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Luh Karunia Wahyuni

Chan-Wei Lin

Tyng-Guey Wang

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Review Article

Evaluation of Pediatric Subjects with Swallowing Disorder Part I: Physiology and Pathology

Luh Karunia Wahyuni, Chan-Wei Lin,[1] Tyng-Guey Wang[1,2]

Faculty of Medicine, University of Indonesia, Cipto Mangunkusumo Hospital, Indonesia;
[1]Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital, Taipei;
[2]Department of Physical Medicine and Rehabilitation, College of Medicine, National Taiwan University, Taipei.

Feeding and swallowing disorders are important issues in a pediatric population, which may lead to malnutrition, dehydration, or increased risk of pulmonary complications. Pediatric dysphagia is more complex than adult dysphagia in some aspects because it includes developmental progress in anatomical structures and physiological functions. To manage pediatric feeding and swallowing disorders, comprehensive knowledge regarding the development of normal swallowing and of the pathologies of common diseases related to pediatric dysphagia are necessary. In this article, we will review the pediatric swallowing structures and physiology, and address the feeding and swallowing problems in common pediatric diseases, including cerebral palsy, cleft lip and/or palate, and Down syndrome. (Tw J Phys Med Rehabil 2013; 41(3): 155 - 161)

Key Words: deglutition disorders, feeding, pediatrics

INTRODUCTION

Pediatric feeding problems comprises a wide range of feeding disorders and/or swallowing dysfunctions observed in infants and children, which may lead to malnutrition, dehydration, pulmonary complications, and even inadequate growth in those individuals of high risk.[1] Feeding disorders cause problems in various eating activities that may or may not be accompanied by difficulty in swallowing food and liquid. Feeding disorders in infants and children may be characterized by food refusal, disruptive mealtime behavior, rigid food preferences, less than optimal growth, and failure to master self-feeding skills expected during developmental stages. Swallowing disorders (dysphagia) are problems in one or more phases of swallowing that include oral preparatory, oral, pharyngeal, and esophageal phases.[2] The aims of this article are to review the feeding and/or swallowing dysfunctions in infants and children, based on the physiological and pathological theories; and also to address the dysphagic features in common diseases, such as cerebral palsy, cleft lip and/or palate, and Down syndrome.

ANATOMICAL DIFFERENCES BETWEEN THE NEWBORN AND ADULT MOUTH AND PHARYNX

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Correspondence to: Dr. Tyng-Guey Wang, Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital, No. 1, Changde Street, Zhongzheng District, Taipei 100, Taiwan.
Tel：(02) 23123456 ext 67587 E-mail：tgw@ntu.edu.tw

Several anatomical differences exist in infants and older children. In infants, the tongue is relatively larger compared with the oral cavity than the proportion of tongue in adult. [3] The bilateral presence of sucking pads assists the tongue in maintaining milk bolus in the center, and also provides stability of cheeks during sucking.[4] The pharynx of infants displays a gentle curve from the nasopharynx to the hypopharynx. However, as infants grow, the gentle curve gradually changes, forming an approximately 90° angle between the nasopharynx and oropharynx, similar to that in adults. The soft palate and arytenoids are prominent. The epiglottis of an infant is narrow and vertical, whereas that of an older child and adult is flat and wide. Moreover, the epiglottis of infants sets high at the C1 vertebral body level, and is conjunct with the soft palate; whereas the epiglottis of adults descends to the C3 vertebral body level. [4-6] (Figure 1) In infants, the small oral cavity in combination with the close proximity between the tongue, soft palate, and pharynx and the larynx appears to facilitate nasal breathing during sucking.[3]

In infants, the hyoid bone is set high, i.e., right under the mandible, and the thyroid cartilage is contiguous with the hyoid bone. The larynx of infants is located anteriorly and superiorly, below the tongue base. This arrangement explains why that there is less vertical laryngeal displacement in infants.[3] In addition, the location of the larynx allows maximum airway protection during swallowing, with minimal effort of laryngeal elevation.[4] The base of the tongue and larynx descend during the first year of life. In newborns, the larynx and pharynx are initially located at the level of the third and fourth cervical vertebrae and descend to the level of the sixth cervical vertebrae during childhood, reaching the seventh cervical vertebrae by 15–20 years of age.

