Pediatric Aspect of Dysphagia

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Contents

Abstract

Pediatric dysphagia is specific because of the different developmental stages from the neonatal period to the infancy. Diagnosis and treatment will be different if it concerns a newborn or a young child having already experienced oral feeding. Furthermore, swallowing and feeding disorders, having a direct impact on the nourishment function of the parents, will have repercussions on the child–parents relationship. Swallowing disorders are frequently multifaceted, and impairments can be morphological, functional or induced. The assessment of these disorders includes anamnesis (reviewing family, medical, developmental, and feeding history), physical examination (searching for nutritional impact, cardiopulmonary state and looking for developmental anomalies or genetic dysmorphism), swallowing evaluation (analyzing oropharyngolaryngeal structure and function by observation, fiber-optic endoscopy, videofluoroscopy, ultrasonography), and feeding evaluation (implicating parents and caregivers). Management of these disorders is a complex task, thus an interdisciplinary team and recurrent assessments are required so as to match the child's development and capacities. Its main aims are to prevent repercussions on developmental milestones and to assure the safety of the child and the psychological balance of child–parents relationship.

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1 Introduction

The child's swallowing evolves; this is one of its principal characteristics. In adults, dysphagia is a loss of the abilities. In children, its evolution is modified, impacting on the morphological development of the organs like on the other functions of the aerodigestive tract such as breathing and speech.

The maturation of swallowing is organized over the first few years of life until 6 years as reported by most authors or 10 years as reported by some authors (Schindler et al. 2011), a date when mastication is fully controlled. This long evolution starts in utero. From 7 weeks' gestational age (GA), the brainstem receives the first sensory information from the pharyngolarynx. The sensory effectors are in place at the end of the embryonic phase. The principal anatomical structures develop as follows: the mandible at 4 weeks, the palate between the 6th and 12th weeks, and the esophagus at 7 weeks' GA. At this time, the fetus starts to swallow the amniotic liquid. From 10 weeks' GA, pharyngeal deglutitions are observable on ultrasonography (Miller et al. 2003). Suction is mature from the 15th week. A sucking–swallowing pattern appears from 18 to 24 weeks' GA. It becomes functional from 34 to 37 weeks' GA. Fetal sucking and swallowing plays a significant role in the morphogenesis of the oropharyngeal cavities. It takes part in the development of the digestive tract, the fetal trophicity, and its fluid balance. It is also the period of the first food experiments, the olfactory particles crossing the placental barrier. The observation of this sucking and swallowing, on ultrasonographic examinations of the second and third quarters of pregnancy, can be used to predict the sucking and swallowing of the baby at birth (Couly et al. 2009; Miller et al. 2003).

All must be in place at birth to ensure good coordination between sucking, swallowing, and breathing. The primary reflexes allow the newborn to ensure its vital needs are met. By rooting, the newborn moves towards the nipple. By grasping it remains attached to its mother. At this stage, the baby is acquiring feeding behavior. The alternation of hunger and satiety gives a rhythm to the baby's days in relation to the alternation of wakefulness and sleep. These various steps are paramount in the psychoemotional structuring of the baby. The progressive contributions of the nutrients must be in agreement with the quantitative and qualitative needs for each age. Food diversification supports the progressive evolution as do textures and tastes, while respecting the organic and neurological evolution of the child and its sensorimotor abilities.

Any modification or obstacle in this long evolution may contribute to significant delays in the emergence of the other oromotor behaviors, including babbling, speech, and language production. The causes of swallowing disorders are multifaceted, and their consequences will depend on the stage of the child's development.

This is why early and suitable evaluation and management are necessary to limit the functional effects of swallowing disorders on the aerodigestive crossroads.

2 The Different Developmental Stages

At birth, the newborn must pass from the liquid atmosphere into the air. The breath goes through the pharyngeal cavities, via the glottis, the trachea, and the bronchi. The alveoli become smooth, and the baby cries for the first time. Then the child starts to suck. The passageway for nutrients from the mouth to the digestive tract depends on the effectiveness and coordination of muscles and on a very precise synchronization (Amaizu et al. 2008).

2.1 The Neonatal Period

At this stage, the baby will coordinate nutritive sucking, swallowing, and breathing.

2.1.1 Sucking

Sucking is an alternation of suction, intraoral negative pressure, and expression/compression, mouthing, or stripping of the nipple by the tongue against the hard palate. The two basic forms are nonnutritive sucking, on a finger or pacifier, and nutritive sucking, when a nutrient is ingested from a bottle or the maternal breast. The sucking pattern evolves. It is immature in preterm infants, consisting primarily of expression/compression. This is followed by the appearance of suction and the progressive establishment of the rhythmic alternation of suction and expression. The sucking pattern of term infants is characterized by the rhythmic alternation of suction and expression/compression. Lau et al. (2000) have demonstrated that the bottle-feeding performance is positively correlated with the development stage of sucking. They used a five-point scale to characterize the infant's oromotor skills. This scale evaluates the presence or absence of suction and rates the rhythmicity of suction and expression/compression in preterm infants (Table 1).

The sucking efficiency can also be analyzed from the ingested milk flow in the preterm infant. It increases significantly between the 34th and 36th weeks' GA, exceeding 7 mL/min with the 35 weeks (Mizuno and Ueda 2003). The same holds for the pressure of suction and its duration. A functional maturation but also a good coordination of the muscle groups is essential. The coordination of the movement of the oromotor structures controls the changing intraoral pressures that occur during a suck cycle. Successful sucking is dependent on intact brainstem pathways and transmission of impulses through the cranial nerves to healthy musculature in the mouth, tongue, and pharynx.

Table 1 The five-point sucking scale (Lau et al. 2000)

Stage	Description
1a 1b	No suction; arrhythmic expression Arrhythmic alternation of suction and expression
2a 2b	No suction; rhythmic expression
	Arrhythmic alternation of suction and expression; sucking bursts noted
3a 3b	No suction and rhythmic expression Rhythmic suction and expression; suction amplitude increases, wide amplitude ranges, prolonged sucking bursts
4	Rhythmic suction and expression; well-defined suction, amplitude ranges decreased
5	Rhythmic, well-defined suction and expression; increasing suction amplitude; sucking pattern similar to that of a term infant

The pace and alternation of suction and expression will vary during the first month of life in the term infant without a disorder. A 1:1 suck–swallow ratio is most frequent (78.8%), and then there will be bursts of two or three sucks for one swallow as if the child has adapted to be more effective (Qureshi et al. 2002). The normal feeding infant is reflexive without suprabulbar input (Stevenson and Allaire 1991). The maturation of nutritive sucking progresses in a caudocephalad way in the brainstem (Bosma 1985). The baby then becomes able to modify these various paces and acquires new food strategies. The reflex behaviors become automatic functions strengthened by voluntary movements.

2.1.2 Breathing

During nonnutritive sucking, the infant swallows only little saliva, and coordination of sucking and breathing is not important to avoid inhalation. The situation is different during nutritive sucking, the alternations between sucking, swallowing, and breathing being closely dependent. To be effective, the newborn must take milk without aspiration, desaturation, or bradycardia. The patterns most frequently encountered are 1:1:1 and 2:2:1 ratios of sucking, swallowing, and breathing (Lau et al. 2003). According to Lau et al., oral feeding difficulties in a preterm infant are more likely to result from a coordination defect between swallowing and breathing than from sucking–swallowing interaction. During nutritive sucking, the newborn swallows during apnea, preferentially at the beginning of the inspiratory phase or at the end of expiration, at low lung volume. However, during the first oral feeding experiments, it can also swallow at the end of inspiration/beginning of expiration or during the inspiratory phase. After 12 months, a swallowing pattern similar to that of an adult is most frequent: a swallow followed by expiration.

2.1.3 Airway-Protective Reflexes

Protection of the airway during swallow is a reflexive, multilevel function consisting of the apposition of the epiglottis and aryepiglottic folds and the adduction of the false and true vocal folds. The fetus is in an all-aqueous environment and can swallow and inhale amniotic fluid. For the newborn, the challenge is to defend the airways from aspiration of liquid during feeding. Laryngeal chemoreflex includes reflexes such as startle, rapid swallowing, apnea, laryngeal constriction, hypertension, and bradycardia. Water or acidic liquids in contact with the laryngeal epithelium trigger these reflexes. The receptors involved are concentrated in the interarytenoid cleft, at the entrance of the larynx. Laryngeal chemoreflex can cause prolonged apnea in infants. But these responses are functional: swallowing removing fluid from the laryngopharyngeal airway and vocal chord constriction combined with apnea preventing aspiration (Thach 2008). As the infant matures, rapid swallowing and apnea become much less pronounced, whereas cough arousal and possibly laryngeal constriction become more prominent. These changes result from the maturation of the central processing of afferent stimuli rather than reduction of sensitivity.

2.1.4 Central Control

The neuromotor function of the child depends on the stages of motor control maturation. At birth, up to 6 weeks before and 6 weeks after the term of 40 weeks' GA, infant motricity is under brainstem control without suprabulbar input. At this stage feeding is reflexive. The functional development of the central nervous system progresses in an ascending way. The synaptogenesis begins around 6–8 weeks' GA. The development of dendrites and synaptic connections is a dynamic process whose maximum development occurs postnatally. The body structure of the neuronal circuitry is more dependent on the movements themselves than on the genetic program (Lagercrantz and Ringstedt 2001; Hanson and Landmesser 2004).

The wiring of the precise neural circuits seems to be dependent on neuronal activity, which could be stimulated either by sensory input or endogenously driven activity. The fetal swallowing movements will thus play a main role in the organization of specific neural pathways. Conversely sucking–swallowing disorders will have a negative effect on the good development of these circuits. As feeding development progresses, basic brainstem-mediated responses come under voluntary control through the process of encephalization, up to 2 years, going down from the cortex to the spinal cord. The sensory feedback of the gustatory and somatoesthesic stimulations gradually modulates the central patterning of lapping, sucking, swallowing, and chewing.

