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REVIEW

Dysphagia In Multiple Sclerosis Patients: Diagnostic And Evaluation Strategies

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Abstract: Dysphagia after multiple sclerosis (MS) is a common disabling symptom which can lead to serious complications. Regular screening and assessment of dysphagia in patients with MS are important. Using valid and reliable instruments to measure dysphagia in MS patients is a crucial component in clinical practice and of research quality. There are various strategies to diagnose and assess the dysphagia in patients with MS. Screening strategies are for early diagnosis of the dysphagia. Clinical, non-instrumental strategies are used to verify the presence and to determine the severity and cause of dysphagia. Instrumental strategies are complementary to clinical examination to provide objective data on the various aspects of swallowing dysfunctions. This review revealed a few validated tools for dysphagia assessment in MS. The Dysphagia in Multiple Sclerosis Questionnaire (DYMUS) and the Mann Assessment of Swallowing Ability (MASA) are the only validated MS-specific dysphagia tools. Further development of valid and reliable MS-specific screening and assessment tools that can be administered rapidly and scored easily to detect dysphagia and evaluate clinical outcomes in adults with MS is imperative. Until then, validation and metric evaluation of the screening and assessment tools currently available are required.

Keywords: multiple sclerosis, diagnosis, dysphagia, screening strategy, assessment strategy, outcome measure

Introduction

Multiple sclerosis (MS) is a chronic, demyelinating and inflammatory disease of the central nervous system (CNS) seen usually in young adults. MS is the most common neurodegenerative disorder affecting over 2.2 million people globally.[1] The underlying cause of the MS is incompletely known. However, an inflammatory immune-mediated lesion in the CNS is characterized.[2,3] Patients with MS present with a wide variety of symptoms such as dysphagia.

Dysphagia is defined as any difficulty in swallowing function. The dysphagia is estimated in one-third of the patients with MS.[4] A recent systematic review with meta-analysis found about 43% prevalence of dysphagia in patients with MS.[5] The swallowing function may be impaired in MS resulted from the lesions in cortico-bulbar tracts, paresis of cranial nerves, disorders of cerebellum and brainstem, and cognitive dysfunctions.[6] Dysfunctions may occur at any stage of the normal swallowing in the mouth, pharynx, and esophagus. The presence of dysphagia can cause serious complications such as aspiration pneumonia, malnutrition, dehydration, and airway obstruction. The high prevalence of patients affected, dysphagia-related disabilities, and the subsequent impact of costs on family and health care system emphasize the need for accurate early diagnoses and treatment of dysphagia in patients with MS.

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There are various strategies for the assessment of dysphagia in patients with neurological conditions. The clinicians and investigators may utilize tools from subjective methods such as observations of patients for dysphagia symptoms during eating solid food and drinking liquid to the instrumental techniques of videofluoroscopy and videoendoscopy. Whatever the strategy, an appropriate tool for dysphagia assessment must be accessible, validated in the population being tested, have high reliability, and have the potential to grade the level of dysphagia severity. Hence, instruments used for MS-related dysphagia assessment in clinical and research settings must be reliable and valid to ensure that the highest quality assessments are performed. In daily clinical practice, patients would benefit from an accurate assessment and diagnosis since it allows appropriate individual treatment to be planned, resulting in a more effective treatment of dysphagia. In research settings, proper dysphagia assessment provides the opportunity for high-quality research in the MS-related dysphagia. The aim of the present review is to describe the strategies used to identify and assess swallowing dysfunctions in MS patients with dysphagia.

Diagnosis And Assessment Of Dysphagia

The early identification and assessment of dysphagia after MS is essential. Patients with MS suspected to have dysphagia must undergo a comprehensive examination. The examination initiates with screening for identification of dysphagia and proceeds with clinical non-instrumental examination to establish if dysphagia is present. This procedure may be complemented with instrumental evaluations. There are standardized tests, patient-reported outcome questionnaires, and observational methods for screening and assessment of dysphagia.

Screening for dysphagia is essentially different from the clinical examination procedure. Screening strategies are applied first and its findings are used for further clinical assessment and in planning the appropriate treatment to reduce the risks such as pneumonia.[7,8] The screening tools are brief, bedside clinical tests used to detect dysphagia, thus must be highly sensitive. The clinical examination of swallowing is administered later to confirm the presence of dysphagia, to quantify the dysphagia severity, and to identify the need for instrumental assessment. The clinical assessment of swallowing uses, primarily, non-instrumental strategies that include the taking history and a detailed assessment of oral, pharyngeal, and laryngeal anatomy, sensory and motor function, behavioral, cognitive, language abilities, and a feeding trial. The clinical assessment of swallowing enables the clinicians to understand the underlying dysfunction in swallowing of patients and select appropriate medical and rehabilitation strategies.[8] The clinical instruments of swallowing must be highly specific to correctly identify the subjects not having dysphagia.

Screening Strategies

Dysphagia screening strategies are rapid pass-fail procedures to identify patients at risk of dysphagia with the requirement for further assessments to establish the diagnosis.[9,10] Screening strategies are designed for initial diagnosis and identification of patients with likelihood of dysphagia. Earlier diagnosis of patients has potentials to reduce the costs and improve the outcomes. Thus, all the patients who are identified at risk of dysphagia during screening must be referred to dysphagia specialists for further assessments and possible earlier treatment. Dysphagia screening tools must be feasible, valid, and highly sensitive to identify patients at risk of swallowing dysfunction.

