

Nutritional Management of Diarrheal Diseases

Meenakshi Mehta

In developing countries, acute diarrheal diseases (ADD) still continue to be an important cause of mortality(1,2), particularly in children with malnutrition. ADD contributes to growth retardation in 10-88% patients(3). Persistent diarrhea (PD) exists in 3-20% of patients (4,5). PD leads to worsening of malnutrition(6-8), and is associated with a high risk of morbidity and mortality(4,9). The nutritional management of diarrheal diseases is challenging and should ideally evolve around diets based on simple, low cost, practical and easily available foods, acceptable by children of all age group.

Pathophysiological Changes

Despite malabsorption of macronutrients during diarrhea, 80-90% of carbohydrates, 70% of fat and 75% protein are absorbed from diets based on common foods(10). Thus when children with diarrhea are fed an adequate diet, enough nutrients are utilized to prevent weight loss and sustain growth, without appreciably increasing the stool volume or duration of illness(11). Recent studies have indicated that enteral feeding may result in faster recovery with shorter hospitalization compared to parenteral nutrition(12). Withholding of food, on the contrary delays repair of the damaged

intestinal lining and return of the ability to produce digestive enzymes(13); this may also lead to malabsorption of nutrients and PD.

Nutritional Management of Acute Diarrhea

The approach to nutritional therapy includes: (i) Continued feeding during acute illness; (ii) Compensatory increase in feeding during convalescence; (iii) During an acute diarrheal episode, as the mucosal digestive and transport mechanisms are impaired, dietary adjustments are advisable to take optimal advantage of the functioning intestinal absorptive capacity which depends on the amount of nutrients presented per unit time. This can be achieved by offering small and frequent feeds. Metabolic balance studies have documented complete nutrient absorption by the infants when they received continuous rather than bolus feeding(14); (iv) There is no physiological basis for resting the bowel during or following acute diarrhea. Fasting further reduces the digestibility of the food in the intestine and is dangerous in already weak children. Fasting must, therefore, be avoided. Full calorie intake during diarrhea is safe and improves nutrition and weight gain(15-17); (v) Dietary fats especially triglycerides should be included to provide calories and facilitate energy intake when appetite is impaired; and (vi) The patient must be offered at least one extra meal after an episode of acute diarrhea.

Caution must be exercised to avoid hyperosmolar foods like heavily sweetened juices, soft drinks and bottle or canned sweet drinks as they are hypersomolar and aggravate diarrhea. Lactose malabsorption needing dietary

Reprint requests: Dr. Meenakshi Mehta, 9, Shavali, C/3, BMC Colony, K.A.G. Khan Road, Worli, Bombay-400 018.

modification is extremely rare in acute diarrhea. It may be encountered in a small proportion of cases in whom the diarrhea persists beyond 8-10 days, with progressive weight loss and >1% reducing substances in the stool (15). Intolerance to animal (cow and buffalo) milk protein is often rare. Animal milk can, therefore, be given diluted preferably together with some cereals(15).

Host Factors

The dietary management should consider host factors like age of patient, pre illness feeding practice, state of hydration and presence of infection. Age is an important factor because a few digestive pathways are not fully developed at birth and early infancy. Pancreatic amylase, for example, is not secreted adequately until an infant is 6 months old and hence may lead to limitation of starch absorption. Similarly decreased rate of bile acid synthesis is likely to interfere in solubilization of long chain dietary fatty acids(18). Pre illness feeding practices are important in determining the nature of consistency of foods which are required. If infection is suspected, antibiotics may be started depending on the local prevalence of common etiological agents(19). The state of hydration determines the initial food to be offered to the patient. Rehydration, in addition to replacing fluids and electrolytes helps to restore the appetite, making it possible to resume early feeding(13). Anorexia is mainly restricted to the acute febrile phase and generally up to 100% of breast milk and 80% of recommended daily intake is accepted by infants even during acute phase of diarrhea(15,20).

Recovery from diarrhea includes achievement of catch up growth, besides cessation of liquid stools. An intake of at least 125% of the recommended diet should be attempted with nutrient dense

food till the child achieves pre-illness weight and ideally until the child achieves normal nutritional status(15).

Specific Dietary Recommendations

The specific dietary recommendations are summarized in *Fig. 1*.