In summary, the neurophysiological control of feeding and swallowing is complex and involves sensory afferent nerve fibers, motor efferent fibers, paired brainstem swallowing centers, and suprabulbar neural input. Close integration of sensory and motor functions is essential to the development of normal feeding skills. Feeding development, however, depends on structural integrity and neurological maturation. It is a learned progression of behaviors. This learning is heavily influenced by oral sensation, motor development, and experiential opportunities. Finally, the basic physiologic complexity of feeding is compounded by individual temperament, interpersonal relationships, environmental influences, and culture.

2.1.5 The Maturation of the Digestive Tract

The neuromuscular development of the gastrointestinal tract appears relatively early during the gestational period, but the ontogeny of the peristaltic coordination depends on digestive tract segments (Dumont and Rudolph 1994). The three esophageal portions do not have same maturation. In the median portion of the esophagus, the proximal part of the smooth musculature is acquired well before term. On the other hand, the peristalsis in the two other areas remains variable in half of swallows at full term if there are no disorders (Staiano et al. 2007). Two types of esophageal peristalsis have been described during the neonatal period (Gupta et al. 2009). The first one is initiated during swallowing, transferring the bolus from the pharynx through a relaxed upper esophageal sphincter into the esophageal segments. This primary peristalsis on the level of the striated muscles is under the control of central pattern generators, whereas for the smooth musculature it depends on interactions between central and peripheral neurological control mechanisms. The presence of this primary peristalsis has been observed as early as 32 weeks' GA in the fetus. The secondary peristalsis is described like an adaptation reflex to the esophageal distension. It is under the control of the vagus nerve. This peristalsis has also been described as early as 32 weeks' GA.

2.1.6 Postural Control

The full-term newborn without a disorder is in discreetly asymmetrical flexion. This passive tonicity associated with the primary reflexes (rooting, grasping) permits the newborn to remain fixed at the breast, thus allowing it to have an effective food catch (Radzyminski 2005). The ability to control the head position is also important in the first few days of life. In the study of Radzyminski (2005), letdown was significantly related to active tone. This is interpreted like an active tonicity allowing the baby to comprehend the exterior surroundings and thus to better manage its feeding with the maternal breast.

2.1.7 Neuroendocrine Control

The presence of an effective sucking–swallowing pattern after birth plays a main role in the feeding of the infant. Several hormones have been described as being fundamental in this control: leptin, already known as an orexigenic hormone, and more recently oxytocin. Schaller et al. (2010) showed the effectiveness of oxytocin in the treatment of feeding disorders in the Magel2-defective mouse (animal model of Prader–Willi syndrome). They hypothesized that oxytocin could be used to treat impaired feeding onset in the newborn.

The maintenance of energy homeostasis requires a balance between intake and expenditure. The alternation of hunger and satiety plays an important role in the regulation of food intake. Smith and Ferguson (2008) have well described the neurophysiology of hunger and satiety, which are regulated by complex central nervous system circuitries. Central feeding circuits are localized in hypothalamic nuclei which communicate with each other and project to an area in the brainstem. The regulation is under the control of hormonal and neural feedback. Gastrointestinal and gustatory feedback are the primary controls of ingestive behavior (Smith and Ferguson 2008).

2.2 From 2 Months to 2 Years

The child's swallowing abilities progress with its neuromotor development (Hedberg et al. 2005). This long period of sensorimotor acquisition, named encephalization time, follows the evolution of the corticobulbar tracts. The reflex becomes a voluntary gesture, then automatic motion. Suckling, tongue motions in an anteroposterior direction, corresponds to the abilities of the 6-month-old infant. The bending axial posture evolves gradually from the supine position to the sitting station. The jaw movement is then free, allowing the acquisition of sucking, upright movement of the tongue. Suckling and sucking are combined between 6 and 12 months. They form the bolus control in the oral cavity preceding chewing. The child evolves from a gross to an increasingly fine motricity, alternative pressure preceding malaxation then chewing. At 2 years, the phase of oral preparation starts to be in place (Table 2).

Table 2 Neuromotor development in an infant

Age	Oral sensorimotor function for feeding	Oral structure	Neuromotor skills	Cognitive and communication skills
1st month	Suckling < latching Incomplete lip closure Nasal respiration Unable to release nipple	Tongue fills oral cavity Relatively small mandible No distinct oropharynx Larynx high in neck	Rooting and grasping reflex Hands flexed across chest during feeding Asymmetrical flexion	Facial expression of fear or pain Differentiates vocal voice from other sounds Recognizes parents' voices
2nd month	Suckling with active lip movement > latching Range of movement for jaw Lip closure improved		Letdown Able to control head position VD: Asymmetrical position DD: Lifts head up at	Smile answer Fixes gaze on an object and follows moving ones too Start of labial consonant and [r]
3rd to 4th month	Introduction of spoon, but nipple feeds only Dissociation of movements of lips and tongue Effective and voluntary control of mouth	Chin tuck does not occur until this time	No more grasping reflex Midline orientation VD: Lifts chest and head up DD: Extended and flexed movements of legs	Incites smile Vocal plays and imitates vocalizations and clicks as "fish sound" and tongue clicks Blows bubbles with saliva
5th to 6th month (transition to feeding by spoon)	Sucking, but suckling pattern prominent Start of weaning Gag reflex on new textures Tongue reversal after spoon removal Teething	Growth of neck Larynx goes down in neck Rhinopharynx closed during swallowing	Can likely roll over Bears weight on its leg Able to sit with support Pulls itself up to a sitting position Holds on to a rattle	Perceives itself as different from its mother Smiles to its image in a mirror
7th to 9th month (cup drinking)	Coordinated lip, tongue, and jaw movements Movement of lateral tongue over solids Gag reflex becomes protective		Sits without support Bounces, pulls itself up, and crawls Mouth used to investigate the environment	Afraid of strangers Jabbers and imitates sounds Waves bye-bye Points
10th to 12th month	Self finger feeding Start of chewing, control of sustained bite Closes lips on spoon and uses them to remove food from the spoon	Tongue posteriorization Growth of vocal tract	Stand holding on to things First steps	Intonational jabber and first words Able to understand simple commands
13th to 18th month	All texture taken Well-coordinated swallowing and breathing Lateral tongue motion Straw drinking		Walk acquired Climb up and down the stairs	Well-coordinated phonation Associates words, simple sentences Emotional instability: Impatient, frustrated when it cannot communicate
19th to 24th month	Swallows with lip closure Up–down tongue movements precise Rotary chewing Independent feeding		Runs and jumps Shoots at balloon Climbs more surely Less likely to fall	Marked equilibrium, added maturity, and calm Symbolic plays Stock lexicon of 200 words, first sentences

Adapted from Arvedson and Brodsky (2001)
VD ventral decubitus, *DD* dorsal decubitus, < less than, > more than

3 Etiologies in Children

Any obstacle in the evolution and the development of this set of complex processes can cause swallowing, feeding, and speech disorders. It is necessary to distinguish sucking–swallowing disorders in the neonatal period from feeding behavior disorders in a young child. Neonatal sucking–swallowing disorders, considering them according to the level of trouble, can be classified from the central nervous system to the peripheral nervous system (Fig. 1). The various impairments can be morphological, functional, or induced by enteral feeding, for example.

3.1 Suprabulbar Lesions

Between the basal nuclei and frontal cortex, the causes are classified as encephalopathy, congenital malformations, perinatal stroke, or asphyxia.

3.1.1 Encephalopathy

(a) Neonatal encephalopathy: Risk factors are maternal thyroid disorders, and placental anomalies more than neonatal asphyxia (Badawi et al. 2005; Nelson 2005). Neuroprotective treatments such as hypothermia would appreciably decrease the risks in newborns suffering from moderate neonatal encephalopathy (Gluckman et al. 2005).

(b) Degenerative encephalopathy: Mucopolysaccharidosis, epileptic encephalopathy, and leukodystrophy.

3.1.2 Congenital Malformations

Gyration abnormalities and agenesis of corpus callosum and of vermis cerebellum are congenital malformations.

3.1.3 Perinatal Stroke or Asphyxia

In the case of cerebral palsy, the prognosis depends on the existence of associated neonatal encephalopathy (Badawi et al. 2005). Most perinatal strokes are not diagnosed during the neonatal period. It is necessary to think of stroke and perform neuroradiological investigations when neurological signs or dysphagia arise during the first few months after birth (Wu et al. 2004).

For Armstrong-Wells et al. (2009), neonatal encephalopathy and seizure are the clinical criteria of symptomatic perinatal stroke. In a study done between 1993 and 2003, of 323, 532 births, they found a prevalence of 6.2 per 100,000 infants.

3.2 Bulbar Lesions

Bulbar lesions cause neonatal sucking–swallowing disorders. They can be classified as follows.