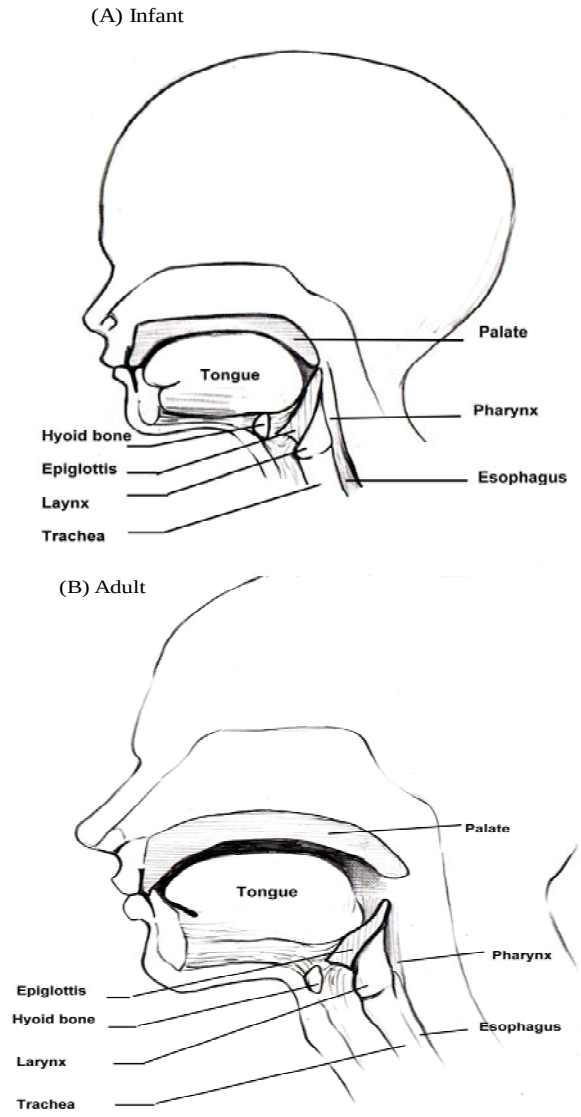

Figure 1. Anatomy of the head and neck with regard to feeding in an infant and an adult
In an infant (A), the tongue is relatively larger compared with the oral cavity than that in the adult (B). The epiglottis is conjunct with the palate in an infant (A), whereas the epiglottis is apart from the palate in an adult (B). The hyoid bone and larynx are set in a higher position in an infant (A) than that in an adult (B).

SUCKING

Sucking is the intake phase of eating liquid and soft solids. It involves taking the liquid into the mouth and moving it to the back of the oral cavity for swallowing. It is a rhythmic movement of an infant's mouth at the breast, bottle, fingers, or a toy. It has nutritive value and provides non-nutritive support for calming and organizing the body, and early establishing the child/caregiver bonding.[7, 8] The non-nutritive pattern is more rapid, with no cessation of breathing. It is important to preserve feeding skills in infants, particularly when nutritive sucking is withheld because of therapy or illness. In nutritive sucking, a breath precedes sucking and swallowing. Multiple sucks and swallows are possible with a single breath. In older infants and children, swallowing/breathing pattern becomes

irregular after they begin swallowing both solids and liquids, and then their swallowing is restricted to expiration.[9]

Swallowing can be identified at as early as 11 weeks of gestational age (GA). True suckling can be seen from 18 to 24 weeks of GA, whereas non-nutritive sucking is observed at 27–28 weeks of GA. A 1:1:1 ratio of breathe, suck, and swallow is noted at 34 weeks of GA, which allows sufficient oral feeding to meet nutritional needs. Episodes of several sucks and swallows occurring in a single breath are seen by 35–36 weeks of GA.[9]

