Chapter 5

Swallowing Disorders in Newborn and Small Children

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Additional information is available at the end of the chapter

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Abstract

This chapter reviews the main aspects of dysphagia in children: epidemiology, etiology, physiopathology, bedside assessment, and instrumental assessment in the perspective of planning treatment. More details will be given on the endoscopic assessment in children of different ages in consideration of the information useful in planning treatment. This chapter offers a review of the literature on the topic and a simple diagram of the main aspects of the management of dysphagia in children. This chapter aims to offer a simple and useful guide for students and professionals working in the field and suggestions for the implementation of clinical steps in daily practice when and where managing children with swallowing disorders is a reality.

Keywords: swallowing, deglutition disorders, children, newborn, feeding

1. Introduction

Swallowing disorders in children is a topic of great interest, from the epidemiological, clinical, rehabilitative, and, not least, cultural perspective. If significant steps forward have been made in recent decades in all aspects of adult swallowing (under normal conditions and for different comorbidities), medical knowledge about aspects of swallowing in childhood (normal, abnormal, and deviant) has not improved at the same speed. This has created a major gap between the more practical aspects of patient care and people requiring specific interventions.

Before proceeding to the discussion of the most typical physiopathological and clinical aspects related with this disorder, a brief epidemiological and etiological framework of the problem is appropriate.

2. Epidemiology

Data about the incidence (new cases) and prevalence (disorder in a given period of time) of swallowing disorders in childhood are not reported separately in the literature. This is mainly due to the heterogeneity of the population studied, in reference to the assumed consistency and the different ways of detection of the disorder. It is estimated that 25–45% of normally developing children can have eating disorders and swallowing problems, and in children with developmental disorders, the prevalence is estimated to be 30–80%. Feeding problems associated with serious sequelae (lack of growth and chronicity) were reported in 10.3% of children with physical disabilities (26–90%), medical conditions, and prematurity (10–49%). This is due to an improvement in survival rates of premature babies with low birth weight and with complex medical conditions [1–3]. **Tables 1** and **2** summarize the main morbid conditions and possible interactions (comorbidities) that are associated with swallowing disorders in children.

	Disease
Neurological	Encephalopathies (cerebral palsy, perinatal anoxia), Traumatic Brain Injury, Neoplasms, Mental delay, Prematurity and developmental delays
Anatomical and structural	Congenital (tracheoesophageal fistula, palatal cleft), Acquired
Genetic	Chromosomal (Down S.), Syndromic (Pierre Robin, Treacher-Collins), Dysmetabolisms
Systemic diseases	Respiratory (chronic lung disease, bronchopulmonary dysplasia), Gastrointestinal (GI dysmobility, constipation), Cardiac
Psychosocial and behavioral	Oral deprivation
Secondary reversible diseases	Iatrogenic

Table 1. Main pathological conditions causing swallowing disorders.

Coexisting diseases
Motor
Sensory and psychic
Perceptual
Praxis
Gnosis
Cognitive
Communicative behavioral

Table 2. Main pathological conditions associated with swallowing disorders.

3. Etiology

From the etiological point of view, only a brief reference to the most common causes of dysphagia in children, including conditions associated with developmental abnormalities, that is, early onset conditions, requiring prolonged or chronic measures of medical, rehabilitation, and/or residential support, is necessary.

These conditions (**Table 1**) are mainly associated with neurological disorders (cerebral palsy, meningitis, encephalopathy, pervasive developmental disorders, traumatic brain injury, and muscle weakness): factors affecting neuromuscular coordination (prematurity and low birth weight), complex diseases (heart disease, lung disease, gastroesophageal reflux disease, and delayed gastric emptying), structural anomalies (cleft lip and/or palate, laryngomalacia, tracheoesophageal fistula, esophageal atresia, cervical-facial abnormalities, and choanal atresia), and genetic syndromes (Pierre Robin, Prader-Willi, Treacher-Collins, and deletion of chromosome 22q11).

To these conditions, the iatrogenic conditions related to the use of drugs (reduced reactivity, hypotonus, and decreased appetite), surgery, or medical measures, which require alternative ways of feeding or assisted breathing, and any other conditions that induce sensory deprivation of orofacial and pharyngeal structures, including a limited availability of food, which may be associated with social, emotional, and environmental problems (e.g., difficulty of parent-child interaction) (**Table 2**) [4], must be added.

4. Physiopathological premises

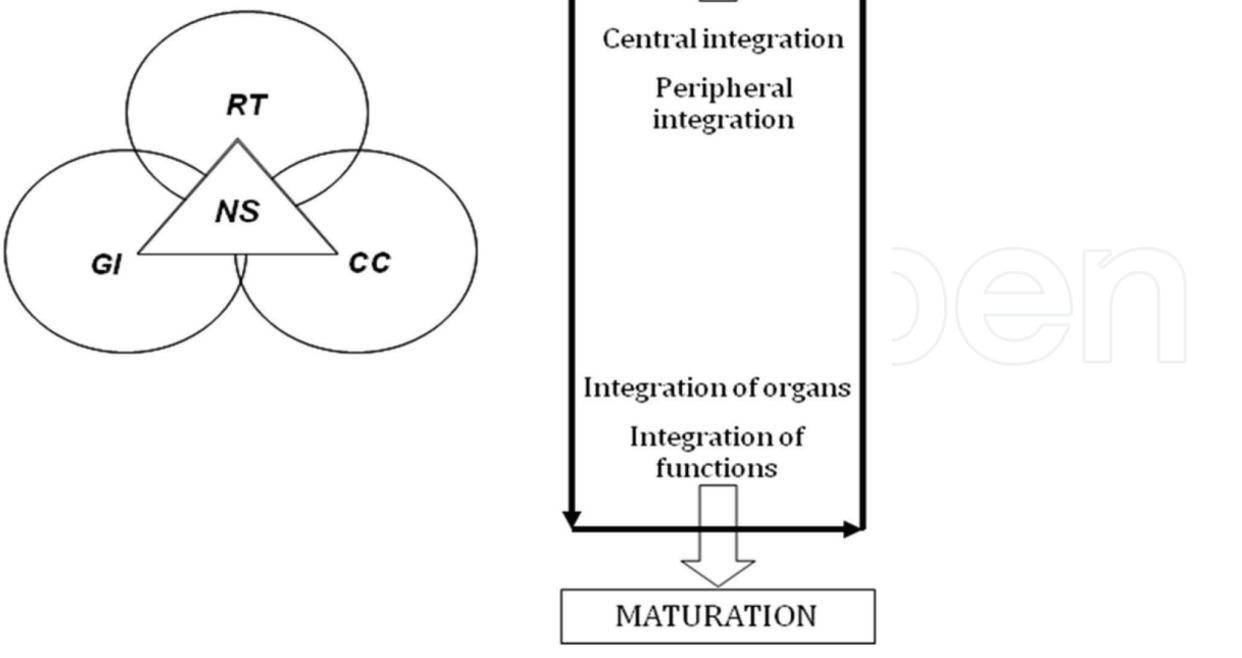
The cultural problem that has created such a gap between child and adult dysphagia is represented by the fact that the swallowing act evolves into a continuum that already starts during intrauterine development and continues throughout the lifespan. The passage between these two conditions, therefore, is slow, but the differences between child and adult swallowing and pathophysiological conditions of one and the other make the two realities very different to each other and not comparable. An adequate approach to childhood dysphagia implies, inevitably, a reminder of the pathophysiological aspects, with a short premise that a swallowing act has, in the child, a predominantly nourishing component and a protective action on the lower respiratory tract.

