

Feeding Problems and Oropharyngeal Dysphagia in Children

Pamela Dodrill

Pamela Dodrill, Specialist Speech Pathologist, Health Research Fellow, Royal Children's Hospital, Herston Rd, Herston, Brisbane 4029, Queensland, Australia

Correspondence to: Pamela Dodrill, Specialist Speech Pathologist, Health Research Fellow, Royal Children's Hospital, Herston Rd, Herston, Brisbane 4029, Queensland, Australia

Email: pamela_dodrill@health.qld.gov.au

Telephone: +61736368508

Fax: +61736361978

Received: January 31, 2014

Revised: April 25, 2014

Accepted: April 28, 2014

Published online: May 21, 2014

ABSTRACT

Like adults, infants and older children can present with swallowing and feeding difficulties. Unlike adults, children have rapidly developing body systems, and even short-term problems with swallowing and/or feeding can interrupt normal development and cause serious long-term sequelae. In order for a child to reach their physical and cognitive growth potential, sufficient energy and nutrients must be consumed. Feeding difficulties can have a detrimental effect on dietary intake and, hence, growth. This article aims to provide an overview of the typical development of feeding skills in children, as well as of interventions aimed at assisting children with feeding and swallowing difficulties. A review of the literature indicates that many intervention techniques utilized by clinicians have not been formally evaluated by high-quality research studies and, thus, further research in this area is needed to support and guide clinical practice.

© 2014 ACT. All rights reserved.

Key words: Children; Feeding; Dysphagia

Dodrill P. Feeding Problems and Oropharyngeal Dysphagia in Children. *Journal of Gastroenterology and Hepatology Research* 2014; 3(5): 1055-1060 Available from: URL: <http://www.ghrnet.org/index.php/joghr/article/view/694>

NORMAL FEEDING DEVELOPMENT DURING INFANCY

Feeding skills undergo a period of rapid development throughout the first year of life. During the first months after birth, an infant's nutritional needs are met by a diet of breast milk or infant formula. Later on in infancy, solid foods are introduced to supplement milk feeds. The transition from a liquid-based diet to a diet consisting of solids and liquids is an important developmental process that allows infants to consume a larger volume and variety of nutrients, which is important in meeting their expanding dietary requirements as they grow^[1-3]. From birth to 12 months of age, healthy infants generally experience a 50% increase in their length and a 200% increase in their weight^[3]. Clinically, a child's growth is used as a crude indicator of their nutritional intake and feeding skills, such that, if they are growing well, it would generally be assumed that their dietary intake must be sufficient to meet their nutritional requirements and, if fully orally fed, that their feeding skills are sufficient to allow them to consume the required nutrition^[4,5].

During infancy, a child progresses from being fully dependent on a feeder, through a period of semi-dependence, where they begin to take on some responsibility and make some choices related to feeding^[6,7]. Later still, children learn to feed themselves with complete independence. Early neurological development allows the transition from brainstem-mediated suckling reflexes to voluntary oral movements during eating, which require higher cortical input^[6-8]. Anatomical changes result in an enlarged oral cavity, allowing more space for food to be manipulated within the mouth^[6,7]. In addition, developmental gains in the area of gross motor skills allow the infant to sit upright with decreasing amounts of support, and to commence self-feeding.

In order for an infant to feed competently during the suckling period, they need to display functional suckling and swallowing skills, as well as the ability to coordinate suckling, swallowing, and breathing. Later, during the transitional feeding period, infants also need to learn to competently chew and bite, so that they can safely consume solid foods of more challenging textures. Increasing levels of oral-motor skill are required to progress from breastfeeding/ bottle

feeding onto beginner (pureed) solid foods that are taken from a spoon, and then on to mashed and soft solid pieces that can be broken down with the tongue, and later soft- and hard-mechanical food textures that require chewing +/- biting (Table 1)^[7,9]. Increasing oral-motor skills are also required to move from drinking from the breast/bottle onto drinking via a spout or straw cup and then an open cup^[7].

Infants generally begin weaning onto solid foods at the same time that they begin to be able to sit in an upright position and bring their hands to their mouth. Postural support is an important pre-requisite for the introduction of solids, as gross motor control of the trunk and neck is needed to support the fine motor skills involved in chewing and biting^[6,7]. As infants mature, their trunk control, neck control, and jaw control all mature in a sequential process^[6,7]. Supportive seating, as well as manipulation of the size and firmness of food pieces offered by the caregiver, assists to maximise the child's ability to eat efficiently and safely^[9].

