

Tube Feeding in Children

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Education Gap

Enteral tube feeding (TF) is an important part of the care of acutely ill children as well as an essential technique to deliver nutrition to children who have chronic conditions. However, the techniques of TF are neither a part of medical school courses nor specifically taught in pediatric residency programs. Thus, learning how to initiate, monitor, moderate, and transition TF is often learned by trial and error.

Objectives After completing this article, readers should be able to:

1. Understand the need for nutritional assessment and nutrition support.
2. Recognize indications and contraindications for tube feeding (TF).
3. Plan the evaluation of a patient who requires TF.
4. Recognize the factors that are important to make the proper selection of enteral access for TF.
5. Plan the initiation and administration of TF.
6. Recognize the potential complications of TF and learn troubleshooting methods.
7. Coordinate care for home nutrition support and assist in the transition to oral feedings.
8. Understand the social needs of patients who have TF.

INTRODUCTION

Tube feeding (TF) is a mode of providing enteral nutrition when oral feeding is not possible or not sufficient. TF is delivered through a medical device that can be placed into the stomach, duodenum, or jejunum via either the nose, mouth, or the percutaneous route. This review focuses on TF in children beyond the neonatal period.

Nutritional support can be either enteral or parenteral. Enteral nutrition (EN) refers to any method of feeding that uses the gastrointestinal (GI) tract to deliver part or all of a child's nutritional requirements. It can include a normal oral diet or feeding via tube. Parenteral nutrition (PN) refers to the delivery of nutrients by

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vein. Studies have shown that EN is preferred over PN because it leads to earlier gut function, fewer infections, lower cost, and shorter hospital stay. (1)(2)(3) In addition, EN delivers nutrients directly to the GI tract, avoiding deleterious changes in the normal gut physiology and the aberrant physiology that ensues when nutrients are infused directly into the systemic circulation without the benefit of the modifying functions of the GI tract and liver. (4) PN is reserved for patients who have GI tract dysfunction that prohibits adequate nutrient absorption.

Nutrition is important for normal growth and development in children. Nutritional assessment, therefore, should be an integral part of the care for every pediatric patient. Complete nutritional assessment includes a medical history, nutritional history that includes dietary intake, physical examination, anthropometrics, pubertal staging, skeletal maturity staging, and biochemical tests of nutritional status. (5)(6)(7)(8) Most healthy children have the ability to ingest enough nutrients to meet their needs, but children with chronic medical conditions or prolonged illnesses may not be able to meet their nutritional goals. Approximately 10% to 15% of children in the United States have special health care needs. Most of these children are at risk for poor growth. It is important for clinicians to identify these children, assess their nutritional needs, and provide adequate nutritional support for their growth and development.

INDICATIONS FOR TF

TF is used for children who have inadequate or unsafe oral intake and a functioning GI tract (Table 1). If the GI tract is able to absorb some but not all of the nutritional needs, partial EN should be attempted. If the patient has normal swallowing function, oral supplements may be added to achieve the complete nutrition intake and to maintain oral skills.

CONTRAINDICATIONS FOR TF

When oral feeding is not possible or is inadequate, TF is the method of choice because it is more physiologic than PN. The only absolute contraindication for TF is a nonfunctioning GI tract, such as GI obstruction or severe intestinal ischemia. Conditions such as intestinal fistulae and severe pancreatitis are no longer considered contraindications.

CHOICE OF ENTERAL ACCESS FOR TF

Once it is decided that TF is necessary, the clinician must determine the most appropriate enteral access based on the individual clinical situation. The choice of enteral access is

TABLE 1. Indications for Tube Feeding

1. Insufficient oral intake
- Anorexia
-Food aversion
-Malabsorption (cystic fibrosis, short bowel syndrome, pancreatic insufficiency)
-Increased needs (congenital heart disease, bronchopulmonary dysplasia)
2. As a primary therapy
-Metabolic disease
-Intolerance to fasting
-Inflammatory bowel disease
3. Oral motor dysfunction
-Prematurity
-Neuromuscular disease
-Neurologic disease
4. Abnormal gastrointestinal tract
-Congenital malformations
-Esophageal stenosis
-Intestinal pseudo-obstruction
5. Injury/critical illness
-Burn
-Trauma
-Surgery
-Sepsis

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dependent on various factors, including the patient's GI tract anatomy and function, indication for feedings, expected duration of feedings (short term of weeks to months or long term of months to years), and the risk of aspiration. An upper GI radiographic series should be performed to rule out anatomic barriers to TF such as malrotation or gastric outlet obstruction. A careful history can identify signs and symptoms suggestive of aspiration. In some cases, a swallow study under fluoroscopy may be helpful to evaluate swallowing function and the risk of aspiration. A number of options for enteral access are available (Table 2).

