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Clinical Focus

Frontline Interventions: Considerations for Modifying Fluids and Foods for Management of Feeding and Swallowing Disorders Across the Life Span

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Purpose: Individuals with dysphagia across the age continuum may require dietary modifications of fluids and foods for safe and adequate oral intake. Considerations of this frontline intervention are presented in this clinical forum dedicated to the discussion of dysphagia.
Method: This clinical focus article reviews the technical challenges of providing modified fluids and foods across the life span as well as the literature specific to its origins, efficacy, challenges and solutions to standardization, and the methods for ensuring quality service delivery.
Conclusion: Dietary modification is an often-used method of dysphagia management that presents unique challenges to the clinician for successful application. Speech-language pathologists in clinical practice across all settings must remain dedicated to evidence-based practice as they navigate service delivery of this strategy to individuals with dysphagia across the life span.

Swallowing disorders (dysphagia) impact individuals across the life span with varying prevalence depending upon the precipitating medical condition (Bhattacharyya, 2015; Hutcheson et al., 2019; Peladic et al., 2019; Rofes et al., 2018; Senior, et al., 2019). Dysphagia is a growing, global health problem that requires evidence-based diagnostic and treatment methods. Prevention of dehydration, malnutrition, and pneumonitis (lung irritation) are targets of effective intervention. Pneumonia (lung infection) secondary to aspiration is a major threat, as it may often be a precursor to serious respiratory compromise and even death if not addressed in a timely, effective, and direct manner. While medications, such as antibiotics, may remedy pneumonia, it will most likely recur if the anatomic or biophysical sources of the dysphagia are not addressed.

Thin liquids, such as water, formula, breast milk, and even one's own saliva, are some of the most difficult consistencies for individuals with dysphagia across the life span to swallow safely (Dodrill & Gosa, 2015; Garcia & Chambers, 2010). A major target of dysphagia management is elimination of aspiration of liquids. Use of thickened liquids (by adding a thickening agent to thin liquid or using a naturally thick liquid) is a common management strategy for individuals with dysphagia who aspirate thinner liquids (Cichero & Lam, 2014; Hadde et al., 2019). Making the liquid thicker slows the rate of liquid flow through the mouth and pharynx. This may allow time for sufficient airway closure and/or prevent airway penetration (Dodrill & Gosa, 2015), and eliminate aspiration in many people. Other reported benefits of thickening liquids include increasing the sensory properties of the bolus, thereby increasing awareness of the bolus and affecting the timing of the pharyngeal sequence in relation to respiration to facilitate airway protection (Cichero & Lam, 2014; Gosa et al., 2011; Newman et al., 2016).

In the case of beverages, eliminating aspiration while quenching thirst, hydrating, and providing adequate nourishment are intervention targets for which methods will be discussed herein. While liquids are the most common

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consistency for aspiration, higher textured foods can also pose a risk for aspiration and must be addressed for individuals with dysphagia. In the case of more solid foods, methods for interventions targeting elimination of aspiration while maintaining appealing taste and texture in the context of adequate nourishment and a comfort feeling of satiation will be discussed.

Methods for Intervention

Methods of intervention for dysphagia are traditionally categorized into two major groups: (a) compensatory or (b) rehabilitative. Compensatory interventions are those that can be done to or for the individual with dysphagia with minimal, if any, effort exerted by the individual and are often provided by a caregiver. Compensatory methods must usually be performed repeatedly during every single swallow. Such strategies include adapting the manner in which foods or fluids are delivered to the oropharynx, minimizing the amount or size of a bolus to sip, bite, or chew; slowing the rate of the intake; and positioning the head and neck to biomechanically improve the bolus flow. Rehabilitative strategies are designed to improve the physiology of the swallow sequence to permanently improve swallow function. Such strategies include exercises to improve the strength and/or coordination of the swallow. These types of strategies require the individual with dysphagia to commit to a rigorous rehabilitation plan that is designed with appropriate frequency and intensity of exercises and strategies in mind to positively affect the swallow sequence in a permanent fashion.

Compensatory and rehabilitative methods each have advantages. Compensatory strategies minimize the need for individuals with dysphagia to have intact cognitive skill or memory, as most often they are facilitated by a care provider. Also, compensatory strategies often elicit an immediately improved response and, therefore, can provide a frontline "quick fix," such as providing a beverage of thicker consistency for airway protection (once verified, of course, with diagnostic tools) to an individual with dysphagia who aspirates a thinner fluid. An example of this in the adult population is the acute stroke patient who aspirates thin liquid but has a positive prognosis for rapid spontaneous recovery of oropharyngeal and laryngeal function. Compensatory interventions may be useful to keep this individual "safe" during a recovery period, while they are building sufficient intraoral strength or range of motion through performing repeated rehabilitative interventions. Rehabilitative interventions are most effective for individuals who have the cognitive skills and memory to retain instructions and endurance to practice repeatedly, usually on a strict schedule over time.