Newborns require full postural support during feeds. From birth to 4 months of age, infants diet consists entirely of fluid, taken in the form of breastfeeds or bottle feeds^[1,2]. Young infants rely on adaptive oral reflexes (i.e. rooting and suckling) to locate and ingest feeds, and display a forward-backward tongue pattern while feeding^[6,7]. Young infants are unable to consume or effectively digest any solid foods^[1,2], and display protective oral reflexes (e.g. tongue protrusion, phasic bite, and strong gag reflexes) to protect the airway^[6,7].

At 4 months of age, most infants are still only consuming fluids (as either breastfeeds or bottle feeds). However, from 4-6 months infants begin to display separation of tongue and jaw movements, and transition from a reflexive suckle (forward-backwards) to a suck (up-down) tongue pattern while feeding^[6,7]. During this time, infants begin to be able to sit more upright, but still require full postural support (e.g. seated in a baby chair with straps, or on the feeder's lap with the feeder's arm supporting the head and trunk)^[7]. Most infants will begin to bring their hands to their mouth at this stage for oral self-exploration. This helps to desensitise some of the protective reflexes (e.g. tongue protrusion) and, toward the end of this period, many infants will begin to consume beginner (i.e. pureed) solids from a spoon (Table 1).

At 7-9 months of age, the infant diet still consists mostly of fluids, but infants are able to consume a greater volume and variety of solid foods^[1,2]. Infants continue to consume fluids from the breast or bottle, but many begin to be able to drink from a cup^[6,7]. As infants develop the core stability to sit up with less external support, and as many of the protective oral reflexes diminish and/or are integrated into more sophisticated, voluntary oral skills (e.g. phasic bite transitions to chewing)^[7], infants can begin to consume mashed solids and

small pieces of soft foods (Table 1). As hand-to-mouth coordination improves, most infants begin some (messy) self-feeding^[7], however, much assistance from caregivers is still required during mealtimes at this age.

At 9-12 months of age, infants are generally consuming a mixed diet of fluids and solids. During the day, an increasing proportion of fluids may be taken from a cup, though infants still require breastfeeds or bottle feeds to meet their nutritional requirements^[1,2]. Most infants can sit without support at this age, and most are beginning to stand and walk. However, the majority of infants continue to be fed in a baby chair or on a caregiver's lap, in order to provide postural support while they continue to develop their fine motor skills^[7]. Self-feeding is more common at this age, and improved jaw stability and tongue lateralisation skills allow infants to bite and chew soft-mechanical foods (Table 1)^[7,9].

From 12-24 months of age, toddlers' oral feeding skills continue to improve and become more refined and coordinated, which results in improved efficiency of mealtimes and a greater variety of foods consumed. Children gradually learn to bite through hard-mechanical foods (Table 1)^[9] during this period. Toddlers also become more competent at using utensils to assist with eating. This process occurs in parallel with improvements in general motor development and sensory integration (the neurological process that organises sensations from the environment and one's own body, such as sight, smell, touch, taste, and proprioception, to allow a functional response), as well as with maturation of cognitive processes^[6,7]. Toddlers continue to require assistance from their caregivers in offering appropriate foods in manageable size portions, and should be supervised while eating any foods that pose a choking risk^[9].

INTERRUPTIONS TO EARLY FEEDING DEVELOPMENT

Given the inter-relationship between anatomical and neurological maturation in early development, as well as between sensory, motor, and cognitive development, there is a potential for difficulties to occur if any or all of these processes are interrupted during the developmental process^[6,7].

By virtue of their premature delivery, early development is interrupted in preterm infants. Premature exposure to the ex-utero environment forces preterm infants to breathe and feed for themselves at a time when oxygen and nutrients would have been provided to them by the placenta had they remained in utero. In addition, preterm infants are forced to support their body against the effects of gravity, rather than have the support of amniotic fluid and the uterine wall

Table 1 Transitional food textures.