Orogastric (OG) feeding is used most frequently in preterm infants before they develop a gag reflex (34 weeks' gestation). Preterm infants are obligate nose breathers, so OG feeding avoids obstruction of the nares. OG feedings are

TABLE 2. **Choice of Tube**

TYPE OF TUBE	DURATION OF FEEDING	PLACEMENT	COMMENT	USE
Orogastric	Short-term	Bedside	<ul style="list-style-type: none"> Used in preterm infants up to 34 weeks' gestation Safe with basilar skull fracture 	<ul style="list-style-type: none"> Feeding Medication Hydration
Nasogastric	Short-term	Bedside	<ul style="list-style-type: none"> With or without stylet 	<ul style="list-style-type: none"> Feeding Medication Hydration
Nasointestinal (including any nasal tube that extends beyond the pylorus)	Short-term	Fluoroscopic	<ul style="list-style-type: none"> Displaces easily Weighted or unweighted 	<ul style="list-style-type: none"> Feeding Hydration
Gastrostomy	Long-term	Surgical	<ul style="list-style-type: none"> Not ready for immediate use 	<ul style="list-style-type: none"> Feeding Medication Hydration
Percutaneous endoscopic gastrostomy (PEG)	Long-term	Endoscopic or radiologic techniques	<ul style="list-style-type: none"> Can be used 4 hours from placement 	<ul style="list-style-type: none"> Feeding Medication Hydration
Low-profile device	Long-term	Initial endoscopic	<ul style="list-style-type: none"> More convenient and easier to care for than gastrostomy tube 	<ul style="list-style-type: none"> Feeding Medication Hydration
Internal balloon or internal "mushroom"		Thereafter at bedside (home)	<ul style="list-style-type: none"> Aesthetically more pleasing 	
Gastrointestinal (including any gastric tube that extends beyond the pylorus) gastrojejunostomy or percutaneous endoscopic jejunostomy	Long-term	Endoscopic, radiologic, or both	<ul style="list-style-type: none"> Possible to access both stomach and small bowel Easily dislodged 	<ul style="list-style-type: none"> Limits reflux and aspiration Feeding Hydration
Jejunostomy	Long-term	Surgical or endoscopic	<ul style="list-style-type: none"> No access to stomach 	<ul style="list-style-type: none"> Feeding Hydration Limits reflux and aspiration
Low-profile jejunal device Internal mushroom bolster or fluid-filled balloon	Long-term	Endoscopic	<ul style="list-style-type: none"> More convenient Aesthetically more pleasing No access to stomach 	<ul style="list-style-type: none"> Feeding Hydration Some medications

preferred over nasogastric (NG) feedings in the presence of a basilar skull fracture. OG feedings are also used when the nares are obstructed (eg, cystic fibrosis).

NG feeding is the method of choice in children with normal gastric function and a low risk of aspiration who require short-term nutrition support. It is the simplest, least expensive method and requires no invasive procedures. Frequently, it is used for patients being evaluated for more permanent tubes to ensure tolerance for intragastric feedings. NG tubes have been used for long-term nutrition support in patients who have learned to place the tube each night, infuse feeding slowly overnight, and remove the tube in the morning. Even for patients at some risk for aspiration, NG feeding is not contraindicated. Infusing feedings over a long period of time can result in less emesis by limiting the gastric contents at any given time. It is important to recognize that TF by any method does not decrease the likelihood

of aspiration of swallowed secretions, an issue with many neurologically impaired children. An NG tube can be placed at the bedside, but proper position should be verified radiologically or by aspiration of acidic stomach contents. Auscultation over the stomach is not recommended. (9)

Gastrostomy tubes (G-tubes) are preferred for intragastric feeding that is expected to last longer than 3 months. G-tubes can be placed surgically, endoscopically, or radiologically. Surgically placed tubes have the advantage of creating a formal attachment between the abdominal wall and the stomach wall, thus reducing the possibility that the tube becomes dislodged, potentially contaminating the peritoneal cavity. For the other 2 methods of placement, 2 months are required for an attachment to form (tract maturation).

A disadvantage of a surgically placed G-tube is that it cannot be used immediately. Some surgeons do not use a surgically placed tube for several days, in contrast to endoscopically or

radiologically placed tubes, which can be used within a few hours of insertion.

If a simultaneous antireflux procedure is planned, surgical placement makes sense. However, there is no indication for a prophylactic fundoplication in a patient without a history of reflux. Even in the presence of prior reflux, a G-tube does not necessarily worsen reflux and, at times, may improve it.

G-tube placement carries a risk of infection (intraabdominal abscess or peritonitis) or, in endoscopically or radiologically placed tubes, colonic perforation. Not infrequently, air is introduced into the peritoneal cavity during the course of either radiologic or endoscopic G-tube placement. This is not a substantial complication because the air reabsorbs without treatment. However, it can be alarming if an abdominal radiograph is obtained because the air in the cavity mimics the radiologic findings of bowel perforation.

All G-tubes are prone to local irritation, with formation of granulation tissue, local skin irritation, and skin infection. After the tract has matured, the G-tube can be replaced with a "low-profile" device, which is aesthetically more pleasing and easier to maintain. Low-profile devices cause less irritation. A kit is available that allows initial placement of a low-profile device. The standard percutaneous endoscopic gastrostomy (PEG) kit contains a PEG tube with an external bolster, safety trocar cannula, safety-shielded scalpel, retrieval snare, Y-port, and C-clamp. Low-profile devices have either a mushroom-shaped bolster or a fluid-filled balloon that keeps the tube in the lumen of the stomach. The advantage of the mushroom is that it is difficult to dislodge, and the advantage of the fluid-filled balloon is that the fluid can be removed and the tube replaced. Accidental loss of fluid from the balloon can result in the tube coming out unintentionally.