Other compensatory strategies focus on the food or liquid itself. For example, enhancing the taste or temperature to evoke or magnify sensory stimulation may improve aspects of the swallow response. Providing foods that comprise a single and cohesive texture may be more safely swallowed compared to multiple textures consumed simultaneously. The clinical dietetic community has long focused on the rheologic parameter of viscosity (an expression of internal friction measured in centipoise) almost solely, as applied to thinner and thicker liquids the levels of which they referred to as "thin," "nectar," and "honey thick." Viscosity and other relevant rheological parameters have become an important focus, which will be addressed more specifically later in this clinical focus article.

Rehabilitative methods of intervention are more demanding of the individual with dysphagia as compared to compensatory strategies. Interventions are performed by the individual with swallowing impairment and should directly and permanently improve swallow function over time. A major subcategory of rehabilitative interventions is exercise. Methods may include strengthening or improving range of motion or speed. Devices, instrumentation, and feedback may enhance this category of intervention. Generally, active (as opposed to passive) rehabilitative strategies require self-initiated practice and repetition. An advantage of successful outcomes of rehabilitative methods is that the exercise carries over to the anatomy and physiology, so that swallowing (eating and drinking) can be executed more naturally and effectively (e.g., stronger over a sequence of swallows) and may carry over to improve health status. A standardized lingual strengthening program (Swallow Strong) has been shown to even reduce pneumonia diagnoses, number of hospital admissions, and bed days (number of days in hospital). The Swallow Strong program incorporated an 8-week isometric progressive resistance oropharyngeal therapy regimen facilitated by use of the Madison Oral Strengthening Therapeutic device with regular follow-up by a registered dietitian and infectious disease nurse practitioner (Rogus-Pulia et al., 2016). All interventions, whether rehabilitative or compensatory, should be tested and confirmed as effective during instrumental evaluation, such as the videofluoroscopic swallow study (VFSS) or fiberoptic endoscopic evaluation of swallowing.

VFSS

The VFSS, also known as the modified barium swallow, is a radiographic procedure designed to define the anatomy and physiology of the patient's oropharyngeal swallow, and examine the effectiveness of selected strategies in eliminating aspiration or excess oral or pharyngeal residue. VFSS utilizes a lateral view of the patient sitting in an upright position. Anterior–posterior views are also obtained and provide additional important information. In the adult population, the patient is presented with varying volumes of liquids containing barium liquid (1, 3, 5, and 10 ml, cup drinking). Each volume is tested at least twice. In infants, barium liquid is offered via bottle, and swallow samples are viewed at various stages throughout the feed (this is often referred to as "fatigue testing"). If the patient presents with swallowing difficulty, compensatory strategies can be implemented, and the patient can be retested. After a complete VFSS, the speech-language pathologist (SLP) should have a clear and complete understanding of

the patient's swallowing physiology. This knowledge facilitates effective treatment planning for rehabilitating safe swallowing function (Kahrilas et al., 1997; Logemann, 1997).

VFSS is considered the assessment instrument of choice by many professionals due to its ability to visualize the bolus as it moves throughout the upper digestive tract in real time (Martin-Harris & Jones, 2008). During VFSS, various bolus volumes and textures are presented to the patient suspected of having dysphagia. Prior to the creation of the standardized Modified Barium Swallow Impairment Profile (MBSImP) protocol for VFSS in 2007, there were no set guidelines for consistent, reliable presentation of volumes and textures. Food and liquid variables that contribute to the accurate description of swallowing impairment were identified through the creation and validation of the MBSImP and include differing volumes of thin liquid (starting with smaller volumes from a spoon and increasing volume to allow for cup and straw drinking), nectar-thick liquid, honey-thick liquid, pudding, and cookie (Martin-Harris et al., 2008). Thicker liquids are known to reduce the risk of penetration–aspiration by slowing the flow of the bolus through the mouth and pharynx, but often increase the risk of postswallow residue (Cichero et al., 2017). Liquid barium was frequently utilized in VFSS prior to MBSImP, but in different concentrations and unknown viscosities due to the addition of gums or starches to reduce foaming or suspension with no known standards.