A variety of screening tools have been identified to diagnose the dysphagia in MS. Most of them are not validated in patients with MS but was found having potential for use as a screening tool. They are a single item question, clinical tests, or self-administered questionnaires (Table 1).

Dysphagia In Multiple Sclerosis (DYMUS)

The DYMUS is the only validated self-administered, patient-reported outcome (PRO) questionnaire developed specifically for dysphagia screening in patients with MS.[11] It has 10 items asking patients to answer with "Yes" (coded as "1") or "No" (coded as "0") about their present swallowing problems for solid and liquids (Table 2). The DYMUS total score is calculated by summing of the item scores and ranges from 0 to 10. Dysphagia is diagnosed if DYMUS total score is ≥1 and is interpreted "'alarming'" when the total score is ≥3. The original version of the DYMUS has shown a very good internal consistency reliability (Cronbach's alpha=0.88) and significant correlation with the Kurtzke's Expanded Disability Status Scale, EDSS (p=0.0007).[11]

As shown in Table 2, the DYSMUS has two reliable subscales: 1) Dysphagia for solid and 2) Dysphagia for liquid.[11]

Table 1 Screening Strategies Of Dysphagia In Multiple Sclerosis (MS)

Tools	Items/ Structure	Outcome	Domain	Score	Population	Reliability	Validity
Dysphagia in Multiple Sclerosis (DYMUS)[11]	10/Nominal	Function, Activity	Dysphagia	Yes" (coded as "1") or "No" (coded as "0") for each item, total score from 0 to 10 points	MS (n=226)	Internal consistency (Cronbach's alpha=0.88)	Convergent validity [correlation with EDSS[a] (p=0.0007)]
Shortened Dysphagia in Multiple Sclerosis (DYMUS)[17]	5/Nominal	Function, Activity	Dysphagia	Yes" (coded as "1") or "No" (coded as "0") for each item, total score from 0 to 5 points	MS (n=100)	Internal consistency (Cronbach's alpha=0.904); test-retest reliability (Cohen's kappa=0.54–0.80)	Convergent validity (correlation with the 10-item EAT-10[b], r=0.798–0.886)
Water-swallowing test[27]	Test/Nominal	Swallow, Impairment	Dysphagia, Aspiration	Normal-Abnormal	MS (n=79), healthy (n=181)	Not evaluated	Not evaluated
Dysphagia Screening Questionnaire for MS subjects (DSQMS)[36]	5/Ordinal	Function	Dysphagia	A 5-point scale for each question rating level of severity, frequency, and change	MS (N=525)	Not evaluated	Not evaluated

Note: [a]Expanded Disability Status Scale; [b]Eating Assessment Tool.

The second larger validation study (n=1734) confirmed the internal consistency reliability (Cronbach's alpha=0.914), discriminant validity, and dimensionality of the original DYMUS questionnaire.[12] The disease-specific 10-item DYMUS questionnaire has been cross-culturally adapted and validated to different languages.[13–16] The study by Printza et al (2018) to validate the DYMUS into Greek language found the question on the weight loss is redundant and suggested the DYMUS modification.[14] It is the only study that examined the healthy Greek people and presented normative data for DYMUS, which is essential for clinical use of a questionnaire.[14] Authors suggested a cut-off score of 2 on the DYMUS for the dysphagia diagnosis.[14] A further validation of DYMUS in patients with MS confirmed the reliability and validity of the original 10-item DYMUS and resulted in the removal of 5 items (Q3, Q5, and Q8-Q10).[17]

The shortened version of the DYMUS with five items showed high internal consistency reliability (alpha = 0.904)[17] (Table 3). The scoring of the shortened DYMUS for identifying the presence of dysphagia is similar to the original ten-item version[11] such that the dysphagia can be identified by at least one "Yes" answer.[17] The shortened DYMUS is easy to use and quickly administer PRO questionnaire for screening of MS patients with dysphagia and has good reliability [internal consistency and test–retest reliability (Cohen's kappa=0.54–0.80)] and convergent validity,[17] but further validation investigations are required to determine its psychometric properties of sensitivity and specificity.

The both original and shortened DYMUS, as bedside screening instruments, can be used to quickly administer to detect swallowing impairments in MS patients with likelihood of dysphagia. The two subscales of original 10-item DYMUS can be used to independently assess the swallowing difficulty with solid materials or liquids, which can help clinicians in selecting the best appropriate management strategy for dysphagia. The DYMUS, however, focuses primarily on the oropharyngeal dysphagia to prevent aspiration.[11,17] The shortened DYMUS, at least in theory, with only 5 items can reduce the clinical burden much more than the original DYMUS making it as a more useful screening instrument for detecting dysphagia in MS. Studies to compare the original DYMUS and the shortened DYMUS in terms of clinical utility and psychometric characteristics in patients with MS are suggested.