Texture	Oral movements required to consume texture
Fluids (e.g. breast milk, formula, water)	Bolus suckled from the breast or bottle; tongue moves in a forward-backward plane of movement when drawing fluid into the mouth
Pureed food (e.g. rice cereal, yoghurt, pureed fruit, vegetables, and meats)	Bolus taken from a spoon; tongue moves in a forward-backward plane of movement during mastication
Mashed food (e.g. mashed potato, pumpkin, banana, and avocado)	Bolus taken from a spoon, fork, or fingers; food is masticated by the tongue; tongue moves in a forward-backward plane of movement during mastication
Soft pieces (e.g. pieces of banana and avocado, cooked pieces of potato and pumpkin)	Bolus taken from a fingers, spoon, fork, or chopsticks; food is masticated by the tongue; tongue moves in a forward-backward plane of movement during mastication
Soft mechanicals (e.g. cooked chicken, pasta, and vegetables, meatballs, cheese)	Bolus is cut up or broken then taken from a fork, chopsticks, or fingers; food is masticated by the teeth; tongue lateralization is required to move food onto the chewing surfaces
Hard mechanicals (e.g. beef steak, raw apple, raw carrot)	Bolus is cut up or a bite is taken; the bolus is usually taken from fingers or possibly a fork; food is masticated by the teeth; tongue lateralization is required to move food onto the chewing surfaces
Mixed textures (e.g. baked beans in sauce, pieces of cooked chicken and pasta in with mashed vegetables)	Bolus is usually taken from a spoon; components of food are fluid or pureed, and tongue moves in a forward-backward plane of movement; other components of food need to be masticated by the teeth, and tongue lateralization is required to move food onto the chewing surfaces.

around them. Further, either as a direct result of their premature birth or as a coinciding event, many preterm infants present with severe co-morbidities^[10,12]. Both the impairments themselves, as well as the interventions required to treat them, have the potential to further interrupt feeding development in these infants^[10,11,12]. In addition, prolonged hospitalisation (and the resulting frequent exposure to hospital lights, alarms, and painful procedures) can interfere with the infant’s sensory development, and can affect the family’s ability to interact and bond with their child^[10,11].

A summary of some of the possible interruptions to early oral feeding development commonly cited as being associated with illness and medical treatment is included in table 2^[6,7].

Table 3 contains a list of conditions that are commonly associated with feeding difficulties^[7,8,12]. It should be noted that some of these conditions have the potential to impact on oral feeding directly (i.e. they may affect sucking strength, suck-swallow-breath coordination, or the ability to bite and chew effectively), and others impact on oral feeding indirectly (i.e. they may not directly impact on the oral or pharyngeal phases of swallowing, but may cause pain, discomfort, or fatigue with feeds, or limit the volume the child can consume by mouth). However, during the period of time when young children are developing their oral feeding skills, any feeding disturbances can potentially impact on later feeding skills through interruption of the normal developmental process^[6,7].

Often, prematurity and/or chronic, ongoing illness can result in periods of time where infants cannot feed by mouth. Then, even once an infant is well enough and mature enough to attempt oral feeds, it may be some time before their feeding skills have developed enough to support independent oral feeding^[6,7,11,12]. During the period of time

when medically complex infants are unable to feed exclusively by mouth, they will require some form of artificial tube feeding to meet their energy, nutrition, and fluid requirements^[4,5].

As discussed in table 2, in the short term, tube feeding (as well as other invasive procedures that occur in and around the mouth, such as suctioning and intubation) may cause obstruction and/or irritation of the structures involved in feeding^[13-41]. In the longer term, the iatrogenic effects of medical interventions affecting the mouth and associated structures, as well as a lack of oral feeding practice, may contribute to the development of altered oral sensitivity and/or oral aversion, as well as inefficient feeding patterns^[27-35,38-40]. In addition, any coinciding developmental delays in motor skills or alterations to muscle tone may result in poor postural support and reduced control of the muscles of the mouth involved in oral feeding^[7,11]. Further, due to the effects of prematurity and/or illness, many medically complex infants will display poor nutritional and energy reserves, which may result in low endurance levels for the work of feeding^[11].

FEEDING AND SWALLOWING DIFFICULTIES

During normal swallowing, the bolus is propelled from the oral cavity through the pharynx and down the oesophagus. At the same time, the vocal folds close and a brief deglutition apnoea occurs, along with superior and anterior laryngeal excursion^[6,42]. This helps to ensure that the bolus ends up in the gut and not in the airway. Dysphagia occurs when there is a problem with bolus containment and/or propulsion, and may occur at the oral, pharyngeal, and/or oesophageal phases of swallowing^[6,42]. A prolonged apnoea event occurs when the airway closes over and fails to re-open in time for

Table 2 Possible interruptions to oral feeding development associated with illness and medical treatment.