G-tubes should be changed periodically. Some centers recommend changing G-tubes every 3 months. Other centers do not advocate a routine, but change the tubes when they appear worn or become nonfunctional. Parents can be taught to change the low-profile devices that have an internal balloon in the stomach. Because G-tubes do not prohibit simultaneous oral feeding, they are excellent for transitioning from TF to oral feeding. When TF is no longer needed, the G-tube can simply be removed. Most often the stoma seals and heals. Occasionally, it remains open, requiring either endoscopic closure using internal clips or formal surgical closure.

Nasointestinal feeding tubes can be used for the short-term delivery of feedings beyond the stomach. These tubes can be placed by a number of methods. A weighted or unweighted tube can be passed into the stomach with extra length of the tube allowed to remain in the stomach and to

pass into the duodenum and jejunum by peristalsis. Neither erythromycin, metoclopramide, nor weighting has been associated with any benefit in promoting passage of the tube by peristalsis. This method is time-consuming and not always successful. Nasointestinal tubes can be placed endoscopically using a number of techniques. The endoscopic techniques are invasive, require anesthesia, and are not always successful. The radiologic placement of nasointestinal tubes has proven to be the fastest and most reliable approach. Nasointestinal tubes are easily dislodged and may require frequent replacement.

A previously placed G-tube can be converted into a GJ tube by replacing the G-tube with a device that looks similar to the G-tube but has an extension that traverses the pylorus and extends into the small intestine. The extension is usually placed into the jejunum by a radiologist, although there are methods to carry the extension into the jejunum with an endoscope. Usually the tract must be mature (ie, the G-tube must have been in place for 2 months) to make this conversion. One commercial kit allows for a small tube to be placed through a newly inserted G-tube and then past the pylorus into the small intestine. The smaller tube has an adapter that fits the tube snugly into the PEG tube, thereby eliminating leakage.

Jejunostomy feeding tubes can be placed directly through the skin and into the jejunum either surgically or endoscopically. These two techniques are not used frequently because both methods eliminate access to the stomach, which is often necessary for venting.

PREPYLORIC VERSUS POSTPYLORIC FEEDINGS

Prepyloric feeding is more physiologic than postpyloric feeding because feeding into the stomach allows a more normal digestive process. Most patients tolerate prepyloric feeding if the stomach is functionally and structurally normal. The stomach acts as a reservoir and can tolerate larger volumes and higher osmotic loads than the small intestine. Prepyloric feedings allow for the use of bolus feeding, creating a more flexible feeding schedule that is closer to a natural pattern of eating. Bolus feedings may lead to better gastric contractility because they are cyclical and associated with peaks and troughs of insulin secretion. Prepyloric feedings also provide a protective effect against hyperosmolar formulas because duodenal osmoreceptors regulate gastric emptying and retain the formula in the stomach until ingested formula is isosmotic. This decreases the risk of dumping. Dumping syndrome is the result of high-volume or high-osmolar fluid entering the duodenum. This induces inappropriate gut hormone release and vasomotor

GI symptoms such as abdominal pain, bloating, and diarrhea. One of the major concerns with the prepyloric feeding is the potential risk of pneumonia from aspiration of formula from the stomach. (10)(11) Therefore, clinicians should be cautious in administering prepyloric feedings to patients with severe gastroparesis and a history of aspiration.

Postpyloric feeding is defined as feeding beyond the pylorus, either into the duodenum or into the jejunum distal to the ligament of Treitz. Postpyloric feeding can be delivered via nasoduodenal tube, gastrojejunal tube, or surgical jejunostomy. This is useful for patients who are at risk for aspiration pneumonia or who have intolerance to gastric feeding, recurrent emesis, or severe gastroesophageal reflux. (11)(12) Postpyloric feedings bypass the stomach, thus decreasing but not eliminating the risk of reflux and aspiration. Especially in neurologically impaired children who are unable to protect their airways, postpyloric feeding can be helpful. Patients with gastroparesis or with emesis as a result of chemotherapy also can benefit from postpyloric feedings. Most postpyloric tubes have a "gastric port" that allows venting of the stomach and administration of medications that need to be given into the stomach.

Postpyloric feedings bypass the digestive and antibacterial functions of the stomach. Because the small intestine cannot tolerate hyperosmolar feedings, postpyloric feedings must be administered slowly over most of the day, thus precluding bolus feedings. The major disadvantages of postpyloric feeding are the difficulty in placement of tubes and the risk of tube migration back into the stomach. The tubes are long and have a small caliber, which creates the chance of occlusion. Placement into the proximal jejunum is preferable because it decreases the likelihood of feedings refluxing into the stomach and esophagus, with aspiration into the airway. Also, tubes ending in the jejunum are less likely to become displaced, a problem with all postpyloric tubes.

BOLUS VERSUS CONTINUOUS FEEDING

TF can be administered continuously or intermittently (boluses). The 2 methods are often combined, such as continuous feeding during the night and bolus feeding during the day. This combination is useful for ambulatory patients who require large volumes to meet their nutritional requirements. The method of delivering nutrition is dependent on various factors, such as the type of tube (prepyloric or postpyloric), medical condition of the patient (age, ambulatory status, underlying diseases), expected tolerance to feedings, nutritional requirements, and other factors (availability of parental support, acceptance, availability of equipment, cost).

