Food for Thought: Two Case Studies on Blenderized Tube Feeding Diets and Successful Tube Weaning

Corresponding Author: *Amanda Gordon, MS, RD, LDN, IBCLC*
Pediatric Dietitian, Feed to Succeed LLC, 901 Buccaneer Drive, N, Glenview, IL 60026
Phone: 847-724-8015, amanda@feedtosucceed.com

Dan Frazier, RDN-AP, CNSC
Registered Dietitian, Real Food Blends
890 E Sidewalk Road
Suite 101
Chesterton, IN 46304
Phone: 412-974-8598
danfrazierRD@gmail.com

Betsy Hjelmgren, MS, RDN, CSP, LDN
Pediatric Dietitian/Owner
Feed to Succeed LLC
901 Buccaneer Drive, N
Glenview, IL 60026
Phone: 847-724-8015
betsy@feedtosucceed.com

Ellie Trefz, MS, CCC-SLP, CLS
Speech Language Pathologist
Ann & Robert H. Lurie Children's Hospital of Chicago
225 E. Chicago Ave
Chicago, IL 60611
Phone: 312-227-0484
etrefz@luriechildrens.org

Background:

Tube feeding, often referred to as enteral nutrition (EN), refers to the delivery of nutrients through the gastrointestinal tract, which meets part or all of an individual's caloric requirements.[1] EN can include nutrient delivery through an oral diet via liquid supplements or via a feeding tube.[1] For the purpose of this article, we will refer to EN in the context of feeding via a feeding tube. Many adults and children alike are reliant on tube feedings at home to deliver adequate nutrition and hydration. Studies using Medicare and Medicaid data in the United States indicate that the use and incidence of home enteral nutrition (HEN) is on the rise in the U.S., while the incidence of home parenteral nutrition (HPN), or intravenous nutrition support, is decreasing.[2]

There are many conditions for which children have tubes placed for feeding and hydration, including complex medical diagnoses and physical, anatomical, or neurologic conditions.[3,4] HEN can also be used in situations of pediatric feeding disorders, not otherwise specified by the above conditions.[5] In many situations, when feeding tubes are placed in small children for medical, structural, or behavioral/psychosocial reasons, the goal is often to eventually have the child wean from EN and gain the skills for accepting oral feedings. Further, the goal is to meet their nutritional needs and growth goals through an oral diet. Studies indicate that the younger a child is, the easier it may be to wean them from EN to an oral diet.[6,7] Lively, et al. explains this may be due in part to less psychological dependence on the tube.[6] Tube-fed children who are trialed on oral feedings can develop and display oral feeding problems. Some of the behaviors that tube-fed children display when oral feedings are presented include gagging, oral-motor hypersensitivity, tongue chewing, and withdrawal from food offered.[8]

In the past decade, caregivers, patients, and clinicians alike have shown an increased interest in utilizing whole food blenderized tube feeds in an effort to mitigate feeding intolerance concerns. Several clinical studies have documented the effects of blenderized tube feeding (BTF) and the associated reduction in gastrointestinal complications, increased gut microbiota diversity, decreased healthcare costs, reduction in hospital admissions, and improvements in quality of life.[9,10,11] In a study by Pentiuk et al., gastrostomy-fed children with a history of severe gastroesophageal reflux disease, with symptoms of gagging and retching post-Nissen fundoplication surgery, were found to have significant decrease in gagging and retching after transitioning to a BTF diet.[9] Pentuik et al. indicate the mechanism of how BTF decreases gagging and retching is not completely clear, but it is possible that the viscosity of BTF may slow down the rate of gastric emptying and the blended food may stimulate a hormonal response that has a positive impact on gastric motility, which may contribute to a decrease in retching and vomiting.[9] The decrease in gagging and retching can decrease oral aversion and promote oral intake in children.[9,10]

Learning Objectives:

1. List the clinical applications of blenderized tube feeding
2. Discuss the benefits of food and nutritional variety for tube-fed children
3. Describe the interdisciplinary approach to tube weaning

