

Swallowing difficulties can have a detrimental effect on dietary intake and, hence, growth and development

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Pediatric Dysphagia: Physiology, Assessment, and Management by Pamela Dodrill and Memorie M. Gosa

Key insights

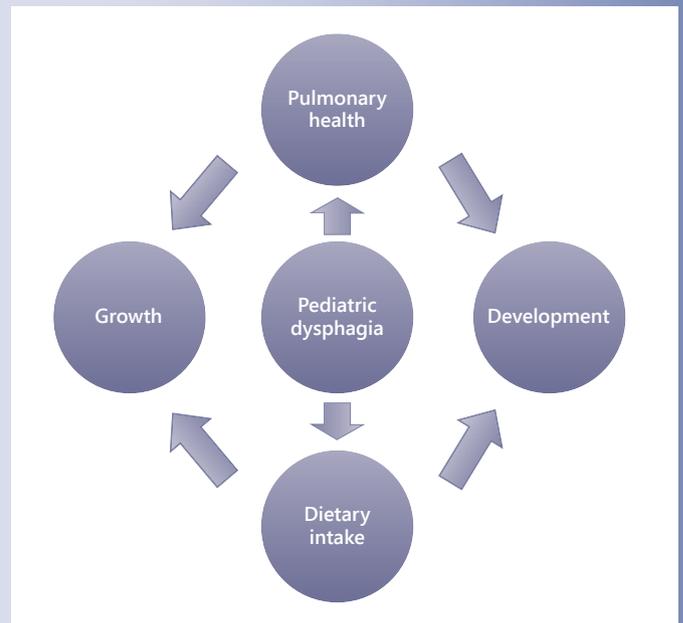
Swallowing difficulties (dysphagia) in pediatric populations can have an adverse impact on pulmonary health. Dysphagia can also affect dietary intake, thereby potentially affecting both growth and development. Dysphagia can arise in many patient populations, including children with acquired brain injury or other neuromuscular disorders, craniofacial or airway malformations, as well as those with respiratory, cardiac, or gastrointestinal disease. Due to the heterogeneity of the pediatric dysphagia population, treatment and management of dysphagia must be tailored to the clinical characteristics of the individual patient.

Current knowledge

Dysphagia is defined as any disruption to the swallow sequence that results in a compromise in the safety, efficiency, or adequacy of nutritional intake. It is important to note that dysphagia is a skill-based disorder distinct from behavioral feeding problems that may arise in children who have sufficient skills for normal eating and drinking. Children with dysphagia can present with multiple variations of swallowing impairments affecting any or all of the phases of swallowing. The causes of dysphagia in pediatric populations are often different from those seen in adult patients.

Practical implications

A thorough assessment is needed in order to establish the cause of the dysphagia and guide the treatment strategy. Therapeutic interventions for children with oral-phase swallowing problems are aimed at improving the sensory and motor skills needed for drinking and eating. For children with swallowing problems affecting the pharyngeal phase, therapy generally involves modifying the child's swallowing strategy or modifying



Accurate diagnosis and effective management of pediatric dysphagia is necessary due to its potential for significant morbidity and possible mortality in pediatric populations.

the food bolus. The return to a normal diet in children with dysphagia requires a gradual, multidisciplinary approach that enables systematic neuromuscular training of the relevant phase of swallowing.

Recommended reading

Dodrill P: Feeding problems and oropharyngeal dysphagia in children. *J Gastroenterol Hepatol Res* 2014;3:1055–1060.

Pediatric Dysphagia: Physiology, Assessment, and Management

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Key Messages

- Swallowing difficulties can have a detrimental effect on pulmonary health and can also impact nutritional intake.
- It is estimated that swallowing difficulties occur in approximately 1% of children in the general population, though the incidence rate is much higher in some clinical populations.
- Common instrumental assessment for children suspected of dysphagia includes videofluoroscopic swallow study and fiberoptic endoscopic evaluation of swallow. Common management strategies include the use of thickened fluids for children with demonstrated aspiration of thin fluids.

Key Words

Swallowing · Dysphagia · Deglutition

Abstract

Infancy and childhood represent a time of unparalleled physical growth and cognitive development. In order for infants and children to reach their linear and neurological growth potential, they must be able to reliably and safely consume sufficient energy and nutrients. Swallowing diffi-

culties (dysphagia) in pediatric populations can have a detrimental effect on dietary intake and, thus, growth and development. As a result, it is imperative to accurately identify and appropriately manage dysphagia in pediatric populations. This article provides an overview of dysphagia in children, as well as common causes of childhood swallowing difficulties, populations at risk for pediatric dysphagia, techniques used to assess swallowing in pediatric patients, and the current treatment options available for infants and children with dysphagia.

