NUTRITION INFORMATION CENTRE
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CYSTIC FIBROSIS (CF) AND NUTRITION

The information explosion in the science of nutrition very often creates the impression that available information is contradictory. Consequently, it is no longer easy to distinguish between fact, misinformation and fiction. The Nutrition Information Centre of the University of Stellenbosch (NICUS) was established to act as a reliable and independent source of nutrition information.

What is CF?

It is the most common hereditary disease. Diseases such as CF that are caused by genes are called genetic diseases.

CF is a disorder of the cells that line the lungs, small intestines, sweat glands and pancreas. Sticky mucus contributes to the destruction of lung tissue and impedes gas exchange in the lungs. It also prevents nutrient absorption in the small intestines, since it blocks ducts from the pancreas that release digestive enzymes.

People with CF exhibit some or all of these symptoms to varying degrees: salty tasting skin, excessive appetite along with poor weight gain, loose, foul-smelling stools (steatorrhoea), persistent cough, wheezing or lung infection. Other symptoms may include the following: clubbed fingers, digestive disorders, smaller than average height and weight (stunting or failure to thrive), susceptibility to heat prostration and dehydration, male sterility, diabetes or liver disorders.

CF patients are frequently hospitalised for chronic lung infections and digestive disorders. The disease is commonly associated with energy deficiency in children and adults. Chronic undernutrition will lead to failure to thrive. Nutrition and survival are intimately interrelated in CF. In most treatment approaches, nutritional support is now seen as an integral part of the multidisciplinary care of CF patients with aggressive programs instituted to prevent malnutrition.

How common is CF?

Although it affects all ethnic groups, CF is the most common autosomal recessive disorder among Caucasians with a frequency of about 1 in 2500 live births. According to available data, there are about 30 000 Americans, 3 000 Canadians, 20 000 Europeans with CF. In South Africa, although approximately 1 in 20 Whites, 1 in 55 Coloureds and 1 in 90 Blacks carry the CF gene, it is estimated that 1 in 2 000 whites, 1 in 12 000 coloureds and 1 in 32 000 blacks have CF.

How is CF diagnosed?

The clinical diagnosis of CF has never been simple. The spectrum of CF phenotypes is very complex, with some patients presenting with the full range of clinical features and others showing only a single CF feature, e.g. male infertility.

Several methods are available for diagnosing CF. For families with previously identified CF, prenatal screening may be possible. Several countries and some states in the United States conduct routine neonatal screening for the disease. Neonatal CF screening involves a pancreatic test that evaluates immunoreactive trypsinogen or a DNA test. The test is performed on newborns to determine whether the baby has CF. Although these two test results indicate CF may exist, a sweat test with a positive result confirms the diagnosis and remains the golden standard diagnosis. CF as opposed to the mixture of presentation you are using.

The sweat test measures the amount of salt (sodium chloride) in the sweat. In this test, an area of the skin, usually the forearm is made to sweat by using a chemical called pilocarpine and applying a mild electric current. To collect the sweat, the area is covered with a gauze pad or filter paper and wrapped in plastic. After 30-40 minutes the sweat is collected and analysed. Higher than normal amounts of sodium and chloride in the sweat suggest that the person has cystic fibrosis. (>60mEq/L).

How Is CF Treated?

Since CF is a genetic disease, it cannot be cured at present. In future gene therapy at an early age may offer new treatment avenues. The current nutritional treatment of CF depends on the stage of the disease and the organs involved. Optimal nutritional management, however, is essential to optimize growth, quality of life and survival of these patients.

NUTRITIONAL PROBLEMS, CARE AND TREATMENT

Nutritional management is one of the central parts of CF care and in the past four decades major strides have been made in the nutritional management of people with CF. It has been recognized that being relatively underweight is a major factor affecting survival, since patients who die of CF generally experience nutritional failure in the immediate years preceding death.

Energy Balance and Chronic Undernutrition

Chronic undernutrition with weight loss and growth failure has long been recognized as a feature in CF due to a variety of complications that may adversely affect nutritional status.