Exclusively Breastfed Infants

Breastfeeding must be continued despite the theoretical concern about lactose malabsorption. Stimulation of the receptors of the nipple by continued suckling helps maintain milk production. Breastfeeding reduces severity and complications of acute diarrhea(21). Withdrawal of breastfeeding during diarrhea, apart from its deleterious effect on nutritional status, is also associated with 5 times higher risk of dehydration compared with continuation of breastfeeding(22).

Milk or Formula Fed Infants

Young infants who derive their sole nutrition from milk and are not yet consuming solid or semi-solid complementary food need particular attention. Some clinicians advise dilution of animal milk due to the hypothetical risk of lactose malabsorption which is, however, very rare during acute diarrhea. Increasing evidence suggests advantage with feeding full-strength milk as soon as dehydration is corrected(23).

Older Infants and Young Children

These children are comparatively easier to manage as they receive a mixed diet. Since they receive part of their nutritional needs from non-milk foods, the concern for lactose malabsorption is not as relevant as compared to that in solely milk fed young infants. Information on the digestibility of common foods during the early stages of acute diarrhea is limited. But there is no difference of opinion that these

Fig. 1 Nutritional management of acute diarrhea

State of hydration		Type of patients		Recommended feeding
During rehydration phase	→	Breastfed infants	→	ORS + breastfeeds
	→	Non-breastfed infants	→	ORS + animal milk + liquid food mixtures + cereals + sugar + oil
	→	Severely malnourished children	→	ORS + food mixtures- nasogastric feeding if required
After rehydration phase	→	Breast fed infants	→	Breastfeeds
	→	Non-breastfed infants	→	Animal milk + feeds prior to onset of diarrhea
	→	Infants 4-6 month	→	Breastmilk + energy rich feeding mixtures in liquid + oral milk + cereal + sugar + oil + animal milk
	→	Older children	→	Energy rich food in mixture+ cereal + pulse + sugar + oil + dark green leafy vegetable+ yellow orange fruits/semi solid/liquid form

foods should be given along with the usual weaning foods which are prepared from the dietary articles commonly consumed by the community. The weaning food should preferably be derived from the staple foods (cereal, roots, underground vegetables) with added food or milk which fulfills the same qualifications of weaning food. This mixed diet is nutrient rich and liked by the child, for example milk and rice gruel, milk and broken wheat (dalia), milk and rawa (suji). Other common foods which are often added are legumes, green leafy vegetables and animal products. Fermented milk products like curds, yoghurt and butter milk are popular in some communities and are useful in lactose malabsorption. During the process of fermentation the lactose is hydrolyzed to glucose and galactose(24). These diets should be enriched with sugar or jaggery. Mothers

should be advised to use the available and commonly used vegetable oil rather than insisting on oils with medium chain triglycerides like coconut oil. The diet should be well cooked, mashed and pureed for ease of administration in infants. Alternatively the diets can be cooked, mixed homogenously and made to liquid consistency for feeding young infants or those who are unable to swallow and have to be fed by a nasogastric tube(1,9). Amylase rich food (ARF) have also been advocated to decrease the bulk and increase the caloric density of the diet(25).

Monitoring and Criteria for Improvement

Total food intake, willingness to drink or eat and improvement in activity are useful parameters of successful therapy for diarrhea. Weight gain up to 20-30 g/day is not uncommon and is a good indicator of

improvement. Dietary failure is suspected when there is refusal to eat or vomiting, increasing stool output or no change in the frequency or consistency of stool(15). Presence of hypothermia in small infants, irritability or listlessness, failure to respond to the treatment offered and worsening of diarrhea and dehydration indicate occult systemic infection and warrant treatment with appropriate antibiotic. Carbohydrate malabsorption may be suspected if the patient passes large watery explosive stools, has perianal soreness, abdominal distension and presence of reducing substances in the stool. The offending carbohydrate, most commonly lactose, should be decreased in the diet in such cases.

Nutritional Management of PD

The clinical features of PD allow categorization into two groups: (i) Patients pass several loose stools daily but remain well hydrated; the major consequences being growth faltering and severe malnutrition; and (ii) Patients with high purge rates where hydration is difficult to maintain. The latter constitute only 3-5% of the total patients with PD(5). Indicators for immediate referral to the hospital include: (i) age < 6 months; (ii) dehydration; (iii) severe malnutrition; (iv) systemic infection; (v) dysentery; and (vi) presence of secondary lactose intolerance.