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Normal Swallowing

The act of eating or drinking can be broken down into four main phases: (1) oral phase (i.e. suckling or mastication, and the transportation of the bolus towards the pharynx); (2) triggering of the swallowing reflex; (3) pharyngeal phase (i.e. transportation of the bolus through the pharynx), and (4) esophageal phase (i.e. transportation of the bolus through the esophagus to the stomach).

In neonates and young infants, all four components of swallowing are reflexive and involuntary. Later in infancy, the oral phase comes under voluntary control, which is essential to allow children to begin to masticate solid food. Safe and effective mastication (i.e. biting and chewing) relies on appropriate sensory registration of the food source and a coordinated motor response influ-

Table 1. Comparison of the suckling phase with the eating and drinking phase of intake

Suckling phase	Eating and drinking phase
The oral phase is reflexive	The oral phase is volitional
Intake is of a single consistency (fluid)	Intake is of variable consistencies (fluid and solid)
Plane of tongue movement is unidirectional	Plane of tongue movement is multidirectional
Suckling movement is brain stem mediated, using a central pattern generator	Greater cortical input is required to control complex masticatory movement patterns for biting and chewing

Table 2. Common presentations of oral-pharyngeal dysphagia in children

Oral phase	Absent oral reflexes, primitive/neurological oral reflexes, weak suck, uncoordinated suck, immature biting and/or chewing, disordered biting and/or chewing, poor bolus propulsion, poor bolus containment
Triggering of swallow reflex	Absent swallow reflex, delayed triggering of the swallow, suck/swallow/breath incoordination
Pharyngeal phase	Laryngeal penetration, aspiration, choking, pharyngeal residue, nasopharyngeal reflux

enced by cognitive thought processes [1]. See table 1 for a comparison of involuntary with voluntary phases of intake.

In later life, the triggering of the swallow reflex is generally an involuntary activity; though, it can be controlled voluntarily. However, the pharyngeal and esophageal phases of swallowing are involuntary activities. The general sequence of events during the pharyngeal and esophageal phases remains the same throughout a person's life, and these events can be summarized as follows: (a) closure of the nasopharyngeal port through movement of the velum; (b) pharyngeal closure through contraction of the superior, middle, and inferior pharyngeal constrictors; (c) closure of the vocal folds with brief cessation of respiration; (d) hyolaryngeal excursion and closure of the larynx through epiglottic tilt; (e) opening of the upper esophageal sphincter through relaxation of the cricopharyngeus muscle and biomechanical forces contributed

through hyolaryngeal excursion, and (f) peristaltic contraction of the esophagus to move the food or liquid into the stomach. See figure 1 for illustration of a typical infant swallow sequence as viewed through videofluoroscopic imaging.

Abnormal Swallowing

Dysphagia is any disruption to the swallow sequence that results in compromise to the safety, efficiency, or adequacy of nutritional intake. Because swallowing and breathing share a common space in the pharynx, problems in either of these processes, or lack of synchronization between processes, can affect a child's ability to protect their airway during swallowing and ingest fluid and food safely [1]. Research suggests that approximately 1% of children in the general population will experience swallowing difficulties [2], though the incidence rate is much higher in some clinical populations (e.g. children with cerebral palsy, traumatic brain injury, and airway malformations) [3].

It is important at this point in the discussion to distinguish dysphagia as a skill-based disorder, which is very different from a behaviorally based feeding disorder. Behavioral feeding disturbances (or food/fluid aversion) occur when a child is unwilling to consume a fluid/food despite sufficient physical skills to do so. Behavioral feeding disturbances may arise in association with dysphagia. However, often, there is no apparent physical reason for behavioral feeding issues. In these cases, undetected pain (e.g. as associated with tonsillitis, pharyngitis, or teething), aversive experiences in or around the mouth (e.g. tube feeding, suctioning), or sensory disturbances (e.g. oral hypersensitivity) need to be ruled out before a feeding difficulty is attributed to behavior alone. See the paper by Silverman in this issue of the journal for further discussion on the topic of management of behavioral feeding disorders.

