Feeding and swallowing disorders in newborn age

Mincarelli Chiara, Orzan Eva, Grasso Domenico Leonardo

I.R.C.C.S. Institute for Maternal and Child Health "Burlo Garofolo", Trieste (Italy);

Abstract

Introduction: Twenty-five to forty-five percent of normally developing children and up to eight % of children with developmental delays have oral feeding difficulties. Such disorders, even of short duration, can disrupt normal development and cause serious long-term sequelae.

Materials and Methods: We performed a review Meta-Analyses, Randomized Controlled trails and Reviews published since 2008 in English retrieved within the PubMed database. Fifteen articles were included that specifically focused on feeding and swallowing disorders in the newborn.

Results: Assessment of neonatal dysphagia is divided into: noninstrumental and instrumental. The types of non-instrumental assessment are evolving, though in clinical practice they remain predominantly qualitative. Fiberoptic endoscopic examination of swallowing (FEES) and videofluoroscopic examination (VFS) are used for instrumental assessment, but recently other examinations are emerging.

Treatment can also be divided into: surgical and nonsurgical. Surgery is essential for infants with malformations in the aerodigestive tract that would not be able to feed orally otherwise.

Non-surgical treatments can be compensatory to help the infant at mealtime or habilitative to help the infant develop oral skills.

Conclusions: The newborn intake of neonatal feeding and swallowing disorders is recent. Further study are needed to define the proper assessment of these disorders, in order to identify the treatments that in most cases dwell on taking care of preterm infants.

Keywords: Neonatal; Feeding; Swallowing; Dysphagia

Introduction

Infants and children may present swallowing difficulties (Dodrill, Gosa 2015, 24-31). Such disorders, even of short duration, can disrupt normal development and cause serious long-term sequalae (Dodrill, Gosa 2015, 24-31). A child can only grow adequately and physiologically both physically and cognitively if the nutrients their body needs are provided (Dodrill, Gosa 2015, 24-31). Difficulties in feeding and swallowing can lead to lower food intake and consequently slower growth (Dodrill, Gosa 2015, 24-31).

The ability to feed safely and effectively at the breast or bottle is often not a maternal concern, but 25-45% of normal-developing infants/children and up to 80% of infants/children with developmental delays have difficulty with oral feeding (Lau 2015, 7-14).

In this review, we review the treatment of swallowing and feeding disorders in infants and their assessment, diagnosis, and treatment.

Materials and Methods

This study is carried out by the analysis of Meta-Analyses, Randomized Controlled Trails and Reviews published since 2008 and searched within the PubMed database. The studies examined to implement this Review are those published in English.

A computerized search was conducted on PubMed by entering items such as: neonatal/ newborn dysphagia, assessment neonatal/ newborn dysphagia, treatment neonatal/ newborn dysphagia, oral motor intervention

dysphagia, Development of the digestive apparatus.

Fifteen articles were included that specifically discuss feeding and swallowing disorders in the newborn. Five articles were excluded because they included the general pediatric population and four because they focused exclusively into gastro-oesophageal disorders.

Physiological development

Research indicates that feeding and swallowing abilities begin to form during the intrauterine period (Lau 2015, 7-14; Viswanathan, Jadcherla 2020, 223-241; Yardımcı-Lokmanoğlu 2024, 1435-1446). At the embryonic stage, the primitive anterior intestine plays a crucial role in the development of key structures of the digestive and respiratory appartatus (Frisdal, Trainor 2014, 403-418; Viswanathan, Jadcherla 2020, 223-241). These include the oral cavity, pharynx, esophagus, stomach, larynx, trachea, bronchi, lungs, and diaphragm (Frisdal, Trainor 2014, 403-418; Viswanathan, Jadcherla 2020, 223-241). Through fetal development in the gestational period, various functions, such as sucking, swallowing, and breathing, begin to emerge (Raol 2018, 645-660; Viswanathan, Jadcherla 2020, 223-241). The first acts of swallowing are observed at around 11 and 12 weeks of gestation, followed by sucking movements at around 18 to 20 weeks (Viswanathan, Jadcherla 2020, 223-241). During this early period of life, neurological regulation of sucking, swallowing, and breathing mainly involves central brainstem pattern generators (CPGs) (Lau 2015, 7-14; Viswanathan, Jadcherla 2020, 223-241; Yardımcı-Lokmanoğlu 2024, 1435-1446). In addition to CPGs, a neuronal mechanism consisting of other brain regions, such as the cerebellum, amygdala, and tegmental area of the midbrain, the suprabulbar cortical center of swallowing, is involved in this complex dynamics (Yardımcı-Lokmanoğlu 2024, 1435-1446).