It all rests on the close relationship that exists, even in an evolutionary sense, between structure and function. If an organ evolves (morphologically and topographically), the functions it performs also have to adapt to this evolution. If the functions that the organs perform are vital functions (breathing and swallowing—aimed at nutrition), is it possible that the importance of such functions conditions the structure?

So what is the role of external events, for example, environmental, which are able to affect the relationship between shape and function? These considerations would lead us away from the topic of our chapter. Going back to the initial topic, it must surely be said that the swallowing

act, as a complex and integrated neuromotor event, begins "in utero" [5, 6]. The possibility of developing swallowing acts precociously affects the close relationship that exists between the digestive, respiratory, and cardiocirculatory apparatus in the embryo and fetus. Very early on, these apparatus make connections with neural structures, which are themselves evolving and beginning their myelination. All such structures are immersed in a liquid environment, circumscribed by the wall of the uterus. The containment cavity and growing structures are affected by the relationships with the nervous structures: such relationships involve a delicate balance between growth and maturation, which takes place at the organ and apparatus level. So the central and peripheral integration among neural structures is perfected in parallel to the integration with the organs-apparatus integration and the functions they carry out (**Table 3**).

Pharyngeal swallowing appears between 10 and 12 weeks of gestation and a complete suckling appears in the 18–24th weeks: it is between the 34th and 36th weeks that the fetus produces efficient swallowing, able to contribute to volume adjustment of the amniotic fluid. This swallowing activity is also essential to the development of the gastrointestinal apparatus and of the fetus itself [6, 7]. However, after birth, maturation structures and functions do not guarantee an adequate oral feeding, suggesting that extrinsic factors, related to the learning of external inputs, have a significant role in this maturation [8]. This optimization of the organs



NS: nervous system; RS: respiratory system, GI: gastrointestinal tract; CC: cardiocirculatory tract.

Table 3. Organ-function integration between center and periphery.

acquires the connotations of their real development toward an efficient and safe swallowing. Such enabling requires a long time: a child develops motor patterns similar to adults, only during adolescence. This underlines the complexity of this function, which, throughout life, is enriched with more and more complex socializing and cultural meanings. The concept of feeding, as an element intimately connected with swallowing, is established very early on. This concept is linked to the set of functions that are linked to oral structures: first of all, neuromotor skills [2] and also communication and social functions, as previously mentioned. As strictly regards feeding, it provides an increasingly sophisticated enabling of the oral structures, which allows the management, in the oral cavity, of increasingly more diversified boluses, in terms of consistency, volume, temperature, viscosity, and elasticity. The feeding activities allow a perfect conformation of the oral cavity to the anatomical adaptations that involve the head and neck fully during growth [9]. These same anatomical adaptations also involve the pharynx, so the interaction between feeding and swallowing, and more properly the interaction between the oral and pharyngeal phase of swallowing, becomes more and more intimate and functional. This adaptation is aimed at creating a neuromotor act that has to be effective (protective of the lower respiratory tract), efficient (complete transport of volumes), and functional (supporting of hydration and nourishment), while maintaining its own individual character and social pleasure. **Table 4** summarizes the oromotor abilities required by a small child (before 2 years) as a function of the consistencies managed [10]. In such a rapidly evolving system, the development of oral motor skills assumes great importance. These skills are being developed within a system that is changing quickly in both the structural and neuromotor sense: this occurs rapidly within the first 3 years of life [5, 10]. During this period, children are engaged in a great variety of oral experiences, sometimes oriented to satisfying

Months	Progression of foods and fluids	Oromotor abilities	Gross motor abilities
0–4	Liquid	Sucking the nipple	Head control
4–6	Purèe	Sucking from spoon	Sitting position, hands forward
6–9	Purèe, soft solid	Drink from glass, vertical mastication (reduced lateral movements)	Hands to the mouth, pincer hands, begins to hold the spoon, and begins to eat with hands
9–12	Ground, coarse purèe	Drink from glass independently	Refined pincer hands and eating with hands
12–18	All consistencies	Tongue lateral movements, drinking from a straw	Greater autonomy at meals, discovering foods and bringing to the mouth
18–24	Research of chewable foods	Lateral chewing	
>24	Harder solids	more mature chewing	Autonomous, manages utensils and glasses without spilling

Table 4. Neuromotor skills and oral management of the bolus within 2 years of age.

their basic nutritional need: this need is associated with the exploration of the surrounding environment, which should always be comfortable and rewarding. From a clinical point of view, a problem exists when a child is "locked" into a specific feeding schedule, when it is anchored to a feeding scheme beyond which they cannot progress. As the oral motor skills represent a sequential progression of increasingly complex skills, any interruption in this progression can limit their development and cause the loss of previously acquired skills [11].

5. Stages of oromotor development

At birth, a child needs to be able to breathe on its own and to feed safely. This implies, as already mentioned, a perfect cooperation of the swallowing effectors, which reflects a state of optimal health (relating to the development of the respiratory, gastrointestinal, and cardiovascular apparatus), optimal nervous integration, and optimal mother-child relationship.