Common presentations of pediatric dysphagia symptoms are listed in table 2. As described above, during a normal swallow sequence, the laryngeal vestibule closes, which helps to protect the airway and to ensure that the food or fluid bolus ends up in the gastrointestinal tract and not in the respiratory tract. *Laryngeal penetration* occurs when the bolus enters the laryngeal vestibule (fig. 2a). *Aspiration* occurs when the bolus enters the airway below the level of the vocal folds (fig. 2b). *Choking* occurs when a bolus physically blocks the airway [4]. Choking events can be immediately life-threatening, given that airway obstruction affects the child's ability to breathe.

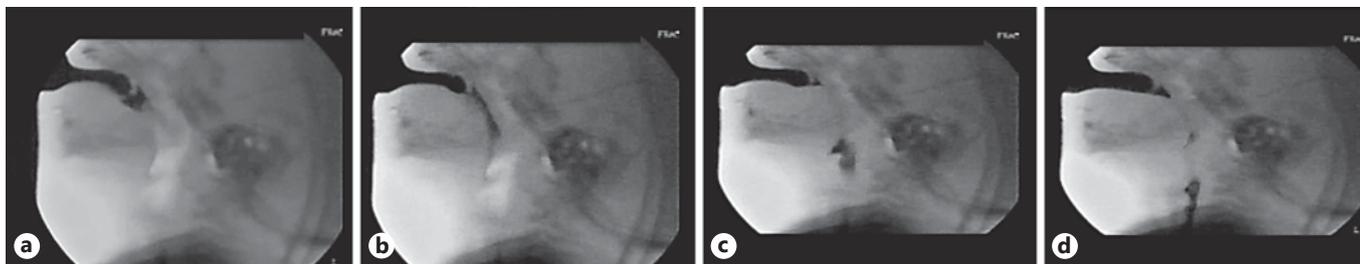


Fig. 1. Typical swallow sequence. **a, b** Oral phase of swallow: includes preparing the bolus for swallow, chewing if necessary, and transferring the bolus from the oral cavity into the pharynx. **c** Pharyngeal phase of swallow: includes the safe transfer of bolus

through the pharynx to the esophagus. **d** Esophageal phase of swallow: includes the peristaltic action of the esophagus to move the bolus into the stomach.

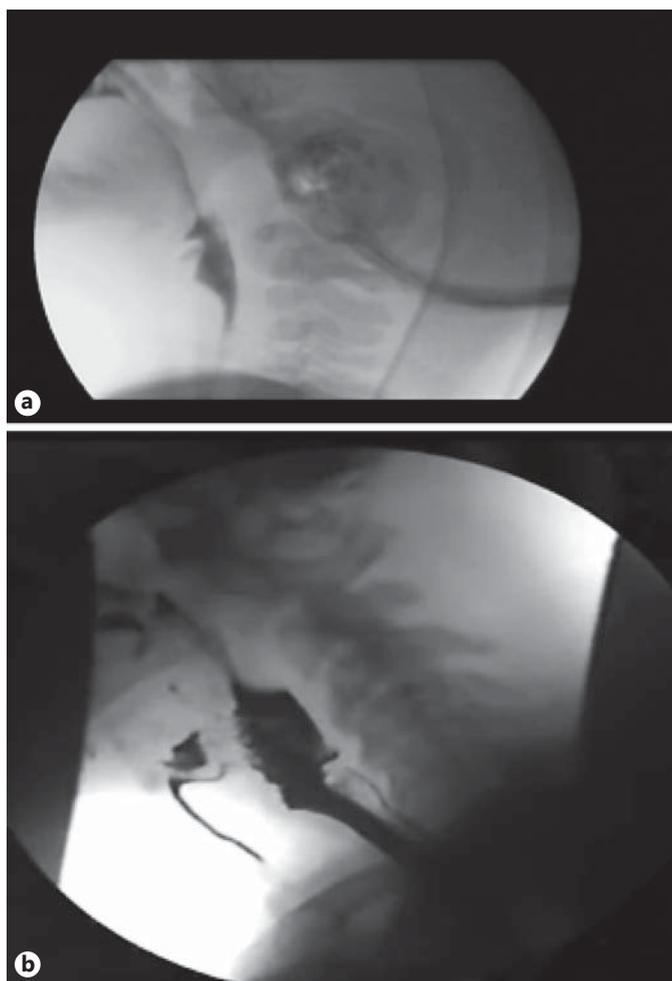


Fig. 2. Illustration of laryngeal penetration and aspiration. **a** Laryngeal penetration: entrance of bolus material into the laryngeal vestibule at any point down to the level of the vocal folds, but it does not go below the vocal folds. **b** Aspiration: entrance of bolus material below the vocal folds into the trachea.