These CPGs interact with each other and respond to peripheral sensory and motor inputs, including a variety of sensory stimuli such as taste, touch, and smell (Viswanathan, Jadcherla 2020, 223-241).

Sucking is the result of a series of coordinated movements, including suction and expression (Lau 2015, 7-14; Viswanathan, Jadcherla 2020, 223-241).

Suction involves actions such as closing the soft palate, sealing the lips around the breast or bottle nipple, and lowering the lower jaw to create intraoral pressure (Lau 2015, 7-14; Viswanathan, Jadcherla 2020, 223-241). Expression, on the other hand, is caused by compressing the tongue on the hard palate, breast or bottle nipple (Lau 2015, 7-14; Viswanathan, Jadcherla 2020, 223-241).

Sucking can be divided into non-nutritive sucking (NNS) and nutritive sucking (NS) (Lau 2015, 7-14; Lau 2016, 616S-21S; Viswanathan, Jadcherla 2020, 223-241).

NNS is a rhythmic oral movement that is activated at 2 cycles per second and involves minimal swallowing, allowing independence between sucking and breathing (Lau 2015, 7-14; Lau 2016, 616S-21S; Viswanathan, Jadcherla 2020, 223-241).

NS consists of a perfect coordination of sucking, swallowing, and breathing, implying adequate child development associated with neurological and anatomical integrity (Lau 2015, 7-14; Lau 2016, 616S-21S; Viswanathan, Jadcherla 2020, 223-241).

NS involves slower oromotor rhythmic timing (1 cycle per second) to properly coordinate sucking with swallowing and breathing (Lau 2015, 7-14; Lau 2016, 616S-21S; Viswanathan, Jadcherla 2020, 223-241).

NNS and NS develop by improving the rhythmicity and coordination between suction and expression, changing the relationship between suction, swallowing and breathing over time, increasing the duration of suction and improving its efficiency (Lau 2015, 7-14; Viswanathan, Jadcherla 2020, 223-241). This development occurs in 5 stages in which expression precedes the full development of suction (Lau 2015, 7-14; Lau 2016, 616S-21S; Viswanathan, Jadcherla 2020, 223-241).

During early infancy, sucking changes over time and from a reflex controlled primarily by the brainstem it then becomes an intentional and voluntary movement (Viswanathan, Jadcherla 2020, 223-241).

Neonatal swallowing can be divided into an oral phase, a pharyngeal phase, and an esophageal phase (Lau 2015, 7-14; Lau 2016,

616S-21S; Viswanathan, Jadcherla 2020, 223-241).

The oral phase consists of sucking, creating a negative intraoral pressure that relates to a positive pharyngeal pressure (Lau 2015, 7-14; Lau 2016, 616S-21S; Viswanathan, Jadcherla 2020, 223-241). This relationship brings the bolus into the oropharynx (closed palate veil) and triggers the act of swallowing through elevation of the hyo-laryngeal complex, closure of the vocal cords, tilting of the epiglottis, pharyngeal contracture and propulsion, and relaxation of the upper esophageal sphincter (UES) (Lau 2016, 616S-21S; Viswanathan, Jadcherla 2020, 223-241). A true glossopalatal sphincter is created that prevents predeglutition falls and allows proper bolus management by creating positive and negative intraoral and pharyngeal pressures (Lau 2016, 616S-21S).