The main causes of PD include persistent infection with enteric pathogens, malabsorption particularly of carbohydrates and fat, often following acute infection and rarely dietary protein intolerance. The growth failure associated with PD is not exclusively the result of malabsorption but also due to inadequate energy intake.

Pathophysiology of PD(8)

Malabsorption of carbohydrates may be due to reduced pancreatic function, reduced luminal amylase, decrease of brush border enzymes glucomylase and the

disaccharides including lactase, sucrase, maltase and isomaltase. Since lactase is the most vulnerable enzyme, lactose malabsorption is common following viral diarrhea with damage of the villus tip cells. In patients with lactose malabsorption, undigested lactose from small intestine passes to the colon, resulting in an osmotic diarrhea. Other carbohydrates are also fermented in the colon into short chain organic acids with secretory properties. Lactase deficiency is also known to occur in malnourished children without diarrhea(3). Digestion of fats is affected due to insufficient pancreatic lipase and disturbance of bile acid metabolism, leading to steatorrhea, especially in malnourished children. Cow's milk allergy and intolerance usually occurs before 6 months of age and is attributed to lactoglobulin fraction of the milk. An important aspect of pathophysiology of PD includes bacterial colonization of the jejunum, ileum and colon. In breast fed babies, lactobacilli and bifidus factor, suppress overgrowth of abnormal bacteria. With supplementary feeding or weaning, this effect wanes off and abnormal colonization occurs with *E. coli*, *Klebsiella*, *Enterobacter*, *S. aureus*, or *Streptococci* in small intestine and *Clostridium difficile*, and *Bacteroides* in colon.

Principles of Management

The management of these children is difficult and poses a serious challenge to the clinician. Appropriate feeding is important in a child with PD. In addition to diarrhea and malnutrition, these infants often have associated dehydration, electrolyte imbalance and systemic infections which are occasionally not diagnosed.

Specific Recommendations

The specific nutritional recommendations are summarized in Fig. 2.



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few breastfed infants experience continued diarrhea, they never develop malnutrition or dehydration and continue to gain weight. Older infants and children, in

Breastfeeding in infants being fed previously should be continued. Although a

whom weaning has already been started, should also continue receiving breastmilk if available. Their nutrient requirements, however, will have to be met with from animal milk (if not lactose intolerant) and other diets.

Animal Milk or Formula Milk

Pediatricians often eliminate milk, dilute it with water or add extra water to milk formula to reduce the lactose content irrespective of the severity of illness. In patients with mild PD without associated dehydration, reduction in milk intake may be attempted initially. This can be achieved with cereals, milk, rice gruel with sugar or dalia. Alternatively curd which is better tolerated than milk may be used alone(10) or mixed with cereals(24). In patients with severe PD, total elimination of artificial milk is necessary. Severe PD is suspected if there is associated dehydration and high purge rates (>7 ml/kg/h) or very frequent, large and watery stools. Presence of reducing substances more than 1% in stools strengthens the case for total milk elimination in patients with severe PD.

Semisolid Diets

Breastfeeding or animal milk should be supplemented with frequent (once every 3-4 h) offering of diets based on staple food enriched with oil and sugar (energy 0.7 to 1 Cal/g). For example, khichri with oil, curd mixed with mashed potatoes or banana or rice with added sugar in the form of semisolid or liquid-gruel which the child is able to accept, are well tolerated. The exact composition can vary depending on the common staples used by the community as weaning food. Dark green leafy vegetables (DGLV) or yellow orange vegetables (YOV) or fruits can be also added as the source of (3-carotene and iron to these diets(9). Particular attention should be directed to provide folate, vitamin B₁₂, vitamin A, zinc and iron in the diet.

Use of Soya Based Formulas

Clinical experience shows that soya based formulas used as dietary substitute for other diets are not tolerated well by about 50% hospitalized children with PD.

It is possible that this could be attributed to the sugar or maltodextrin contained in these formulas. There is also a potential risk of soya protein intolerance in some infants(5).

