe clinically are just the visible consequences of what is happening in a much more complex underlying system. To advocate for prompt consultation and evaluation of all patients with stroke and generate pathophysiology-informed assessments and management recommendations, the clinician must understand the fundamentals of the neural control of swallowing and the ways in which they drive behavior.

Section 1 of this book outlines essential Background Knowledge in three foundational chapters: 1. Introduction to Dysphagia and Stroke, 2. The Neural Control of Swallowing, and 3. Normal Swallowing Anatomy and Biomechanics. Chapter 1 provides an overview of our most recent understanding of the prevalence of dysphagia following stroke, key imaging technologies used to evaluate neurological damage, and ways in which these epidemiological and neuroimaging insights shape current approaches to identifying at-risk patients and interpreting the mechanisms underpinning poststroke swallowing impairment.

Chapter 2 opens by looking back—situating today's understanding of swallowing neural control within the broader historical arc of how our understanding of swallowing control has developed. As outlined in more detail elsewhere (Huckabee et al., 2023), early work, largely from animal models and experimentally evoked swallowing, focused on a brainstem central pattern generator in the medulla that produced a stereotyped "reflex," with cortical areas seen mainly as triggers rather than active contributors.

With the advent of modern neuroimaging and electrophysiology technologies, this view has expanded. Strong evidence now shows that

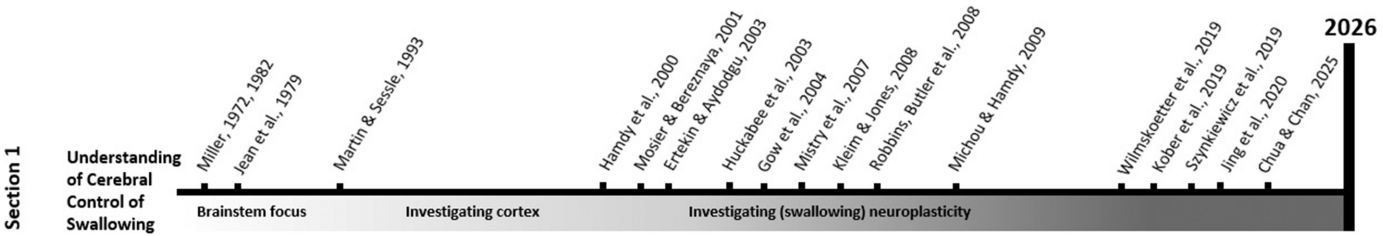

Figure SI–1. Historical overview of our expanding understanding of swallowing neural control from early brainstem focus to increasing understanding of cortical and subcortical contributions. The included references are examples of key studies but do not reflect the entirety of peer-reviewed published literature on that topic. Adapted from Huckabee et al. (2023). Copyright © Springer Nature. Reproduced with permission.

cortical and subcortical networks integrate sensory and motor cortices with limbic, cerebellar, and extrapyramidal systems. This shifted the concept of swallowing from a simple reflex to a cortically modulated, pattern-generator-driven behavior. Rather than a single generator, swallowing is understood as a flexible, distributed network shaped by task demands, sensory input, and experience. Figure S1–1 visually represents a selection of foundational research that has advanced our understanding of brainstem and cortically driven control of swallowing.

Chapter 3 concludes Section 1 by outlining our current understanding of swallowing biomechanical function, integrating current evidence on the coordinated roles of the oropharyngeal musculature, airway protection mechanisms, and bolus-flow dynamics. It summarizes how neuromuscular timing, structural movements, and pressure generation interact to enable safe and efficient bolus propulsion. This chapter also highlights key kinematic and physiologic parameters commonly evaluated in contemporary assessment, such as hyolaryngeal excursion, pharyngeal constriction, upper esophageal sphincter opening, and airway closure. It also identifies the biomechanical signatures associated with normal versus impaired swallowing, setting the foundation for the holistic assessments explored in later sections.

Section Highlights

New Learners	*Practicing Clinicians*
• Clear grounding in the prevalence of dysphagia after stroke, helping learners understand why every stroke patient warrants consideration for swallowing assessment.	• Integrates contemporary research and modern neuroimaging insights to support pathophysiology-informed diagnostic reasoning and targeted clinical decision-making.
• Foundational introduction to swallowing neurophysiology and biomechanics, building a coherent mental model of how neural control and movement patterns create (or disrupt) safe swallowing.	• Explores the evolution from reflex-based to cortically modulated models of swallowing, reinforcing current approaches to neuroplasticity-driven rehabilitation.