Table 1 Possible interruptions to oral feeding development associated with illness and medical treatment.		
PRIMARY CONDITION	INTERVENTION	OUTCOMES
PREMATURITY Premature: 1. Anatomical and physiological development (cardiac, respiratory, gastrointestinal systems) 2. Neurological development (reflexes, tone, coordination)	ARTIFICIAL FEEDING Enteral nutrition (gavage feeds) 1. Nasogastric (NG) 2. Orogastric (OG) 3. Gastrostomy 4. Transpyloric (TP) 5. Jejunostomy Parenteral nutrition	PRIMARY CONDITION PERSISTS TO SOME DEGREE 1. Ongoing morbidity 2. Energy imbalance
MORBIDITY Impairment of: 1. Major body systems (neurological, cardiac, respiratory, gastrointestinal systems) 2. Swallowing mechanism (oral region, pharynx, larynx, oesophagus)	OTHER INTERVENTIONS Intubation (and/or suctioning) 1. Orotracheal 2. Nasotracheal 3. Via tracheostomy	EFFECTS OF INTERVENTION Immediate 1. Local irritation of swallowing mechanism 2. Obstruction of swallowing mechanism 3. Injury to swallow mechanism 4. Altered breathing Long-term 5. Disuse of muscles involved in swallowing 6. Altered sensitivity in swallowing mechanism
OTHER ISSUES Physiological instability 1. Altered alertness/ state 2. Poor endurance 3. Altered appetite (medication, reduced gastric emptying, constipation) Altered nutritional and energy requirements 1. Increased energy requirements (morbidity, such as cardiac and respiratory disease) 2. Increased energy losses (poor absorption, gastro-oesophageal reflux) 3. Low nutritional stores	VARIABLES 1. Age when intervention started 2. Duration of intervention 3. Frequency of intervention 4. Total vs. supplemental tube feeding (i.e. opportunity for any oral experience) 5. Route for tube feeding (via oral/ nasal cavity or directly into gut) 6. Rate of tube feeding (bolus or continuous) 7. Type of feed offered 8. Positioning during feeds	INTERRUPTED DEVELOPMENT FOR INFANTS 1. Delayed development of oral-motor skills 2. Defensive oral behaviour/ food/ fluid aversion 3. Reduced association between feeding and reduction of hunger 4. Lack of mealtime routines 5. Limited exposure to tastes/ textures/ feeding utensils 6. Altered bonding opportunities with parents 7. Reduced parental confidence in feeding infant
REASONS FOR COMMENCING INTERVENTION 1. Risk of aspiration 2. Risk of inadequate growth 3. Delivery of medication (e.g. chemotherapy)		

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

Prematurity
Low gestational age at birth
Low birth weight
Comorbidities associated with prematurity
Respiratory and cardiac disorders that can impact on feeding and swallowing
Apnoea of the newborn
Bronchopulmonary dysplasia/ chronic lung disease
Laryngo/trachea/bronchomalacia
Patent ductus arteriosus
Cyanotic heart defects
Gastrointestinal disorders that can impact on feeding and swallowing
Necrotising enterocolitis
Gastroschisis
Hirschsprung's disease
Tracheo-oesophageal fistula and oesophageal atresia
Gastro-oesophageal reflux
Food allergies and intolerances
Neurological disorders that can impact on feeding and swallowing
Intra-ventricular haemorrhage
Periventricular leukomalacia
Hydrocephalus
Seizures
Microcephaly
Birth asphyxia and cerebral palsy
Acquired brain injuries
Congenital abnormalities that can impact on feeding and swallowing
Cleft lip/palate
Moebius syndrome
Downs syndrome
Iatrogenic complications that can impact on feeding and swallowing
Tube feeding
Respiratory support
Tracheostomy
Medication
Ingestional injuries (e.g. detergents, battery)
Tonsillitis and tongue tie
Autism spectrum disorders, sensory processing disorders
Behavioural/ learned feeding difficulties

regular breathing to continue after a swallow^[43,44]. Airway penetration occurs when the bolus (liquid or solid) enters the laryngeal vestibule. Aspiration occurs when the bolus enters the airway below the level of the vocal folds^[42]. Choking occurs when a solid bolus physically blocks the airway^[6].