The average volume of milk taken by an infant in each suck is 0.2 ml; 300 sucking and swallowing motions are required to consume 60 ml of milk.[10] In breast-fed infants, the milk volume in each suck declines gradually, with 0.14 ml in each suck in the beginning but decreasing to 0.01 ml in each suck at the end.[11]

Hunger levels and liquid flow influence the pace of sucking in most infants. At the beginning of the meal when the infant is hungry, sucking generally is more rapid than it is toward the end when satiation sets in. Breast-fed infants begin the meal with a more rapid non-nutritive suck at an approximate rate of two sucks per second. Once the milk-ejection reflex has occurred and the mother's milk begins to flow, the sucking slows to the nutritive sucking rate of one suck per second. Swallowing typically occurs with each suck toward the beginning of the meal, but may move toward more sucks per swallow as the infant finishes the meal. Infants use a pattern of sucking bursts separated by brief pauses during the meal. Both the strength of the suck and the relationship of sucking bursts and pauses are influenced by the amount and timing of milk flow through the nipple.[12]

The infant sucks liquid into the mouth by a combination of actions that cause pressure changes. Positive and negative pressures combine to promote strong and efficient sucking.[13] Positive pressure or compression extracts the fluid from the breast or bottle. The baby compresses the nipple with the gums against the base of the nipple or with the tongue against the palate. This positive pressure on the nipple pushes the liquid into the mouth.[12] Negative pressure is described as a suction that draws fluid into the nipple and then out of the breast or bottle into the mouth. (Figure 2) Suction is created as the oral cavity is sealed around the nipple and the jaws move downward. The back of the tongue depresses, enlarging

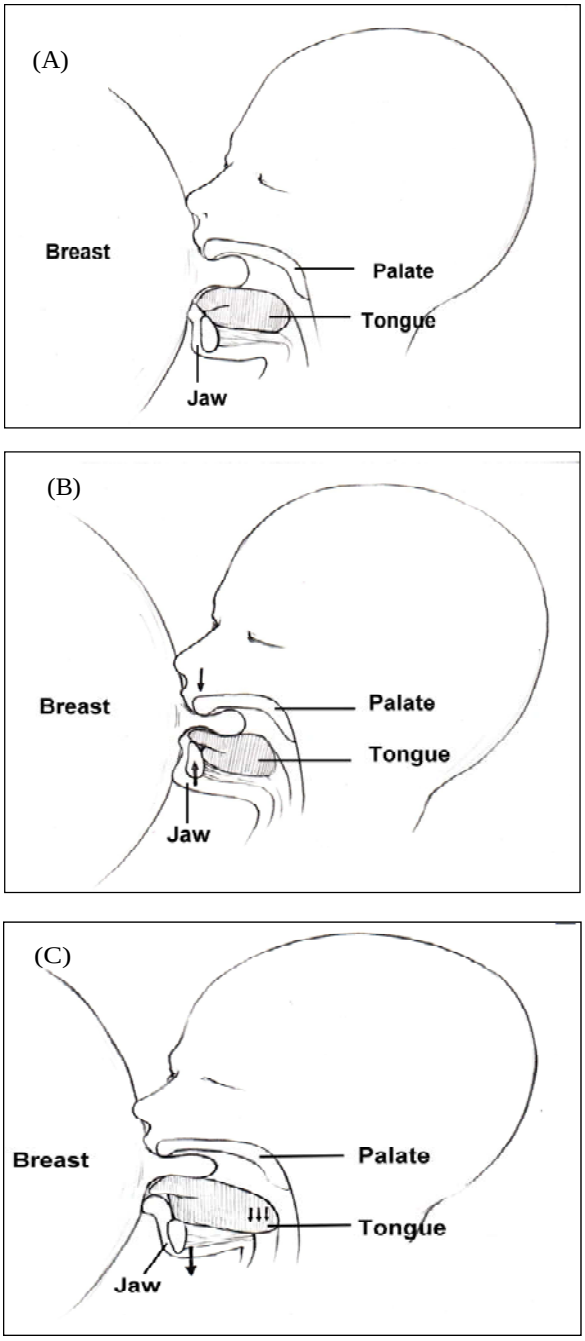

Figure 2. The mechanism of sucking: positive pressure and negative pressure
(A) During sucking, the milk is drawn from the breast into the mouth. The oral cavity must be sealed. (B) Positive pressure: compression of the nipple produces a positive pressure, which pushes the liquid into the mouth. (C) Negative pressure: Sucking with the back of the tongue depressed and downward movement of the jaw enlarge the sealed oral cavity, which creates a negative pressure that draws fluid into the nipple and then out of the breast into the mouth.