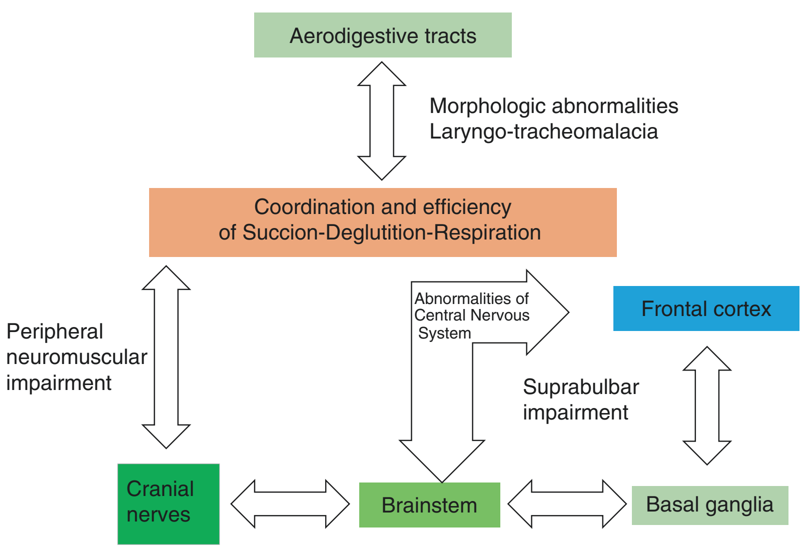

Fig. 1 Summary of various injuries

3.2.1 Neonatal Dysfunctions of the Brainstem

These cause sucking–swallowing–breathing disorders, glossopharyngolaryngoesophageal dysmotricity, and heart rate dysregulation. Neonatal dysfunctions of the brainstem were initially described in children with Pierre Robin syndrome. The metameric organization of the rhombencephalon explains facial malformations associated with failure of cranial nerves (Fig. 2). Moreover, lack of fetal sucking increases the facial dysmorphism observed, such as glossoptosis, microretrognathia, and ogival cleft palate. Other dysfunctions are involved in known genetic syndromes such as Möbius syndrome (agenesis of nerves VI and VII) and Goldenhar syndrome (oculoauricular dysplasia usually affecting one side of the face with microtia and a missing eye).

Sometimes the clinical presentation is not complete "para Robin," with the dysfunction of the brainstem being without palatal anomalies but with typical facial characteristics according to genetic syndromes such as DiGeorge syndrome, microdeletion of chromosome 22 (de Lonlay-Debeney et al. 1997), Kabuki syndrome, and Noonan syndrome, characterized by early eating disorders and a break in the growth curve. Finally, children with CHARGE syndrome (coloboma, heart malformation, atresia of choanae, retarded growth and development, genital hypoplasia, and ear abnormalities or deafness) have durable and complex feeding difficulties. Cranial nerve dysfunction impacts feeding development with weak sucking/chewing, swallowing difficulty, gastroesophageal reflux (GER), and aspiration (Dobbelsteyn et al. 2008).

3.2.2 Clastic

These lesions cause antenatal or perinatal anoxic ischemia of the brainstem.

3.2.3 Malformative

The lesions are visible on MRI and can cause olivopontocerebellar impairments or posterior fossa atrophy. They can cause Arnold–Chiari

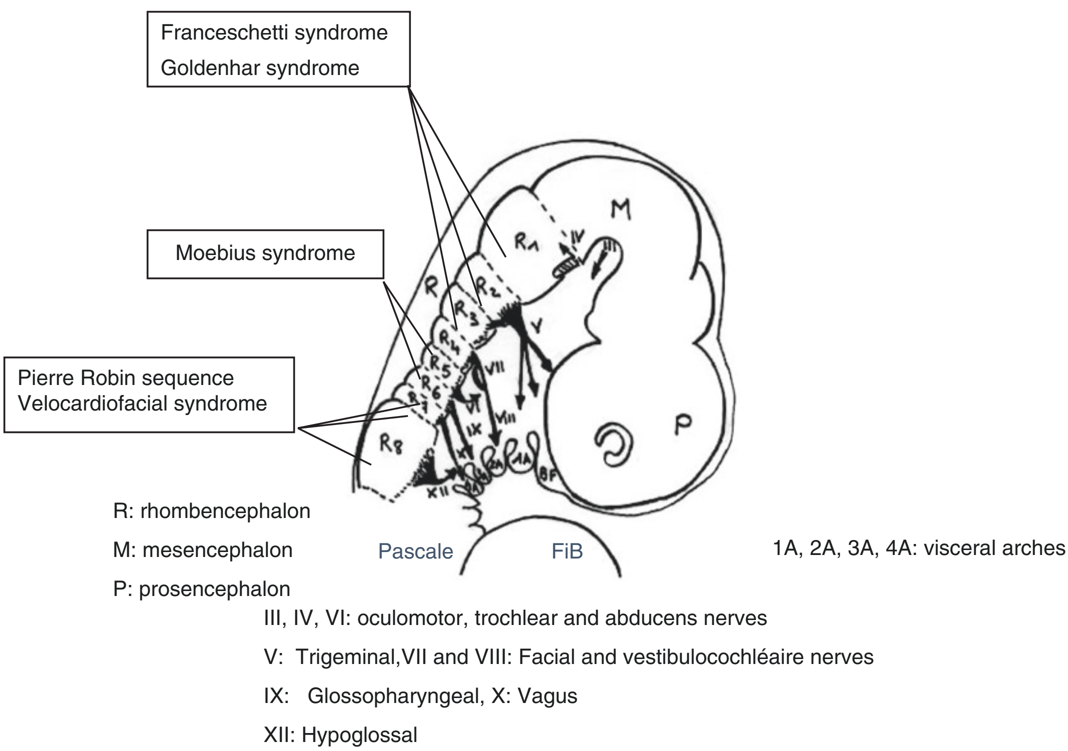

Fig. 2 Rhombomere diagram and cellular emergence of branchial nerves. (From Abadie et al. 1996)

syndrome, occipitocervical malformations (Albert et al. 2010), or Dandy–Walker syndrome, cystic dilatation of the fourth ventricle.

3.3 Peripheral Causes

3.3.1 Neuromuscular Junction or Muscle Impairment

They are often hereditary as in the myotonia of Steinert, or motor and sensory neuropathy.

3.3.2 Upper Respiratory Tract Disease

These diseases contribute to swallowing and breathing disorders. They include laryngotracheomalacia, diastema, and exceptionally laryngeal rhabdomyosarcoma of the larynx (Ferlito et al. 1999). In the case of laryngomalacia, laryngeal tone and sensorimotor integrative function of the larynx are altered (Thompson 2007). Thompson (2007) underlines the worsening role of GER, neurological disorders, and a low Apgar score.

3.3.3 Motility Disorders of the Digestive Tract

(a) GER is often incriminated. An increase of gastric liquid in the esophagus is frequent in healthy children. It is the consequence of anatomical characteristics (reduced length of the diaphragmatic portion and low capacity of the esophagus), diet (exclusively liquid feeding), position (mostly supine position). However, if pharyngitis is associated with inflammation of the esophagus or worse acid aspiration, this GER becomes pathological. The North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition and the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition have published guidelines for evaluation and management of GER (Vandenplas et al. 2009). The reflux is associated with upper airway symptoms in children. But from a review of the literature, the correlation and the risk of upper airway symptoms attributable to GER are difficult to determine (Rosbe et al. 2003). However, the presence of laryngopharyngeal reflux and respiratory symptoms may indicate the need for antireflux therapy (May et al. 2011).

(b) Esophageal transit disorders: A defect of contraction, an esophageal dyskinesia, a faulty upper esophageal sphincter relaxation, or a desynchronization of opening can be the origin of swallowing disorders with aspirations. An esophageal atresia is to be searched for in a systematic way. It is frequently associated with a tracheoesophageal fistula. Esophageal atresia and tracheoesophageal fistula are congenital malformations that occur in one in 3500 births. The association is a multifactorial complex disease that involves genetic and environmental factors (de Jong et al. 2010).

(c) Finally, a delay in gastric emptying can support backward flows and can impact on hunger–satiety balance.

3.3.4 All Morphologic Abnormalities from the Oral Cavity to the Stomach

Oropharyngeal lymphangiomas, cysts of the tongue, and facial clefts can be observed in the upper aerodigestive tract. At the level of the esophagus and stomach, one can encounter tracheoesophageal fistulas, esophageal atresia, and stricture (Castilloux et al. 2010; Till et al. 2008; Prasse and Kikano 2009). Microgastria, which will require exclusively enteral feeding, can also have long-term repercussions for the sensorimotor development of the aerodigestive tract.

3.3.5 Food Allergy and Sucking–Swallowing Disorders

These are encountered in an exceptional way as recalled by Abadie (2008). However, in the older child some can be the origin of eosinophilic esophagitis inducing vomiting and food blocking (Abu-Sultaneh et al. 2010).

3.3.6 Induced Causes

These are multifactorial complex diseases involving environmental factors and consequences of the initial pathology. They follow from the lack of neonatal oral experimentation, with the traumatizing effect on the aerodigestive tract from suction probes, intubation, and an enteral feeding tube. Moreover, the mode of continuous enteral feeding or exclusive parenteral feeding will have noxious effects on the acquisition of pace by the child and in particular that of hunger–satiety. Finally, major disturbances in the link between the mother and child with an often traumatizing birth, an obligatory more or less long separation, and the impossibility for the mother to play her life-sustaining part are worsening factors. This is why most dysphagic infants had difficult perinatal antecedents, including prematurity (Salinas-Valdebenito et al. 2010).

3.4 The Young Dysphagic Child

All the causes previously mentioned can be encountered as can anorexia and feeding disorders as described in the following sections.

3.4.1 The Common Anorexia of Opposition in the Second Half of the Year

Anorexia arises in the first 3 years of life, most commonly between the ages of 9 and 18 months, as infants become more autonomous and make the transition to spoon feeding and self-feeding. The following are often found to have occurred: a traumatic event, aspiration during a mouthful, an infectious episode, especially as it required hospitalization, and a change in the child's life and its relationship with its mother (e.g., family death). The meal time is then marked by anxiety, the child is opposed to any attempt at spoon feeding, whereas often a feeding bottle is accepted just as drinking from a glass. The lack of interest in food contrasts with strong interest in exploration and interaction with caregivers. The child remains joyful, plays, and stays awake.