Common Causes of Dysphagia

Children with dysphagia can present with multiple variations of swallowing impairments affecting any or all of the phases of swallowing, similar to adults with dysphagia. However, the causes of dysphagia in pediatric populations are often somewhat different than in adult patients [5]. Table 3 summarizes common causes of dysphagia in pediatric patients [1, 5–13].

Recent literature in the field of pediatric dysphagia has focused largely on a number of specific populations at risk for swallowing difficulties, such as children with cerebral palsy, acquired/traumatic brain injury, other neuromuscular disorders, craniofacial malformations, airway malformations, congenital cardiac disease, gastrointestinal disease, and ingestional injuries, as well as children born preterm.

Dysphagia and Aspiration in Pediatric Populations

Oropharyngeal dysphagia should be considered in the differential diagnosis of any young child who presents with unexplained respiratory complications. In a study of children without known dysphagia risk factors who demonstrated unexplained respiratory problems [14], almost 60% were found to aspirate liquids and, of these, 100% of aspiration events were silent (i.e. no cough). Aspiration frequently occurs when available glottic reflexes fail, and this can compromise the integrity of the respiratory system [15]. A large acute aspiration event, or chronic aspiration of even small volumes of fluid or food, can result in significant respiratory morbidity, and sometimes mortality, in pediatric patients [16]. Tongue strength, hyoid movement, bolus dwell time in the pharynx, respiratory rate, and phase of respiration interrupt-

ed during pharyngeal swallow have all been identified as relevant factors to aspiration risk [17]. The incidence of pneumonia in pediatric populations with dysphagia has been significantly correlated with specific diagnoses, such as trisomy 21, asthma, gastroesophageal reflux disease (GERD), lower respiratory tract infection, and moist cough [18]. Research suggests that pediatric patients with multisystem diagnoses, in addition to dysphagia, appear to be at greatest risk for developing pneumonia [18].

Assessment Techniques

Techniques used for diagnosing and monitoring pediatric dysphagia include clinical evaluation tools and quality of life measures, as well as a range of instrumental evaluation tools. Important clinical issues that need to be considered when performing pediatric dysphagia assessment and making clinical recommendations are included below.

Screening and Clinical Assessment Tools

The Schedule for Oral-Motor Assessment and the Dysphagia Disorder Survey are two of the more commonly used standardized clinical assessment tools for evaluating and describing swallowing abilities in pediatric populations [19, 20]. It should be noted that, while there are a number of formal pediatric feeding and swallowing assessment tools available, most were developed to assist in classifying the feeding skills of children with cerebral palsy and/or other neurodevelopmental disorders. See Benfer et al. [21] for further discussion and comparison of the clinimetrics of various published feeding assessment measures. It should be noted that, in current clinical practice, many clinicians do not routinely use formal assessment tools when assessing children with suspected dysphagia; rather, many clinicians will use informal checklists based on normal swallowing and feeding development to guide their evaluation. Clinical detection of a wet voice, wet breathing, and cough are often associated with thin-fluid aspiration (i.e. water, milk) [22]. Other research has shown that while a '3-oz' (90-ml) water swallow screening has a high sensitivity for detecting thin-fluid aspiration in children, it has poor specificity [23].

Not surprisingly, given the high rates of silent aspiration in the pediatric population [24], there are several studies in the literature which question a clinician's accuracy for predicting airway compromise based on clinical observation alone [25–27]. Thus, regardless of clinical

Table 3. Disorders commonly affecting feeding and swallowing in infants and children

Prematurity
Low gestational age at birth
Low birth weight
Comorbidities associated with prematurity
Respiratory and cardiac disorders
Apnea of the newborn
Pulmonary dysplasia
Respiratory distress syndrome
Bronchopulmonary dysplasia (chronic lung disease)
Laryngo-/tracheo-/bronchomalacia
Cyanotic and acyanotic heart defects
Gastrointestinal disorders
Necrotizing enterocolitis
Hirschsprung's disease
Gastroschisis
Tracheoesophageal fistula and esophageal atresia
Congenital diaphragmatic hernia
GERD
Eosinophilic esophagitis
Food allergies and intolerances
Neurological disorders
Microcephaly
Hydrocephalus
Intraventricular hemorrhage
Periventricular leukomalacia
Birth asphyxia and cerebral palsy
Acquired brain injuries
Seizures
Congenital abnormalities
Tongue tie
Cleft lip/palate
Moebius syndrome
Down syndrome
Maternal and perinatal issues
Jaundice
Diabetes
Fetal alcohol syndrome
Neonatal abstinence syndrome
Iatrogenic complications
Tube feeding
Tracheostomy
Respiratory support
Certain medications (especially those that affect arousal, awareness, muscle tone, or saliva production)
Ingestional (caustic) injuries
Cleaning agents
Battery

signs observed, if a clinician suspects airway compromise during swallowing based on respiratory (or other) symptoms, the patient should be referred for instrumental assessment to confirm the presence of airway compromise and determine aspiration risk.