the oral cavity and changing the intraoral pressure. This combination acts to refill the nipple and draw in fluid from the breast or bottle.[13] To create this suction, the oral cavity must be sealed or there will be no change in intraoral pressure.[12]

CHEWING AND MASTICATION

At around 12 months old, sucking diminishes and transfers to drinking with cups in children.[14] At around 12 to 24 months old, chewing skills continue to evolve with up-and-down and diagonal rotatory movements, added with lateral activity of tongue and stability of jaw contribute to effective crushing and grinding of foods.[14-16] The consistency of foods for chewing increases gradually with ages; whereas children could chew firm foods without choking around 12 months old, and could chew foods that produce juice around 15 months old.[17] Children tend to master mastication at around 3 years old, paralleling the growth of oral cavity and face, the descent of pharynx and larynx, and the maturation of neuromuscular coordination.[18, 19] The coordination of the jaw, tongue, lips, cheeks and teeth movements relies on integration of the sensorimotor cortex, forebrain and midbrain structures.[19]

SWALLOWING PROBLEMS ASSOCIATED WITH CEREBRAL PALSY

Children with cerebral palsy (CP) frequently have swallowing problems, including oral, pharyngeal, or esophageal dysphagia impairment. Previous researches show that oral motor dysfunction with subsequent feeding problems may be observed in approximately 90% preschool children with CP.[20] In addition, children with very mild CP may show evidences of oral motor involvement and reduced functional feeding skills.[17, 21]

The degree of involvement of oral musculature varies. Children may exhibit inappropriate oral reflexive behaviors, inability to hold material in a cohesive bolus, and/or disorganized lingual movements, which may fail to smoothly move the bolus posteriorly. Often, as the individual is chewing, particles of food break away and spread throughout the oral cavity. Some of these pieces may fall into the pharynx and then into the open airway. Only rarely is the pharyngeal swallow triggered when these small amounts fall into the airway, possibly because the voluntary oral stage of swallow has not been initiated.[5, 8]

Cricopharyngeal dysfunction is rarely a problem in children with CP. As the child grows and the laryngeal position lowers, opening of the upper esophageal sphincter may normalize. In general, laryngeal closure during swallow is adequate so that no aspiration is seen during the swallow. Most aspirations in children with CP occur before the swallow, usually because of reduced tongue control for chewing or because of delayed pharyngeal swallow or after the swallow because of poor tongue base action or poor laryngeal elevation creating inefficient swallowing with residue in the pharynx.[8]

SWALLOWING PROBLEMS ASSOCIATED WITH CLEFT LIP AND/OR PALATE

The severity and type of cleft, which varies from one infant to another, will determine how the infant is able to feed. If the infant only has a cleft lip, negligible effects are observed during feeding. The presence of an intact palate is important for the sucking process.[22]

The problems often experienced by infants with a cleft palate include poor sucking, choking, nasal regurgitation, long feeding time, poor weight gain, and excessive intake of air. In an infant with a cleft palate, the normal feeding process is interrupted because of a weak sucking pressure and the difficulties encountered when trying to compress the nipple. [12, 21] To compensate for this, the infant uses the tongue tip and the alveolar ridge to form a closure around the nipple. The absence of such a closure could result in milk leaking from around the cleft. Holding the baby in a cleft-side up position when feeding from either of the breasts can help prevent milk from leaking out.[22]