3.4.2 Severe Form of Infantile Anorexia

Children with infantile anorexia have an anxious neurosis, depression, or even maternal deprivation. The baby can only express its suffering through its body. Food refusal is accompanied by other signs, such as loss of contact, avoidance, irritability, sleep disorders, vomiting, and ruminations, which will worsen nutritional repercussions (Thouvenin et al. 2005). Failure to thrive is often associated with poorer cognitive development, learning disabilities, and long-term behavioral problems. Chatoor et al. (2004) described the importance of distinguishing between nonorganic forms of growth deficiency related to maternal neglect and growth deficiency that is related to dyadic conflict during feeding. They suggested that the concern for the nutritional needs has to be balanced with the management of feeding difficulties in young children.

3.4.3 Autism Spectrum Disorders

Although not revealing, anorexia or another feeding disorder is very frequently encountered in invading neurobehavioral alterations (Nicholls and Bryant-Waugh 2009).

3.4.4 Feeding Disorders

These involve problems in a range of eating activities that may or may not be accompanied by swallowing difficulties. These disorders may be characterized by disruptive mealtime behavior, rigid food preference, or food refusal:

(a) Pick eating: One can think of this as a child cherry picker who selects and eats only very modest amounts. There is no attachment disorder and the nutritional repercussion remains mild.
(b) Food phobias with behavior disorder: Selection of a color or an exclusive consistency, or the need to sniff at food before putting it in the mouth. They can also be the expression of an infantile neurosis beginner.
(c) Pica: Children who swallow in addition to foodstuffs nonnutritive substances such as stones and paper. This feature can be seen in a specific way between the ages of 9 and 12 months, and is then not pathological. On the other hand, it becomes abnormal if it continues, and is often associated with backwardness or behavior disorders in certain genetic syndromes such as Prader–Willi syndrome and also in autism spectrum disorders.

3.4.5 The Dyspraxia of Feeding

This is encountered in children with specific language impairments, oromotor dyspraxia, and during meals, difficulties in bolus formation.

Tongue movement and chewing are limited. The child is described as a whole-food swallower when given mixed textures.

4 Assessment and Treatment of the Child with Swallowing Disorders

Diagnosis and treatment will be different if it concerns a newborn in a neonatology intensive care unit or a young child having already experienced oral feeding.

In the first case, it is necessary to be able to answer three main questions:

1. When should oral feeding be proposed?
2. What stimulations support a good maturation of oromotor abilities?
3. How can the functional consequences for food and verbal acquirements be avoided?

For the young dysphagic child, there will also be an etiologic diagnosis of the disorder, and an analysis of its consequences for feeding, hydration, and nutrition and the pulmonary repercussions. The evaluation must be able to inform about:

- The symptoms of the disorder and its evolution
- Whether or not there is an association with other dysfunctions and integration in a neurological or syndromic clinical presentation
- The somatic and psychogenic part of the feeding disorder (Abadie 2004).

4.1 The Premature Baby and the Infant in the Neonatology Service

The realization of the noxious effect of unfavorable surroundings on the morbidity of premature babies led to the installation of a newborn individualized developmental care and assessment program (NIDCAP) in most neonatology intensive care units. This program aims at limiting stress by controlling the extraneous auditory, visual, vestibular, and tactile stimulations. It is achieved by putting the child in the fetal position with a soft application, with supporting presence of the two parents (mini isolated rooms). Its positive effects in the short- and long term were objectified by many studies (McAnulty et al. 2009; Symington and Pinelli 2001; Ullenhag et al. 2009).

The premature baby is deprived of sensory stimulations normally tested by the fetus during the third quarter of pregnancy. They are replaced by noxious stimulations in the form of probe introductions such as intubation, suction, or enteral feeding tubes. To propose early positive stimulations of the oral sphere seems to be essential, as mentioned by Lapillonne (2010), but which ones can be proposed? Promoting breastfeeding as soon as it is possible seems to be most suitable for premature babies. It is necessary, however, that the preterm infant has the capacity to manage this. Acquiring a safe and efficient swallow and the capacity for oral feeding of infants in neonatology intensive care units are some of the prerequisites for the reduction of the consequences of the hospitalization. Safe swallowing is conditioned by sucking–swallowing–breathing coordination avoiding aspirations while allowing proper ventilation.

For the preterm infant, the principal difficulty is the integration of breathing in an already delicate sucking–swallowing pattern. Moreover, the respiratory condition is often precarious especially if it is associated with bronchodysplasia. Gewolb and Vice (2006) compared two cohorts of infants born between 26 and 33 weeks' GA. In the group with bronchodysplasia, they found a clear immaturity of acquisition and a greater incoordination of sucking, swallowing, and breathing.

The second difficulty is for the weary baby feed efficiently in a short time (about 20 min and no more than 30 min). Indeed the purpose is to feed so that the infant consumes sufficient volumes to gain weight appropriately. The transition from tube to oral feeding in the preterm infant depends on the teams. For some, any premature baby can manage the transition even for very tiny quantities. This is used in the "Kangaroo Mother Care", a continuous skin to skin contact, which includes thermal care, supports for breastfeeding and for early recognition and response to illness. The ability to make the transition from gavage to oral feeding depends on neurodevelopmental status, which is related to behavioral organization, cardiorespiratory regulation, and the ability to produce a rhythmic sucking–swallowing–breath pattern (Delaney and Arvedson 2008). The readiness of the infant for oral feeding may differ (Nyqvist et al. 2001; Delaney and Arvedson 2008; Lau et al. 2000).

4.1.1 The Different Means of Evaluation

(a) Morbidity assessment: This involves the awareness of the general state of the child according to the neonatal medical index, which has five stages, stage 1 being a baby without an intercurrent medical problem and stage 5 concerning serious complications. The birth weight and not the term are also part of the score. Delaney and Arvedson (2008) mentioned that it is important to differentiate "premature by date" from "premature by weight," for which the latter already has an important perinatal morbidity.

(b) Behavioral assessment: According to the NIDCAP, the reactions of premature babies can be staged in keeping with five behavioral subsystems: autonomic, motor, state regulation, attention, and self-regulation or regulatory system. Assessment of the infant's current functional competence and state of equilibrium determines if it is possible or not to propose oral feeding or oral stimulations. The infant must be either calm, awake, and in a stable cardiorespiratory state.

(c) Sucking behavior assessment: Some authors have linked oral feeding abilities with an effective nonnutritive sucking (Pinelli and Symington 2001). Others have shown that it is the oral feeding experimentation which improves the sucking capacities (Pickler et al. 2006). During nutritive sucking, two patterns exist, a continuous sucking and an intermittent sucking stopped by breathing. The continuous sucking, which is more common at the beginning of feeding, represents a long single sucking burst. Sucking does not automatically initiate swallowing. The preterm infant which has a respiratory rate from 40 to 60 inspirations per minute cannot have too frequent swallowing under penalty of interference with breathing. In a study of 88 preterm infants, Pickler et al. (2006) noted that experience in oral feeding may result in rapider maturation of sucking characteristics, increasing very quickly the numbers of sucks, sucking bursts, and the sucking rhythm. For them it is especially the infant's level of arousal and the neonatal medical index which will condition the possibilities of oral feeding, more than the capacities for sucking–swallowing–breathing coordination. Other authors prefer proposing oral feeding only when sucking–swallowing and breathing are well coordinated (Delaney and Arvedson 2008; Lau 2007).

For breastfed infants, Nyqvist et al. (1996) proposed an assessment using the preterm infant breastfeeding behavior scale. This scale evaluates the reflex activities (rooting, grasping), sucking, and swallowing. It also considers the number of sucks and sucking bursts. It considers, under the term "behavior," the awakening of the child, the influence of the surroundings, and the maternal behavior. Thoyre et al. (2005) described a method based on the assessment of early feeding ability of preterm infants. The ability is evaluated according to 36 items gathered in three domains: oral feeding readiness, oral feeding skills, and oral feeding recovery. The items require yes/no answers or rankings from 1 to 4 (Table 3).

(d) Surface electromyography. This is a noninvasive objective method for evaluating the muscle activity during oral feeding. Nyqvist (2008) recommends coupling it with observation of mouthing and sucking bursts and the trains of sucks to evaluate the infant's competencies during breastfeeding. The electrodes in this study were placed on orofacial muscles (orbicular, mylohioid, geniohyoid, stylohyoid, and digastric) and on pharyngeal muscles. Gomes et al. (2009) in a review of the literature underlined the significant role of the masseter muscle during breastfeeding. The feeding bottle was not tested in this study.

4.1.2 Management

(a) To support nonnutritive sucking: The observation that babies intubated orally maintained their sucking capacity and even sucked the intubation tube led many neonatology intensive care units to propose in a quasisystematic way the use of a pacifier (Delaney

Table 3 Oral feeding readiness, skill, and recovery—example of items (Thoyre et al. 2005)

Oral feeding readiness				
Able to hold body in a flexed position with arms/hands toward midline	Yes	No		
Demonstrates energy for feeding, maintains muscle tone and body flexion through assessment period	Yes	No		
Oral feeding skill				
Ability to remain engaged in feeding				
Predominant muscle tone	Maintains flexed body position with arms toward midline	Inconsistent tone, variable muscle tone	Some tone consistently felt, but somewhat hypotonic	Little or no tone felt; flaccid, limp most of the time
Ability to organize oral–motor functioning				
Opens mouth promptly when lips are stroked at feeding onsets	All	Most	Some	None
Once feeding is under way, maintains a smooth rhythmic pattern of sucking				
Ability to coordinate swallowing and breathing				
Able to engage in long sucking bursts (7–10 sucks) without behavioral stress signs or an adverse or negative cardiorespiratory response				
Ability to maintain physiologic stability				
In the first 30 s after each feeding onset, oxygen saturation is stable, and behavioral stress cues absent				
Stops to breathe before behavioral stress cues appear				
Clear breath sounds; no grunting breath sounds (prolonging the exhale, partially closing glottis on exhale)				
Oral feeding recovery (during the first 5 min after feeding)				
Predominant state	Quiet alert	Drowsy	Sleep	Fuss/cry

and Arvedson 2008). Nonnutritive sucking is a motor reflex activity which will make it possible to improve the capacity to control and coordinate nutritive sucking. A pacifier is proposed for any premature infant of more than 28 weeks' GA.