Bolus feedings are given to patients who receive intragastric feedings because the stomach can tolerate large volumes. Once the feeding volume required for a 24-hour period is determined, it is divided into 4 to 6 bolus feedings that can be administered by syringe, gravity, or with a pump. Bolus feedings are more physiologic and allow patient mobility. They are the preferred method of delivery for ambulatory patients. They also are less expensive and easier to administer than continuous feedings. However, bolus feedings may not be successfully used in patients with reflux or gastroparesis or those who require large feeding volumes. Patients might experience nausea, vomiting, diarrhea, or abdominal distension with bolus feeding. (8)(12)

Continuous feedings are delivered via an infusion pump. They can be administered through jejunal, gastrostomy, or nasointestinal tubes. Continuous feedings are administered at a constant hourly rate over an 8- to 24-hour period, depending on the patient's nutritional requirements. Continuous feedings are beneficial for critically ill patients, malnourished patients, and those who have malabsorption due to intestinal diseases. They are also used for patients who have intolerance to gastric bolus feedings. Nocturnal feedings are useful for providing extra energy to ambulatory patients. Continuous feedings are more expensive due to equipment requirements and supplies and they restrict ambulation. (8)(12)

INITIATION OF TF

After a thorough evaluation by a multidisciplinary team that consists of variable combinations of a gastroenterologist, nurse, dietitian, speech-language pathologist, occupational therapist, psychologist, surgeon, and radiologist, the decision to initiate TF is taken.

Initiating and administering a TF regimen requires careful assessment of the nutritional status of each patient to ensure that the best regimen is prescribed, monitored, and maintained. Assessment takes into account each patient's age, medical status, and GI tract function as well as type of feeding tube, feeding goals, and desired feeding schedule. If results of this assessment suggest that TF is indicated, the first step is to select an appropriate formula (Tables 3 and 4).

Once a formula is selected, TF may be administered by bolus, continuous, or a combination of these methods. For most patients there is no need to dilute formula; full-strength formula is started and volume gradually increased as tolerance is demonstrated.

Initiation and advancement of TFs can vary greatly among clinicians and individual medical facilities, but most medically stable patients can tolerate fairly rapid progression

TABLE 3. Choice of Formula for Infants

FORMULA CATEGORY	INDICATIONS	EXAMPLES/PRODUCT MANUFACTURER	MACRONUTRIENT SOURCE (VARIES BY INDIVIDUAL PRODUCT)	COMMENTS
Human Milk	Preferred nutrition source for virtually all infants* when mother's milk and/or donor milk is available		PRO: whey-predominant, whey:casein ratio varies FAT: human milk CHO: lactose	<ul style="list-style-type: none"> • Nonhomogenized • Special care and technique needed when feeding via tube • 20 kcal/oz, crematocrit can be performed to measure kcal concentration
Postdischarge Formulas for Prematurity	Posthospital discharge formulas for former preterm infants	Enfamore [®] Lipil, ^a Similac [®] NeoSure ^{®b}	PRO: whey, casein, cow milk protein FAT: high-oleic, soy, coconut oils, MCT, DHA, ARA CHO: corn syrup solids, lactose, maltodextrin	<ul style="list-style-type: none"> • Standard concentration is 22 kcal/oz • High in protein, vitamin D, calcium, and phosphorus • 250-310 mOsm/kg water
Standard Infant Formulas	Normal gastrointestinal tract	Enfamil [®] Premium, ^a Enfamil [®] Gentlease, ^a Gerber [®] Good Start [®] Gentle, ^c Similac [®] Advance ^{®b}	PRO: cow milk protein, whey protein concentrate (Gentlease and Good Start contain partially hydrolyzed protein) FAT: palm olein, soy, coconut, high-oleic sunflower, DHA, ARA CHO: lactose, galactooligosaccharides, polydextrose, corn syrup solids	<ul style="list-style-type: none"> • Standard concentration is 20 kcal/oz • Similac concentration is 19 kcal/oz • 230-310 mOsm/kg water
Soy-based Infant Formulas	Galactosemia, primary or secondary lactose intolerance, families preferring vegan formula option	Enfamil [®] Prosobee, ^a Gerber [®] Good Start [®] Soy, ^c Similac Soy Isomil [®]	PRO: soy protein isolate and L-methionine FAT: palm olein, soy, coconut, high-oleic safflower/sunflower, DHA, ARA CHO: corn syrup solids, sucrose	<ul style="list-style-type: none"> • Lactose-free • 20 kcal/oz standard concentration • Similac concentration is 19 kcal/oz • 180-200 mOsm/kg water
Extensively Hydrolyzed Infant Formulas	Food protein intolerance, malabsorption, steatorrhea, intractable diarrhea	Similac [®] Alimentum, ^{®b} Nutramigen [®] Lipil, ^a Pregestimil ^{®a}	PRO: cow milk protein hydrolysate FAT: long-chain fat, variable MCT (0%-55% of fat), DHA, ARA CHO: corn syrup solids, modified corn starch, dextrose, sucrose	<ul style="list-style-type: none"> • Hypoallergenic • Lactose-free • 20 kcal/oz standard concentration • 320-370 mOsm/kg water
Elemental/Free Amino Acid Infant Formulas	Severe protein allergy, eosinophilic gastrointestinal disorders, malabsorptive conditions, short bowel syndrome	Alfamino [®] Infant, ^d Elecare [®] Infant, ^b Neocate [®] Infant, ^e PurAmino ^{TMa}	PRO: free amino acids FAT: high-oleic safflower oil, soy, coconut, sunflower oil, variable MCT (33%-43% of fat), DHA, ARA CHO: corn syrup solids	<ul style="list-style-type: none"> • Hypoallergenic • No cow milk protein, soy, fructose, galactose, or lactose • 330-350 mOsm/kg water

*Contraindicated in some instances, such as galactosemia, maternal human immunodeficiency virus/AIDS, active tuberculosis, and some inborn errors of metabolism.