Mealtime behaviour disturbances or food/ fluid aversion commonly arise in association with dysphagia, aspiration, or a choking event^[6,7]. At other times, there is no apparent physical reason for behavioural feeding issues, although aversive experiences in or around the mouth (e.g. tube feeding, suctioning), undetected pain (e.g. as associated with tonsillitis, pharyngitis, or teething), or sensory disturbances (e.g. oral hypersensitivity) are usually involved at some level^[6,7].

INTERVENTIONS FOR FEEDING AND SWALLOWING DIFFICULTIES

Interventions for feeding and/or swallowing difficulties need to be targeted at the cause/s of the problem in order to be effective. For this reason, a thorough assessment is required to guide any intervention offered. Paediatric feeding assessments generally involve assessment across a number of different developmental areas that have the potential to impact of feeding^[6,7], and these are detailed in table 4. Once the nature and any possible factors contributing to the feeding/ swallowing difficulty have been established, the treatment plan can be developed.

It is widely accepted that interdisciplinary team management

Table 4 Areas commonly assessed during a paediatric feeding assessment.

Medical history
Diet
Growth
General development
Cognitive skills
Oral anatomy
Oral-motor skills
Sensory processing
Positioning for feeding
Self-feeding skills
Feeding skills during mealtimes
Swallowing safety
Trials of different feeding utensils
Trials of different feeding strategies
Behaviour during mealtimes
Parent-child interaction
Parent stress associated with mealtimes

of feeding and swallowing difficulties is desirable, involving members from various medical specialties, nursing, dietetics, and developmental therapies (i.e. speech pathology, occupational therapy, physical therapy, and psychology), as appropriate, working together to manage the various components of the problem. In addition, it is also widely recognised that it is essential to have parent involvement in assessment, setting therapy goals, delivering therapy, and monitoring progress, to ensure that any intervention is meaningful for the child and family, and to assist with the generalization of therapy gains to the home environment.

For children with oral phase swallowing problems, a review of the literature suggests that treatment generally involves working on improving the sensory and/or motor skills required for drinking and eating^[6,7,45-47]. While commonly used in clinical practice, there are only a few small, randomised controlled trials evaluating these techniques in young preterm infants^[45-47]. A recent Cochrane systematic review investigating the use of oral sensori-motor techniques in older children with dysphagia related to neurological problems^[48] found that there is currently insufficient high-quality evidence from randomized controlled trials to provide conclusive results about the effectiveness of any particular type of therapy technique for children in this population and, thus, further research is required to evaluate these treatment strategies.

For children with swallowing problems affecting the pharyngeal phase, a literature review suggests that treatment generally involves teaching the child to modify their swallowing strategy or for the feeder to modify the bolus^[6,7,42,49,50]. A summary of interventions used with infants with poor suck-swallow-breath coordination and older children with poor swallowing and breathing coordination is detailed in table 5 and 6. A few small studies have reported these strategies to be effective in improving physiological stability during feeds and improving volume of intake in young in preterm infants^[49,50], though no randomised controlled trials have been conducted. Further research is required to evaluate the effectiveness of treatment strategies in both infants and older children.

For children with mealtime behaviour disturbances or food/ fluid aversion, therapy is usually either based on the principles of operant conditioning (clinician-driven, top-down, prompt-and-reward therapy) or systematic desensitization (child-driven, bottom-up, play-based therapy). A few small studies have reported that behavioural treatment based on operant conditioning is effective in children with Autism Spectrum Disorder (ASD)^[51,52,53], though no randomised controlled trials have been conducted to date. Further research is required to evaluate the effectiveness of behavioural treatments

Table 5 Summary of interventions reported to be used with infants with poor suck-swallow-breath coordination.

EVENT	Child can't control bolus	Child actively controls bolus	Feeder actively controls bolus
EVENT DETAILS	1. Aspiration 2. Prolonged apnoea	1. Gag/ cough to clear bolus from airway 2. Slower sucking 3. Weaker sucking 4. Stop sucking	1. Mother expresses some breast milk to slow flow before offering breastfeed 2. Slow flow teat is used on bottle 3. Milk is thickened to slow flow 4. The infants is positioned in a side-lying position or semi-upright position to slow the flow of milk in the mouth 5. The feeder uses pacing, where they give the child intermittent breaks from sucking
POSSIBLE CONSEQUENCES	1. Lung damage 2. Hypoxia	1. Child may not finish feed 2. Reduced risk of lung damage or hypoxia	1. Feeds may take longer 2. Greater input is required from the feeder 3. Reduced risk of lung damage or hypoxia

Table 6 Summary of interventions reported to be used with older children with poor swallowing and breathing coordination.