Eating Assessment Tool (EAT-10)

The EAT-10 is a commonly used self-administered and symptom-specific PRO questionnaire for assessing the

Table 2 Ten-Item Dysphagia In Multiple Sclerosis (DYMUS) In Solid Subscale (7 Items In Bold) And Liquids Subscale (3 Items Not In Bold)[a] For Assessing Swallowing Function In Patients With Multiple Sclerosis

Questions	Answers
1. Do you have difficulties swallowing solid food (such as meat, bread, and the like)?	Yes ☐ No ☐
2. Do you have difficulties swallowing liquids (such as water, milk, and the like)?	Yes☐ No☐
3. Do you have a globus sensation in your throat during swallowing?	Yes ☐ No ☐
4. Do you have food sticking in your throat?	Yes ☐ No ☐
5. Do you cough or do you have a choking sensation after ingesting solid foods?	Yes ☐ No ☐
6. Do you cough or do you have a choking sensation after ingesting liquids?	Yes ☐ No ☐
7. Do you need to swallow several times before completely swallowing solid food ?	Yes ☐ No ☐
8. Do you need to cut food in small pieces before swallowing ?	Yes ☐ No ☐
9. Do you need to take many sips before completely swallowing liquid?	Yes ☐ No ☐
10. Do you have weight loss?	Yes ☐ No ☐

Notes: [a]Reprinted from the *Journal of the Neurological Sciences*, Vol 269/edition number 1, Bergamaschi R, Crivelli P, Rezzani C, et al, The DYMUS questionnaire for the assessment of dysphagia in multiple sclerosis, Pages No. 49-53, Copyright (2008), withpermission from Elsevier.[11] The bold indicates the solid subscale.

Table 3 Shortened Dysphagia In Multiple Sclerosis (DYMUS)[a] For Assessing Swallowing Function In Patients With Multiple Sclerosis

Questions	Answers
1. Do you have difficulties swallowing solid food (such as meat, bread, and the like)?	Yes ☐ No ☐
2. Do you have difficulties swallowing liquids (such as water, milk, and the like)?	Yes ☐ No ☐
3. Do you have food sticking in your throat?	Yes ☐ No ☐
4. Do you cough or do you have a choking sensation after ingesting liquids?	Yes ☐ No ☐
5. Do you need to swallow more and more times before completely swallowing solid food?	Yes ☐ No ☐

Note: [a]Data from Bergamaschi et al.[11]

patient's perception of dysphagia in various clinical diagnoses including MS.[13,14,17–19] It consists of 10 questions scored on a five-point scale (0–4) which 0 indicates no problem, and 4 indicates severe problem (Table 4). The total score is calculated with summing the item scores and ranges from 0 to 40 with higher score that indicates greater swallowing problem. An EAT-10 total score of ≥3 identifies the patients with dysphagia.[18] The original English EAT-10 is responsive to change and has shown excellent internal consistency reliability (Cronbach's alpha=0.96), test–retest reliability (0.72–0.91), and criterion and discriminant validity ($p<0.001$).[18] The EAT-10 questionnaire has been cross-culturally adapted and validated to different languages.[19–27] The EAT-10 questionnaire assesses the body function, activity, and participation of the swallowing.

A study used the Turkish EAT-10 to detect aspiration in patients with various neurological disorders (n=259) including MS (n=24) and stroke (n=118) and found it useful to identify dysphagia patients with unsafe airway protection.[25] A previous study with a large sample of patients with dysphagia (N=360) found the EAT-10 is able to predict aspiration risk with the sensitivity of 71% when the EAT-10 score is greater than 15, and patients with EAT-10 score > 15 are 2.2 times more at risk of aspiration.[26] The readability of EAT-10 has been also demonstrated that supports its use in neurological conditions with dysphagia including MS.[27]

To investigate the reliability and validity of the Turkish DYMUS in patients with MS (n=117), significant correlations were revealed between the DYMUS and EAT-10 ($r = 0.90$, $p<0.001$).[13]

Several studies have evaluated the criterion validity of the EAT-10 by comparing the pretreatment and posttreatment EAT-10 scores.[18,19,21] The original English EAT-10 was administered to 46 patients before and after treatment and

Table 4 Eating Assessment Tool (EAT-10).[a] Circle The Appropriate Response. To What Extent Are The Following Scenarios Problematic For You? 0 = No Problem 4 = Severe Problem

Responses	Grade				
1. My swallowing problem has caused me to lose weight.	0	1	2	3	4
2. My swallowing problem interferes with my ability to go out for meals.	0	1	2	3	4
3. Swallowing liquids takes extra effort.	0	1	2	3	4
4. Swallowing solids takes extra effort.	0	1	2	3	4
5. Swallowing pills takes extra effort.	0	1	2	3	4
6. Swallowing is painful.	0	1	2	3	4
7. The pleasure of eating is affected by my swallowing.	0	1	2	3	4
8. When I swallow food sticks in my throat.	0	1	2	3	4
9. I cough when I eat.	0	1	2	3	4
10. Swallowing is stressful.	0	1	2	3	4

Note: [a]Data from Belafsky et al.[18]

improvements with intervention were demonstrated in the EAT-10 items.[18] The EAT-10 scores of Greek version were compared before and after rehabilitation in 36 patients with dysphagia of various conditions and significant changes were found.[19] The Italian EAT-10 was used in 38 patients with dysphagia who received rehabilitation and significant improvement in the EAT-10 scores was documented.[21]

The EAT-10 is a validated, easily read and understood outcome tool that can be utilized to determine the initial diagnosis and severity of dysphagia in a wide clinical diagnoses presenting with swallowing disorders. The EAT-10 is simple, easy to use, and quicker to administer (<2 mins)[11] make it a suitable candidate as a screening instrument to determine the risk of dysphagia in patients with MS. The EAT-10, however, should be specifically validated in patients with MS as a bedside screening tool, and to determine its usefulness as a PRO measure in longitudinal designs for measuring the effectiveness of treatments over time.