Through the relaxation of the UES, the esophageal phase begins (Lau 2015, 7-14; Lau 2016, 616S-21S; Viswanathan, Jadcherla 2020, 223-241).

The bolus, through peristaltic waves triggered by the anterograde of the pharyngeal phase, is transported down the esophagus toward the stomach by the relaxation of the lower esophageal sphincter (LES) (Lau 2015, 7-14; Lau 2016, 616S-21S; Viswanathan, Jadcherla 2020, 223-241).

During swallowing, respiratory function is temporarily interrupted, with infants typically having 40-60 breaths per minute (Lau 2015, 7-14).

Failure to coordinate sucking, swallowing, and breathing can lead to complications such as desaturations, penetrations, aspirations, and pneumonias (Lau 2015, 7-14).

Therefore, ensuring the harmonious functioning of these processes is critical to the health and development of the infant (Lau 2015, 7-14; Lau 2016, 616S-21S; Viswanathan, Jadcherla 2020, 223-241).

Feeding and swallowing disorders

Since 2007, American Speech-Language-Hearing Association documents have adopted the term "feeding and swallowing disorders" as dysphagia and developmental delays and/or feeding and swallowing disorders (van den Engel-Hoek 2017, 95-105). These can occur alone or in association (Prasse, Kikano 2009, 247-251). Arvedson et al. (2010) identified 4 categories to classify feeding and swallowing disorders in infants and children: transient, developmental, chronic, and progressive (van den Engel-Hoek 2017, 95-105). Due to medical advances, survival rates of premature, low birth weight and complex infants have increased (Lefton-Greif 2008, 837-ix; Pados 2016, 143-150; Raol 2018, 645-660); accordingly, feeding and swallowing disorders have also increased.

Infants with these problems are diverse and may present with the following issues: neurological conditions (immaturity, delays, and defects), malformative pictures of the aerodigestive tract, genetic conditions, conditions affecting sucking/swallowing/ breathing coordination, and other comorbidities affecting swallowing. (Lefton-Greif 2008, 837-ix; Prasse, Kikano 2009, 247-251).

In order to identify the signs and symptoms of neonatal dysphagia, which may be more or less visible, it is necessary to rely on health professionals and caregivers (Prasse, Kikano 2009, 247-251). In pediatric and neonatal age, signs such as poor interest in food, long time during feeding, food spillage from the oral cavity, GAG reflex during feeding, vomiting and coughing during feeding, difficulty in swallowing food, difficulty breathing, stridor during feeding, and failure to grow. Other signs of swallowing problems that have emerged include tongue thrusting, nasal regurgitation, and gastroesophageal reflux. Finally, chronic respiratory infections and lung disease may suggest aspiration (Prasse, Kikano 2009, 247-251). In addition, severe parental stress is often associated (Lefton-Greif 2008, 837-ix).

Assessment

The assessment starts with the observation of the infant in feeding and swallowing skills, also looking for signs and symptoms during mealtime (Dodrill, Gosa 2015, 24-31; Raol 2018, 645-660; Reynolds 2016, 37-43).

The oral phase is examined through a careful analysis of the infant's neuromotor and sensory abilities, including oral skills (Reynolds 2016, 37-43). Both NNS and NS are assessed, to try to observe their development and effectiveness (Reynolds 2016, 37-43). If

problems are found, strategies can be tried to make feeding safer and more effective (Reynolds 2016, 37-43).

To carry out such assessments there are several observational tools, some specific to breast feeding, others to bottle feeding, but it should be considered that none of them have complete reliability and validity as they do not have a formal test (Pados 2016, 143-150). Instead, it is observed that qualitative rather than instrumental assessment is carried out in clinical practice (Dodrill, Gosa 2015, 24-31).