(b) To treat the infant by taking account of its level of vigilance of its physiological state of stability or instability according to the NIDCAP: The infant is allowed to regain the quiet state by keeping it in a flexed position during the transfer time and bringing its hands back to the middle of the body near the mouth to help the self-regulation. The infant should be calm before nutritive sucking is attempted. Clinicians and caregivers have to structure and adapt the care and interaction to enhance the infant's own competencies and strengths, to prevent the infant being in pain, stress, or discomfort.

(c) To facilitate oral feeding: Many authors think that the systematic proposal of breastfeeding or bottle feeding is the most effective stimulation and that other sensitive stimulations are not necessary (Thoyre et al. 2005; Pieltain et al. 2007; Nyqvist 2008; Ullenhag et al. 2009). Facilitating means to mitigate the inefficiency of sucking having been proposed such as the feeding cup or using soft or perforated pacifiers. It is then necessary to be wary of too fast a flow, which may incur risks of inhaling and shock. This is why Lau and Schanler (2000) advise the use of a "vacuum-free bottle." For them, self-paced milk flow seems the technique most suitable for use with preterm infants. Delaney and Arvedson (2008) described the transition between enteral and oral feeding as difficult for the preterm infants of less than 32 weeks' GA because of neurological immaturity and cardiorespiratory instability.

(d) To complement feeding by parenteral feeding: Pieltain et al. (2007) described the importance of early efficient feeding, as in the first few days of life, in low-weight premature infants. This is "aggressive feeding," i.e., rich in protein. The high proteinic contribution makes it possible to preserve the low weight of these infants and to limit their insulin resistance. Lapillonne (2010) prefers the term "optimal feeding." The aims of preterm management are multiple and are to improve the growth and its quality, to preserve the cerebral, neurosensory, and pulmonary development, and to mitigate digestive diseases dominated by ulceronecrotizing enterocolitis and GER disease.

Oral feeding, because of great neuromotor immaturity, often causes stress and increases the state of agitation and suffering of these fragile babies. In all cases, early clinical assessment and management of sucking–swallowing is one of the priorities. In this way, the long-term complications could be decreased as described by Buswell et al. (2009) in a cohort of preterm infants whose food functions were evaluated at 10 months of corrected age.

4.2 The Young Child

Assessment of infants and children with dysphagia and feeding disorders involves an interdisciplinary evaluation (Arvedson 2008). These disorders are multidetermined and need a multiaxial diagnosis. The interdisciplinary feeding/swallowing team approach allows optimal management decisions and understanding of health conditions and specific issues (Arvedson 2008). The parents are imperatively involved and so are the child's caregivers. The anamnesis locates the disorder in the family context and the setting of the meal. Knowledge of the oral history of the child is essential to specify the origin of the disorder in its food and neurophysiological development.

When should a specific evaluation be requested? It will be systematic when personal autonomy during meals is impossible; this is the case for children with cerebral palsy or multiple disabilities. It is also the case for young patients with a disease with a high risk of feeding and swallowing disorders, e.g., in a genetic syndrome and in brainstem or cerebellum impairments.

A specific evaluation is necessary when the duration of feeding is abnormally prolonged, when mealtimes are stressful, and when there is increasing irritability of the child or on the contrary lethargy.

Food refusal might be diagnosed if there is any somatic cause.

Finally, vomiting, nasal food reflux, respiratory signs during or after meals, and frequent bronchopulmonary infections must also alert the physician to the need for a specific evaluation.

One is frequently confronted with a child who either does not chew or does not accept pieces of food during food diversification.

How should the child be approached? From 0 to 2 years, it is necessary for the child to be closest to its usual situation. The friendly evaluation takes place during a meal or in a play context: grimaces resulting from mouth and vocal plays, linguistic situations adapted to its developmental age.

After 2 years, it is then possible to perform a morphological and dynamic evaluation of the child's oral functions and its swallowing, but before an examination of the mouth is undertaken, the child must have confidence in the physician.

4.2.1 Assessment Process

The assessment of infants or children with signs of feeding or swallowing disorders includes first the anamnesis reviewing family, medical, developmental, and feeding history and then physical examination and swallowing evaluation. In some cases other diagnostic tests may be required:

1. The anamnesis: The findings of interviews of parents, medical and educational professionals, and caregivers specify the reason for the evaluation, the complaints, and the repercussions of the disorder. The taking of the anamnesis appreciates the medical and psychological context.
   (a) Grounds for evaluation: The most frequent difficulty for infants is a sucking–swallowing incoordination noticed by parents or caregivers. Bottle feeding or breastfeeding is slow and hard, often interrupted by the child crying. This also applies to weak suction, the baby sucking with difficulty and often stopping. A long period of apnea during feeding can be observed too. This is more alarming if all these signs are associated with hypoxia and bradycardia, implying oral feeding should be stopped. Oral or nasal regurgitations as well as episodes of cough at the time of the meals are often signs of a protective reflex from aspiration. Less specific signs are food refusal and prolonged feeding duration. Slow weight gain or worse weight loss is often one of the signs of the nutritional repercussion of a swallowing disorder. This evaluation may also be required to survey a disease with a risk of swallowing disorders such as a Pierre Robin sequence or cerebral palsy. Finally, the occurrence of repeated bronchopulmonary infections or severe asthma should lead one to suspect the existence of chronic aspiration.
   (b) The feeding history summarizes the main steps and in particular weaning and specifies on which consistencies the disorder depends, its degree of severity, and its constancy with time. It also reflects the parents' difficulties to feed their child.

Assessment of the impact of feeding defines the consistencies given to the child and specifies for liquids if they should be water, milk, and fruit juice and for pasty consistencies if they should be compotes or dairy produce. Does the child take semisolid foods such as blank or rice pudding? Does it accept soft solids (fruit cocktail) or tough solids (cookies and meats)? The symptoms, medical context, and evolution of the disorder are correlated with the oral-food trainings. The functional repercussion on the feeding makes it possible to envisage the upcoming risks. Limme (2011) stressed the importance of food diversification in the development of the masticatory function. This will allow the harmonious growth of the jawbones and the dentoalveolar structures.

It is also important to specify if it is or was necessary to resort to enteral, parenteral, or ancillary feeding

2. Medical and developmental history can yield possible clues to the causes of dysphagia, in particularly prenatal birth, a genetic syndrome, and a neonatal accident.
   (a) Physical examination: As Arvedson (2008) says, this is the prefeeding assessment.
      - Assessment of nutritional impact notes the somatic growth patterns, in particular weight, height, and body mass index curves as well as the occipital frontal circumference and thoracic circumference (Lapillonne et al. 2011; Thibault et al. 2010). So recalled by Amiel-Tison (2005), "Increase in the volume of skull is particularly dramatic in the second part of gestation and the first 6 months of the life." A stagnation or a failure of growth is the unquestionable sign of a repercussion on good cerebral development. The thoracic circumference is a notable marker of the nutritional status of the child.
      - Assessment of cardiopulmonary state: For the infant, bronchopulmonary infections and asthma are often markers of the repercussion of the dysphagia. But sometimes they can also be nasopharyngitis blocking the possibility of feeding. Moreover, one cardiopulmonary dyspnea interferes with the synchronization of breathing and swallowing and can be the cause of aspirations. This assessment is made to note deviations from normal expectations, in particularly respiratory patterns such as breathing rate at rest and

during effort. Can the child breathe by nose and by mouth?

- Observation of developmental anomalies directed toward a genetic diagnosis. The developmental anomalies can be an epicanthus for the eyes, a low implantation of the ears or abnormal lobules, or the characteristic form of the upper lip in Prader–Willi syndrome. In the same way, systematic observation is required for anomalies of the palmar folds, hands, feet, fingers, and toes. "Café au lait spots" will suggest a neurofibromatosis.
- Neurodevelopmental examination: A semiological analysis according to the age and the neuromotor skills is essential. It can follow the scale of Amiel-Tison et al. (2005) or the Gesell stages in the revised test of Brunet-Lézine.

The observer notes the child's behavior and its spontaneous motility in resting posture and during interactions with its parents. The observations include the position, movement patterns, asymmetry or the stiffness of posture, response to sensory stimulation, temperament, and self-regulation abilities.

Then the examination of the child is performed in a dual situation, with the child lying on its back until 6 months of age or sitting on the examination bed or on the knees of a parent if it needs further reassurance. The physical examination appreciates axial and segmentary tonicity, proximal and distal muscle strength, and Babkin and jerk reflexes. Finally, the clinician should focus on cranial pairs V, VII, IX, X, and XII.

(b) Oropharyngolaryngeal structure and function assessment

- The oral examination must analyze the anatomical structures, the muscular functions, and symmetry at rest and in movement of the oral cavity and the face. The aspect of the lips, the jaw, the tongue position, and the shape and height of the palate are significant components that should be observed. In the infant, oral reflexes (rooting, gagging) and nonnutritive sucking have to be noted. In general, laryngeal function is noted by voice quality.
- Instrumental evaluation of swallowing: The visualization of oral, pharyngeal, and upper esophageal phases of swallowing is performed with fiber-optic endoscopic evaluation of swallowing and a videofluorosopic swallow study. Arvedson (2008) advocates the use of ultrasonography too. Although ultrasonography is not used routinely, it provides useful data on the temporal relationships between movement patterns of oral and pharyngeal structures in the fetus, infant, and child during swallowing (Miller et al. 2003; Bosma and Hepburn 1990; Fanucci and Cerro 1994).