3-Ounce (90-cc) Water Swallow Test

A screening test for dysphagia must be clinically useful and to have high sensitivity and specificity for the accurate identification of individuals who are at risk for dysphagia and to rule out individuals not at risk for dysphagia. Screen for dysphagia must be performed on all MS patients prior to prescription of food, fluids, or medications by mouth because abnormal swallowing is common in MS although they may not complain of it.[28]

The 3-ounce water swallow test is a widely used sensitive screening tool for individuals who are at risk for oropharyngeal dysphagia and aspiration (sensitivity 76%, 94%).[29] Individuals are required to drink 3 ounces (90 cc) of water from a cup without interruption in a seated upright position. Criteria for abnormality and referral for further evaluation of swallowing include 1) inability to complete the drinking water; 2) occurrence of coughing or choking; and 3) a wet or hoarse vocal quality exhibited either during or within 1 min of test completion.[29] The ability of the 3-ounce water swallow test to detect aspiration during bedside swallowing screening has been reported.[29–33] A study carried out on 93 neurological patients with at risk of swallowing dysfunction including MS (n=7) documented that the association of history of cough on swallowing and positive 3-ounce water test is a useful screening tool.[31] A recent larger study to investigate the clinical utility of the 3-ounce water swallow test performed in conjunction with the fiberoptic endoscopic evaluation of swallowing (FEES) on a large sample of adult patients with a wide range of diagnoses (n=3000) found a high sensitivity of 0.97 and that if a patient passes the 3-ounce water swallow test without difficulty, the clinician can recommend oral feeding without further instrumental testing.[34]

The 3-ounce water swallow test has high sensitivity, is validated against VFSS and VESS, and has been evaluated incorporating a large and heterogenous sample of dysphagia patients. As well, it can be carried out without any special equipment, its administration is easy, and time of administration is short. It follows that the 3-ounce water swallow, taken

collectively, presents as a suitable option for dysphagia screening in MS patients. But, the 3-ounce water swallow test is not validated in MS population. Studies in patients with MS that use sound methodologies and have objective criterion measures to examine the clinical usefulness and diagnostic accuracy of the 3-ounce water swallow test in screening for dysphagia are warranted.

Water-Swallowing Test

Water swallowing is difficult for neurological patients with dysphagia. The water-swallowing test is developed to detect aspiration by having the patients at risk of dysphagia to drink water. There are different methods that use different quantities of water from 3 mL to 150 mL.[28,35] In an observational study of patients with MS to assess the frequency of dysphagia, dysphagia-related symptoms, 79 consecutive patients with MS and 181 healthy controls were enrolled.[28] Dysphagia was measured using a 26-part questionnaire, bulbar neurological signs, and a water test. Patients were asked to complete the questionnaire on the dysphagia-related symptoms (on a yes/no answer or to score from 0 to 4 according to their frequency). No information is provided on the reliability and validity of the questionnaire used (Table 1), and the authors commented that one can not rely on the patients' subjective complaints. To perform the swallowing test, the patients were asked to drink a cup of 150 mL water as fast as possible while in a comfortable sitting position, and the volume swallowed, number of swallows, time of per swallow (s), and swallowing capacity (mL/s) were recorded. Moreover, coughing during swallowing and coughing, drooling or changed voice quality after swallowing were noted. Dysphagia was diagnosed if an abnormality was presented in the water test. The authors concluded it as a useful screening test in MS and an appropriate simple method for dysphagia quantification in the clinic and bedside.[28]

The water-swallowing test does not require any specific equipment and can be easily performed and analyzed quickly. Further studies with water-swallowing test of different quantities are required to determine its reliability, validity as well as sensitivity and specificity in patients with MS, and compare the small vs large amounts of water (e.g., 3 mL, 30 mL, 150 mL) to determine the most sensitive amount of water for bedside screening.

Dysphagia Screening Questionnaire For MS (DSQMS)

The DSQMS was developed to screen patients with MS for dysphagia (n=525) with the aim to alert health professionals about the importance of early detection and treatment of dysphagia (Table 1).[36] The DSQMS is a self-reported questionnaire asking questions regarding the presence and frequency of coughing and choking while eating, anxiety about swallowing during oral intake, the presence and severity of swallowing difficulty, and any changes in swallowing function (improved or reduced) at the present time (Table 5).[36] The DSQMS contains 5 questions, and each question is scored on a 5-point scale for rating level of severity, frequency, and change. The caregiver can assist the patient in completing the questionnaire. The DSQMS addresses the fluctuant nature of dysphagia in MS as observed clinically.[36] The DSQMS is not validated in MS patients, and there are no information about the scoring approach and its sensitivity and specificity.

Single Question 'What About Swallowing?