EVENT	Child can't control bolus	Child controls bolus	Feeder controls bolus
EVENT DETAILS	1. Aspiration 2. Choke	1. Gag/ cough to clear 2. Increased chewing (oral-motor exercises may be used to increase chewing strength, chewing speed, chewing effort) 3. Improved sensory awareness (oral sensory exercises may be used to increase sensory awareness) 4. Protective swallowing manouvers (strategies such as chin tuck may be taught)	1. Feeder offers softer or more processed food 2. Feeder offers smaller pieces of food 3. Feeder assists child and offers food at slower pace
POSSIBLE CONSEQUENCES	1. Lung damage 2. Hypoxia	1. Child may not finish feed 2. Feeds may take longer 3. Reduced risk of lung damage or hypoxia	1. Feeds may take longer 2. Greater input is required from the feeder 3. Reduced risk of lung damage or hypoxia

for other groups of children with feeding difficulties, as well as to evaluate the relative effectiveness of different behavioural feeding approaches.

CONCLUSION

Feeding skills undergo a period of rapid development throughout early childhood, alongside general development and growth. Safe and efficient feeding and swallowing skills are important to allow children to meet their expanding dietary requirements as they grow. In a developing system, even short-term problems with swallowing and/or feeding can interrupt normal development and have serious long-term sequelae. This article provides an overview of normal feeding development in children, as well as of interventions aimed at assisting children with feeding and swallowing difficulties. The importance of a thorough assessment to guide intervention is highlighted. A review of the current evidence-base demonstrates that many intervention techniques utilized by clinicians have not been formally evaluated in the literature and, thus, further research is needed to support and guide clinical practice.

CONFLICT OF INTERESTS

There are no conflicts of interest with regard to the present study.

REFERENCES

- World Health Organisation (2013). *Global Strategy for Infant and Young Child Feeding*. Geneva
- National Health and Medical Research Council (2012) *Infant Feeding Guidelines*. Canberra: National Health and Medical Research council
- Centers for Disease Control. *Growth Charts for Infants*: <http://www.cdc.gov/growthcharts/>
- Gomella TL, Cunningham MD, Eyal FG, Zenk KE. *Neonatology: Management, procedures, on-call problems, diseases, and drugs*. 5th Ed. New York: The McGraw-Hill Companies, Inc; 2004
- Behrman R, Kliegman R, Jenson H. *Nelson Textbook of Pediatrics*. 17th Ed. Philadelphia: Saunders; 2004.
- Arvedson JC, Brodsky L. *Pediatric Swallowing and Feeding: Assessment and management*. 2nd Ed. Albany, NY: Singular Thomson Learning; 2002
- Morris SE, Klein MD. *Pre-Feeding Skills: A comprehensive resource for feeding development*. 2nd Ed. Arizona: Therapy Skill Builders; 2000
- Wilson-Pauwels L, Akesson EJ, Stewart PA, Spacey SD. *Cranial Nerves In Health and Disease*. 2nd Ed. Hamilton, Ontario: BC Decker Inc; 2002
- Dietitians Association of Australia and The Speech Pathology Association of Australia Limited (2007). *Texture-modified foods and thickened fluids as used for individuals with dysphagia: Australian standardised labels and definitions*. *Nutrition & Dietetics* 2007; **64**: S53–S76
- McGrath JM, Kenner C, Amspacher KA. Factors that can influence fetal development. In: Kenner C, McGrath JM, Eds. *Developmental Care of Newborns and Infants: A guide for health professionals*. St Louis: Mosby; 2004. p. 131-56
- McGrath JM. Feeding. In: Kenner C, McGrath JM, Eds. *Developmental Care of Newborns and Infants: A guide for health professionals*. St Louis: Mosby; 2004. p. 321-42
- Dodrill P, Donovan T, Cleghorn G, McMahon S, Davies PSW. Attainment of early feeding milestones in preterm neonates. *J Perinatol* 2008; **28** (8): 549-555
- Metheny N. Minimizing respiratory complications of nasogastric tube feedings: State of the science. *Heart & Lung* 1993; **22**(3): 213-23
- Dotson RG, Robinson RG, Pingleton SK. Gastroesophageal reflux with nasogastric tubes. Effect of nasogastric tube size. *Am J Resp Crit Care Med* 1994; **149**(6): 1659-1662
- Cataldi Betcher EL, Seltzer MH, Slocum BA, Jones KW. Complications occurring during enteral nutrition support: A prospective study. *J Parenter Enteral Nutr* 1983; **7**(6): 546-552
- Da Nobrega L, Boiron M, Henrot A, Saliba E. Acoustic study of swallowing behaviour in premature infants during tube-bottle-feeding and bottle-feeding period. *Early Hum Dev* 2004; **78**(1): 53-60
- Greenspan JS, Wolfson MR, Holt WJ, Shaffer TH. Neonatal gas-