Standardization of Liquid Consistencies

Treatment choices in the subcategories of fluids and foods must have a reliable and meaningful relationship to the diagnostic materials utilized in order to be effective. A grant funded by the National Institutes of Health in the 1990s, entitled "Protocol 201—Randomized Study of Two Interventions for Liquid Application: Short and Long Term Effect," was the largest National Institutes of Health–funded clinical trial focusing on oropharyngeal swallowing and resulted in standardized radiopaque diagnostic imaging materials in the United States (E-Z-EM, now Bracco Diagnostic Imaging). These materials known as Varibar (E-Z-EM Canada, Bracco Diagnostics Inc., https://www.varibar.com), simulating thin, nectar- and honey-thick beverage viscosities became, and continue to be, the standard of practice in the United States (U.S. Patent Number 6461589, Standardized Compositions Which Facilitate Swallowing in Dysphagic Patients, Robbins, Sole Inventor, licensed through Wisconsin Alumni Research Foundation by E-Z-EM, Inc.). The standardized radiopaque materials (Varibar; E-Z-EM Canada, Bracco Diagnostics Inc., https://www.varibar.com) are believed to provide improved accuracy and objective measurement of swallowing physiology, biomechanics, and bolus flow through the upper aerodigestive tract (Martin-Harris et al., 2008).

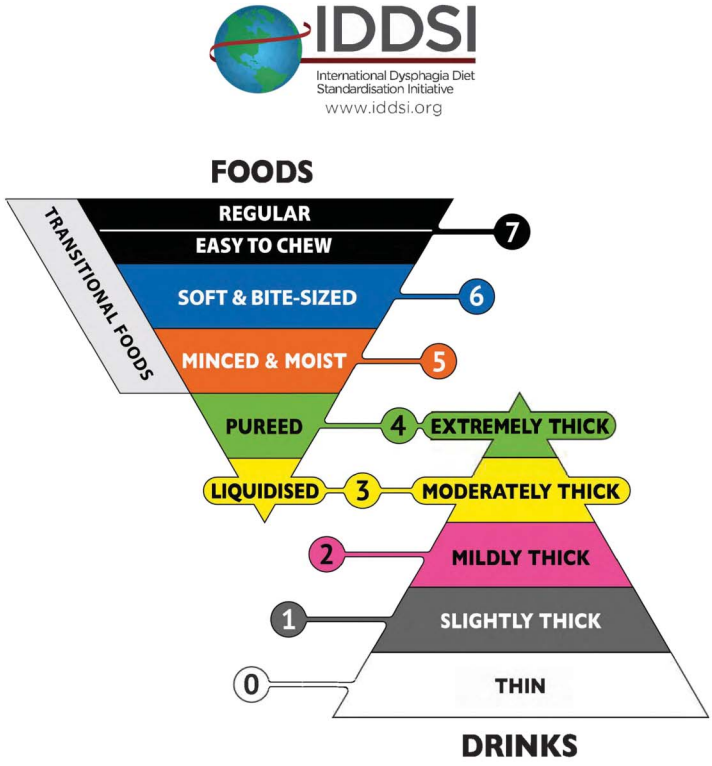
During the following decade, in an effort to achieve the necessary dietary "match" between diagnostic materials and beverages, a grant was funded by the United States Department of Agriculture (USDA), entitled "Development of Biophysically-Based Fluids for Swallowing Disorders" (USDA/National Institute of Food and Agriculture (NIFA) 2009-55503-05206, Hartel, Robbins, Vickers). This work facilitated the study of numerous hydrocolloids, defining important rheological properties beyond viscosity and how they interact with swallowing physiology, safety, and sensory appeal of beverages. Parameters such as flow, yield stress, and shear rate were examined, among others (Vickers et al., 2015). Additionally, given the recurring finding and frequency of the condition known as sarcopenia, particularly in older adults, the addition of specific nutrients, in this case protein, is evident in select beverages for enhancement of muscle mass and strength (Buehring et al., 2013). Adding protein to rheologically optimized beverages for taste and evidence-based safe swallowing is relatively recent and unique (Swallow Solutions, LLC).