The single question 'What About Swallowing? recorded as "no problem" or difficulties in swallowing" is used to identify dysphagia.[37] The diagnostic performance of the What About Swallowing? question has been demonstrated against EAT-10 as a reference test in 303 outpatients (neurological disorders, head and neck cancer) at risk of oropharyngeal dysphagia (sensitivity 0.75–0.76; specificity 0.75–0.84; PPV, positive predictive value 0.93–0.97; NPV, negative predictive value 0.38–0.43). In the Kurtzke Expanded Disability Status Scale (EDSS), one of the eight functional systems assessed is brain stem in which one question is "what about swallowing".[38] In the study on the validation of Greek DYMUS, patients with MS were also asked "what about swallowing", and responses were analyzed against the DYMUS and the EAT-10.[14]

Although standardized questionnaires have advantages, screening tools need to be non-invasive, easy to use and administer, time-consuming, avoid distress to patient, require no special training, and most importantly to be valid and reliable.[39] A single open question "What about swallowing?" is an easy, simple to administer test for use in clinical practice which can facilitate the bedside screening process. The simplicity of the single question "What About Swallowing?" encourages further research on its usefulness and psychometric features in MS patients at risk of dysphagia. Moreover, although previous findings support the validity of the single question "What About Swallowing?" for identifying patients at risk of dysphagia,[37] a comparison with standard instrumental measures (e.g., FESS) as gold standard is merited.

Table 5 Dysphagia Screening Questionnaire For Multiple Sclerosis (DSQMS)[a]

This Questionnaire Is To Be Completed By The Patient. The Caregiver May Assist The Patient. Choose The Answer That Best Describes The Situation At The Present Time.
1. How would you describe how easy it is for you to swallow? a. Very easy b. Easy c. Difficult d. Very difficult e. Nearly impossible
2. If you have any swallowing problems, are they presently a. Much better than usual b. Better than usual c. About the same as usual d. Worse than usual e. Much worse than usual
3. Approximately how often do you cough while eating? a. Never b. Rarely c. Occasionally d. Frequently e. Constantly
4. Approximately how often do you choke while eating? a. Never b. Rarely c. Occasionally d. Frequently e. Constantly
5. How do you feel about eating? Do you feel anxious about swallowing? a. Not at all anxious b. Slightly anxious c. Moderately anxious d. Severely anxious e. Too anxious to eat

Note: [a]Adapted with permission from SAGE Publications. Copyright © 1997. Abraham S, Scheinberg LC, Smith CR, LaRocca NG. Neurologic Impairment and disability status in outpatients with multiple sclerosis reporting dysphagia symptomatology. *J Neuro Rehab*. 1997;11(1):7–13.[36]

Northwestern Dysphagia Patient Check Sheet (NDPCS)

The NDPCS screening test is developed and validated on 200 mixed heterogeneous patients with various causes [stroke (n=69); cancer (n=26); spinal cord injuries (n=21); and 84 patients with unspecified causes] to identify various types of oropharyngeal dysphagia including aspiration, oral dysphagia, pharyngeal delay, and pharyngeal dysphagia.[40] The NDPCS consists of 28 items presented in five categories: medical history, behavioral variables, gross motor function, oral motor function, and observations during swallows. Each item is scored as "safe" or "unsafe". The numbers of unsafe items are summed as the total score for NDPCS. The NDPCS is able to classify patients correctly as having or not having aspiration, disorder of oral stage, pharyngeal delay, and problem in pharyngeal stage of swallowing. The NDPCS has been translated to different languages[41,42] and used as a screening tool to identify dysphagia in MS patients.[43]

The NDPCS provides the comprehensive assessment of dysphagia, but it takes time that restricts its utility for use as a quick bedside screening tool. Further, it aims to identify the origin of dysphagia (oral or pharyngeal) and thus it may be considered as a diagnostic rather than a screening tool. The usefulness of NDPCS as a screening instrument in MS must be justified based on its feasibility and measurement properties of reliability and validity.

Clinical Examination Strategies

The development of screening tools is a response to the importance of early identification of patients at risk of dysphagia and those who aspirate from the oropharyngeal dysphagia. Bedside screening initiates a series of assessments that help to reduce the risk of complications such as pneumonia, to improve the health outcomes, and to reduce the health care costs.[44] All patients considered at risk of dysphagia during screening are required of clinical assessment thus should be referred for further comprehensive clinical, non-instrumental assessment of swallowing and planning for possible earlier treatment. For persons with positive screening test of dysphagia, a physician or an expert speech-language pathologist (SLP) will be required to administer a comprehensive clinical examination to validate the presence of dysphagia, identify the dysphagia severity and underlying pathophysiology, and to prescribe, if necessary, further instrumental evaluation. A clinical examination of patients screened as at-risk aims to determine whether patients show the dysphagia signs and symptoms to commence rehabilitative interventions. In fact, clinical examination of swallowing constitutes a basis for treatment of patients with dysphagia.

A comprehensive clinical examination for swallowing integrates the findings from history taking (patient presenting symptoms, past history, current medical status, medication, swallowing history), physical exam, neurologic assessment of cranial nerves (CN V, VII, IX, X, and XII), patient's mental state, and swallowing trials using solids with a variety of viscosity and liquids. According to the pass-fail method, the patient should exhibit adequate

neuromuscular control to chew food, mix it with saliva, make a bolus, transit it to the posterior oral cavity, and then to the pharynx without coughing and choking to pass to be considered as having no swallowing problem. Patients who fail based on the findings of bedside clinical examination may need further instrumental assessment to detect specific abnormalities leading to swallowing dysfunction.