Key Words: blenderized tube feeding (BTF), tube weaning, enteral nutrition, interdisciplinary

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Additionally, Hron, et al. indicate that BTF may improve stooling patterns in tube-fed children, which is likely related to the incorporation of whole foods and several types and quantities of fiber.[11] The interest in BTF comes largely from enteral nutrition consumers and caregivers with up to 80% of these groups reporting interest.[12] Barriers to receiving dietitian support exist in relation to BTF, as only 24% of dietitians have reported confidence in managing patients receiving BTF.[13]

Case Studies:

The following two case studies demonstrate the success of interdisciplinary care in the tube weaning of two children and the clinical benefit of having a variety of foods and BTF in the process of tube weaning. Patient 1 was able to progress to completely 100% oral feeds despite a history of malnutrition, feeding difficulty, and G-tube placement. This patient was able to wean completely from his feeding tube within one year of starting weekly intensive feeding therapy with a speech-language pathologist (SLP) trained in feeding and a registered dietitian nutritionist (RDN). An occupational therapist, pediatric gastroenterologist, and pediatric endocrinologist also played vital roles as consultants to the SLP and RD as needed. Patient 2 was able to improve oral intake and reduce oral aversion once started on BTF despite a history of bloody stools and multiple formula trials, including elemental formula. The following case studies focus on BTF, intensive feeding therapy, and an aggressive tube weaning approach.

Case Study – Patient 1

The patient, TG, was followed by a pediatric RDN bi-weekly and a SLP/feeding therapist weekly. TG was breastfed and also supplemented with bottles of expressed breastmilk, with a significant deceleration in weight gain velocity and height gain velocity over a six-month period of time from 6-12 months. Past medical history included elevated liver function tests (LFTs), lower extremity edema, and tongue and lip tie. TG was admitted to a children's hospital with dehydration and vomiting at 13 months after presenting to the ER. He was initially started on nasogastric feedings, however, a decision was made to place a gastrostomy tube (G-tube) after one week of hospitalization for longer-term nutrition support due to a history of inadequate intake.

From 13-15 months old, TG was fed expressed breastmilk fortified to 30 cal/oz with a partially hydrolyzed infant formula via G-tube, administered intermittently via an enteral feeding pump, which provided 765 mL, 720 kcal (90 kcal/kg), 11 g protein (1.4 g/kg).

At 16 months, TG was transitioned to 30 cal/oz feeds exclusively with the partially hydrolyzed infant formula, which provided 775 mL, 750 calories (90 cal/kg), 17.5 g protein (2.1 g/kg). Several feeding options were presented to the family, and the decision was made by the family with the support of the RDN to transition TG to a commercial BTF product by bolus feeds at age 17 months, which provided 880 mL and 720 calories (74 cal/kg). He developed significant loose stools and diaper rash. As a result, at 18 months old, TG was transitioned to another commercial blenderized tube feeding product with nutritional variety, which he tolerated better. Commercial formulas, and even the majority of commercial BTF products, are monotonous in nature, meaning that the consumer is fed the same ingredients every day for every meal. The commercial BTF product with nutritional variety used in this case offers a variety of meals to give the consumer both a choice in what they consume as well as variety in their diet (i.e. each meal contains different ingredients). This regimen provided 870 mL and 874 cal (89 cal/kg). Between 17-18 months of old, TG also had a tongue and lip tie revision at the recommendation of the SLP, which helped increase his tongue mobility for oral feedings. Between 19 and 20 months old, TG started showing increased interest in table foods. He continued to get 100% of his estimated needs from his bolus tube feeds, but began to take some table foods by mouth at family meals. As a result, his tube feeds were able to be weaned by 25% at 20 months old. Based on calorie counts from his oral intake as well as improved growth indices, TG's tube feeds were weaned to 50% at 21 months old. At 22 months old, TG's tube feeds were stopped completely, as his table food intake was estimated to meet his nutritional needs and he was meeting appropriate growth parameters, with a length and weight above the 50th%ile and weight for length z-score of +0.99. **Table 1** provides an overview of TG's time on enteral nutrition.