New Learners	*Practicing Clinicians*
• Structured overview of the critical concepts, mechanisms, and terminology needed to interpret clinical signs by "connecting the dots" between what is seen peripherally and what is occurring in underlying neural systems.	• Provides refined explanations of key biomechanical parameters (e.g., hyolaryngeal excursion, upper esophageal sphincter opening, pharyngeal constriction) to sharpen interpretation of instrumental assessments and inform individualized management strategies.

1 Introduction to Dysphagia and Stroke

OVERVIEW OF STROKE

Epidemiology of Stroke

Recent estimates indicate that approximately 12 million people experience a stroke each year worldwide, with racial and ethnic minority groups facing substantially higher risks than non-Hispanic White populations (GBD 2021 Stroke Collaborators, 2024; Feigin et al., 2025). Older age remains one of the strongest predictors for stroke (Howard et al., 2023; Yousufuddin & Young, 2019). Female sex compared with male sex has been linked to higher stroke risk and worse outcomes after stroke, including higher mortality, poorer quality of life, greater rates of poststroke depression, and more activity limitations (Rexrode et al., 2022).

Although many high-income countries have seen declines in stroke incidence and stroke-related mortality over recent decades, low- and middle-income countries continue to experience stable or increasing rates, contributing disproportionately to the global burden. These geographic disparities reflect differences in population aging, risk factor prevalence, access to preventive care, and the availability of acute stroke services (Krishnamurthi et al., 2013; Naghavi et al., 2015; GBD 2021 Stroke Collaborators, 2024).

Worldwide, ischemic strokes represent approximately 62% to 70% of all stroke events, whereas hemorrhagic strokes account for the remaining 30% to 38%. This distribution, however, varies substantially across regions. In high-income countries, an estimated 87% of strokes are ischemic (GBD 2021 Stroke Collaborators, 2024; Martin et al., 2025), reflecting a markedly lower proportion of hemorrhagic events. Low- and middle-income countries experience a higher burden of hemorrhagic stroke, driven by elevated rates of uncontrolled

hypertension, the strongest modifiable risk factor for intracerebral hemorrhage, along with limited access to preventive care and delays in acute treatment. These structural and health system disparities contribute to the persistently greater proportion of hemorrhagic strokes in resource-constrained settings.

Ischemia occurs when blood flow to the brain is reduced or obstructed, most commonly due to atherosclerosis, a progressive buildup of plaque within the arterial lining. Plaque accumulation leads to arterial stenosis and can promote the formation of a thrombus, a stationary clot that restricts cerebral perfusion. Thrombotic infarctions typically involve large arteries (e.g., the middle cerebral artery) but may also affect small perforating arteries (e.g., the lenticulostriate arteries), resulting in a small subcortical infarct.[1] Portions of an atherosclerotic plaque or an existing thrombus may dislodge and travel distally as an embolus, obstructing blood flow when it becomes lodged in a narrower vessel. Embolic strokes frequently originate from the heart, particularly in the context of atrial fibrillation or other cardioembolic sources.

Hemorrhagic strokes arise from the rupture of a cerebral blood vessel and may result from chronic hypertension, which damages vascular wall integrity, or from structural abnormalities, such as intracranial aneurysms or arteriovenous malformations. A wide range of factors increase stroke risk, including hypertension, diabetes mellitus, hypercholesterolemia, heart disease, family history of stroke, physical inactivity, smoking, excessive alcohol use, and cocaine use.