^aMead Johnson Nutrition, Chicago, IL.

^bAbbott Laboratories, Abbott Park, IL.

^cNestlé Infant Nutrition, Florham Park, NJ.

^dNestlé Health Science, Florham Park, NJ.

^eNutricia North America, Gaithersburg, MD.

ARA=arachidonic acid, CHO=carbohydrate, DHA=docosahexaenoic acid, FAT=fat, MCT=medium-chain triglyceride, PRO=protein.

Formula content and specifications as per product manufacturers' websites.

TABLE 4. Choice of Formula for Children Older Than Age 1 Year

FORMULA CATEGORY	INDICATIONS	EXAMPLES/PRODUCT MANUFACTURER	MACRONUTRIENT SOURCE (VARIES BY INDIVIDUAL PRODUCT)	COMMENTS
Standard Pediatric Enteral Formulas	Normal GI tract requiring a complete or supplemental source of energy from tube feeding	Boost [®] Kid Essentials ^{TM,a} Compleat [®] Pediatric, ^a Nutren Junior, ^a PediaSure [®] Enteral 1.0 Cal, PediaSure ^{®b} Adolescents >13 years: Jevity [®] 1 Cal, ^b Nutren [®] 1.0, ^a Osmolite [®] 1.0 ^b	PRO: cow milk protein concentrate (Compleat contains food ingredients: chicken, peas, carrots, tomatoes, and cranberry juice) FAT: high-oleic sunflower oil, soybean, safflower, canola oil, variable MCT (0%-20% of fat) CHO: maltodextrin, sucrose, corn syrup	<ul style="list-style-type: none"> • 1 kcal/mL, 30 cal/oz • Lactose-free • Meets/exceeds 100% of the DRIs for protein, vitamins/minerals for children 1-8 years, 9-13 years in 1,000 mL and 1,500 mL, respectively • For oral or tube feeding use • Fiber content varies • 300-550 mOsm/kg water
Calorie-dense Pediatric Formulas	Normal GI tract requiring increased energy needs, shortened feeding schedules, fluid restriction, or have volume intolerance	Children 1-13 years: Boost [®] Kid Essentials TM 1.5, ^a PediaSure [®] 1.5 ^b Adolescents >13 years: Isosource 1.5, Jevity [®] 1.2, ^b Jevity [®] 1.5 Cal, ^b Nutren [®] 1.5, ^a Nutren [®] 2.0, ^a Osmolite [®] 1.2, ^b Osmolite [®] 1.5 ^b	PRO: cow milk and whey protein concentrate, sodium and calcium caseinate, soy protein isolate FAT: high-oleic sunflower/safflower, soy oil, canola oil, variable MCT (0%-20% of fat) CHO: sucrose, corn syrup solids, maltodextrin	<ul style="list-style-type: none"> • 1.2-2.0 kcal/mL • Lactose-free • Nutritionally complete in varying volumes/patient age-dependent • 370-780 mOsm/kg water • 69%-81% free water; while using these, be sure adequate free water flushes are provided to meet hydration needs of patient
Reduced-calorie Pediatric Enteral Formulas	Age 1-13 years with decreased energy needs requiring a lower-energy complete feeding	Compleat [®] Pediatric Reduced Calorie, ^a PediaSure [®] SideKicks 0.63 kcal/mL ^a	PRO: cow milk and whey protein concentrate, soy protein isolate, sodium caseinate, chicken, pea protein isolate FAT: canola oil, soy oil, variable MCT (0%-20% of fat) CHO: corn syrup, sucrose	<ul style="list-style-type: none"> • 0.6-0.63 kcal/mL • Lactose-free • Beneficial to address disproportionate weight gain often associated with developmental disabilities • Fiber content varies • 300-420 mOsm/kg water
Hydrolyzed Pediatric Formulas	Impaired GI tract function requiring peptide-based complete nutrition formula; may be beneficial for use in malabsorption, short bowel syndrome, chronic diarrhea, delayed gastric emptying, or for previous intolerance issues with intact protein formulas	PediaSure [®] Peptide 1.0, ^b PediaSure [®] Peptide 1.5, ^b Peptamen [®] Junior 1.0, ^a Peptamen [®] Junior 1.5 ^a	PRO: enzymatically hydrolyzed whey protein, hydrolyzed sodium caseinate FAT: canola oil, soy oil, variable MCT (50%-60% of fat) CHO: maltodextrin, sucrose, cornstarch	<ul style="list-style-type: none"> • 1.0-1.5 kcal/mL • Flavored and unflavored • Lactose-free • Fiber content varies • 260-450 mOsm/kg water
Free Amino Acid Pediatric Formulas	For children with impaired GI tract function requiring a hypoallergenic, amino acid-based formula; may be beneficial for use in patients with multiple food allergies, eosinophilic GI disorders, malabsorptive conditions, short bowel syndrome, and other GI tract impairments	Alfamino [®] Junior, ^c Elecare [®] Junior, ^b Neocate [®] Junior, ^d Neocate [®] Splash, ^d Vivonex [®] Pediatric ^a	PRO: free amino acids FAT: high-oleic safflower oil, soy oil, variable MCT (33%-70% of fat) CHO: corn syrup solids, potato starch, modified corn starch	<ul style="list-style-type: none"> • 0.8-1.0 kcal/mL • Flavored and unflavored • Lactose-free • Available in powder or ready to feed (Neocate[®] Splash manufactured as ready to feed) • 360-590 mOsm/kg water