Fiber-optic endoscopic evaluation of swallowing makes sure there is no morphologic or dynamic abnormality (Hartnick et al. 2000). The attempt to swallow is not always easy before 2 years of age, being dependent on the anatomical characteristics of the pharyngolarynx and the need to keep the rhinopharynx free. However, according to Sitton et al. (2011), it is practicable very early, as early as 3 days of life.

Sitton et al. (2011) propose collecting in a systematic way the outcomes of this analysis by specifying, according to textures, the level of release, and the existence or not of penetration and aspiration. Temporal relationships of the different events and the efficiency of the mechanisms of expulsion are also noticed. It is a useful examination to visualize with the parents the pharyngolaryngeal structures, as well as to define some aspects of pharyngeal swallowing of secretions and food. The objective aspects of swallowing are noticed together, allowing the best following of oral feeding recommendations.

A *videofluoroscopic swallow study* allows visualization of the oropharyngeal and esophageal transit. It can be realized on very young children by respecting a suitable placement (Figs. 3 and 4). The irradiation must obviously be controlled using reduced fields and short periods of radioscopy. The study provides information on the dynamics and the temporality of the various events of swallowing. It permits one to check the postures and adjustments of texture to avoid aspiration and to facilitate oropharyngeal transit.

Fig. 3 Installation during videofluoroscopy

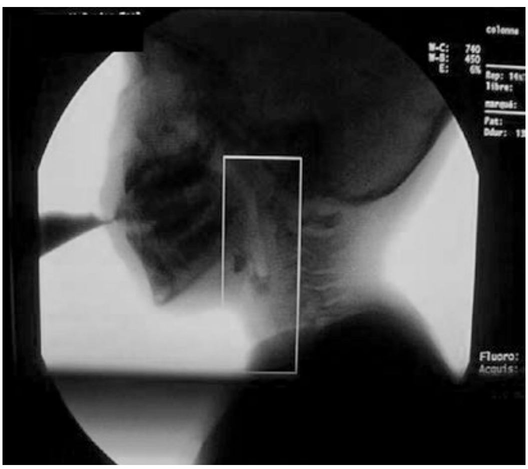

Fig. 4 Installation during videofluoroscopy

In all cases, a functional suction must always be available in case aspiration occurs. In infants, the observer notes the sucking efficiency. The movements of the jaws and the tongue are correlated to the neurodevelopmental level of the child. Pharyngeal time is analyzed as in the adult by considering the synchronization and the efficiency of the protection mechanisms and expulsion in the case of penetration. Arvedson (2008) proposes relating videofluorosopic swallow study findings to various swallowing disorders (Table 4). But it must be remembered that this examination captures only a brief window in time and does not simulate a real meal, and that is why it must be coupled with an observation of a meal.

3. Feeding observation: Observation of the child during meals allows one to collect useful information about eating and drinking (Table 5). Various observation grids can be used, such as the schedule for oral motor assessment (SOMA) (Reilly et al. 1999) and the nursing child assessment feeding scale (ratings of cognitive-growth fostering during meals) (Barnard 1978). The observation of feeding is made with a familiar feeder as typically as would be done with the child at home. The interactions between the parent and the child and positions adopted during feeding are observed. Food consistencies must be varied, starting with those which are usual and best controlled by the child. The child is observed for specific aspects of oral sensorimotor skills and the way of swallowing, in particular if multiple swallows are necessary to clear a single bolus. This feeding observation allows one to adjust the diagnosis and list the necessary adaptations.

(c) Other diagnostic tests are sometimes useful; for example, it is necessary to refer the child to a psychiatrist when the child

Table 4 Videofluorosopic swallow study findings for various swallowing disorders

	Radiographic finding	Possible common swallowing disorder
Bolus formation	Loss of food or liquid from mouth	Loss of lip closure
	Material in anterior sulcus	Loss of lip tension or tone
	Material in lateral sulcus	Loss of buccal tension or tone
	Material pushed out with tongue	Tongue thrust, loss of tongue control
	Limited/immature chewing	Loss of jaw and tongue control
	More than three sucks per swallow	Loss of suck strength or coordination
Oral transit	Searching tongue movements	Apraxia of swallow, loss of oral sensation
	Forward tongue to move bolus	Tongue thrust
	Material remains in anterior sulcus	Loss of lip tone and tongue control
	Material remains in lateral sulcus	Loss of tongue movement or strength
	Material remains on tongue	Loss of tongue movement or strength
	Material remains on hard palate	Loss of tongue strength, or high and narrow palate
	Limited tongue movement	Loss of tongue coordination or disorganized AP movement
	Tongue–palate contact incomplete	Loss of tongue elevation
	Oral transit > 3 s	Delayed oral transit
Pharyngeal phase initiation	Material in valleculae, preinitiation	If brief, no delay in pharyngeal initiation
	Material in piriform sinuses, preinitiation	Delayed pharyngeal initiation
	Material in/on tonsil tissue	Tonsils blocking bolus transit, delayed pharyngeal initiation
	Material on posterior pharyngeal wall	Delayed pharyngeal phase initiation
Pharyngeal phase	Nasopharyngeal backflow/reflux	Loss of velopharyngeal closure or of UES opening
	Penetration to underside of superior part of epiglottis	Incoordination or loss of pharyngeal contraction
	Penetration into airway entrance	Loss of closure of airway entrance
	Residue after swallows in valleculae	Loss of tongue base retraction
	Residue in piriform sinuses	Loss of pharyngeal contractions or of UES opening
	Aspiration before swallow	Delayed pharyngeal swallow initiation
	Aspiration during swallow	Unilateral vocal fold paralysis, incoordination
	Aspiration after swallow	Reduced pharyngeal pressure
	Residue in pharyngeal recesses which may be cleared or not cleared with the next swallow	Loss of tongue base retraction or of pharyngeal contractions or loss of UES opening
Upper esophageal phase	Slow bolus passage through UES	UES prominence, loss of UES opening, reduced pharyngeal pressures may contribute
	Residual on or in UES	Structural abnormality or UES opening
	Retrograde bolus movement from esophagus to pharynx or from the lower to the upper esophagus	Esophageal dysmotility, structural abnormality

Adapted from Arvedson and Lefton-Greif (1998)
AP anteroposterior, *UES* upper esophageal sphincter

Table 5 Examples of observations that may relate to cranial nerve function according to Arvedson and Brodsky (2001)

Cranial nerve	Input	Normal answer	Overdrawn answer
V	Food on the tongue	Chewing	Bolus not formed
VII	Sucking Food on the lower lip Smile	Labial gripping Labial closing Labial retraction	Labial incontinence Limiting or asymmetry of moving Incomplete
IX and X	Bolus into posterior part of the oral chamber	Swallowing reflex initiated in less than 2 s	RDTP or no initiation
XII	Food on the tongue	Refinement of the apex and protrusion	Miss lateral contraction, of rise atrophies

RDTP- Delayed pharyngeal phase initiation

has signs of a feeding disorder more prominent than swallowing disorders. Neurological, cardiopulmonary, and gastrointestinal functions often have to be explored by specialists.

An interdisciplinary approach with professionals across specialities communicating with parents and caregivers is important. This comprehensive assessment has to include the World Health Organization concepts (WHO 2001), involving information related to participation (society level), activities (person level), and impairment (body function level). Management and decisions will be made taking into account:

- Oral sensorimotor and swallowing deficit
- Nutrition status
- Interactions between parents and the child
- Medical and neurodevelopmental status.

4.2.2 Decision Making and Management

At the end of the assessment process, the most important question is: Can this child drink and eat without risk? Then if it can do so, other questions are: What consistencies, what volumes, and what adaptations are possible?

The neurological examination evaluates the central and peripheral tools necessary for oral feeding.

The evaluation of the developmental stage of the child specifies its capacities for training and its oral, feeding, and speech skills.

The oro-facial examination and instrumental swallow examination define the child's physiological swallowing status.

Finally, the examination delineates underlying causes and diagnoses because treatment will differ according to history, current status, and possible evolution.

The different treatment approaches include oral motor exercises, mealtime adaptations, and feeding adaptations:

(a) Oral motor exercises: Active exercises are used to increase strength and endurance and modify muscle tone by inhibiting or eliciting stretch reflex. Slow stretching reduces muscle tone and quick stretching increases it.

Passive exercises are applied to provide sensory input. They may include tapping, vibrations, and massage. They might reduce abnormal oral reflex such as biting reflex or gag reflex.

Sensory applications may be used to enhance a swallow response and to increase closure of the lips.

Arvedson et al. (2010) emphasize that a treatment exercise should closely parallel the desired task and that "age matter" and "time matter" have implications for the timing of intervention. The exercise protocol will depend on the developmental stage and skills of the child.

(b) Mealtime adaptations: The goal is to increase comfort, security, and pleasure. "Successful oral feeding must be measured in quality of meal time experience with best possible skills while not jeopardizing a child functional health status or the parent–child relationship" (Arvedson 2008). The adaptations concern posture and position, adapted equipment (spoons, glass, etc.), and broad adaptations (quiet conditions, no TV or too much noise, etc.).

(c) Feeding adaptations: These may concern the taste, consistency, texture, and temperature of food and liquid. It is also useful to schedule meals and to respect mealtimes to facilitate hunger. Otherwise, ancillary feeding is sometimes required.

Indications depend on clinical observations: Abadie (2008) proposed the following classification:

- Sucking disorder
- Swallowing disorder
- Velopharyngeal dysfunction
- Ventilation disorder
- Disorder of sucking–swallowing coordination
- Feeding disorder
- Oral dyspraxia.