Neurologic Evaluation

The initial diagnostic procedures for acute stroke are centered around the notion that "Time is brain." The medical team's goal is to determine whether the patient needs urgent, time-sensitive medical procedures, such as thrombolysis and/or neurosurgery. Hence, assessment of a patient with suspected acute stroke begins before arrival at the hospital, typically initiated by emergency medical services (EMS). Prehospi-

[1]Small subcortical infarcts, often called lacunar infarcts, are small (≤ 20 mm), deep subcortical ischemic strokes caused by occlusion of small perforating arteries and are a feature of small vessel disease (Duering et al., 2023).

tal providers rapidly evaluate symptoms, establish the time the patient was last known to be well, and screen for stroke using validated tools such as the BE-FAST mnemonic: Balance difficulties, Eye or vision changes, Face drooping, Arm weakness, Speech difficulties, and Time to call emergency services. Early recognition in the field facilitates the timely activation of stroke protocols and prenotification to the receiving hospital. Once the patient reaches the emergency department, the assessment continues. A neurologist or emergency clinician obtains a focused history from the patient or, when necessary, from family or witnesses. Key elements include past medical conditions, current medications, the precise time of symptom onset, circumstances surrounding the event, initial neurological deficits, and the progression or resolution of symptoms. A neurologic examination is completed to determine the exact deficits and consists of evaluation of elemental and higher cortical functions. Elemental functions include examination of cranial nerves, reflexes, and motor and sensory systems. Higher cortical function assessment involves evaluation of attention and memory, affect, language, praxis, visuospatial processing, and neglect. Table 1–1 presents an example of a neurologic examination. The severity of stroke symptoms is commonly documented using the National Institutes of Health Stroke Scale (NIHSS), which provides a standardized, quantitative assessment of neurological impairment. The NIHSS evaluates key domains, including level of consciousness, language, speech, visual fields, motor strength, sensory function, coordination, and attention, to generate a score that reflects overall stroke severity. Higher scores indicate more significant neurological deficits and help guide clinical decision making and monitor changes over time.

Table 1–1. Neurologic Examination

I. Mental Status
   A. Appearance and Behavior
   B. Mood and Affect—depression, anxiety, paranoid, vigilant, distracted, circumstantial, tangential, suspicious
   C. Level and State of Consciousness
      i. Level of consciousness—alert, lethargic, obtunded, stuporous, comatose
      ii. State of consciousness—normal, manic, minimally reactive
   D. Orientation—person, place, time, event

(*continues*)

Table 1–1. (*continued*)

E. Memory—can be assessed in terms of time course and/or function
    i. Time course
        1. Immediate (digit span, serial 7's, immediate recall of three objects)
        2. Short-term (three objects recall at 5 minutes)
        3. Long-term (presidents 5/5, autobiographical)
    ii. Function
        1. Declarative
            a. Episodic (questions relative to recent/remote event: most recent meal, current events in the news, major life events)
            b. Semantic (general knowledge, e.g., capital of Louisiana)
        2. Procedural (describe/demonstrate overlearned tasks such as swinging a golf club)
        3. Working (digit span backwards, serial 7's, oral arithmetic)
F. Frontal Lobes
    i. Dorsolateral (verbal fluency: F-A-S, categories; abstract reasoning)
    ii. Medial frontal (energy level-apathy, anxiety, depression)
    iii. Orbitofrontal (response inhibition-tactile, visual; social inappropriateness)
G. Language
    i. Spontaneous speech (fluency)
        1. Nonverbal aspects of language-aprosodia
    ii. Naming (confrontation-high frequency and low frequency words)
    iii. Repetition (single words, phrases)
    iv. Comprehension
    v. Reading/Writing
H. Praxis (ideomotor, ideational, limb-kinetic, buccofacial)
I. Constructional Ability/Neglect
    i. Visuospatial
        1. Copy complex figure (intersecting pentagon)
        2. Mapping (topographic abilities)
        3. Clock drawing (spontaneous, copy)
    ii. Neglect
        1. Anosognosia (awareness of deficits)
        2. Hemispatial neglect (cancellation, line bisection)
        3. Extinction (auditory, visual, tactile)
        4. Emotional-Affective processing (expressive, receptive aprosodia)
J. Calculations

II. Cranial Nerves (CN)
A. CN I—Olfactory (tested only when indicated by history)
B. CN II—Optic (visual acuity, visual fields, pupil size, regularity, equality, reaction to light, optic fundi)
C. CN III, IV, VI—Extraocular muscle function (tracking, saccadic eye movements)
D. CN V—Trigeminal (jaw movement against resistance, jaw jerk reflex, facial sensation, corneal reflex)
E. CN VII—Facial (symmetry at rest and with movement, corneal reflex, taste anterior 2/3 of tongue, lacrimation and salivation)