Creation of the International Dysphagia Diet Standardization Initiative

The International Dysphagia Diet Standardization Initiative (IDDSI) sought to maximize safety for people with dysphagia through common terminology for patients of all ages, in all settings, of all cultural backgrounds. Although texture modification is one of the most common interventions for dysphagia, the descriptions of thickness levels vary widely throughout the world and even from facility to facility within the same geographical location (Cichero et al., 2017). The first IDDSI meeting was held in 2012 in order to discuss the international standardization of terminology. Two co-chairs lead the group, with 10 other professionals participating, representing 10 different countries. From 2013 to 2016, the IDDSI board established a multidisciplinary guideline development group, involved consumers, clearly identified clinical issues, performed a systematic review and appraisal of literature, developed a process for drafting the recommendation of the multidisciplinary guide development group, and provided consultation beyond the multidisciplinary guide development group. Ultimately, their work culminated in the IDDSI framework (see Figure 1; Cichero et al., 2017).

The IDDSI framework introduced the syringe flow test to measure liquid thickness. The syringe flow test uses gravity-assisted flow of a liquid through a 10-ml slip tip hypodermic syringe to measure its thickness and assign it to a thickness category on the IDDSI framework (see Figure 1). To measure using the flow test, a finger is placed at the syringe nozzle and 10 ml of the target liquid is added into the empty syringe. The finger is removed from the nozzle for 10 s to allow the liquid to flow due to gravity. The finger is placed back on the nozzle after 10 s, and the remaining liquid in the syringe is measured. The amount of liquid left in the syringe correlates with a level of liquid thickness. The IDDSI framework proposes the flow test be used to test the thickness of liquids at the time of consumption to ensure safe swallowing for patients with dysphagia. The length of the syringe is critical to accurate measurement.

Figure 1. The International Dysphagia Diet Standardization Initiative 2016 @ https://iddsi.org/framework. Licensed under the Creative Commons Attribution-ShareAlike International 4.0 License https://creativecommons.org/licenses/by-sa/4.0/legalcode.



The 10-ml syringe should be 61.5 mm from the 0- to 10-ml markings. Suggested brands and models of 10-ml syringe from the IDDSI framework include BD 303134 slip tip and BD 30299 leur lock (Initiative, 2016). In order to calibrate the 10-ml syringe being used, a 10-ml bolus of water may be used. The correctly sized syringe should allow for gravity flow of the water bolus in 7 s (Initiative, 2016).

For assessing foods that are captured by IDDSI Levels 5–7, the fork pressure test was developed. For this test, apply a fork to the food sample by placing the thumb just below the prongs of the fork and pressing just hard enough to cause blanching of the thumbnail. This benchmark allows the tester to know when sufficient pressure is applied. This pressure is quantified as approximated 17 kPa. For Level 6, a food should yield with the recommended pressure and not return to its original shape when released. Transitional foods can also be tested using the fork pressure test, after being soaked in 1 ml of water for 1 min. The sample is transitional if it yields and disintegrates, no longer holding its shape (Initiative, 2016). The spoon tilt test is recommended to assess cohesiveness and adhesiveness of foods. The sample should hold its shape on the spoon and fall easily from the spoon when tilted sideways. There should be little residue left on the spoon. This test helps to differentiate boluses that are moist and cohesive from those that are sticky and/or adhesive. Sticky and/or adhesive boluses would leave excessive residue on the spoon in contrast (Initiative, 2016).

Clinical Preparation of Foods and Liquids to Match VFSS Test Items

As previously discussed, the VFSS requires the use of contrast media, such as barium and low-osmolar iodinated agents, for the documentation of swallowing physiology and the usefulness of the interventions trialed during the study. Authors and clinicians have raised concerns regarding the use of contrast media during VFSS, due to significant variance in preparation and off-label barium uses (Steele et al., 2013).

The standardized barium line, Varibar (EZ-EM Canada, Bracco Diagnostics Inc., https://www.varibar.com), is not approved for clinical use outside of the United States. Additionally, while it has become the standard of practice in the United States, it is not mandated for use at hospitals performing VFSS in the United States, and therefore, some hospital systems in the United States do not use it for VFSS within their facility. As a result, many SLPs in the United States and in other countries prepare barium viscosities using off-label recipes. Clinicians are encouraged to test their off-label barium viscosities using the IDDSI framework to determine the category of thickness prior to administering them during the VFSS. An extensive summary of the considerations for off-label barium product use can be found in Popa Nita et al. (2013) and Steele et al. (2013). In general, when preparing barium products off label, it should be noted that the concentration or density of the suspension varies based on the type of examination the barium was designed to facilitate. As an example, single contrast barium enemas require low-density suspensions of only 15%–20% weight/volume suspensions. For imaging of the oropharynx, as required for VFSS, low-density concentrations are recommended of 20%–40% weight/volume. When preparing barium stimuli in an off-label fashion, the recommendation is for the use of water as the liquid to which the barium stimuli is added. This recommendation is made based on the knowledge that many barium products include nonbarium ingredients, inclusive of gums or starches, that may interact with thickening agents in prethickened liquids, or with macronutrients, such as proteins found in other liquids such as milk or nutritional supplements (Steele et al., 2013).