From the anatomo-functional perspective and aimed at sucking activity, it should be remembered that the child, toothless at birth, has a high larynx (at the height of the first two cervical vertebrae), and a high respiratory rate (70–80/min, with minimal thoracic movements) but mostly a large tongue inside a relatively small mouth. Swallowing of milk occurs with a suckling neuromotor pattern, characterized by in-out tongue movements, facilitated by an opening-closing movement of the mandible, miming a squeezing act. During this activity, the face musculature, mainly the lip muscles, is kept hypotonic and the iolaryngeal axis is high and immobile. Swallowing triggers from the valleculae, and the pharyngeal passage is realized with a suction/swallowing ratio equal to 1. **Table 5** summarizes these events in the light of an overall maturation of the child [12–14]. It should be remembered that, at this

Months	Motor activity	Feeding activities	Jaw	Tongue	Lips
0–1	Reflex movements of limbs Raises the head	Sucking of finger (if approached to the mouth)	Phasic bite	Tongue = jaw	Mimic muscles silent
1–2	Circular movements of limbs Raises the head	Hands to the mouth (if lying down)	Phasic bite	Tongue at rest Tongue besides gums	Lip synchronous with other facial muscles
3–5	Trunk control Head control Sitting position	Head-trunk control Objects to the mouth	Phasic bite Stable jaw (head control)	Movements of tip-body-base Gag from mid-third of the tongue Inhibition lingual movements	Development of facial muscles lips control separate lips movements Lips-cheek activities

Table 5. Neuromotor patterns and effectors: sucking.

time, swallowing is purely reflex, relegated to the activity of the bulbar swallowing center. At weaning, anatomical changes allow the realization of new swallowing patterns. The tongue tends to flatten out and acquires the ability to perform up/down movements between the mandible and the hard palate. Lips acquire tone to achieve a greater attachment to the nipple. The laryngeal lowering allows the volumetric increase of the pharynx and the realization of a negative pressure inside the mouth. The child is now able to move a greater volume of liquids, reaching a sucking/swallowing ratio superior to 1. These events become possible due to a progressive disappearance of oral reflexes. Swallowing triggers from the valleculae, as above, but the increased flow and the lower position of the larynx can facilitate episodes of penetration. **Table 6** summarizes these events [12]. The myelination of subcortical and

Months	Motor activity	Feeding activities	Jaw	Tongue	Lips
6–9	Sits and turns Objects from hand to hand Manipulates objects Explores with indexes He/she gets up briefly	Sucking of finger (if approached to the mouth) Independent movements of tongue/jaw (trunk control) He/she holds bottle	Phasic bite abolished Stabilized mandible Lateral movements	Up-down movements Gag reduced Perceived consistency (bolus crush) Lateralizes the bolus	Lower lip stabilizer active Use of perioral muscles Bolus between molars: use of the lips and cheeks
10–12	Crawling Gets up Upright position	Fine motor skills development	Controlled pressure of soft foods Opening/closing controlled Circular-rotary movements	Use of all intrinsic tongue muscles (various shapes) All moving angles Combination of movements	Active lips/cheeks used to manage soft foods Contracts lower lip: clearing from teeth and gums Occasional packeting/drooling Rare drooling
13–24	Fast walking Jumps with 2 feet Walking on tiptoe Draws closed forms Makes puzzles	Head-trunk control Objects to the mouth	Circular-rotary movements No turning of head to bite (most mandibular control)	Consistence modifies lingual movements Tongue on right and left Tongue clears the mouth Tongue/mandible: independent movements (12–24) Lips licking (18–20)	Maintaining lip prehension during lingual and mandibular movements

Table 6. Neuromotor pattern and effectors: weaning.

subsequently cortical structures, as previously mentioned, interfere with the bulbar centers (neuromotor control): now swallowing becomes an automatic act, submitted to the sensorial afferents coming from the periphery, mainly from the oral cavity. The growth of orofacial structures allows for more and more precise and refined neuromotor patterns enabling the development of oral skills and the ability to manage boluses of different volume and consistency [15]. **Table 7** summarizes these anatomical variations in young children up to 2 years old and older than 6 years. Between 2 and 6 years of age, swallowing mainly reaches the optimization of the oral activities and the stabilization of the pharyngeal phase. Even the anticipatory phase of swallowing tends to stabilize in this age group. As regards chewing, this activity is enriched by movements of laterality and circularity of the tongue and mandible, with transport of the bolus in the molar region and the beginning of trituration of harder and harder consistencies. The duration and number of masticatory cycles, as well as their efficiency in terms of strength, precision, and coordination, develop progressively. From 6 to 12 years, chewing is further perfected. A reduction in the number and duration of the chewing cycles occurs with a strengthening of the propulsive phase, due to the strengthening of the masticatory muscles. In the meantime, the tone of mentalis and orbicularis muscles decreases. Also in this phase the exposure to different consistencies and volumes is a powerful stimulus to the optimal use of swallowing effectors, all activities that, in the nervous system, are supported by mechanisms of neuronal sprouting (brain plasticity). The correct knowledge of these events and of the time frames mentioned earlier underlies the correct assessment of children with swallowing disorders. The failure to achieve abilities, chronologically expected in an age band, will surely negatively compromise the achievement of further abilities.

	Younger child	**Older child**
Oral cavity	Tongue fills the mouth	Tongue lies on the floor of mouth
	Edentulia	Primary teeth
	Tongue at rest between the lips and against the palate	Tongue behind your teeth and not against the palate
	Cheeks rich in fat	Chewing using buccinator muscles
	Small jaw	Relationship between jaws almost normal
	Sulci important during sucking	Sulci less important during sucking
Pharynx	Oropharynx not well defined	Lengthening of the pharynx with oropharynx defined
	Skull base with obtuse angle to the nasopharynx	Skull base with right angle
Larynx	1/3 of the adult	
	1/2 glottis cartilaginous	1/3 glottis cartilaginous
	Epiglottis vertical and narrow	Epiglottis wider and flattened

Table 7. Growth of structures in the younger and older child.

6. Signs and symptoms

It has previously been said that the alterations of the oromotor development, in one or more associations summarized in **Table 3**, result in an arrest in the development of the child's feeding skills, with the possibility of losing skills already acquired. Dysphagia, which is not properly diagnosed, can result in multiple clinical signs, in various combinations.

First, it can determine weight loss and a failure to thrive so as to require a parenteral or enteral nutritional support. Dehydration, respiratory complications or aspiration pneumonia, food adversion, and rumination (i.e., involuntary regurgitation of undigested food that can be chewed and re-swallowed) are other possible signs of dysphagia.