For the organization of management plans with parents and caregivers, it seems more relevant to us to separate the various disorders encountered into:

- Child who does not know how to; this is like a maturation disorder.
- Child who cannot; this is a secondary disorder.
- Child who does not want to; this is a behavioral disorder.

Specific therapies are as follows:

(a) Child who does not know how to: The child does not know because of a shift of acquisition or impossibility to train the infant in the case of prematurity, dysmaturity, or lack of training. For example, in the case of tracheotomy, the larynx is deprived of sensory stimulation and the coordination of swallowing and respiration can be lost. For enteral feeding, it may be the oral sensorimotor skills that are not trained and the lost of hunger feeling. It is necessary to stimulate the oral sensorimotor skills and psychological maturation. The child has to find again pleasure in suction and the sensation of hunger to avoid refusing food.

(b) Child who cannot: The child cannot do because of a genetic syndrome or malformations. In the foreground are neuromotor disorders, which of are central, peripheral, or muscular origins. According to the lesional level, there might be weak suction or a lack of sucking reflex. Feeding duration is prolonged, often associated with drooling, delayed initiation of pharyngeal swallow, and penetration (Table 5). There can also be craniofacial anomalies with midline defects such as cleft palate or oropharyngeal tumor such as lymphangioblastoma. In this case, the oral phase of swallowing is generally disturbed and may result in airway obstruction, requiring a tracheotomy. Finally, gastrointestinal tract disorders including motility problems may contraindicate oral feeding and sometimes even enteral feeding. Without appropriate stimulations, the child will not be able to perform the necessary experiments for a harmonious oral construction. So it may secondarily have a faulty knowledge skill. The treatment consists in adaptational strategies to counteract the neuromotor dysfunction or anatomical anomalies.

(c) Child who does not want to: The child does not want to eat, or to test other textures or tastes. This is rather a feeding disorder. The child swallows correctly but not for a long time, as if it were very quickly satisfied. The child refuses to continue by clamping its mouth shut and turning its head away when the spoon approaches its mouth. Sometimes it may vomit purposefully. The meal is then stopped. Oral intakes remain insufficient. This may induce fractionation meals which can worsen GER. After 6 months, it is essential in a healthy child to maintain almost 3 h between each meal. In older children, solid food refusal can occur for a variety of reasons, including but not limited to airway or gastrointestinal tract factors, oral sensorimotor deficits, and disordered parent–child interactions. The distinction has to be made between an early feeding problem possibly amenable to education and an entrenched eating disorder requiring systematic diagnosis and treatment. A compartmental therapy is indicated for the child and its parents. Throughout meal sessions, the therapist points out to the parents the behaviors that can reinforce food refusal. As described by Borrero et al. (2010), these can include attention (coaxing, threats, praise, reprimands, etc.), escape (spoon or drink removal, allowing the child to leave the table), and tangible delivery (switching to a previously consumed food, to a drink following food presentation, etc.). The child trying new textures and tastes during playtime is indicated.

Swallowing and feeding disorders in a child, from sharing the direct impact on the nourishment function of the parents, will have repercussions on the parent–child relationship. A holistic assessment and management of these disorders cannot be done without the collaboration of the parents. This assessment involves considerations of the broad environment, parent–child interactions, and parental concerns. To be interested in dysphagia in children is to consider the child with its difficulties in its family circle and social environment. It is essential to enable the child to progress as well with the eating plan as in its socialization (Fig. 5).

The first support will be psychological support. The part of the interdisciplinary team is very important:

- To explain to the parents the swallowing disorder and the difficulties their child has
- To help them be more confident about their own capacities to manage these difficulties
- To reassure them and to trust in their child's competencies.

Then there will be educational support: they have to learn adaptational strategies, position, and broader-based sensory and motor intervention to facilitate meal and feeding behavior.

5 Summary

To summarize, management of dysphagia in infants is a complex task based on several approaches. Indeed, these disorders affect the safety of children, the psychological balance of parents, and the delay in developmental milestones. Therefore, an interdisciplinary team and recurrent assessments are necessary so as to match the child's development and capacities. The principal aims are to prevent feeding and speech disorders.

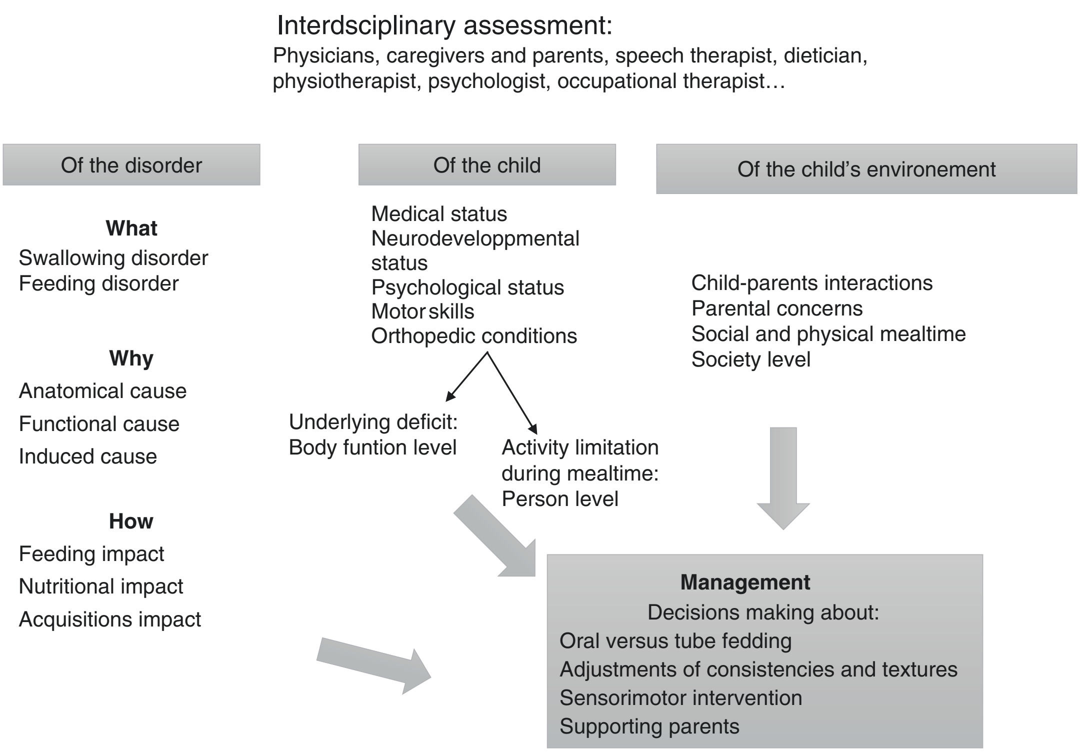

Fig. 5 Decision making

References

Abadie V (2004) Diagnostic approach in oral disorder in young children. Arch Pediatr 11(6):603–605

Abadie V (2008) Apparently isolated feeding behavior troubles in infant. Arch Pediatr 15(5):837–839

Abadie V, Cheron G, Lyonnet S et al (1996) Isolated neonatal dysfunction of brainstem. Arch Pediatr 3(2):130–136

Abu-Sultaneh SM, Durst P, Maynard V, Elitsur Y (2010) Fluticasone and food allergen elimination reverse subepithelial fibrosis in children with eosinophilic esophagitis. Dig Dis Sci 56(1):97–102

Albert GW, Menezes AH et al (2010) Chiari malformation type I in children younger than age 6 years: presentation and surgical outcome. J Neurosurg Pediatr 5(6):554–561

Amaizu N, Shulman R et al (2008) Maturation of oral feeding skills in preterm infants. Acta Paediatr 97(1):61–67

Amiel-Tison C (2005) Neurologie périnatale, 3rd edn. Masson, Paris, pp 35–73

Amiel-Tison C et al (2005) Why is the neurological examination so badly neglected in early childhood? Pediatrics 116(4):1047. author reply 1047–1048

Armstrong-Wells J, Johnston SC et al (2009) Prevalence and predictors of perinatal hemorrhagic stroke: results from the Kaiser Pediatric Stroke Study. Pediatrics 123(3):823–828

Arvedson JC (2008) Assessment of pediatric dysphagia and feeding disorders: clinical and instrumental approaches. Dev Disabil Res Rev 14:118–127

Arvedson JC, Brodsky L (2001) Pediatric swallowing and feeding: assessment and management, 2nd edn. Singular Publishing Group, Albany, pp 283–388

Arvedson JC, Lefton-Greif MA (1998) Pediatric video fluoroscopic swallow studies: a professional manual with caregiver guidelines. The Psychological Corporation, San Antonio

Arvedson JC, Clark H et al (2010) Evidence-based systematic review: effects of oral motor interventions on feeding and swallowing in preterm infants. Am J Speech Lang Pathol 19(4):321–340

Badawi N, Felix JF et al (2005) Cerebral palsy following term newborn encephalopathy: a population-based study. Dev Med Child Neurol 47(5):293–298

Barnard K (1978) The family and you. MCN Am J Matern Child Nurs 3(2):82–83

Borrero C, Vollmer T et al (2010) Concurrent reinforcement schedules for problem behavior and appropriate behavior: experimental applications of the matching law. J Exp Anal Behav 3(93):455–469

Bosma JF (1985) Post natal ontogeny of performances of the pharynx, larynx and mouth. Am Rev Respir Dis 13(5):S10–S15

Bosma JF, Hepburn LG et al (1990) Ultrasound demonstration of tongue motions during suckle feeding. Dev Med Child Neurol 32(3):223–229

Buswell CA, Leslie P et al (2009) Oral-motor dysfunction at 10 months corrected gestational age in infants born less than 37 weeks preterm. Dysphagia 24(1):20–25