In terms of infant VFSS barium preparations, there have been varied and mixed results in terms of how barium preparations relate to breast milk and formula reported in the literature (Cichero et al., 2011; Frazier et al., 2016; Gosa & Dodrill, 2017; Stuart & Motz, 2009). Clinicians should be aware of the type of infant fluid (formula, expressed breast milk, or water) and the type of barium being compared when reviewing the results of various studies. A summary of relevant findings from studies examining the relationship of barium products as compared to infant fluids is available in Table 1.

From this published literature, it is clear that there are many factors that can influence the thickness of infant formulas. Clinicians are encouraged to use available testing methods to ensure that the prescribed formulas match the barium test consistencies from the VFSS.

Pediatric Considerations in Dysphagia Management

Dysphagia in children, as in adults, can result in a number of adverse consequences for those affected (see Table 2). Management of dysphagia in the pediatric population may involve empiric trials of therapeutic/rehabilitative strategies and/or use of compensations. It should be noted, however, many of the rehabilitative strategies used with adults with swallowing impairment may not be possible with young children, as young children do not have the cognitive skills to understand or follow detailed instructions, or the self-awareness to voluntarily control movement of anatomic structures. Some therapeutic strategies may be possible with positioning changes or modeling (e.g., chin tuck, head turn), but in reality, these may be difficult to implement in this population. Children, for the most part, do not have volitional control over their diet or mealtime environments and therefore depend on their caregivers to implement the recommended compensations and strategies to improve the safety and efficiency of their oral intake. Hence, clinical management in children generally focuses on the usefulness of therapeutic compensations (see Figure 2).

Use of Modified Liquids in Pediatric Populations

The use of thickened liquids is routinely recommended by health professions for two main pediatric populations: (a) children with dysphagia and primary aspiration risk, and (b) infants who display gastroesophageal reflux and possible secondary aspiration risk. As discussed, the rationale behind thickening liquids for patients with dysphagia is to slow the rate of fluid flow through the oropharynx and reduce primary aspiration during swallowing. Children suspected of dysphagia should be assessed by a qualified clinician (e.g., SLP), who will perform a clinical feeding evaluation with imaging study as needed. If a child demonstrates that he or she is not able to swallow regular (thin) liquids safely following trials of all available compensatory strategies, then alternative means of hydration must be provided. The effectiveness of thickened liquids in preventing primary aspiration can be evaluated objectively during imaging (e.g., VFSS). Depending on the severity of their dysphagia, children may require fluids to be thickened to different degrees to be able to swallow safely, without primary aspiration. Some children may not be able to swallow any consistencies of fluids safely and, therefore, require all fluids to be given via tube feeding (Dodrill & Gosa, 2015; Gosa et al., 2011).

Infants suspected of demonstrating reflux of feeds should see a primary care provider (e.g., pediatrician) as a first step and may require referral to a gastroenterologist if concerns regarding gastric acid reflux disease exist. In some cases, infants who reflux feeds will be commenced on thickened bottle feeds as part of their medical treatment (Rosen et al., 2018). The rationale for providing thickened feeds is that thickened liquids may be less likely to be refluxed from the stomach back into the esophagus and/or airway (i.e., secondary aspiration). The effectiveness of thickened bottle feeds in reducing reflux is usually rated subjectively by parental report of reduction of reflux symptoms (i.e., less emesis, less irritability), but can be measured objectively with instrumental assessment (e.g., pH probe; Gosa et al., 2011; Rosen et al., 2018).

As discussed, it is important that clinicians test the thickness of the liquids prescribed (and test liquids used in imaging studies) to ascertain whether they meet the desired thickness level. Tests will need to be repeated if the

Table 1. Summary of infant barium considerations.