Over 12 months, TG received a G-tube, initiated enteral feeds by pump, transitioned to commercial formula by bolus feeding, and gradually increased his table food intake to meet 100% of his estimated nutritional needs. His tube feeding regimen was successfully decreased by 25, 50, and then 100% while increasing oral intake, which resulted in a complete discontinuation of his

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enteral nutrition in the span of about three months.

Case Study – Patient 2

The second patient, SP, was born full term, with a history of LGA (large for gestational age), hypoglycemia, cardiac dysfunction (Atrial Septal Defect), ASXL2 gene mutation, a choroid plexus papilloma (benign brain tumor), a history of seizures, and G-tube dependence. As an infant, SP was started on standard infant formula by bottle but a swallow study shortly after birth found aspiration, and he was switched to tube feeds by G-tube. He was discharged from the neonatal intensive care unit (NICU) on a partially hydrolyzed infant formula fortified to 27 cal/oz. Due to persistent emesis, he was transitioned to an extensively hydrolyzed infant formula, also fortified to 27 cal/oz, which did not improve emesis. SP continued on this formula regimen until age 12 months. At 12 months, he was transitioned to peptide-based pediatric formula, however, he experienced gas and gastrointestinal (GI) upset. Next, he was switched to pediatric amino acid-based formula due to blood in stool; however, this persisted. He was seen by a pediatric gastroenterologist in June 2016 to rule out GI disease. After a rectal exam, blood in the stool ceased and did not return.

Our team initially assessed SP via a referral from the Early Intervention Program at 16 months old. His family reported poor formula tolerance including frequent retching, emesis, gagging with oral stim, difficulty tolerating position changes, severe oral hypersensitivity, severe oral aversion, and heme-positive stools. He had a history of trialing multiple partially hydrolyzed formulas and his family wanted to explore using whole food boluses by G-tube instead of continuing to seek other formula options. He was taking a ready-to-feed hypoallergenic formula with added cornstarch via G-tube by syringe bolus during the day and by pump feedings overnight at a continuous rate. The formula was providing 942 mL free water, 933 calories (73 cal/kg), and 17.3g protein (1.36 g/kg). At the time of his assessment, he was at the 98th percentile and 100th percentile respectively for height and

Table 1: TG Timeline

Date	Significant Event	Nutritional Information	Growth Parameters
Age 12 - 15 months	Fed breastmilk fortified to 30 kcal/oz via G-tube using feeding pump	765 mL 720 kcal (90 kcal/kg) 11 g protein (1.4 g/kg)	@12 mo Weight z-score -1.76 Length z-score -2.52 Weight/length z-score -0.63
Age 16 months	Transitioned to 30 kcal/oz partially hydrolyzed infant formula via G-tube	775 mL 750 kcal (90 kcal/kg) 17.5 g protein (2.1 g/kg)	Weight z-score -2.06 Length z-score -2.88 Weight/length z-score -0.94
Age 17 months	Transitioned to a commercial BTF product. Simultaneously transitioned from intermittent pump feedings to bolus feedings	880 mL 720 kcal (74 kcal/kg)	Weight z-score -1.56 Length z-score -2.38 Weight/length z-score -0.62
Age 18 months	Transitioned to a commercial blenderized tube feeding with nutritional variety due to loose stools and diaper rash	870 mL 874 kcal (89 kcal/kg)	Weight z-score -1.98 Length z-score -2.27 Weight/length z-score -0.05
Age 20 months	Started showing more interest in table foods		Weight z-score -1.18 Length z-score -2.05 Weight/length z-score -0.26
Age 21 months	Tube feeding weaned by 25% due to growing interest in table foods		Weight z-score -1.09 Length z-score -2.08 Weight/length z-score -0.09
Age 22 months	Tube feeding weaned to 50%		Weight z-score -0.74 Length z-score -2.33 Weight/length z-score +0.58
Age 24 months	Tube feeding completely discontinued		Weight z-score -1.5 Height z-score -1.67 BMI z-score -0.21