- tric intubation: Differential respiratory effects between nasogastric and orogastric tubes. *Pediatr Pulmonol* 1990; **8(4)**: 254-258
- 18 Hawes J, McEwan P, McGuire W. Nasal versus oral route for placing feeding tubes in preterm or low birth weight infants. *Cochrane Database Syst Rev*. 2004 (3)
- 19 Haxhija EQ, Rosegger H, Prechtel HF. Vagal response to feeding tube insertion in preterm infants: Has the key been found? *Early Hum Dev* 1995; **41(1)**: 15-25
- 20 Mukhtar AI, Stothers JK. Cardiovascular effects of nasogastric tube feeding in the healthy preterm infant. *Early Hum Dev* 1982; **6(1)**: 25-30
- 21 Noviski N, Yehuda YB, Serour F, Gorenstein A, Mandelberg A. Does the size of nasogastric tubes affect gastroesophageal reflux in children? *J Pediatr Gastro Nutr* 1999; **29(4)**: 448-451
- 22 Symington A, Ballantyne M, Pinelli J, Stevens B. Indwelling versus intermittent feeding tubes in premature neonates. *J Obstet, Gynecol, Neonat Nurs* 1995; **24(4)**: 321-326
- 23 Peter CS, Wiechers C, Bohnhorst B, Silny J, Poets CF. Influence of nasogastric tubes on gastroesophageal reflux in preterm infants: A multiple intraluminal impedance study. *J Pediatr* 2002; **141(2)**: 277-279
- 24 Rochat P, Goubet N, Shah BL. Enhanced sucking engagement by preterm infants during intermittent gavage feedings. *J Dev Behav Pediatr* 1997; **18(1)**: 22-26
- 25 Sands T, Glasson M, Berry A. Hazards of nasogastric tube insertion in the newborn infant. *Lancet* 1989; **334(8664)**: 680
- 26 Holden CE1, MacDonald A, Ward M, Ford K, Patchell C, Handy D, Chell M, Brown GB, Booth IW. Psychological preparation for nasogastric feeding in children. *Br J Nurs*. 1997; **6(7)**: 376-381
- 27 Tos M, Bonding P. Middle ear pressure during and after prolonged nasotracheal and/or nasogastric intubation. *Acta Oto Laryngologica*. 1977; **83(3-4)**: 353-359
- 28 Kamen RS. Impaired development of oral-motor functions required for normal oral feeding as a consequence of tube feeding during infancy. *Adv Perit Dial* 1990; **6**: 276-278
- 29 Michaelis CA, Warzak WJ, Stanek K, Van Riper C. Parental and professional perceptions of problems associated with long-term pediatric home tube feeding. *J Am Diet Assoc* 1992; **92(10)**: 1235-1238
- 30 Palmer MM. Weaning from gastrostomy tube feeding: Commentary on oral aversion. *Pediatr Nurs* 1998; **24(5)**: 475-478
- 31 Senez C, Guys JM, Mancini J, Paz Paredes A, Lena G, Choux M. Weaning children from tube to oral feeding. *Childs Nerv Syst* 1996; **12(10)**: 590-594
- 32 Vogel S. Oral motor and feeding problems in the tube fed infant: Suggested treatment strategies for the occupational therapist. *Occ Ther Health Care*. 1986; **3**: 63-79
- 33 Warady BA, Kriley M, Belden B, Hellerstein S, Alan U. Nutritional and behavioural aspects of nasogastric tube feeding in infants receiving chronic peritoneal dialysis. *Adv Perit Dial* 1990; **6**: 265-268
- 34 Dello Strologo L, Principato F, Sinibaldi D, Appiani AC, Terzi F, Dartois AM, Rizzoni G. Feeding dysfunction in infants with severe chronic renal failure after long-term nasogastric tube feeding. *Pediatr Nephrol* 1997; **11(1)**: 84-86
- 35 Dodrill P, McMahon S, Ward E, Weir K, Donovan T, Riddle B. Long-term oral sensitivity and feeding skills of low-risk pre-term infants. *Early Hum Dev* 2004; **76(1)**: 23-37