From these assumptions, the major requests for phoniatric-logopedic evaluation of children with swallowing disorders are derived. Most commonly, children refuse some consistencies or have a difficult approach to meals, with little interest in eating. All these conditions may reflect alterations in the physiology of swallowing such as a slow gastric motility or constipation. A child who refuses new consistencies may suffer from gastroesophageal reflux and other gastrointestinal disorders. A gastroesophageal reflux can cause pain during or after the meal, which children associate with feeding.

This can impede feeding and cause severe behavioral problems that make it difficult, if not impossible, for the parents to feed the baby adequately. As mentioned earlier, a limited taste experience related to oral intake may affect inadequacies in the oral sensorimotor development. Parents can also signal that the child does not show a sense of hunger but rather shows a sense of aversion or avoidance to sensory stimulation, making meal times a real struggle. Every child is different and these conditions may be present in various combinations [16]. **Table 8** summarizes some of the main conditions which lead to a request of consultation. The

Incoordination between sucking and swallowing (shockable rhythm)
Weak feeding
Alterations in breathing or apnea during the meal
Gagging excessive or frequent coughing during the meal
Occurrence of difficulties in supply
Diagnoses associated with dysphagia, malnutrition, or craniofacial anomalies
Shutdown/reduction in body weight gain from 2 to 3 months (malnutrition)
Marked irritability during the meal
History of respiratory diseases and feeding difficulties
Lethargy during the meal
Feeding time more than 30–40 min
Unexplained refusal of food and malnutrition (failure to thrive)
Drooling that persists beyond 5 years
Nasal regurgitation during the meal
Delay in the maturation and development of food habits

Table 8. Sending criteria to phoniatric-logopedic assessment.

table shows conditions referring to a variety of swallowing disorders, some mentioned in the section on etiology. It is obvious that if the baby is born with a craniofacial malformation, the oral and/or pharyngeal phase of swallowing will consequently result as compromised.

7. The bedside evaluation (non-instrumental clinical evaluation)

The clinical approach to children with swallowing disorders does not differ substantially from the approach to other pathological conditions. In children, as in adults, it has to be borne in mind that dysphagia is a symptom, underlying one or more morbid or comorbid conditions. The approach to children is complicated by the inability of the young patients to directly express their discomfort and this is often mediated by caregivers.

To summarize, possible goals of the non-instrumental clinical evaluation are as follows: to identify the possible etiology of dysphagia, to formulate hypotheses about its nature and severity, to estimate functions and their integration (sensory-motor skills and breathing), to induce therapeutic modifications, to investigate safe food options for the child and to raise awareness among family members, to indicate the best instrumental evaluation, and to identify the possibilities of and the patient's ability to cooperate in medical examinations.

Therefore, the clinical approach to children with swallowing disorders is influenced by the age of the child, the main pathology, and the comorbidities. The importance of age has already been emphasized: depending on their age, the children should have specific oromotor skills and there is the gradual disappearance of reflex activities. **Table 9** summarizes the main steps of the non-instrumental clinical evaluation.

In clinical practice, the absence of standardized assessment protocols is a serious concern: the literature offers us different protocols (**Table 10**) [17–22] but their application is not always standardized and verified by an instrumental gold standard. This lack of tools interferes with the collection of information and the comparison of the skills of the young patients.

The non-instrumental clinical evaluation has to provide the proposal of foods in different volumes and consistencies, depending on the age of the child. It will occur with specific modalities depending on whether the child is fed (**Table 11**) or not fed orally [nill per os (NPO)] (**Table 12**).

In children with tracheotomy, non-instrumental evaluation will be conducted in the same way as in children with an intact airway considering that, in children, few data are available about the impact of tracheotomy on swallowing abilities. When possible, the tests with bolus are performed verifying the presence of bolus traces or blue-dyed water in the airway. The use of speaking valves has to be encouraged, allowing phonation, increasing laryngeal reflexivity with a better lower airway protection, and clearing secretions. The use of speaking valves reduces mechanical ventilation dependence time and stay in NICU, and accelerates decannulation and recovery of oral feeding.

At the end of the non-instrumental clinical evaluation, with respect to what has been previously reported, it is necessary to identify those children for whom a referral for an instrumental clinical evaluation is worthwhile. **Table 13** summarizes the assessment process up to this point.

Clinical history • Prenatal infections, medications, drugs • Delivery (Apgar) • Peri/neonatal (dietary history)	• Beginning and description of the disorders • Other medical or nutritional disorders • Prolonged hospitalization or surgery • Age of acquisition of food mode • Supply adequacy and behavior at meal		
General observation: • Facies • Muscle tone • Vestibule and the oral cavity • Jaw mobility • Veil mobility • Chest and breathing • Neuropsychological development • Postures and positions	Anatomy • Abnormalities • Malformations • Deformity	Reflexes • Swallowing • Gag • Rooting • Cough • Mouth opening • Tongue lateralization • Biting • Babkin	Behaviour • Postural control of the body • Oral postural control • Voice • Oral praxis and blow
Observation during the meal	• Alert • Activity level: quiet, active, weeping • Receptivity to food		
Swallowing osbervation: • Respiratory signs (cough, apnea, desaturation) • Gurgling voice • Other: bradycardia, pallor, sweating	NPO child • From 1 to 3 ml of liquid • From 1 to 3 ml semi-solid		PO child • Teat: usual liquid bolus • Spoon: viscous semi-solid, dense and grainy, soft solids • Fingers: solid chewable • Spoon: soft solids, soft complex solid, hard solid and dense liquids • Cup: liquid and thickened liquids

Table 9. Steps of non-instrumental clinical evaluation (bedside evaluation).

Neonatal oral motor assessment Scale (NOMAS) (Palmer et al [17]) (Breast feeding/Bottle feeding)
Systematic assessment of the infant at the breast (SAIB) (Association of Women's Health, Obstetric and Neonatal nurses, 1990)
Preterm infant breast-feeding behavior scale (PIBBS) (Nyqvist et al. [19])
Breast feeding evaluation (Tobin [20]) (term infants)
Feeding flow sheet (Vandenberg [21]) (bottle feeding)
Infant feeding evaluation (Swigert [22])

Table 10. Main bedside protocols of evaluation.