Instrumental Assessment Used in Pediatric Dysphagia

Videofluoroscopic swallow study (VFSS) and fiberoptic endoscopic evaluation of swallow (FEES) are the most commonly used instrumental assessments in pediatric dysphagia. VFSS allows for the assessment of the swallow in all of the swallowing stages. During this study, the patient is presented with barium-impregnated liquid and food, and videofluoroscopic monitoring is used to document oropharyngeal swallow function and swallowing disturbances [28]. Recent research studies have brought attention to the importance of having test fluids match prescribed fluids in terms of viscosity [29–31]. In addition, current literature suggests utilizing a pulse rate of at least 15 radiographic pulses per second for accurate interpretation of VFSS results [32].

In contrast to the VFSS, the FEES exam does not require intake of barium or radiation exposure, but it does require that a patient tolerate the passing of a nasal endoscope. FEES provides images of the larynx and hypopharynx before and after (but not during) the pharyngeal swallow, which allows the detection of structural and physiological swallowing impairments, as well as an assessment of aspiration risk. FEES is a safe and effective tool for evaluating dysphagia in pediatric populations [33–35] and also allows for evaluation of laryngopharyngeal sensation in children with dysphagia [36, 37].

An agreement on the gold standard for pediatric dysphagia assessment has not been reached in the literature. The overall diagnostic agreement between FEES and VFSS has been reported as low, but agreement on the presence of laryngeal penetration and aspiration between the two exams is high [38]. In general, VFSS and FEES exams can be complimentary, and both provide accurate diagnosis of dysphagia in pediatric populations when applied and interpreted by experienced clinicians [39].

While VFSS and FEES exams are the most commonly utilized exams in pediatric dysphagia practice, other tools have received recent attention for their diagnostic usefulness as adjunct assessments for the diagnosis of dysphagia in pediatric populations. Digital cervical auscultation provides objective acoustic information about the swallowing process that may be able to augment clinical judgment and assist caregiver education in children with dysphagia [40, 41]. Accelerometry has been identified as a possible noninvasive way to distinguish between safe and

unsafe swallows, and it deserves further investigation [42, 43]. Ultrasound is being used in preliminary investigations of infants while they are being breastfed to provide visualization of bolus movement through the pharyngeal area [44] and may possibly be useful in other populations. There have been several recent investigations into the usefulness of manometry and impedance as detectors of swallowing dysfunction [45–51]. These tools provide in-

formation about pharyngeal and esophageal motility, as well as presence of gastroesophageal reflux. Possible advantages that have been identified for these procedures in swallow assessment include the fact that they do not involve radiation and are portable, allowing for bedside assessment and extended

evaluation time [45–51]. However, researchers agree that further study is necessary before the widespread application of these techniques in the diagnosis of pediatric dysphagia [45–51].

Swallowing-Related Quality of Life Measures

Caring for children with feeding and swallowing problems has the potential to adversely impact the health-related quality of life of their caregivers. A recent study described a tool, the FS-IS, which has been validated as an instrument that can identify caregivers who might benefit from additional support [52], with the aim of ultimately improving the care of their children with feeding/swallowing disorders.

Management of Pediatric Swallowing Disorders

In clinical practice, therapy intervention for children with oral-phase swallowing problems generally involves exercises aimed at improving the sensory and/or motor skills required for drinking and eating. For children with swallowing problems affecting the pharyngeal phase, therapy intervention generally involves the child to modify their swallowing strategy or teaching the feeder to modify the bolus. Examples are detailed in table 4.