In an infant with a cleft palate, building up this suction is similar to blowing up a punctured balloon. In turn, without this suction, the infant cannot extract milk from the nipple. Despite the inability to create a negative pressure, if the nipple is placed into the infant's mouth, the sucking reflex will cause the infant to lift his tongue

to press against the nipple and extract milk. The absence of a hard palate means that the nipple will be pushed directly into the cleft, resulting in two problems. First, the nipple is not pressed flat against the palate, so little milk is extracted. Second, if the nipple is in the cleft and milk is extracted, it will directly pass into the nose rather than the mouth and will escape through the nostrils. The escape of milk through the nose results in insufficient quantities of milk being swallowed, thus lengthening the entire process of feeding.[12, 22]

SWALLOWING PROBLEMS ASSOCIATED WITH DOWN SYNDROME

Feeding problems in infants and young children with Down syndrome (DS) are frequent, and may lead to failure to thrive. These feeding problems may be caused by underlying conditions frequently associated with DS, including congenital heart defects (present in 40%–60% patients with DS), gastrointestinal disorders,–or impaired oral motor function. Impaired cardiac function may cause features of fast and difficult breathing, fatigue during feeding, and limited weight gain, which lead to dysphagia in DS. [23, 24] However, feeding difficulties in patients with DS are often attributed to the general hypotonia and related impaired oral motor function.[25, 26]

The combination of reduced oral space and limited oral motor control contribute to feeding problems in infants with DS. Because of a small oral cavity and midfacial hypoplasia, the infant's lips are thin, the palate is usually flatter with a high arch in the midline, and the nasal passages are narrowed. Narrowed nasal passages and increased respiratory secretions interfere with nasal breathing and oral feeding in infants with DS.[25, 27] Reduced oral space and low muscle tone can both result in tongue protrusion. Both absolute and relative macroglossia can sometimes occur in infants with DS, resulting in additional problems with breathing, chewing, and speech development.[28, 29]

CONCLUSION

Evaluation of feeding and swallowing disorders in infants or children is complex, which requires a comprehensive knowledge, including that of anatomical and mechanical characteristics of pediatric swallowing and disease-specific swallowing abnormalities. Children could not express the difficulties clearly, hence, detailed history taking, including feeding history, signs of dyspnea, vomit, weight gain, and thorough physical examination, including the integrity of oral structures, sucking function, pattern of breathing and swallowing are important. Furthermore, to establish the child-caregiver bonding is crucial in management of pediatric dysphagia. We have reviewed the clinical manifestations and management in three common diseases, cerebral palsy, cleft lip and/or palate, and Down syndrome, that may guide the clinical practitioners to early identify children at risk. Although there is an increased amount of studies conducted in the field of pediatric dysphagia, evidences discussing the mechanism and management of dysphagia remains sparse. Continued research to develop strong evidences in the field of pediatric feeding and swallowing disorders is mandatory.

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小兒吞嚥障礙之評估 - 第一部分：生理與病理機轉

Luh Karunia Wahyuni　林家瑋 [1]　王亭貴 [1,2]

Faculty of Medicine, University of Indonesia, Cipto Mangunkusumo Hospital, Indonesia
國立臺灣大學醫學院附設醫院復健部 [1]　國立臺灣大學醫學院復健部 [2]

進食異常與吞嚥障礙是小兒族群的重要議題，因爲兩者可能導致營養不良、脫水，甚至增加肺部併發症之危險性。小兒之吞嚥障礙問題比成人更爲複雜，因爲必須考量，隨著成長與發育，吞嚥之解剖構造以及生理功能上的變化。治療小兒進食與吞嚥障礙，必須對於正常的吞嚥機轉，與生理發展有所認識，同時也必須熟稔造成兒童吞嚥困難的常見疾病。本文將綜論小兒吞嚥相關解剖構造、生理功能變化，同時闡述重要常見疾患，如：腦性麻痺、唇/顎裂，以及唐氏症病人，之進食及吞嚥障礙表現。（台灣復健醫誌 2013；41(3)：155 - 161）

關鍵詞：吞嚥障礙(deglutition disorders)，進食(feeding)，小兒(pediatrics)

通訊作者：王亭貴醫師，國立臺灣大學醫學院附設醫院復健部，台北市 100 中正區常德街 1 號
電話：(02) 23123456 轉 67587　　E-mail：tgw@ntu.edu.tw