^aNestlé Health Science, Florham Park, NJ.^bAbbott Laboratories, Abbott Park, IL.^cNestlé Health Science, Florham Park, NJ.^dNutricia North America, Gaithersburg, MD.

CHO=carbohydrate, DRI=dietary reference intake, GI=gastrointestinal, MCT=medium-chain triglyceride, PRO=protein.

Formula content and specifications as per product manufacturers' website.

to reach their established goal within 1 to 2 days of initiation (Table 5). Medically fragile patients (particularly those at risk for refeeding syndrome) or patients with compromised GI tracts often require slower progression of feedings. Patients should be monitored closely for the initial 3 to 5 days to ensure adequate nutrient delivery and for potential complications. The family should be involved in the process of designing and implementing a TF regimen, especially if the patient is to be discharged on home TF. Ultimately, the family is responsible for administering the daily feeding, and it is imperative that the schedule work well for all involved.

COMPLICATIONS

Fortunately, most complications associated with TF are more of a nuisance than they are causative of morbidity. However, serious complications can occur and can be a manifestation of the underlying disease or the enteral feeding itself. For example, vomiting or retching is often seen in children with developmental delays or due to an intervention such as a fundoplication. Complications can be attributed to the mechanics of the TF, infections, metabolic issues, intolerance, noncompliance, lack of patient or parent satisfaction, and failure to reach nutritional goals.

Complications seen immediately after G-tube insertion include misplacement, bleeding, and infection and should be referred to the service that placed the tube: gastroenterology, interventional radiology, or surgery. The proceduralist who placed the tube usually addresses these complications. Later problems can occur that are vexing at the least and

interfere with care at the worst. Table 6 lists some of these complications, possible causes, and how to troubleshoot them. Table 6 does not discuss gastric residuals because gastric residual volumes do not correlate with risk of aspiration in critically ill patients and cessation of feedings based on gastric residual volumes underfeeds ill patients and does not prevent aspiration.

HOME NUTRITION SUPPORT

Once the TF is established and the patient shows a clinical response, discharge planning should begin. The important components of discharge planning are patient/caregiver training and arranging for supplies and necessary equipment, home nursing care, and follow-up evaluations with clinicians. Home care involves a team consisting of physician, nurse, dietitian, case manager, discharge planner, vendor for supplies, and home nursing services.

The patient/caregiver should be educated about the disease process and the need for TF, handling of equipment (using feeding pump), managing feedings (feeding regimen, preparation and administration of formula), and methods for troubleshooting common problems and monitoring for complications. It is also crucial to explain to the family when to call the health care team. The family should be provided with both routine and emergency telephone numbers. Arranging for supplies and services at home is handled either by the home care team of the hospital or a commercial home care company. The home care company provides numerous services, including the equipment, home nursing, and delivery of nutrient supplies.

TABLE 5. Initiation and Advancement of Tube Feeding

TYPE	PATIENT AGE	INITIAL INFUSION RATE	ADVANCEMENT	GOAL
Continuous	0-12 months	1-2 mL/kg/h	1-2 mL/kg every 8 hours	5-6 mL/kg/h
	1-3 years	1 mL/kg/h	1 mL/kg every 8 hours	4-5 mL/kg/h
	4-10 years	20-30 mL/h	20-30 mL every 8 hours	3-4 mL/kg/h
	11-18 years	30-60 mL/h	30 mL/h every 8 hours	100-150 mL/h
Bolus	0-12 months	30-60 mL every 2-3 hours	15-60 mL/feeding	150 mL every 4-5 hours
	1-3 years	30-90 mL every 2-3 hours	60 mL/feeding	180 mL every 4-5 hours
	4-10 years	75-90 mL every 3 hours	60 mL/feeding	210 mL every 4-5 hours
	11-18 years	90-120 mL every 3 hours	60 mL/feeding	240 mL every 4-5 hours
Cyclic	0-12 months	1-2 mL/kg/h	1-2 mL/kg/2 h	75 mL/h x 12-18 h per day
	1-3 years	1 mL/kg/h	1 mL/kg/2 h	90 mL/h x 8-16 h per day
	4-10 years	25 mL/h	25 mL every 2 hours	120 mL/h x 8-16 h per day
	11-18 years	30 mL/h	30 mL every 2 hours	150 mL/h x 12 h per day

Adapted with permission from: Baker SS, Baker RD, Davis AM. Pediatric Nutrition Support. 2007; Jones & Bartlett Learning, Burlington, MA. www.jblearning.com. Copyright 2007.