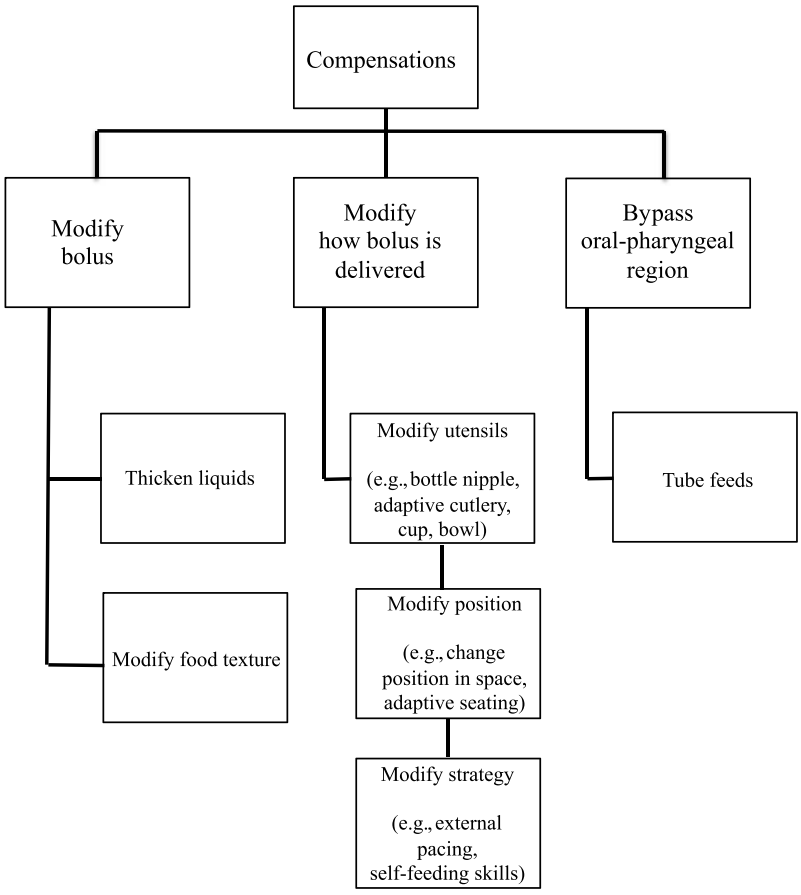
Citation	Infant formula(s)	Barium product used	Conclusion
Stuart & Motz (2009)	Enfamil Lipil with Iron, 20 calories/oz Enfamil Lipil with Iron, 20 calories/oz thickened to nectar consistency with either rice/oat cereal, pulverized rice/oat cereal, and SimplyThick	Thin barium, Lafayette Tonopaque powdered barium at 40% weight/volume or 60% weight/volume Nectar-thick, Varibar (EZ-EM Canada, Bracco Diagnostics Inc., https://www.varibar.com)	Thin and thick barium mixtures were significantly thicker than corresponding thin and thick formulas as measured by a Brookfield Engineering LVDV II +Pro Cone/Plate Viscometer at spindle and speed combinations.
Cichero et al. (2011)	Karicare, Karicare Soy, Karicare Anti-Regurgitation, Karicare Soy mixed with Karicare Food Thickener (maize starch)	Liquid Polibar at 100% weight/volume mixed with the infant formulas	Significant differences in all rheological and material property parameters among the barium-impregnated liquids and the thickened and unthickened infant formula as measured by an Advanced Rheometric Expansion System strain-controlled rheometer associated with fluid shifts, electrolyte imbalances.
Frazier et al. (2016)	Similac 20 calories/oz, Enfamil 20 calories/oz, Similac Sensitive, Enfamil Added Rice, and breast milk (from two different donors)	Liquid E-Z Paque Barium (Bracco) and E-Z Paque Barium Powder (Bracco) prepared to 60% weight/volume suspension and diluted to 20% weight/volume suspension	Standard infant formulas and the breast milk samples met the lower end of the National Dysphagia Diet's (NDD) range for thin liquids, and the two specialty formulas were much thicker and were closer to the lower boundary of the NDD nectar-thick liquid range; E-Z Paque Barium Powder (Bracco) had a lower viscosity as compared to the Liquid E-Z Paque Barium (Bracco) despite identical barium concentration; Liquid EZ Paque Powdered Barium (Bracco) mixed to a 20% weight/volume concentration resulted in viscosity at the lower end of the NDD thin range, all measured by a TA-Instruments AR2000 Advanced Rheometer.
Gosa & Dodrill (2017)	Good Start (Nestle) and Good Start (Nestle) mixed with single grain rice cereal (Gerber), modified cornstarch thickener, and gum-based thickener mixed to nectar and honey consistencies	Varibar (Bracco) thin liquid barium (< 15 cP), nectar-thick liquid barium (150–450 cP), and honey-thick liquid barium (800–1,800 cP)	Thin liquid barium was equivalent to standard infant formula; formula mixed with rice cereal was equivalent to the barium nectar consistency, and formula mixed with the gum-based thickening agent was equivalent to the barium honey consistency; all other formula and thickening combinations were significantly different than the comparative barium test consistencies as measured by the clinical line spread test.