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weight, despite calorie intake below DRI for age. He was also receiving feeding therapy with an experienced SLP, but progress with table foods and purees had been slow. SP was taking tastes of pureed food one time per day, but his parents reported that it was a struggle. He underwent a video fluoroscopic swallow study (VFSS) and was cleared to take nectar-thick
liquids. Hypoglycemia was a persistent issue for SP. His family was advised to add cornstarch to his feeds by the endocrinologist, and began putting cornstarch in his tube feeding at 3 months of age to regulate his glycemic control.

The RDN recommended a trial of a BTF diet with a commercial product by bolus via G-tube, initially with small volumes (15-30 mLs) two times per day, with corresponding decreases in his carbohydrate supplement for BG control. Over the next nine months, SP transitioned to bolus feeds of commercial BTF five times per day. BTF were initiated by bolus feeding at 30 ml/feeding and gradually increased to a goal of 120 ml/feeding. His G-tube feeding regimen also included some hydrolyzed formula, oatmeal, chocolate milk, cornstarch, and a soluble fiber supplement to further help with BG control and regulation. He received a continuous nighttime feeding of skim milk, cornstarch, and a soluble fiber supplement. This regimen provided a total of 1434 cal (98 cal/kg), 35g protein (2.4 g/kg), 1076 mL free fluid. SP was also noted to make progress with oral feedings, as he was taking up to 2.5 oz of jarred baby food purees per mealtime.

By 33 months old, SP was taking three meals of pureed foods orally per day or was consuming a commercial BTF formula orally as meal replacement. He continued to receive his continuous overnight G-tube feeding to help with blood glucose regulation (skim milk, cornstarch and soluble fiber supplement). He also received a 160 mL G-tube feeding in the morning (chocolate milk, water, oatmeal, cornstarch and a soluble fiber supplement). His regimen of oral feeding, one bolus G-tube feeding and an overnight G-tube feeding provided 1100 mL fluid, 950-1000 calories (56-60 cal/kg), 32-35g protein (1.9-2.1 g/kg). He continued to progress with the variety and textures of table foods that he was willing to eat. At 4 ½ years old (53 months), SP started school. He was initially G-tube fed at school twice per day but was able to transition to oral meals and snacks without G-tube supplementation during the day.

Table 2 provides an overview of SP's time on enteral nutrition

Discussion:

Both patients successfully transitioned to oral diets, inclusive of a wide variety of foods and textures. TG was able to successfully wean to 100% oral feedings without use of his G-tube to meet his estimated energy, nutrient and hydration needs. SP was able to transition to three meals and two

Table 2: SP Timeline

Date	Significant Event	Nutritional Information	Growth Parameters
< age 12 months	27 kcal/oz partially hydrolyzed infant formula, persistent emesis, transitioned to extensively hydrolyzed infant formula		N/A
Age 12 months	Transitioned to pediatric peptide-based formula, symptoms of gas, GI upset, and bloody stools. Transitioned to a ready-to-feed amino acid-based formula; symptoms persist	942 mL 933 kcal (73 kcal/kg) 17.3 g protein (1.36 g/kg)	N/A
Age 16 months	Begun trialing commercial BTF with nutritional variety		Weight z-score +1.64 Length z-score + 3.18 Weight/length z-score +0.24
Age 26 months	Diet plan consists of commercial BTF with nutritional variety 5x/d, formula, oatmeal, chocolate milk, and soluble fiber supplement. Improvement in oral intake, decrease in oral aversion	1076 mL 1434 kcal (98 kcal/kg) 35 g protein (2.4 g/kg)	Weight z-score +1.85 Height z-score +2.34 BMI z-score +0.46
Age 33 months	Progressed to three oral meals/d with pureed foods or consuming commercial BTF with nutritional variety. One bolus feeding/d	1100 mL 950-1000 kcal (56-60 kcal/kg) 35 g protein (2.1 g/kg)	Weight z-score -0.06 Height z-score +2.74 BMI z-score -0.29
Age 53 months (4 years, 5 months)	Started school, transitioned to full oral feedings		Weight z-score +1.55 Height z-score +1.97 BMI z-score +0.72

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snacks per day orally which provided 75% of his daily estimated caloric needs, with supplemental nocturnal G-tube feedings and a bolus feeding in the morning before school providing the other 25% of calories and to maintain glycemic control.