Non-Instrumental Strategies

The clinical examination remains the primary method for assessing swallowing dysfunctions in various neurological conditions including MS. Clinical non-instrumental strategies have a critical role in the diagnosis and assessment of the dysphagia as well as treatment outcomes in patients with MS. These strategies are aimed to verify the presence of dysphagia, its severity, and the abnormal alterations which resulted in the swallowing problem. The information obtained from a clinical examination would direct the physician/therapist to make decision about the next appropriate step including consultation with other specialists, utilizing instrumental tests, or applying treatment. The prevalence of dysphagia in patients with MS is high, but there is no MS-specific standardized specific instrument for clinical assessment of dysphagia. However, there are standardized clinical measures for dysphagia patients such as the Mann assessment of swallowing ability (MASA)[45] and the Functional Oral Intake Scale (FOIS).[46] The reliability and validity of the MASA have been primarily evaluated in 128 patients with first-ever acute stroke.[45] The MASA has been recently used as an outcome measure in MS patients with dysphagia.[47,48] The FOIS is validated in 302 acute stroke patients and used recently to classify the oral intake of MS participants.[49]

Mann Assessment Of Swallowing Ability

The MASA is a reliable, simple, easy to use and quick test designed for bedside clinical examination of the swallowing function in patients with neurological diseases. The MASA is an efficient, cost-effective, and non-instrumental examination strategy that can detect the eating and swallowing impairments, and specify the candidates with dysphagia and aspiration risk for the instrumental examination. The MASA test has 24 items, and each item is scored via a different weighted 5- or 10-point scale. The total MASA score is ranged from 38 to 200 in which the higher score indicates better swallowing function. It has cut-off criteria for severity of dysphagia (no dysphagia = 178–200; mild ≤168–177; moderate ≤139–167; severe ≤138) and aspiration (no aspiration = 170–200; mild ≤149–169; moderate ≤141–148; severe ≤140).[45]

The MASA is a valid and reliable tool with a sensitivity of 73%, specificity of 89%, and provides good interrater and intrarater reliability.[50,51] The reliability of MASA was investigated in MS patients and a good interrater ($k= 0.76$, $SE= 0.082$, $p < 0.001$) and intrarater reliability ($k= 0.71$, $SE= 0.09$, $p < 0.001$) were found.[46] The MASA, thus, can be included as a standard measure to document the dysphagia characteristics and the changes in swallowing function of patients with MS. However, further research needs to be carried out in patients with MS to provide additional data on the validity of the MASA against instrumental FEES or VFSS and standard clinical tests (e.g., EAT-10) as reference gold standards.

Functional Oral Intake Scale

The FOIS is a 7-point ordinal swallowing measure.[46] Levels 1 through 3 indicate the tube dependent, and levels 4 through 7 relate to total oral intake (Table 6). It is developed primarily in patients with stroke to document the functional eating ability of food and liquid by mouth.[46] The FOIS needs no training for clinicians familiar with management of adult dysphagia. This functional standardized scale has been shown to have adequate reliability, validity, and responsiveness to detect changes over time. A recent study used the FOIS to classify the functional swallowing in patients with MS.[49] The FOIS must be evaluated for reliability, validity, sensitivity, and specificity in patients with MS before to be widely used in clinical practice and research.

Table 6 Items Of Functional Oral Intake Scale[a]

Levels	Description
1	Nothing by mouth
2	Tube dependent with minimal attempts of food or liquid
3	Tube dependent with consistent oral intake of food or liquid
4	Total oral diet of a single consistency
5	Total oral diet with multiple consistencies, but requiring special preparation or compensations
6	Total oral diet with multiple consistencies without special preparation, but with specific food limitations
7	Total oral diet with no restrictions

Note: [a]Reprinted from the *Archives of Physical Medicine and Rehabilitation*, Vol 86/ edition number 8, Crary MA, Mann GD, Groher ME, Initial psychometric assessment of a functional oral intake scale for dysphagia in stroke patients, Pages No. 1516-1520, Copyright (2005), with permission from Elsevier.[46]

Water-Swallowing Speed Test (WSST)

A timed test of swallowing has been proposed for assessing the patients with neurogenic dysphagia. Three indices [volume per swallow (mL), time per swallow (s), and swallowing capacity (mL/s)] may be calculated from drinking water by patients. These indices might be used in screening those at risk of dysphagia. Reliability and validity studies for swallowing capacity indices indicate they are useful measures for assessing dysphagia.[52–55]

The WSST (mL/s) is a quantitative measure in the examination and monitoring of neurological subjects at risk of dysphagia. A high interrater and test–retest reliability have been demonstrated for WSST.[53] The validity of WSST was suggested by high sensitivity (96%), but the lower specificity of 69% was attributed partly to false-positive tests in patients mainly due to MS.[53] A study aimed to examine the validity of 100-mL water-swallowing test to calculate the water-swallowing speed in assessing swallowing dysfunction in patients with clinically suspected dysphagia (n=59) and found the water-swallowing speed is highly sensitive (85.5%) for identifying patients at risk of dysphagia.[56] Based on simplicity and high sensitivity, estimating water-swallowing speed appears to be a suitable bedside tool for the early detection of dysphagia. The reliability, validity and clinical utility of the WSST need to be additionally evaluated for use in patients with MS.

Instrumental Strategies

Diagnosis of dysphagia can be implemented by various strategies of history taking, screening strategies, and comprehensive clinical examination. Later in the course of examination, when the non-instrumental clinical examination fails to identify the problems, an instrumental swallowing examination may be indicated to gather objective information. As well, in situations where patients with certain clinical conditions (e.g., cognitive or communicative impairments) have not adequate cooperation, an instrumental examination may help regarding swallowing ability and correct diagnosis.