Currently, there are two specific instrumental examinations to observe swallowing function and the possible presence of penetration and/or aspiration episodes (Dodrill, Gosa 2015, 24-31; Raol 2018, 645-660; Reynolds 2016, 37-43):

Endoscopic fiber-optic examination of swallowing (FEES) (Figures 1 and 2): allows by means of a transnasal probe to observe anatomical structures, their muscle tone, dynamics, secretion management, pharyngo-laryngeal sensitivity (Abadie, Couly 2013, 1539-1549; Raol 2018, 645-660; Reynolds 2016, 37-43). In addition, colored food can be observed for swallowing efficiency (Abadie, Couly,2013, 1539-1549; Reynolds 2016, 37-43), through indirect information, or stagnations (Raol 2018, 645-660; Viswanathan, Jadcherla 2020, 223-241). It can be done either through bottle feeding or at the breast (Abadie, Couly ,2013, 1539-1549; Raol 2018, 645-660; Reynolds 2016, 37-43).

The videofluoroscopic (VFS) examination (Figures 3 and 4) requires administration of baritate meal to the infant and allows recording of the swallowing dynamics with possible episodes of penetration and inhalation (Abadie, Couly 2013, 1539-1549; Raol 2018, 645-660; Reynolds 2016, 37-43). This examination allows complete observation of the swallowing act (Abadie, Couly 2013, 1539-1549; Raol 2018, 645-660; Viswanathan, Jadcherla 2020, 223-241). This examination requires transferring the infant to radiology by exposing them to radiation (Abadie, Couly 2013, 1539-1549; Raol 2018, 645-660; Reynolds 2016, 37-43), and if they are usually breast-fed, they must be bottle-feed with a baritate meal during the examination (Raol 2018, 645-660; Reynolds 2016, 37-43).

Fig. 1. NBI endoscopic view of glottis and supraglottic.

Fig. 2. Endoscopic fiber-optic examination of swallowing with food colouring

In association with these instrumental examinations, several studies have recently discussed other assessment tools (Abadie, Couly 2013, 1539-1549; Dodrill, Gosa 2015, 24-31; Viswanathan, Jadcherla 2020, 223-241):

High-resolution pharyngoesophageal manometry/impedance manometry assesses esophageal pressures, opening and closing of esophageal sphincters, and peristalsis by allowing assessment of their coordination and

function (Abadie, Couly 2013, 1539-1549; Dodrill, Gosa 2015, 24-31; Viswanathan, Jadcherla 2020, 223-241).

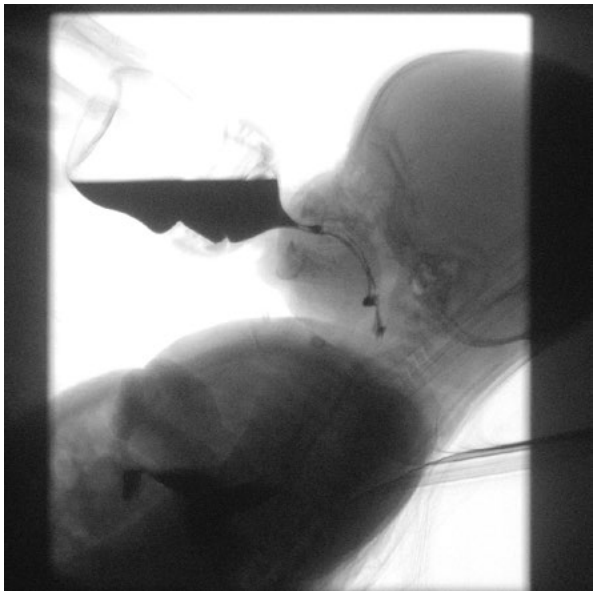

Fig. 3. Neonatal videofluoroscopy.

Fig. 4. ENeonatal videofluoroscopy with inhalation.

Digital cervical auscultation offers objective acoustic information that could help the clinician to better understand the swallowing mechanism (Dodrill, Gosa 2015, 24-31).