In both cases, the overarching treatment goal was to decrease tube dependence, normalize the feeding experience, and allow for enjoyment of family meals and activities surrounding food. Goals were achieved due to parental motivation, a blenderized tube feeding diet which decreased vomiting and reflux, intensive feeding therapy, a significant and monitored decrease in caloric provision from tube feeding, and an interdisciplinary approach. Both patients were seen by the SLP weekly with a focus on increasing oral-motor skills and acceptance of a variety of tastes and textures. Frequent communication between sessions with the RDN occurred to discuss progress and update the RDN on skills. During co-treated sessions, the RDN, SLP, and family would discuss caloric goals, family food goals, and strategies to adjust foods to meet these goals to fit the child's current oral-motor skills. As the RDN began to reduce the number of sessions needed, the SLP continued to treat the child weekly, verifying the oral motor skills continued to develop and progress. Consultation and additional support was provided by occupational therapy and pediatric medical specialists including gastroenterology, otolaryngology (ENT), and endocrinology as appropriate. Both patients also transitioned from an elemental or semi-elemental formula to a blenderized tube feeding diet prior to starting any tube weaning and prior to progressing with their oral intake.

Diet is a contributor to the health of the gut microbiota.[10] Further, nutritional variety is positively correlated with gut bacteria diversity.[10] The health of the gastrointestinal system, and therefore gut microbiota, is an interesting concept when evaluating the impact of BTF. Gallagher et al. reported positive changes to the gut microbiota in pediatric patients who were changed from formula to blenderized diets.[10] Interestingly, one of the patients in this case series had reduced intolerance symptoms and eventual independence from his feeding tube once switched to a commercial BTF product with variety from a commercial BTF product without variety. This finding could point to the importance of nutritional variety and coalescence between overall health and the gut microbiota.

The concept of nutritional completeness is a significant concern of clinicians working with tube-fed patients, which may be a barrier to prescribing BTF. Interestingly, literature has demonstrated equal or greater micronutrient content amongst BTF, with the exception of vitamin D, from a variety of foods with no supplement added when compared to formula.[10,11] Additionally, formulas described as being nutritionally complete have led to micronutrient deficiencies, which reinforces the belief that micronutrient needs should be tailored to the individual patient and closely monitored by the RDN.[14]

Conclusion:

As progress occurs in a stepwise fashion, it proved an effective strategy to transition the tube-fed children presented in these case studies from a commercial formula to a commercial BTF prior to the initiation of a tube wean. It normalized the feeding experience and potentially reduced the impact of adverse GI side effects experienced from tube feeding to decrease oral aversion. These case studies have demonstrated that children can have adequate growth on a BTF, and have demonstrated improved progress with oral intake on such an approach. It is important to be mindful of the endpoint when a child is started on a tube feed.

For most children, tube feeding should be a temporary part of their medical care along the path to overall growth and development, including the development of age-appropriate self-feeding skills and eventual tube weaning. A team approach is essential to safely wean children from tube feed regimens in order to take all aspects of the child's health and wellness into account. These aspects include the acquisition of adequate oral-motor skills through a trained speech or occupational therapist, the ability to meet the nutritional demands of growth independent of the tube as assessed and managed by a skilled dietitian, and the stability of the child's medical status directed by a physician. Additionally, the social-emotional impact of tube feeding reliance and potential parental stress plays an essential role in the success of the wean, thus necessitating attention to mental health and well-being of the parent and the child. Overcoming tube dependence with an interdisciplinary approach is ultimately the key to success for children ready to wean from feeding tubes.

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