• Place the baby in an optimal way to elicit swallowing and coordination:
• Semi-reclined
• 3–4 months
• After weaning
• Difficulties in oral transport
• Neurological disorders (difficulty with boluses by spoon)
• Seat supporting the head (preferred)
• Behavior during the meal: failure, drowsiness, avoidance or refusal of food, food preferences
• Evaluate praxis with:
• Teats or tools
• Bolus: volume, consistency, order of presentation

Table 11. Bedside evaluation and test with bolus in orally fed child (PO).

• Breathing and eating disorders not related to oral intake of foods
• In case of correlation instrumental evaluation (airway protection)
• Clinical judgment on the possibility of oral feeding
• Pooling:
• Impaired early oral or pharyngeal phase: stop the test
• Impaired oral preparation:1 cc of liquid back in the mouth (pipette)
• Adequate oral preparation: bolus to the lips or with a spoon
• Tests: very small bolus (1–3 ml) via pipette or teat
• Proceed to check the appearance of respiratory signs.

Table 12. Bedside evaluation and test with bolus in non-orally fed child (NPO).

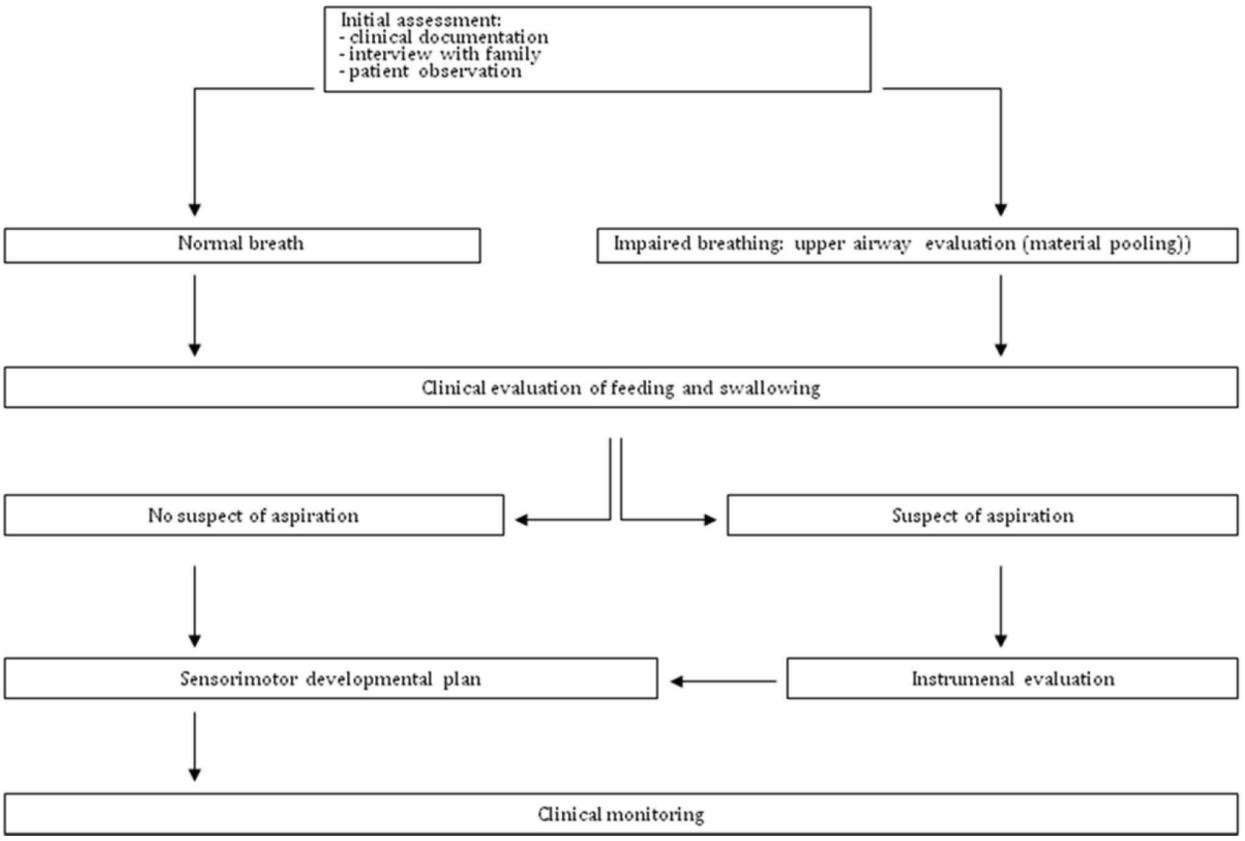


Table 13. Evaluation process: synthesis.

8. The instrumental clinical evaluation

The two main instrumental tools for assessing swallowing in children, as in adults, are represented by the dynamic radiological and the dynamic endoscopic evaluations, respectively, known with the Anglo-Saxon acronyms of VFSS (videofluoroscopic swallowing study) [23] and FEES (fiberoptic endoscopic evaluation of swallowing) [24]. These procedures evaluate the behavior of swallowing effectors during the passage of the bolus, which implies that the child, who is a candidate for such procedures, can be fed orally [25]. During the procedure, the clinician can rely on monitoring the heart activity, breathing, and O_2 saturation, in order to obtain additional information about physical or behavioral changes associated with the swallowing disorder. Similarly, the colorimetric variations of the skin (pallor or cyanosis), nasal regurgitation, and alterations of sucking-swallowing/breathing rhythm may be considered.

Broadly, the instrumental evaluation, compared to the bedside evaluation, has the advantages shown in **Table 14**. It is worth remembering that with regard to the information they provide, FEES and VFSS are not equivalent but complementary. The clinician chooses the procedure most appropriate in relation to the characteristics of the young patient or to the information being sought, in the awareness that the two procedures have both advantages and disadvantages [26] (**Table 15**).

- Display of upper aerodigestive tract (oral cavity, velopharyngeal sphincter, pharynx, larynx, and cervical esophagus)
- Evaluate muscular activities (symmetry, force, pressure, tone, range and degree of motion, coordination, and speed)
- Evaluate sensation
- Evaluate aspiration and cough
- Evaluate residue in hypopharynx and larynx
- Evaluate the esophageal etiology of dysphagia
- Evaluate the safest and most efficient way of nutrition and hydration
- Evaluate the efficient protection of postures and maneuvers

Table 14. Advantages of the instrumental clinical evaluation compared to the clinical non-instrumental evaluation.