The instrumental strategies provide an objective evaluation of swallowing function to help the clinicians to clarify whether a significant dysphagia exists with regard to the patient's symptoms, and to identify the type of dysphagia (oral, pharyngeal, esophageal, or a combination of these components) and determine the risk of aspiration. The objective information provided through instrumental examinations of swallowing function assists the clinicians to reach a diagnosis and to determine the most appropriate management strategy. The findings of instrumental assessments provide the basis for recommendations regarding oral feeding or non-oral feeding.

Instrumental strategies of swallowing assessment include VFSS and FEES. The VFSS and FEES are commonly used to diagnose and assess oropharyngeal dysphagia and guide dysphagia treatment strategies. These two instruments assess the body structure and function of the swallowing.

Videofluoroscopic Swallowing Examination Strategy

The VFSS also known as modified barium swallowing study is the most commonly used instrument for an X-ray visualization of the swallowing to determine the nature and extent of the dysfunctions in the swallowing process. The instrumental VFSS examination of swallowing has a key role in identifying swallowing dysfunctions as it provides a real-time visualization of bolus flow, allows structural kinematic analysis and detecting the aspiration. Thus, it makes the clinicians and therapists to completely and dynamically assess the all swallowing phases, to diagnose the pathophysiological mechanism of aspiration, and reveal the presence of inhalation with high sensitivity;[57] consequently, the VFSS provides feedback about the presence of aspiration and how to eliminate the aspiration. It follows that the most suitable approaches, based on the VFSS findings, can be adopted that ensure management and prevention of dysphagia for safe swallowing.

The VFSS strategy, as a gold standard,[58] has been used in patients with MS.[59] The VFSS can help the clinicians to see in real time any abnormalities in the swallow of patients with MS as it progresses from small to large volumes of thin liquids, and thin to thicker viscosities. The lateral and frontal views of oral, pharyngeal and esophageal phases of swallowing are recorded to observe how food is passing from mouth through throat and down into esophagus, and the information on bolus transit times, motility problems, amount and etiology of the aspiration are obtained. It is important to determine whether the patient with MS exhibits systematic changes in swallow physiology in response to changing volume and viscosity as observed in healthy subjects. VFSS is the only instrument that allows for direct assessment of the oral cavity and pharynx and allows for the examination of esophageal

functioning.[59] Swallowing functioning can be assessed before, during, and after the swallow.

A study evaluated the subjective symptoms of swallowing dysfunction in MS patients (n=18) and correlated it with VFSS findings.[59] It was shown that patients who complained of permanent dysphagia (n=4) had aspiration. Patients with mild and intermittent difficulties in swallowing had undercoating of the epiglottis or laryngeal penetration (n=6). Of patients without any swallowing symptoms (n=8), only 2 had a normal videofluoroscopy.[60] A study reported the VFSS findings in MS patients as decreases in bolus formation, delayed in pharyngeal swallow, decreases in pharyngeal contraction, and decreases in relaxation of upper esophageal sphincter.[59]

The VFSS provides objective measure for determining the details of swallow dysfunction. The dysphagia is common in even asymptomatic patients with MS; thus, the VFSS in all patients with suspected aspiration should be carried out to provide additional objective measure of swallowing dysfunction. At present, studies on the use of VFSS in patients with MS are lacking. Although the swallowing dysfunctions may not be specific to the type of CNS disease,[59] the place of VFSS in examination of MS patients with dysphagia is to be determined.

Fiberoptic Endoscopic Examination Of Swallowing Strategy

The fiberoptic endoscopic examination of swallowing (FEES) is a useful, well-tolerated, and instrumental technique for objective study of oropharyngeal swallowing function.[61] The FEES is the second widely used instrumental strategy to reliably evaluate the pharyngeal stage of swallowing and examine the dysphagia-related symptoms. During FEES, multiple swallow trials of thin and thick liquids and small-sized solids are given to patients. The FEES involves a thin fiberoptic camera to record video images of a patient prior to and during swallowing food and liquid. The FEES is used to detect the residue and aspiration in patients for whom the VFSS evaluation may be difficult or impossible to perform.[62]

The FEES can be used to assess aspiration, penetration, and residues with acceptable sensitivity. A good agreement between VFSS and FEES, especially regarding aspiration (82.3–90% agreement) has been demonstrated; the analysis of FEES vs VFSS showed that the sensitivity of FEES was 88% and specificity was overall lower but was 92% for detection of aspiration.[63–65] A study investigated the sensitivity and specificity for laryngeal penetration, tracheal aspiration and pharyngeal residue for both the VFSS and FEES and showed that with the VFSS considered as the gold standard, sensitivity of the FEES for laryngeal penetration was 87%, aspiration 96%, and pharyngeal residue 68%.[66] The specificity of the FEES for both laryngeal penetration and aspiration was 100%, and pharyngeal residue was 98%. When the FEES was used as the gold standard, the sensitivity of the VFSS for both laryngeal penetration and aspiration was 100%, and pharyngeal residue was 96%. The specificity of the VFSS for laryngeal penetration was 58%, aspiration 63% and pharyngeal residue 78%.[66]

A study to compare VFSS vs FEES with the VFSS used as a reference, the FEES showed high sensitivity (≥80%). The comparison between the two concerning drop before swallowing showed good specificity (84.4% for semi-solids and 86.7% for liquids). In the case of post-swallowing residue, FEES vs VFSS revealed good validity (75% for semi-solids) with specificity and sensitivity for the semi-solids. The analysis of FEES vs VFSS for aspiration showed that the overall validity was low (≤65%).[67] A further study on intra- and interobserver agreement on FEES measurements found it ranging from 0.76 to 0.93 and from 0.61 to 0.88, respectively.[68] While the FEES can be administered across the entire duration of a meal and in more flexible environments than the VFSS, there are elements of swallowing physiology that are not as directly observable during FEES examination as compared with VFSS (in particular, esophageal phase function).