Facial electromyography allows to study the functioning of the V; VII; IX, X and XII cranial nerve necessary for safe and effective sucking and swallowing (Abadie, Couly 2013, 1539-1549).

Impedancemetry evaluates the possible presence of acid and non-acid gastroesophageal reflux (GER) (Dodrill, Gosa 2015, 24-31; Viswanathan, Jadcherla 2020, 223-241).

Accelerometry might investigate safe from unsafe swallowing and can distinguish them but needs further study (Dodrill, Gosa 2015, 24-31).

Ultrasound studies bolus movement in the pharynx (Dodrill, Gosa 2015, 24-31).

Treatment

Speaking of rehabilitation, when it comes infants this term is not appropriate as one must implement habilitation, an ex novo learning of a skill, in this case feeding and swallowing (Lau 2016, 616S-21S).

If these children are not taken care of and treated they may issues such as: growth failure, aspiration pneumonia, gastroesophageal reflux, and/or inability to establish and maintain proper nutrition and hydration (van den Engel-Hoek 2017, 95-105).

Current treatments are different, both surgical and rehabilitative (Raol 2018, 645-660). Surgical interventions are necessary to treat severe malformations in the air-digestive tract that in order to bring these children to oral feeding (Raol 2018, 645-660).

The nonsurgical treatments in the literature are various:

Pacing: in which we help the infant to coordinate better, preventing desaturation, bradycardia;

Changing position during meal intake: through the lateral position with the head slightly higher than the feet, better coordination is observed as it is a position that allows the infant to coordinate better and not have gravity increasing the flow of the meal.

Nipple change: offering a nipple with a slower flow can help the infant coordinate better (Raol 2018, 645-660).

In addition, oral motor intervention corresponding to the combination of oral stimulation, NNS stimulation and oral support is found in clinical practice in recent years (Arvedson 2010, 321-340; Li 2022, 635-640; Tian 2015, 1310). Studies on these treatments on the preterm show an improvement in the

survival of infants, a decrease in the adversity they may face, a decrease in the transition time to oral feeding and consequently an earlier hospital discharge (Arvedson 2010, 321-340; Li 2022, 635-640; Tian 2015, 1310). However, more studies are needed to observe the role of this treatment on weight gain and growth and development of the preterm infant (Arvedson 2010, 321-340; Tian 2015, 1310).

Conclusions

These disorders are diverse and cause problems of different severity and management due to numerous and heterogeneous etiologies.

The uptake of these disorders has arisen recently, which is evident from the few studies available in the literature. Assessment to date is mainly based on a qualitative assessment associated with FEES and VFS but new diagnostic strategies are being investigated that could help to understand the swallowing mechanism of each individual infant.

Regarding rehabilitation, studies are fewer than the evaluative ones and in most cases dwell on preterm infants. Previously, compensatory treatments were thought of to help the infant cope with oral feeding as best as possible; in recent years, orality support and motility development are being developed to help and support effective and safe NS.

Thus, there is a need to implement further studies on this topic, both for evaluation and treatment in the various types of neonatal feeding and swallowing disorders.

The consideration In the present paper of studies publiched only in English and only from a single database may result in a limitation of sources to the study.

References

Abadie, V., & Couly, G. (2013). Congenital feeding and swallowing disorders. *Handbook of clinical neurology*, *113*, 1539–1549. https://doi.org/10.1016/B978-0-444-59565-2.00024-1

Arvedson, J., Clark, H., Lazarus, C., Schooling, T., & Frymark, T. (2010). Evidence-based systematic review: effects of oral motor interventions on feeding and swallowing in preterm infants. *American journal of speech-language pathology*, *19*(4), 321–340. https://doi.org/10.1044/1058-0360(2010/09-0067)

Dodrill, P., & Gosa, M. M. (2015). Pediatric Dysphagia: Physiology, Assessment, and Management. *Annals of nutrition & metabolism*, *66 Suppl 5*, 24–31. https://doi.org/10.1159/000381372