	Advantages	**Disadvantages**
FEES	Less invasive	Pharyngeal phase only
	Easy to perform	White-out
	Well tolerated	Indirect consideration about
	Possible for a long time (fatigue viewing)	• Oral
		• Esophageal phase
	Portable (acute and sub-acute patients)	Fear and discomfort
	Routine	Poor vision in repeated swallowing acts
	Economic	Not possible if changes in upper airway
	Therapeutic feedback	
	Decision making of oral feeding	
	Natural foods	
	Direct visualization of structures	
	Motor and sensory activities	
	Three-dimensional similar view	
	Optimal pooling evaluation	
	Pooling management viewing	
VFSS	Whole deglutition evaluation	Invasive (radiological exposure)
	Time parameterization	Uncomfortable execution
		Environment and suitable personnel
		Expensive
		Bi-dimensional view (under estimation of pooling matter)
		Motor activity only (reaction to aspiration, if documented)
		Fatigue evaluation missing

Table 15. Advantage and disadvantage comparison between VFSS and FEES.

8.1. VFSS

It is a procedure that uses ionizing radiation and should be used sparingly, especially in very young children. When indicated, the tool verifies the actual usefulness in improving the safety and efficacy of the swallowing act, under different examination conditions: varying the consistency or the viscosity of the bolus, verifying the clearing of the mouth, pharynx, or esophagus; varying the position of the child, implementing postures or maneuvers (when possible); varying the speed of feeding, child position, and changing pacifier or spoon characteristics [27, 28].

8.2. FEES

When performing an endoscopy, the possibility of achieving the maximum collaboration of the child is crucial. Any device useful for making the child and its parents less anxious and for increasing compliance has to be adopted. The family is asked to bring pacifiers, bottles, or utensils commonly used during meals and also to bring the dishes commonly eaten by the child: either the most liked or those that create the greatest difficulties. The choice of endoscope size is based on the age of the child: obviously, the smaller the endoscope, the lower the imagine definition. With a child of over 3 years of age, it is possible to use standard size endoscopes (2.4 mm in diameter), with a younger age group smaller devices are advisable (1.5 mm diameter). To optimize cooperation and minimize discomfort, anesthetic spray puffs or a small amount of cotton, soaked in a 1:1 mixture of 4% lidocaine and oxymetazoline, can be introduced into the nasal cavity [29]. A viable alternative is to lubricate the tip of the endoscope with a 2% lidocaine gel. This is always desirable in patients with airway lability (very young children or of low weight) in compromised general conditions or with tracheotomy. For the endoscopic evaluation, the baby may be supine in a cot or a pram but for the dynamic study of swallowing he/she should preferably have the chest lifted: the baby can be held in the mother's arms or on her knees.

Older children can be seated in a high chair without any help. If the child tends to assume specific postures during the meal (due to a physical impairment, as in cerebral palsy) they will be maintained after the introduction of the endoscope and verified during the test. Similarly, the efficiency of therapeutic postures or maneuvers will be checked. The procedure substantially does not differ from that used for adults [30]: the static, anatomical, dynamic, and non-swallowing assessments are performed with the tip of the endoscope in the naso-nasopharyngeal, high, and low position. The tests with bolus are performed with the tip of the endoscope in the high position.

9. The anatomo-functional evaluation

In the *naso-rhinopharyngeal position*, the clinician will evaluate hypertrophy of the nasal mucosa and turbinate, secretions pooling, septal bumps and other anatomical anomalies, shrinkage or choanal atresia, hypertrophy of adenoid, and the upper surface of the soft palate. During phonation and deglutition, the contraction of the veil, if symmetrical, will be evaluated. While swallowing, a veil incompetence is always pathological and the cause of nasal regurgitation of secretions or bolus.

In the *high position* (beyond the free edge of the soft palate), the clinician evaluates the hypopharyngeal region: base of the tongue, tonsils, and the larynx position, considering that it descends gradually in the neck with age: from C1 to C4 from birth to puberty. Particular attention should be given to material pooling: if present at the beginning and during the evaluation. Its increase not followed by clearing is abnormal [31, 32]. The clearing of secretions is assessed during spontaneous swallowing acts or on request [26, 30]. Secretions that engulf the pyriform sinus must induce a swallow, even if the child cries.

In the *low position*, a careful assessment of the larynx is performed. Particular attention should be paid to abnormalities that may interfere with the sphincterial function: malacia, cleft, and cyst. Mobility is evaluated during respiration, phonation, or crying. Signs of reflux disease have to be evaluated: hyperemia, hypertrophy of the posterior commissure, circumscribed or diffused edema involving the vocal cords, and endolaryngeal secretions.

The delicate touch of the aryepiglottic folds with the tip of the endoscope activates the adduction reflex, mediated by the superior laryngeal nerve: the reflex is essential for an adequate protection of the lower airways during swallowing. For the same purpose, pulsed air can be used, supplied with variations of pulsing or of intensity [flexible endoscopic evaluation of swallowing with sensory testing (FEESST)] [33, 34]. In children who are noncooperative, who have cognitive disorders, or are very young, only the adduction reflex can be appreciated [34].

10. The test with bolus

After the anato-functional assessment and in relation to age, foods of different consistencies and volume will be proposed to the child. The foods preferably have a natural color or are dyed. The child is fed by its parents. It is always advisable to start with pleasing food, in order to increase the compliance to the test, then subsequently, as for adults, to use food which is more difficult to manage in the oral cavity [30, 35]. During the test with bolus, different parameters have to be considered.

The first parameter to evaluate is the *site* and *latency* of the swallowing reflex, in children this is more difficult to define in relation to the small size of the pharynx. Liquid bolus can hesitate in the valleculae before being swallowed, as a normal variant of the swallowing act. If the bolus falls by gravity into the pyriform sinuses before swallowing and remains in this site, the possibility of false route is greater. The delivery of the bolus from the oral cavity into the pharynx without swallowing is referred to as premature spillage. When milk is sucked from a bottle, it is collected up to the pyriform sinuses before being swallowed and only an appropriate rhythm, sucking-swallowing-breathing, prevents aspiration [28]. The datum, however, will be included and considered in the context of a complete clinical assessment.

The progression of the bolus into the laryngeal vestibule is called *penetration*, being possible up to the true vocal cords. Penetration is clearly evaluated using endoscopy [28, 30, 35]. When the valleculae are obliterated with lymphatic tissue, the bolus (in particular liquid) can spill over the free edge of the epiglottis before swallowing: in this case, the risk of penetration remains low. If the general conditions of the baby are serious, penetration can have the same significance as aspiration so, when performing tests, it would be better not to expose the patient to this risk.