Both the VFSS and the FEES have advantages and disadvantages. VFSS is the only tool that allows for direct assessment of the oral cavity and pharynx and allows for the examination of esophageal functioning. An advantage of the FEES evaluation is that it can be completed at the patient's bedside or in the office using real food without limitations. There is no evidence on the superiority of either instrument in the evaluation of swallowing dysfunction with neurologic sources.[69] No data are available on the sensitivity and specificity of either method in the MS.[70]

The VFSS or FEES is used for objective evaluation of dysphagia. Many screening tests have been developed to diagnose dysphagia. The screening tests are generally used to determine the presence or absence of dysphagia; they are not used for assessing the severity of dysphagia. To identify the dysphagia and determine its severity based on the findings of the VFSS and FEES, several scales have been developed such as the Penetration-

Aspiration Scale (PAS)[71] and the Dysphagia Outcome and Severity Scale (DOSS).[72]

Penetration-Aspiration Scale (PAS)

The PAS is a widely used standard scale for the interpretation of VFSS and FEES.[73] It is primarily developed for quantifying the severity level of penetration and aspiration. The PAS is an 8-point reliable tool for interpreting the laryngeal penetration and aspiration occurrences observed by VFSS or FEES.[71] The scoring is performed based on the depth of entry of material into the airway and the patient's reaction to this phenomenon. The PAS score ranges from 1 (material does not enter the airway) to 8 (material passes below the vocal folds and no effort to eject it) with higher score indicating higher aspiration severity (Table 7). Recently, an ordered categorical revision of the PAS with four levels of increasing severity has been proposed (Table 8).[73] The reliability and validity of original as well as the revised PAS need to be determined in MS patients with dysphagia.

Dysphagia Outcome And Severity Scale (DOSS)

The DOSS is an easy administered, functional 7-point scale to determine severity of dysphagia based on the modified barium swallow procedure.[72] The dysphagia severity is rated according to the functional levels of nutrition, diet, and independence. The DOSS has an excellent interrater reliability (90%) and intrarater reliability (93%) as established by four clinicians on 135 patients who underwent a VFSS procedure.[72] The DOSS can be used to objectively assess the swallowing dysfunction within 5 min by trained clinicians and to determine the severity of functional dysphagia. Nevertheless, the validity and psychometric properties of the DOSS in various populations including the MS patients with dysphagia are imperative before to be used in clinical and research settings.

A study assessed the swallowing function of the MS patients and their swallowing improvements after transcranial Direct Current Stimulation (tDCS) using DYMUS, bedside clinical examination, FEES, and DOSS.[74]

Table 7 The 8-Point Penetration-Aspiration Scale (PAS) For Rating Penetration-Aspiration[a]

Grade	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

Note: [a]Data from Rosenbek et al.[71]

Table 8 The 4-level Categorical Penetration-Aspriation Scale (PAS)

Level	Description
A	Normal function or an effective response to the material penetration into the supraglottic space (correspondent to the original PAS score of 1, 2, and 4)
B	Presence of material in the laryngeal vestibule after the swallow, extending to the true vocal folds level, but not below (correspondent to the original PAS score of 3, 5, and 6)
C	Failure of protection mechanisms in the presence of some recurrent laryngeal nerve sensory integrity (correspondent to the original PAS score of 7)
D	Impairment of effective cough responses to aspiration and sensory stimulations (correspondent to the original PAS score of 8)

Note: [a]Adapted with permission from Steele CM, Grace-Martin K. Reflections on clinical and statistical use of the penetration-aspiration scale. *Dysphagia*. 2017;32(5):601–616. (http://creativecommons.org/licenses/by/4.0/).[73]

Patients were screened with the DYMUS, and those who were at risk for dysphagia underwent bedside clinical examination as well as FEES. The DOSS was applied to assess swallowing of liquids and solid and to rate the occurrence of airway invasion. The results showed that the DOSS was able to demonstrate improvement after treatment.[74] The DOSS needs to be evaluated in target population of MS enrolling sufficient sample of subjects to provide adequate power for reliability and validation.

Conclusion

The strategies for diagnosis and assessment of dysphagia-related symptoms have been reviewed and categorized into major groups of screening strategies, clinical examination strategy, and instrumental strategy. The psychometric evidence about the available dysphagia diagnosis and assessment strategies in patients with MS is lacking. Among screening and clinical examination strategies, the DYMUS questionnaire and the MASA test have been incompletely evaluated for psychometric properties in patients with MS. The limitations in the present evidence for screening and assessment strategies in patients with MS emphasize the development of new MS-specific tools and psychometric investigations on the reliability and validity of available strategies with methodological quality to improve the strategies for evaluation of different aspects of dysphagia in patients with MS.

Disclosure

The authors report no conflicts of interest in this work.

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