Gastrointestinal or Gut Abnormalities

Pancreatic insufficiency (decrease in digestive enzymes) leads to many of the gastrointestinal (gut) problems including fat malabsorption (steatorrhea), abdominal pain, gut obstruction syndrome and rectal prolapse. Gastro-oesophageal reflux (heartburn) occurs frequently due to decreased sphincter pressure. In patients with advanced lung disease vomiting is common after a strenuous bout of coughing. Loss of appetite is often associated with respiratory infection. Peptic ulcers and pancreatitis may also occur in CF. Excessive mucus in the small bowel can provide a physical barrier to the absorptive surface and lead to decreased absorption of nutrients. Undigested or unabsorbed food in association with this mucus can lead to a partial or complete obstruction of the gut in older children and adults known as meconium ileus (more accurately distal intestinal obstruction syndrome or DIOS), which presents with abdominal pain, distention and constipation. Crohn's disease and coeliac disease also occur more frequently in individuals with CF. Drugs used in treating the complications of CF are also known to lead to gastrointestinal disturbances.

CF Related Diabetes Mellitus:

The islets of Langerhan (cells of the pancreas responsible for the secretion of insulin and glucagon) are the last cells to be damaged in the disease process and fibrosis of the pancreas occurs. Diabetes mellitus and glucose intolerance has been reported respectively in 8-15% and in as high as 75% of individuals with CF. Chronic hyperglycaemia (high blood sugar) may adversely affect weight, lung function and may lead to microvascular complications (damage of the small blood vessels of the limbs and eyes).

Liver Disease:

Another complication associated with CF is liver disease, which may affect up to 20% of adult patients, and leads to an imbalance of bile salts and increase fecal loss of bile acids. Bile salts are essential for the digestion and absorption of fats, fat-soluble vitamins and some minerals.

Nutritional Response to Infection

Acute infectious illnesses are accompanied by a complex variety of nutritional and metabolic responses within the body. The response to infection is associated with an increase in energy expenditure thereby increasing energy needs in the CF patient. Patients characteristically present with a loss of appetite and weight loss. Complex changes occur in the metabolism of all the macronutrients, i.e. protein, carbohydrate and fat. An increase in protein breakdown for example leads to muscle wasting in these patients. CF patients are also known to have high losses of

protein (arising from malabsorption due to diarrhoea), fluids, electrolytes and vitamins and minerals, which may also worsen undernutrition and further impair resistance against infections.

The response to infection also includes a profound impact on the micronutrient status of the patient. Vitamins and minerals are compounds that are essential for normal growth and maintenance of body functions, playing key roles in many different metabolic processes in both health and disease. The presence of infection is thought to increase the requirements of micronutrients such as vitamin A, E, B_6, C, D and folate, which together with decreased nutrient intake further compromise vitamin status in general. It is also known that a decrease in blood levels of trace elements such as iron, zinc and selenium occur during infection. Infections, therefore, are associated with increased requirements of both the macro- and micronutrients.

NUTRITIONAL CARE AND MANAGEMENT:

Excellent guidelines exist for the nutritional treatment of CF. Nutritional management and care of CF involves increasing and maximizing dietary intake, minimizing malabsorption and maldigestion, monitoring of micronutrients (vitamins and minerals) and adapting eating habits to treat the complications associated with CF. The nutritional treatment of every patient should be individualized, with attention paid to percentage of ideal weight for height, body composition, age, degree of pancreatic dysfunction, extend of lung disease, the presence of infection and/or liver disease, esophageal reflux, feeding behavior and family interactions.

It is well recognized that the undernutrition seen in CF is due to an energy deficit caused by three main factors: decreased dietary intake, increased energy requirements and increased nutrient losses. Many patients are able to overcome the consequences of these abnormalities effectively and have a normal growth pattern and good nutritional status.

The diet recommended for CF patients who have diabetes mellitus as a complication is very different to the one recommended for diabetes. In CF patients, a high energy (150% of RDA), high fat (40% of total energy intake) diet, only reducing intake of simple sugars with good glyceamic control and insulin therapy, is indicated.