Aspiration is the progression of secretions or bolus below the true vocal cords. In FEES, this event can occur before or after swallowing: they are events well evaluated in endoscopy [36]. Pre-swallowing aspiration can be due to a delayed triggering or a late laryngeal valve activation. Post-swallowing aspiration can be due to an overflowing from the pharyngeal containment cavities. At the highest point of swallowing, the white-out prevents the direct visualization of aspiration (intra-swallowing aspiration). In this case, aspiration can be inferred after swallowing, by evaluating residue of food in the larynx or cervical trachea or evaluating the expulsion of streaked secretions by coughing [28, 30, 35].

The evaluation of swallowing abilities with bolus can be quantified by the same test as is available in FEES. The progression of bolus through the upper airway can be quantified using the penetration-aspiration scale [37], and the presence of residue can be quantified with the pooling score (*p*-score) [32, 37] both applied with the same characteristics as seen for adults.

11. The treatment plan

The clinical non-instrumental and instrumental evaluations should enable the clinician and the rehabilitator to set up an ideal treatment plan for the child (**Table 13**).

In general, a treatment plan should (1) guarantee the child an adequate nutritional and water intake, (2) be protective of the respiratory tract, (3) support the child in eating and drinking, (4) guarantee the optimal oral sensory stimulation, (5) improve the QoL of the child and family, and (6) help the family in conceiving new therapeutic strategies [38–40].

All of these respecting the actual clinical condition (morbidity and comorbidities) inside the evolutive temporal windows are linked to age of the child. The treatment plan should also consider all the possible settings of a child's life: home, kindergarten, school, and leisure environments. The treatment plan must consider all the indications aimed at achieving the objectives mentioned earlier, by means of medical, surgical, and nutritional strategies. For example, if the child suffers a major reflux, he/she will be treated pharmacologically or surgically, to prevent the negative feedback that the reflux has on swallowing and feeding. Other general considerations, previously underlined, are the importance of ensuring the child the best sensory oral-pharyngeal stimulation and the best oromotor stimulation. Only in this way will the swallowing abilities of the baby progress through all the steps of a satisfactory development.

In planning treatment, the clinician has to consider if the children can be safely fed orally or not, and the general performance of the child during mealtimes. In practice, useful therapeutic strategies are represented by dietary modifications, such as the food being thickened, diluted, chopped, blended, mixed, and viscosity varied, depending on the functional age and disease of the baby. These changes must guarantee a nutritional and water intake able to ensure the growth of the child. Within the first year of life, the use of commercial thickeners should be limited. Sometimes, it could be advantageous to vary the bolus presentation with a break during the feed. With older children, the same effect is produced by varying consistencies. The same strategies should also be considered in tube-fed children (NGT or PEG/JPEG) when the possibility of assuming per os even a single consistency is verified.

The time windows in the physiological growth of the effectors, previously mentioned, should be considered and respected, as far as possible. The use of devices or adapted utensils has the purpose of fractioning the presentation of the bolus, in terms of volume and speed: with younger children, pacifiers in different shapes and with different holes can be used, while with older ones, utensils with modified handles are more appropriate [41, 42]. The use of maneuvers (forced swallowing, Mendelsohn, supraglottic, super-supraglottic, and Masako) changes the timing and strength of the swallowing act: their implementation requires that the child can learn them and be motivated for their execution. Relatively simpler is the use of postures, which can also be implemented passively, very small children can be held in the arms, or older children can be placed in adjustable seating [43]. The use of oromotor exercises [44] provides active or passive activities of the effectors, always without the use of foods. These exercises are aimed at optimizing the efficiency of the lips, jaw, tongue, soft palate, pharynx, larynx, and respiratory muscles. Sensory stimulations act on the swallowing reflex. These gustatory, thermal, or tactile stimulations can be applied on different effectors: cheeks, lips, and tongue. They are indicated for children with reduced responses or reduced opportunities for stimulation. At other times, it is possible to intervene on children who have an excessive response or aversion to stimulations: in this case, the treatment is expected to reduce the reflexivity of the child.

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References

[1] Arvedson JC. Assessment of pediatric dysphagia and feeding disorders: Clinical and instrumental approaches. Developmental Disabilities Research Reviews. 2008;**14**:118-127

[2] Lefton-Greif M. Pediatric dysphagia. Physical Medicine and Rehabilitation Clinics of North America. 2008;**19**:837-851

[3] Kakodkar K, Schroeder JW. Pediatric dysphagia. Pediatric Clinics of North America. 2013;**60**:969-977

[4] Brackett K, Arvedson JC, Manno CJ. Pediatric feeding and swallowing disorders: General assessment and intervention. Perspectives on Swallowing and Swallowing Disorders (Dysphagia). 2006;**15**(3):10-14

[5] Bosma JF. Development of feeding. Clinical Nutrition. 1986;**5**:210-218

[6] Moore KL. The Developing Human: Clinically Oriented Embryology. 4th ed. Philadelphia (NJ): Saunders; 1988

[7] Grassi R, Farina R, Floriani I, et al. Assessment of fetal swallowing with gray-scale and color Doppler sonography. AJR: American Journal of Roentgenology. 2005;**185**:1322

[8] Bingham PM. Deprivation and dysphagia in premature infants. Journal of Child Neurology. 2009;**24**(6):743-749

[9] Buchholz DW, Bosma JF, Donner MW. Adaptation, compensation, and decompensation of the pharyngeal swallow. Gastrointestinal Radiology. 1985;**10**:235-239

[10] Arvedson JC, Lefton-Greif MA. Anatomy, physiology and development of feeding. Seminars in Speech and Language. 1996;**17**:261-268

[11] Mizuno K, Nishida Y, Taki M, Hibino S, Murase M, Sakurai M, Itabashi K. Infants with bronchopulmonary dysplasia suckle with weak pressures to maintain breathing during feeding. Pediatrics. 2007;**120**:1035-1042

[12] Miller AJ. Oral and pharyngeal reflexes in the mammalian nervous system: Their diverse range in complexity and the pivotal role of the tongue. Critical Reviews in Oral Biology & Medicine. 2002;**13**:409-425

[13] Green JR, Wilson EM. Spontaneous facial motility in infancy: A 3D kinematic analysis. Developmental Psychobiology. 2006;**48**(1):16-28