TABLE 6. **Complications of Tube Feeding and Troubleshooting**

COMPLICATION	POSSIBLE CAUSE	TROUBLESHOOTING
Mechanical		
Tube breaks	Manufacturer problem, mishandling, worn out	Replace tube or part
Cannot rotate tube, dimples skin, sometimes skin is irritated	Tube too tight	Resize and change to appropriate size; if balloon present, check volume and be sure not overfilled
Buried bumper, cannot rotate tube but feeds flow freely into the stomach	Tube too tight and becomes imbedded into the gastric wall; caused by too small a tube or mechanical traction on the tube	Contact team that placed tube to assess and replace tube
Clogged tube	Failure to rinse tube after feedings, delivery of "crushed" medications through tube	Replace tube; attempts to force fluids through a clogged tube often result in tube rupture To prevent future clogs, change medications to liquid form if available, educate on proper flushing protocols
Dislodged	Handling by patient	Reposition
Tube hangs out onto abdominal wall	Tube too long or internal balloon issue	Resize and replace with appropriate-sized tube; if balloon present, be sure it is intact and correct volume of water is in place
Leaking at stoma site	Assess tube size; assess for infection and underfilled balloon	Place correct-sized tube, treat infection, check fluid volume in balloon
Granulation tissue	Caused by repeated mechanical trauma	Cauterize with silver nitrate, assess tube for size, educate about handling of tube
Metabolic		
Dehydration	Too little free water, hyperosmolar or high-protein formula	Increase free water, reassess formula
Hyperglycemia	Diabetic with changed insulin requirement	Monitor blood glucose, reduce carbohydrate content, adjust insulin dose
Hyperkalemia	High-potassium formula, renal insufficiency, intravenous potassium, acidosis	Change formula; give potassium binder, insulin, glucose; stop or decrease intravenous potassium; correct acidosis
Hyperphosphatemia	Renal insufficiency	Change formula to a renal-specific formulation; give phosphate binder, calcium supplements
Hypokalemia	Malnutrition, diarrhea, insulin administration	Monitor electrolytes, fluid and electrolyte replacement, assess insulin dose
Hypophosphatemia	Refeeding syndrome, insulin administration	Phosphorus supplements; hold feedings if phosphorus is ≤ 1.0 mg/dL (≤ 0.32 mmol/L) until correction begins, assess insulin dose
Hyponatremia	Overhydration	Adjust fluids
Acute rapid weight gain	Fluid overload	Adjust fluids
Rapid excessive weight gain	Too many calories	Reassess prescription for enteral feeding: formula concentration, rate, length of feeding
Inadequate weight gain	Not enough calories	Reassess prescription for enteral feeding: formula concentration, rate, length of feeding

Continued

TABLE 6. (Continued)

COMPLICATION	POSSIBLE CAUSE	TROUBLESHOOTING
Gastrointestinal		
Diarrhea, general	Osmotic load, infection, contamination of feeding	Assess formula composition; assess method of administration, storage, handling; review all medications, especially liquid ones, for osmotic load (sorbitol content); reduce rate of nutrient delivery; assess for infection
Diarrhea, gastrointestinal tract abnormalities	Flat villus lesion, short bowel, pancreatic insufficiency	Define gastrointestinal problem and treat accordingly: pancreatic supplements, bulking agents; slow rate of administration
Malabsorption	Define cause	Treat identified cause; consider increased use of medium-chain triglycerides, elemental or semi-elemental formula
Vomiting	Gastrointestinal obstruction, tube malpositioned (if using a Foley catheter, the balloon occludes the pylorus), medications administered with feeding, patient positioning, delayed gastric emptying, after a fundoplication	Assess and treat accordingly; reposition or change type of tube; do not administer medications with feedings; reposition patient; slow feeding rate or change to continuous feedings; consider erythromycin trial; if after fundoplication, trial of nasojunal feedings
Constipation	Inadequate fluids, inadequate fiber, inactivity, obstruction, fecal impaction	Assess fluids, consider formula containing fiber, disimpact as necessary, consider osmotic stool softener
Skin is erythematous, warm, or turning tube is painful; pus is visible	Culture	Treat with broad-spectrum antibiotic, re-educate on proper tube care and hygiene of tube site
Abdominal distention	Gastrointestinal obstruction, constipation, aerophagia, bacterial overgrowth	Treat obstruction; treat constipation; if not obstructed or constipated, vent gastric port or consider a Farrell® Valve Bag*

*Farrell Valve Bag System (Corpak Medsystems, Buffalo Grove, IL) is a device that allows continuous venting of tube feedings and provides reservoir for formula.

It is important to realize and relay to families that TF is a dynamic process that can and should be adjusted frequently to best meet the needs of the child. This includes taking into account changes in medical status (which may affect TF tolerance), variations in activity levels or nutrient requirements, decreases or increases in oral intake, and growth.