Castilloux J, Noble AJ et al (2010) Risk factors for short- and long-term morbidity in children with esophageal atresia. J Pediatr 156(5):755–760

Chatoor I, Surles J et al (2004) Failure to thrive and cognitive development in toddlers with infantile anorexia. Pediatrics 113(5):e440–e447

Couly G, Aubry MC et al (2009) Fetal oral immobility syndrome. Arch Pediatr 17(1):1–2

Delaney AL, Arvedson JC (2008) Development of swallowing and feeding: prenatal through first year of life. Dev Disabil Res Rev 14(2):105–117

Dobbelsteyn C, Peacocke SD et al (2008) Feeding difficulties in children with CHARGE syndrome: prevalence, risk factors, and prognosis. Dysphagia 23(2):127–135

Dumont RC, Rudolph CD (1994) Development of gastrointestinal motility in the infant and child. Gastroenterol Clin N Am 23(4):655–671

Fanucci A, Cerro P et al (1994) Physiology of oral swallowing studied by ultrasonography. Dentomaxillofac Radiol 23(4):221–225

Ferlito A, Rinaldo A et al (1999) Laryngeal malignant neoplasms in children and adolescents. Int J Pediatr Otorhinolaryngol 49(1):1–14

Gewolb IH, Vice FL (2006) Abnormalities in the coordination of respiration and swallow in preterm infants with bronchopulmonary dysplasia. Dev Med Child Neurol 48(7):595–599

Gluckman PD, Wyatt JS et al (2005) Selective head cooling with mild systemic hypothermia after neonatal encephalopathy: multicentre randomised trial. Lancet 365(9460):663–670

Gomes CF, Thomson Z et al (2009) Utilization of surface electromyography during the feeding of term and preterm infants: a literature review. Dev Med Child Neurol 51(12):936–942

Gupta A, Gulati P et al (2009) Effect of postnatal maturation on the mechanisms of esophageal propulsion in preterm human neonates: primary and secondary peristalsis. Am J Gastroenterol 104(2):411–419

Hanson MG, Landmesser LT (2004) Normal patterns of spontaneous activity are required for correct motor axon guidance and the expression of specific guidance molecules. Neuron 43(5):687–701

Hartnick CJ, Hartley BE et al (2000) Pediatric fiberoptic endoscopic evaluation of swallowing. Ann Otol Rhinol Laryngol 109(11):996–999

Hedberg A, Carlberg EB et al (2005) Development of postural adjustments in sitting position during the first half year of life. Dev Med Child Neurol 47(5):312–320

de Jong EM, Felix JF et al (2010) Etiology of esophageal atresia and tracheoesophageal fistula: mind the gap. Curr Gastroenterol Rep 12(3):215–222

Lagercrantz H, Ringstedt T (2001) Organization of the neuronal circuits in the central nervous system during development. Acta Paediatr 90(7):707–715

Lapillonne A (2010) Early nutrition and the development of the preterm infant. Arch Pediatr 17(6):711–712
Lapillonne A, Razafimahefa H et al (2011) Nutrition of the preterm infant. Arch Pediatr 18(1):313–323
Lau C (2007) Development of oral feeding skills in the preterm infant. Arch Pediatr 14(Suppl 1):S35–S41
Lau C, Schanler RJ (2000) Oral feeding in premature infants: advantage of a self-paced milk flow. Acta Paediatr 89(4):453–459
Lau C, Alagugurusamy R et al (2000) Characterization of the developmental stages of sucking in preterm infants during bottle feeding. Acta Paediatr 89(7):846–852
Lau C, Smith EO et al (2003) Coordination of suck-swallow and swallow respiration in preterm infants. Acta Paediatr 92(6):721–727
Limme M (2011) The need of efficient chewing function in young children as prevention of dental malposition and malocclusion. Arch Pediatr 17(Suppl 5):S213–S219
de Lonlay-Debeney P, Cormier-Daire V et al (1997) Features of DiGeorge syndrome and CHARGE association in five patients. J Med Genet 34(12):986–989
May JG, Shah P et al (2011) Systematic review of endoscopic airway findings in children with gastroesophageal reflux disease. Ann Otol Rhinol Laryngol 120(2):116–122
McAnulty GB, Duffy FH et al (2009) Effects of the newborn individualized developmental care and assessment program (NIDCAP) at age 8 years: preliminary data. Clin Pediatr (Phila) 49(3):258–270
Miller JL, Sonies BC et al (2003) Emergence of oropharyngeal, laryngeal and swallowing activity in the developing fetal upper aerodigestive tract: an ultrasound evaluation. Early Hum Dev 71(1):61–87
Mizuno K, Ueda A (2003) The maturation and coordination of sucking, swallowing, and respiration in preterm infants. J Pediatr 142(1):36–40
Nelson KB (2005) Neonatal encephalopathy: etiology and outcome. Dev Med Child Neurol 47(5):292
Nicholls D, Bryant-Waugh R (2009) Eating disorders of infancy and childhood: definition, symptomatology, epidemiology, and comorbidity. Child Adolesc Psychiatr Clin N Am 18(1):17–30
Nyqvist KH (2008) Early attainment of breastfeeding competence in very preterm infants. Acta Paediatr 97(6):776–781
Nyqvist KH, Rubertsson C et al (1996) Development of the preterm infant breastfeeding behaviour scale (PIBBS): a study of nurse–mother agreement. J Hum Lact 12:207–219
Nyqvist KH, Farnstrand C et al (2001) Early oral behaviour in preterm infants during breastfeeding: an electromyographic study. Acta Paediatr 90(6):658–663
Pickler RH, Best AM et al (2006) Predictors of nutritive sucking in preterm infants. J Perinatol 26(11):693–699
Pieltain C, Habibi F et al (2007) Early nutrition, postnatal growth retardation and outcome of VLBW infants. Arch Pediatr 14(Suppl 1):S11–S15
Pinelli J, Symington A (2001) Non-nutritive sucking for promoting physiologic stability and nutrition in preterm infants. Cochrane Database Syst Rev 3:CD001071
Prasse JE, Kikano GE (2009) An overview of pediatric dysphagia. Clin Pediatr (Phila) 48(3):247–251
Qureshi MA, Vice FL et al (2002) Changes in rhythmic suckle feeding patterns in term infants in the first month of life. Dev Med Child Neurol 44(1):34–39
Radzyminski S (2005) Neurobehavioral functioning and breastfeeding behavior in the newborn. J Obstet Gynecol Neonatal Nurs 34(3):335–341
Reilly SM et al (1999) Oral-motor dysfunction in children who fail to thrive: organic or non-organic? Dev Med Child Neurol 41:115–122
Rosbe KW, Kenna MA et al (2003) Extraesophageal reflux in pediatric patients with upper respiratory symptoms. Arch Otolaryngol Head Neck Surg 129(11):1213–1220
Salinas-Valdebenito L, Nunez-Farias AC et al (2010) Clinical characterisation and course following therapeutic intervention for swallowing disorders in hospitalised paediatric patients. Rev Neurol 50(3):139–144
Schaller F, Watrin F et al (2010) A single postnatal injection of oxytocin rescues the lethal feeding behaviour in mouse newborns deficient for the imprinted Magel2 gene. Hum Mol Genet 19(24):4895–4905
Schindler O, Ruoppolo G, Schindler A (2011) Deglutilogia, 2nd edn. Omega, Turin, pp 27–50
Sitton M, Arvedson JC et al (2011) Fiberoptic endoscopic evaluation of swallowing in children: feeding outcomes related to diagnostic groups and endoscopic findings. Int J Pediatr Otorhinolaryngol 75(8):1024–1031
Smith PM, Ferguson AV (2008) Neurophysiology of hunger and satiety. Dev Disabil Res Rev 14(2):96–104
Staiano A, Boccia G et al (2007) Development of esophageal peristalsis in preterm and term neonates. Gastroenterology 132(5):1718–1725
Stevenson RD, Allaire JH (1991) The development of normal feeding and swallowing. Pediatr Clin N Am 38(6):1439–1453
Symington A, Pinelli J (2001) Developmental care for promoting development and preventing morbidity in preterm infants. Cochrane Database Syst Rev 4:CD001814
Thach BT (2008) Some aspects of clinical relevance in the maturation of respiratory control in infants. J Appl Physiol 104(6):1828–1834
Thibault H, Castetbon K et al (2010) Why and how to use the new body mass index curves for children. Arch Pediatr 17(12):1709–1715
Thompson DM (2007) Abnormal sensorimotor integrative function of the larynx in congenital laryngomalacia: a new theory of etiology. Laryngoscope 117(6 Pt 2 Suppl 114):1–33
Thouvenin B, d'Arc BF et al (2005) Infantile rumination. Arch Pediatr 12(9):1368–1371

Thoyre SM, Shaker CS et al (2005) The early feeding skills assessment for preterm infants. Neonatal Netw 24(3):7–16

Till H, Muensterer OJ et al (2008) Staged esophageal lengthening with internal and subsequent external traction sutures leads to primary repair of an ultralong gap esophageal atresia with upper pouch tracheo-esophagel fistula. J Pediatr Surg 43(6):E33–E35

Ullenhag A, Persson K et al (2009) Motor performance in very preterm infants before and after implementation of the newborn individualized developmental care and assessment programme in a neonatal intensive care unit. Acta Paediatr 98(6):947–952

Vandenplas Y et al (2009) Pediatric gastroesophageal reflux clinical practice guidelines: joint recommendations of the North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN) and the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN). J Pediatr Gastroenterol Nutr 49(4):498–547

WHO (2001) International classification of functioning, disability and health: world health assembly resolution WHA54.21, 54th session, 22 May 2001

Wu YW, March WM et al (2004) Perinatal stroke in children with motor impairment: a population-based study. Pediatrics 114(3):612–619