[14] Gibson EJ. Exploratory behavior in the development of perceiving, acting, and the acquiring of knowledge. Annual Review of Psychology. 1988;**39**:1-41

[15] Wilson EM, Green JR, Weismer G. A kinematic description of the temporal characteristics of jaw motion for early chewing: Preliminary findings. JSLHR: Journal of Speech, Language, and Hearing Research. 2012;**55**(2):626-638

[16] Piazza C, Dawson J. The failure to thrive: Pediatric feeding disorders. Paradigm. Fall 2000. pp. 8-9

[17] Palmer MM, Crawley K, et al. Neonatal Oral-Motor Assessment Scale: A reliability study. Journal of Perinatology. 1993;**13**(1):28-35

[18] Shrago LC, Bocar DL. The infant's contribution to breastfeeding. Journal of Obstetric, Gynecologic, & Neonatal Nursing. 1990;**19**:209-215

[19] Nyqvist KH, Rubertsson C, Ewald U, Sjödén PO. Development of the preterm infant breastfeeding behavior scale (PIBBS): A study of nurse-mother agreement. Journal of Human Lactation. 1996;**12**(3):207-219

[20] Tobin DL. A breastfeeding evaluation and education tool. Journal of Human Lactation. 1996;**12**(1):47-49

[21] Vandenberg KA. Behaviorally supportive care for the extremely premature infant. In: Gunderson L, Kenner C, editors. Care of the 24-25 Week Gestational Age Infant (Small Baby Protocol). San Francisco, CA: Neonatal Network; 1990. pp. 129-157

[22] Swigert N. The Source R for Pediatric Dysphagia. San Diego, CA: Singular; 1998

[23] Logemann JA. Evaluation and Treatment of Swallowing Disorders. Austin, Texas: Pro-Ed; 1983

[24] Langmore SE, Schatz K, Olsen N. Fiberoptic endoscopic examination of swallowing safety: A new procedure. Dysphagia. 1988;**2**:216-219

[25] Farneti D, Favero E. Valutazione videoendoscopica infantile, adulta e senile. In: Deglutologia. 2nd ed. Omega; 2010

[26] Farneti D. The Instrumental Gold Standard: FEES. Journal of Gastroenterology and Hepatology Research. 2014;**3**(10):1281-1291

[27] O'Donoghue S, Bagnall A. Videofluoroscopic evaluation in the assessment of swallowing disorders in pediatric and adult population. Folia Phoniatrica et Logopaedica. 1999;**51**:158-171

[28] Newman LA, Cleveland RH, Blickman JG, Hillman RE, Jaramillo D. Videofluoroscopic analysis of the infant swallow. Investigative Radiology. 1991;**26**:870-873

[29] Leder SB, Ross DA, Briskin KB, Sasaki CT. A prospective, double-blind, randomized study on the use of topical anesthetic, vasoconstrictor, and placebo during transnasal flexible fiberoptic endoscopy. Journal of Speech and Hearing Research. 1997;**40**:1352-1357

[30] Farneti D. La valutazione videoendoscopica. In: Schindler O, Ruoppolo G, Schindler A, editors. Deglutologia. Torino: Omega; 2001. pp. 167-188

[31] Murray J, Langmore SE, Ginsberg S, Dostie A. The significance of accumulated oropharyngeal secretions and swallowing frequency in predicting aspiration. Dysphagia. 1996;**11**:99-103

[32] Pooling score: An endoscopic model for evaluating severity of dysphagia. Acta Otorhinolaryngologica Italica. 2008;**28**:135-140

[33] Aviv JE, Martin JH, Debell M, Blitzer A. Air pulse quantification of supraglottic and pharyngeal sensation: A new technique. Annals of Otology, Rhinology, and Laryngology. 1993;**102**:777-780

[34] Link DT, Willging JP, Miller CK, Cotton RT, Rudolph CD. Pediatric laryngopharyngeal sensory testing during flexible endoscopic evaluation of swallowing: Feasible and correlative. Annals of Otology, Rhinology, and Laryngology. 2000;**109**(10):899-905

[35] Leder SB, Karas DE. Fiberoptic endoscopic evaluation of swallowing in the pediatric population. Laryngoscope. 2000;**110**(7):1132-1136

[36] Miller CK, Willging JP, Strife JL, Rudolph CD. Fiberoptic endoscopic examination of swallowing in infants and children with feeding disorders. Dysphagia. 1994;**9**:266

[37] Farneti D, Fattori B, Nacci A, Mancini V, Simonelli M, Ruoppolo G, Genovese E. The Pooling-score (P-score): Inter- and intra-rater reliability in endoscopic assessment of the severity of dysphagia. Acta Otorhinolaryngologica Italica. 2014;**34**(2):105-110

[38] Jadcherla SR, Peng J, Moore R, Saavedra J, Shepherd E, Fernandez S, Erdman SH, DiLorenzo C. Impact of personalized feeding program in 100 NICU infants: Pathophysiology-based approach for better outcomes. Journal of Pediatric Gastroenterology and Nutrition. 2012;**54**(1):62-70

[39] Jadcherla SR, Dail J, Malkar MB, et al. Impact of process optimization and quality improvement measures on neonatal feeding outcomes at an All-Referral Neonatal Intensive Care Unit. JPEN: Journal of Parenteral and Enteral Nutrition. 2016;**40**:646

[40] Fucile S, McFarland DH, Gisel KG, Lau C. Oral and non-oral sensorimotor interventions facilitate suck-swallow-respiration functions and their coordination in preterm infants. Early Human Development. 2012;**8**:345-350

[41] Ross ES. SOFFI: An evidence-based method for quality bottle-feedings of preterm, ill, and fragile infants. Journal of Perinatal and Neonatal Nursing. 2011;**25**(4):349-359

[42] Gosa M, Schooling T, Coleman J. Thickened liquids as a treatment for children with dysphagia and associated adverse effects: A systematic review. ICAN: Infant, Child, & Adolescent Nutrition. 2011;**3**(6):344-350

[43] Thoyre SM, Park J, Pados B, Hubbard C. Developing a co-regulated, cue-based feeding practice: The critical role of assessment and reflection. Journal of Neonatal Nursing. 2013;**19**:139-148

[44] Manno CJ, Fox C, Eicher PS, Kerwin MLE. Early oral-motor interventions for pediatric feeding problems: What, when and how. 2005;**3**:145-159

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