Table 2. Possible sequelae of pediatric dysphagia.

Dysphagia characteristic	Associated consequence
Inefficient and/or insufficient oral intake	Dehydration, malnutrition Prolonged mealtime duration Weight loss, growth faltering
Impaired swallowing and airway protection	Cough, gag (reflexes to assist airway protection) Choke (upper airway obstruction) Aspiration (bolus enters lower airway), pneumonitis (lung irritation), pneumonia (lung infection), atelectasis (partial lung collapse)
Other adverse cardiorespiratory events that may occur due to impaired swallowing/airway protection	Interruptions to breathing pattern during oral feeds (apnea/bradycardia/SpO_2 desaturation) Increased work of breathing during oral feeds (tachypnea, wide rib excursions, head bobbing) Increased supplemental O_2 requirement with or without need for positive airway pressure supports such as high-flow nasal cannula, continuous positive airway pressure, and positive pressure ventilation after commencing oral feeds

manufacturers change their products in any way. If thickened liquids are too thin, they may not assist in managing the underlying problem (i.e., primary aspiration during swallowing or reflux with or without secondary aspiration). Conversely, if thickened liquids are too thick, they may cause additional problems (e.g., reduced intake resulting from fatigue, leading to dehydration/malnutrition and poor growth and/or reduced pharyngeal clearance due to insufficient pharyngeal contractile force to clear very thick liquids). Clinicians need to be aware that different types of fluid (water, breast milk, formula, etc.) can react differently with the same thickening agent and that different types of thickening agents may react differently with the same fluid. Additionally, there are nutritional implications for adding some thickening agents, such as rice cereal or oatmeal, as these thickening agents also add additional

Figure 2. Common compensation strategies.



calories to each feeding (Gosa & Dodrill, 2017). Thus, the decision to thicken liquids must be made with input from the child's entire medical team. In their role in dysphagia management, SLPs need to ascertain that the recipe being used produces the correct thickness. The goal is to avoid giving the child liquids that are more or less viscous than those identified as needed during assessment. In addition, caregivers should be educated to recognize clinical signs of fatigue and aspiration demonstrated during feeding (e.g., cough, wet vocalizations, work of breathing), as these signs may indicate the need to adjust fluid thickness.

In recent years, some formulas have become available that are prethickened (thickening agents are added to the formula before packaging). These are generally marketed as AR for "added rice," "antiregurgitation," or "antireflux." Traditionally, to achieve a thickened formula product, a thickening agent must be hand-mixed with the liquid to obtain the required thickness. For the purposes of preventing regurgitation, formulas are usually thickened to a mildly thick (previously known as nectar-thick consistency) or slightly thick (previously known as a half nectar-thick consistency).

Clinicians need to be aware that some thickening agents may contain allergens and take particular care if a child has an allergy or intolerance to corn, wheat, or gluten (as these are common ingredients in thickening agents), or if the child has eosinophilic esophagitis (these children often need to remove all grains from their diet; see Table 3). Clinicians also need to be aware that most suppliers of thickening agents do not recommend the use of their products with infants prior to term age (i.e., preterm neonates), or if the child has been diagnosed with certain gut complications. This is because some thickening agents may not be digested by the premature or damaged gut and may possibly cause serious gut complications (Beal et al., 2012). To be cautious, some facilities do not allow certain thickening agents to be used with infants aged less than 12 months, and some manufacturing companies do not recommend their thickening product be used with any children younger than 3 years of age.

Given some of the potential issues regarding the use of thickened liquids (summarized in Table 3), many therapists and families are eager to try other compensation approaches to avoid or reduce the need to thicken fluids for children with swallowing impairments (see Figure 2). These approaches include use of therapeutic feeding equipment, therapeutic positioning, and therapeutic strategies, such as external pacing (see Figure 2). The goal of all of these compensation strategies is to slow the bolus flow during swallowing and/or to interrupt the feeding process intermittently to allow the child to regain physiologic stability (Dodrill & Gosa, 2015).

Table 3. Factors to consider when thickening liquids in pediatric populations.