Frisdal, A., & Trainor, P. A. (2014). Development and evolution of the pharyngeal apparatus. *Wiley interdisciplinary reviews. Developmental biology*, *3*(6), 403–418. https://doi.org/10.1002/wdev.147

Lau C. (2015). Development of Suck and Swallow Mechanisms in Infants. *Annals of nutrition & metabolism*, *66 Suppl 5*(0 5), 7–14. https://doi.org/10.1159/000381361

Lau C. (2016). Development of infant oral feeding skills: what do we know?. *The American journal of clinical nutrition*, *103*(2), 616S–21S. https://doi.org/10.3945/ajcn.115.109603

Lefton-Greif M. A. (2008). Pediatric dysphagia. *Physical medicine and rehabilitation clinics of North America*, *19*(4), 837–ix. https://doi.org/10.1016/j.pmr.2008.05.007

Li, L., Liu, L., Chen, F., & Huang, L. (2022). Clinical effects of oral motor intervention combined with non-nutritive sucking on oral feeding in preterm infants with dysphagia. *Jornal de pediatria*, *98*(6), 635–640. https://doi.org/10.1016/j.jped.2022.02.005

Pados, B. F., Park, J., Estrem, H., & Awotwi, A. (2016). Assessment Tools for Evaluation of Oral Feeding in Infants Younger Than 6 Months. *Advances in neonatal care : official journal of the National Association of Neonatal Nurses*, *16*(2), 143–150. https://doi.org/10.1097/ANC.0000000000000255

Prasse, J. E., & Kikano, G. E. (2009). An overview of pediatric dysphagia. *Clinical pediatrics*, *48*(3), 247–251. https://doi.org/10.1177/0009922808327323

Raol, N., Schrepfer, T., & Hartnick, C. (2018). Aspiration and Dysphagia in the Neonatal Patient. *Clinics in perinatology*, *45*(4), 645–660. https://doi.org/10.1016/j.clp.2018.07.005

Reynolds, J., Carroll, S., & Sturdivant, C. (2016). Fiberoptic Endoscopic Evaluation of Swallowing: A Multidisciplinary Alternative for Assessment of Infants With Dysphagia in the Neonatal Intensive Care Unit. *Advances in neonatal care : official journal of the National Association of Neonatal Nurses*, *16*(1), 37–43. https://doi.org/10.1097/ANC.0000000000000245

Tian, X., Yi, L. J., Zhang, L., Zhou, J. G., Ma, L., Ou, Y. X., Shuai, T., Zeng, Z., & Song, G. M. (2015). Oral Motor Intervention Improved the Oral Feeding in Preterm Infants: Evidence Based on a Meta-Analysis With Trial Sequential Analysis. *Medicine*, *94*(31), e1310. https://doi.org/10.1097/MD.0000000000001310

van den Engel-Hoek, L., Harding, C., van Gerven, M., & Cockerill, H. (2017). Pediatric feeding and swallowing rehabilitation: An overview. *Journal of pediatric rehabilitation medicine*, *10*(2), 95–105. https://doi.org/10.3233/PRM-170435

Viswanathan, S., & Jadcherla, S. (2020). Feeding and Swallowing Difficulties in Neonates: Developmental Physiology and Pathophysiology. *Clinics in perinatology*, *47*(2), 223–241. https://doi.org/10.1016/j.clp.2020.02.005

Yardımcı-Lokmanoğlu, B. N., Demir, N., Porsnok, D., Sırtbaş-Işık, G., Cengiz, E., Serel-Arslan, S., & Mutlu, A. (2024). Are sucking patterns and early spontaneous movements related to later developmental functioning outcomes? A cohort study. *European Journal of Pediatrics*, *183*(3), 1435–1446. https://doi.org/10.1007/s00431-024-05422-9

Acknowledgement

This article is supported by grant RC 36/23 of I.R.C.C.S. Institute for Maternal and Child Health "Burlo Garofolo", Trieste (Italy)