- 36 Erenberg A, Nowak AJ. Palatal groove formation in neonates and infants with orotracheal tubes. *Am J Dis Child* 1984; **138(10)**: 974-975
- 37 Molteni RA, Bumstead DH. Development and severity of palatal grooves in orally intubated newborns. Effect of 'soft' endotracheal tubes. *Am J Dis Child* 1986; **140(4)**: 357-359
- 38 Abraham SS, Wolf EL. Swallowing physiology of toddlers with long-term tracheostomies: A preliminary study. *Dysphagia* 2000; **15(4)**: 206-212
- 39 DeVita MA, Spierer Rundback L. Swallowing disorders in patients with prolonged orotracheal intubation or tracheostomy tubes. *Crit Care Med* 1990; **18(12)**: 1328-1330
- 40 Ash SP, Moss JP. An investigation of the features of the pre-term infant palate and the effect of prolonged orotracheal intubation with and without protective appliances. *Br J Orthod* 1987; **14(4)**: 253-261
- 41 Borowitz SM, Borowitz KC. Oral dysfunction following Nissen fundoplication. *Dysphagia* 1992; **7(4)**: 234-237
- 42 Logemann J. Evaluation and treatment of swallowing disorders 2nd Ed. Austin, Tx: PRO-ED; 1998
- 43 Menon AP, Schefft GL, Thach BT. Frequency and significance of swallowing during prolonged apnea in infants. *Am Rev Respir Dis* 1984; **130(6)**: 969-973
- 44 Thach BT, Menon A. Pulmonary protective mechanisms in human infants. *Am Rev Respir Dis* 1985; **131(5)**: S55-8
- 45 Fucile S, Gisel EG, Lau C. Effect of an oral stimulation program on sucking skill maturation of preterm infants. *Dev Med Child Neurol* 2005 Mar; **47(3)**: 158-162
- 46 Barlow SM, Finan DS, Lee J, Chu S. Synthetic orocutaneous stimulation entrains preterm infants with feeding difficulties to suck. *J Perinatol* 2008; **28**: 541-548
- 47 Dodrill P. Feeding difficulties in preterm neonates. *Infant, Child, & Adolescent Nutrition* 2011; **3(6)**: 324-331
- 48 Morgan AT, Dodrill P, Ward EC. Interventions for oropharyngeal dysphagia in children with neurological impairment. *Cochrane Database Syst Rev* 2012 Oct 17; **10**: CD009456. doi:10.1002/14651858.CD009456.pub2
- 49 Thoyre SM, Holditch-Davis D, Schwartz TA, Melendez Roman CR, Nix W. Coregulated approach to feeding preterm infants with lung disease: effects during feeding. *Nurs Res*. 2012 Jul-Aug; **61(4)**:242-51. doi: 10.1097/NNR.0b013e31824b02ad.
- 50 Dawson JA, Myers LR, Moorhead A, Jacobs SE, Ong K, Salo F, Murray S, Donath S, Davis PG. A randomised trial of two techniques for bottle feeding preterm infants. *J Paediatr Child Health*. 2013 Jun; **49(6)**: 462-466
- 51 Sharp WG, Jaquess DL, Morton JF, Herzinger CV. Pediatric Feeding Disorders: A Quantitative Synthesis of Treatment Outcomes. *Clinical Child and Family Psychology Review* 2010; **13(4)**: 348-365
- 52 Kerwin ME. Empirically supported treatments in pediatric psychology: severe feeding problems. *J Pediatr Psychol* 1999 Jun; **24(3)**: 193-214; discussion 215-216
- 53 Marshall J, Ware R, Ziviani J, Hill RJ, Dodrill P. Efficacy of interventions to improve feeding difficulties in children with autism spectrum disorders: a systematic review and meta-analysis. *Child: Care, Health and Development*, 2014 (in press).

Peer reviewer: Bernice Mathisen, Associate Professor Bernice Mathisen, Head of Speech Pathology, LaTrobe Rural Health School, Bendigo, Australia.