Factors
Safety of thickening agents (e.g., potential for necrotizing enterocolitis in newborns, allergy risk)
Impact of thickening on equipment use (e.g., bottle nipple size)
Impact of thickening on overall nutritional intake (e.g., increased caloric intake with use of rice cereal and oatmeal)
Impact on thickening feeding efficiency • Infants rely on fluids for both hydration and nutrition • Infants have high needs relative to size (more ml/kg/day fluid requirement than adults, more kcal/kg/day energy needs than adults)

Use of Modified Foods in Pediatric Populations

For neonates and young infants to feed competently (safely and efficiently), they need to display functional suckling/sucking and swallowing skills and the ability to coordinate suckling/sucking, swallowing, and breathing together. Later in their feeding development, children also need to learn to competently chew and bite so that they can safely consume solid foods. Increasing levels of oral motor skill are required to progress from breastfeeding and bottle feeding on to pureed foods that are taken from a spoon beginning at approximately six months of age, then on to mashed and soft solid pieces that can be broken with the tongue, and later soft- and hard-mechanical food textures that require biting and chewing (Dodrill, 2014). Continued development of oral motor skills is also required to move from drinking from the breast or bottle to drinking via a spout or straw cup and then an open cup. Infants generally begin transitioning to solid foods at the same time that they begin to be able to sit in an upright position and bring their hands to their mouth. Appropriate positioning and caregiver selection of developmentally appropriate foods (textures and bolus sizes) maximizes the child's ability to eat efficiently and safely (see Table 4).

By 2–3 years of age, most children have the oral motor skills to eat most solid foods. However, developmental delay and neurologic impairment may be reflected in impaired oral motor skills, requiring modification of food textures. Depending on the degree of impairment or delay, different levels of food modification and/or nonoral supplementation may be required (see Figure 3).

Additional precautions regarding swallowing safety exist for children regardless of their oral skills. These concerns exist because of developing motor skills (e.g., self-feeding skills, coordination when walking and running) and developing cognitive ability (e.g., visual perception, attention, risk assessment) in children (Dodrill & Gosa,

Table 4. Use of modified foods in children.

Considerations of modified foods
Infants start off with thin purees (most modified) and move upward with oral motor and general development.
Feeding dysfunction involves requiring more modification (special preparation, special utensils/seating/strategies) relative to peers (Goday et al., 2019).
Clinicians need to consider both swallow safety and feeding efficiency when recommending modified diets (inefficient and/or insufficient intake = feeding dysfunction; Goday et al., 2019).

Figure 3. Functional Oral Intake Scale (Dodrill, 2015).

1	Nothing by mouth	NPO, all PG
2	Tube dependent, with minimal attempts at liquids/ *foods*	PG + PO trials
3	Tube dependent, with consistent intake of liquids/ *foods*	PO + PG top-ups
4	Total oral diet, but requiring special preparation of liquids (i.e., thickened liquids) ± compensations (e.g., special feeding equipment, feeder uses special strategies)	PO with compensations
4.5	*Total oral diet, but requiring special preparation of solids (e.g., foods of different texture to peers and/or liquid supplements)* ± *compensations* (e.g., special feeding equipment, feeder uses special strategies)	
5	Total oral diet, without special preparation (i.e., regular thin fluids, *foods of same texture as peers, no additional liquid supplements*), but with compensations (e.g., special feeding equipment, feeder uses special strategies)	
6	Total oral diet, with no restrictions	PO

Note: Items in italics only related to children old enough to have solids in their diet (generally 6 months +). PO = *per os*, by mouth; NPO = *nil per os*, nothing by mouth; PG = *per gavage*, by tube.

2015). Furthermore, children have smaller airways, which, in addition to the factors mentioned previously, predispose them to choking risk. Pediatric feeding disorder is defined as impaired oral intake that is not age appropriate, and is associated with medical, nutritional, feeding skill, and/or psychosocial dysfunction (Goday et al., 2019). To be fully functional, a child's feeding skills must be safe, age appropriate, and efficient. Dysfunction in any of these areas constitutes pediatric feeding disorder.

Conclusions

Dysphagia affects millions of people across the life span in the United States. Management may require the use of thickened liquids for at least a percentage of time while the anatomic or biophysical cause of dysphagia is remediated. Clinicians working in this area must be well informed of the challenges to successfully applying this management strategy while ensuring adequate nutrition, hydration, and safety of the patient during feeding. Recent advancements, such as the IDDSI framework, have provided clinically useful tools to assist the SLP in this task. As new types of thickening agents and modified diet products are introduced, the SLP must stay up to date on practice trends and their impact on the populations served in their individual settings.

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