TRANSITION FROM TF TO ORAL FEEDINGS

The decision to start weaning the child from TF depends on his or her nutritional status, oral motor skills, swallowing ability, and concurrent diseases as well as the readiness of the patient/caregivers. For most children, TF has a substantial behavioral component such as absence of sucking, withdrawal from offered food, tongue chewing, gagging, and food aversion with the sight or smell of food. This makes the process more complicated and challenging. Sensory food aversions increase the child's sensitivity to the sight or smell of food and leads to the fear of trying

new food. Posttraumatic feeding disorder is caused by a traumatic oropharyngeal event such as intubation or prolonged tube feeding. (13) Treatment involves a multidisciplinary team consisting of a physician, speech therapist, occupational therapist, dietitian, and child psychologist. The relationship between the child and the caregiver also plays an important role. Behavioral treatments usually involve positive reinforcement, modeling (observation of other person performing goal behavior), and shaping (goal behavior is broken down into components with the final stage of completing the behavior). Other important components of treatment are oral motor stimulation, supplementation, and appetite stimulants. (8)(13)(14)(15)(16)(17)(18)

SOCIAL CONSIDERATIONS

It is important for the health care team to understand that initiating TF is a difficult decision for the patient and family.

Studies have shown that parents' decisions about tube insertion are complex. (19) Parents might have a feeling of guilt or see it as a failure on their part to adequately feed their child. Brotherton et al (20) reported that the key issues based on parents' views about the impact of feeding on daily lives of both the children and their families, included delayed and disturbed sleep, restricted ability to go out, difficulties in finding a place to feed, child care problems, negative attitudes of others toward feeding, and family divisions.

Pederson et al (21) reported that factors associated with the stress reported by parents of children with an enteral feeding tube were severity of their child's illness/disability, the constant caretaking demands placed on the parents, and the level of support provided by the parents' social network. It is, therefore, important that health care professionals prepare the child and the family for the challenges of TF and provide them support.

CONCLUSION

TF is a means of delivering complete nutrition to those who would otherwise not receive it, thus supporting the best possible growth and development. A successful TF program requires input from many health care professionals and

thoughtful planning and dedication to deliver safe nutrition support. A team approach is necessary. The team should always include the patient, the patient's family, and caregivers.

Summary

- Based on overwhelming observational studies as well as consensus, tube feeding (TF) is a means of delivering complete nutrition to those who would otherwise not receive it, thus supporting the best possible growth and development. (Evidence quality B, C, D). (4)
- A successful TF program requires input from many clinicians and thoughtful planning and dedication to deliver safe nutrition support. Based primarily on consensus with some observational and cohort studies, a team approach is necessary (Evidence quality C and D). (19)(20)
- Based on consensus with the support of some observational studies, the team should always include the patient, the patient's family, and caregivers (Evidence quality C and D). (19)(20)

References for this article are at <http://pedsinreview.aappublications.org/content/38/1/23>.

Parent Resources from the AAP at HealthyChildren.org

- Caring for a Premature Baby: What Parents Need to Know: <https://www.healthychildren.org/English/ages-stages/baby/preemie/Pages/Caring-For-A-Premature-Baby.aspx>
- Challenges Faced by Parents of Children with Congenital Heart Disease: <https://www.healthychildren.org/English/health-issues/conditions/heart/Pages/Challenges-Faced-by-Parents-of-Children-with-Congenital-Heart-Disease.aspx>

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1. An 8-month-old infant is admitted to the hospital for failure to gain weight despite home-based efforts to provide adequate energy orally. You discuss with the parents the feeding options of enteral nutrition (EN) and parenteral nutrition (PN). As compared to PN, which of the following EN features makes it the preferred feeding method in this patient?
 - A. Ability to promote earlier gut function.
 - B. Delivery cost is similar to PN.
 - C. Effectiveness is independent of liver function.
 - D. Hospital length of stay is similar to that for PN.
 - E. Infection risk is similar to that for PN.
2. You are asked to lead an orientation program for new nurses at your hospital on oral feeding alternatives. In which of the following clinical scenarios would an orogastric tube be the preferred feeding method?
 - A. Preterm infant (now 32 weeks corrected age) with persistent oxygen requirement.
 - B. Term infant being treated with therapeutic cooling for hypoxic ischemic encephalopathy.
 - C. Term infant with 15q11.2-q13 deletion (Angelman syndrome).
 - D. Toddler with a temporal skull fracture and altered mental status.
 - E. Toddler with Pierre Robin sequence who requires long-term nutrition support.
3. You are placing a nasointestinal tube in an infant with severe oral aversion who has not tolerated gastric feeding. Which of the following is the most reliable method to confirm the successful placement of the tube in this patient?
 - A. Aspiration of bilious stomach contents.
 - B. Auscultation over the abdomen.
 - C. Clinical impression.
 - D. Radiologic confirmation.
 - E. Using a tube/body length nomogram.
4. A 4-year-old girl with dystonic cerebral palsy (Gross Motor Function Classification System V) requires enteral nutrition support because of frequent aspiration pneumonias and poor gut motility. Postpyloric feeding is recommended as the preferred method of enteral feeding. Which of the following statements represents the greatest advantage of postpyloric feeding in this child?
 - A. Eliminates the risk for reflux aspiration.
 - B. Has a lower incidence of tube occlusion.
 - C. Is better tolerated in patients with gastroparesis.
 - D. Minimizes symptoms of dumping syndrome.
 - E. Permits a more flexible feeding schedule.
5. You are meeting with your multidisciplinary team to implement a patient's feeding plan. You discuss with the team the 2 considerations of bolus feeding versus continuous feeding. In deciding to choose between the 2 methods, which of the following factors favors bolus feedings over continuous feedings?
 - A. Gastroparesis.
 - B. Intestinal malabsorption.
 - C. Patient mobility level.
 - D. Poor nutritional status.
 - E. Volume of oral intake.

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