Dietary Management of Severe Persistent Diarrhea with Extensive Disaccharide and Fat Malabsorption

Some patients with PD do not recover when milk is totally eliminated from the diet; they may have severe and extensive malabsorption involving disaccharides other than lactose. They can tolerate carbohydrates only as mono or oligosaccharide. Such patients and those who are too young (<6 months), dehydrated, have severe malnutrition or associated infections cannot be managed at home and should be hospitalized. They need to be managed on either low lactose (level 1), lactose free (level 2) or lactose and sucrose free diets (level 3).

Low Lactose Diet

Such a diet is achieved by partially replacing milk by curd, or combining milk with a cereal like rice, and offering in a thick consistency. It is slowly passed to intestine from where it is absorbed. Rice is the most commonly used cereal, since it is easily tolerated by children and has rarely been associated with allergy(26-28). Rice can be given in the form of plain rice, puffed rice or rice flakes.

Rice can be replaced by sooji, dalia (broken wheat), suji or rawa, sevan (wheat noodles) in the same proportion. The caloric density of the feed can be increased by adding oil (upto 3% is well accepted), sugar or jaggery. Consistency of the feed may be made thicker by increasing the amount of cereal or adding fruits like banana. Cooked DGLV can be added to increase p-carotene and iron contents. An example of low lactose diet with milk and rice is shown in *Table I*.

Lactose Free Diet

Complete elimination of lactose from the diet may be essential in cases who do not tolerate reduced load of lactose. In such cases milk free diets based on staple foods can be prepared.

Diets based on khichri (rice and lentil) have been used along with diet based on curds or yoghurt for PD. We have used diet based on khichri (rice + moong dal) in which oil and jaggery are added to improve palatability and energy (*Table IT*). DGLV are added to give dietary source of vitamin A. The formula is made thin (700 ml volume providing 1.2 g protein/100 ml) for feeding infants under 6 months, or for nasogastric feeding. Thick feeds (volume 300 ml) can also be made.

TABLE I—Low Lactose Diet*

Ingredients	Amount	Cal	Protein (g)
Milk	75 ml	52	2.6
Rice	5g	17	0.4
Sugar	2.5 g	10	—
Water q.s.100 ml		—	
Total		79	3.0

* Liquid consistency 0.7 Cal/ml, volume 100 ml, lactose 4.5 g.

Egg (boiled or egg flip) can also be used. Young infants may be offered egg flip (egg, milk and sugar); glucose may be used as a substitute for sugar in patients with disaccharide intolerance.

Lactose and Sucrose Free Diets

Many children with PD have malabsorption of not only lactose, but other disaccharides (sucrose and maltose) as well and therefore, may not tolerate milk. Although commercial formulas based on soyabean are available, clinical experience suggests that not many children tolerate these diets. For most, these diets prove too expensive and mothers feed their children with these diets only during hospitalization and often discontinue at home.

In such situations, diets based on staples (rice, lentil and oil) or lean meat are easy to prepare, economical and well accepted (*Table III*).

TABLE II—Lactose Free Diet

Ingredients, amount	Calories	Protein (g)	Fat (g)	Carbohydrates (g)	Vitamin A (µg)	Iron (mg)
Rice, 50 g	185	3	0.25	38	—	1.5
Moong dal, 25 g	85	5.5	0.60	15	47.0	2.0
Jaggery, 50 g	200	0.2	—	47.5	168.0	5.7
Oil, 25 g	230	—	25	—	—	—
DGLV*, 25 g	15	0.5	—	3.0	1250.0	6.5
Total	715	9.2	25.8	103.5	1465.0	15.7

* DGLV: dark green leafy vegetables
Thin feed volume 700 ml (1.2 g protein/dl)
Thick feed volume 300 ml

TABLE III-Lactose and Sucrose Free Diet

Ingredients	Amount	Cal	Protein (g)
Chicken	100 g	110	26
Glucose	20-40 g	160	
Coconut oil	40-50 g	450	
Potassium chloride (15 g/dl)	7.5 ml	—	—
Sodium bicarbonate (7.5 g/dl)	20-30 ml	—	—
Total	1000 ml	720	26

Severe glucose malabsorption is rare. Such cases can be treated with intravenous 10% glucose with electrolytes and egg white, meat or chicken with oil given orally. Total parenteral nutrition besides being expensive is rarely required.

Catch up Growth

Most cases of persistent diarrhea require very high energy intakes, *e.g.*, 120-150 Cal/kg/day to achieve catch up growth. Thus, extra energy dense meals may be required for several weeks to achieve normal nutritional status.

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