Interventions Targeting the Oral Phase of Swallowing

Arvedson et al. [53] performed a systematic review of the literature regarding the effect of oral motor exercises (OME) on swallowing in children and concluded that there is insufficient evidence to determine the effects of

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Table 4. Common therapy techniques used with children with dysphagia

Modified fluids	Adding thickening agent to regular fluids; trialing naturally thick fluids
Modified foods	Altering the texture or size of solid foods by boiling, baking, blending, mashing, chopping, etc.; offering naturally easier to eat foods
Special feeding equipment	Offering different bottles and nipples, spoons, cups, etc.
Special feeding strategies	Altering positioning and/or seating equipment; altering pace of delivery (pacing); trialing swallowing maneuvers (e.g. chin tuck) to assist swallow safety

OME on children with dysphagia. Similarly, other authors have cautioned the use of OME as a stand-alone treatment for children with dysphagia [54], given the lack of research support for this practice, and encouraged the use of functional therapy tasks that directly impact on eating and drinking ability and/or safety.

Interventions Targeting the Pharyngeal Phase of Swallowing

Morgan et al. [55] performed a systematic review investigating therapy interventions for dysphagia in children with neurological impairment and concluded that there is currently insufficient evidence regarding the effectiveness of any particular type of swallowing therapy for this population. One recent study evaluated the use of neuro-motor electrical stimulation (NMES) of anterior neck muscles in a heterogeneous group of children with dysphagia [56]. The authors reported that, overall, NMES treatment did not improve the swallow function more than a control intervention. However, the authors suggested that there may be subgroups of children that might experience improvement with NMES treatment and that further research is needed to evaluate this intervention.

A systematic review by Steele et al. [57] investigating the influence of thickening liquids on swallowing physiology and function concluded that thicker liquids reduce the risk of laryngeal penetration and aspiration but also increase the risk of post-swallow residue in the pharynx. Of interest, Weir et al. [58] performed a systematic review questioning the practice of restricting oral intake of water for children with demonstrated aspiration of thin fluids. They concluded that there is currently insufficient evi-

dence to support either a strict approach of full restriction of oral intake of water or a more liberal approach of allowing oral water ingestion.

Significant improvements in both swallow function and sensory testing following GERD treatment have been shown in the literature [59], suggesting that GERD may result in decreased laryngopharyngeal sensitivity, which may contribute to pediatric swallowing dysfunction. Several studies indicate that, although the prognosis for resolution of pediatric dysphagia is often very good, it might take several years [60, 61].

Management of Children with Dysphagia

In cases where dysphagia is apparent in a neurologically intact child, many clinicians advocate that an assessment of the upper airway should be performed to assess for structural malformations [62]. In addition, regardless of the etiology and treatment, it has been suggested that the return to a normal diet in children with dysphagia requires a gradual approach to allow systematic neuromuscular training of the pharyngeal phase of swallowing [62].

Few published studies are available that describe management pathways for children with dysphagia. One recent publication presented a clinical pathway for children with type I laryngeal clefts that factored in age, comorbidity status, severity of aspiration, and the ability to tolerate a feeding regimen [63]. An international survey evaluating service delivery for swallowing problems in children following brain injury reported high variability in practice and suggested that the limited use of referral criteria, care pathways, and guidelines invites the possibility of unequal care and less than optimal outcomes. The authors suggest that further research is required to support the development of both pediatric-specific assessment tools and therapy approaches, as well as clinical protocols and guidelines.

A multidisciplinary approach to diagnosis and management of dysphagia in pediatric populations is well supported [4]. The World Health Organization's International Classification of Functioning, Disability, and Health has been suggested as a standardized method of documenting health and functional status in children with dysphagia [3], which is something that should be considered in assessment and treatment planning.

Conclusion

Like adults, infants and older children can present with swallowing difficulties. Unlike adults, children have rapidly developing body systems and even short-term

problems with swallowing can interrupt normal development and cause serious long-term sequelae. In order for a child to reach their physical and cognitive growth potential, sufficient energy and nutrients must be consumed. Swallowing difficulties can have a detrimental effect on dietary intake and, hence, growth and development.

Populations at particular risk of dysphagia include children with cerebral palsy, acquired/traumatic brain injury, other neuromuscular disorders, craniofacial malformations, airway malformations, and congenital cardiac disease, children born preterm, children with gastrointestinal disease, and children who have had ingestional injuries. Interventions for swallowing difficulties need to be targeted at the cause of the problem in

order to be effective. For this reason, a thorough assessment is required to guide any intervention offered. Once the nature and any possible factors contributing to the swallowing difficulty have been established, the treatment plan can be developed. Common assessment techniques include formal clinical evaluation tools and quality of life measures, as well as a range of instrumental evaluation tools, such as VFSS, FEES, cervical auscultation, accelerometry, ultrasound, manometry, and impedance testing.

Disclosure Statement

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