Increased Energy Requirements:

Patients with CF are encouraged to eat a diet, which provides 150% of the recommended daily energy intake (RDA) for age and sex. They should also be taught to increase energy intake by increasing the energy density of foods. Fat is the most energy rich and appetizing energy source in the diet and patients are encouraged to eat larger than normal portions and to add fat such as butter and cream in selected foods. High-energy snacks between meals are also recommended. Usually, protein intake is adequate and complex carbohydrates are well tolerated.

Dietary Supplements:

Many patients find it hard to eat sufficient food in the day to attain and maintain their ideal body weight. During an exacerbation of CF (for instance an acute attack of pneumonia), energy requirements are at a maximum and this is exactly the time when patients do not have a healthy appetite. Dietary supplements in the form of drinks or tube feeds can be a useful way to increase energy intake. Supportive feeds are also recommended when weight is equal to or less than 85-90% of ideal weight for height in order to prevent further deterioration of nutritional status. Oral supplements, commercial (balanced in terms of macro and micronutrient composition) or homemade (ingredients: full cream milk, ice cream, peanut butter, sugar, fruit juice, milk powder, eggs), are often used. Care should be taken that these supplements are used ***in addition*** to the diet and not as a replacement for normal food.

Failure to respond, weight falling consistently to less than 85% of ideal weight for height, or deteriorating pulmonary function are all indications for more aggressive nutritional support. Long-term, invasive enteral feeding (tube feeding) is often necessary in patients who are candidates for lung or heart-lung transplantation.

Fat and Essential Fatty Acids:

Dietary fat helps to provide the required energy, essential fatty acids and fat-soluble vitamins. It also reduces the volume of food required to meet energy demands and improves the palatability of the diet. Indications of fat intolerance include an increase in the number of stools, greasy stools (steatorrhea), or abdominal cramping. Essential fatty acid deficiencies are rare among patients who are treated with enzyme replacements (see below).

Patients should include good food sources of essential fatty acids (omega 3 and 6 fatty acids) in their diet as part of their daily fat intake. Omega-3 is a group of unsaturated fatty acids found primarily in marine oils and algae. Two such important Omega-3 fatty acids are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). EPA and DHA are abundant in fish such as salmon, mackerel, herring, tuna, snoek, trout, sardines and pilchards. Omega-6 is a group of unsaturated fatty acids found primarily in foods of animal origin and in plant oils such as sunflower oil. In a recent well-controlled study it was found that long-term supplementation (8 months) with eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) eicosapentaenoic plus docosahexaenoic acid, equal to 1.3% of caloric intake in the CF patients, had beneficial effects, such as decreasing inflammation, in CF patients.

Dietary fat intake should provide 35-40% or more of total energy intake or as tolerated.

Vitamin and Mineral Supplementation:

All CF patients have some level of pancreatic insufficiency leading to a degree of fat malabsorption. For this reason most patients are at risk of developing deficiencies of fat-soluble vitamins. Those more at risk appear to be individuals with poorly controlled malabsorption, poor adherence to treatment, liver disease or bowel resection. Low blood levels of vitamin A have been reported in CF despite increased liver stores, suggesting impaired transportation of the vitamin from the liver. Low vitamin E, Vitamin D and vitamin K levels have also been observed. Individuals with CF may be at risk for vitamin K deficiency as result of the use of long-term antibiotics or liver disease as well as malabsorption.

Vitamin E is an antioxidant and may have a role in the protection of lung tissue against oxidative damage in CF. Haemolytic anemia (defects or damage to the red blood cell membranes due to oxidative damage) has also been reported in newly diagnosed infants with CF. Prolonged deficiency of vitamin E is associated with peripheral neuropathy, although in CF this usually only occurs in advanced CF associated liver disease. Tissue vitamin E levels are low in patients who do not receive supplements but can be normalized in most children with 100mg of vitamin E per day.

Sodium requirements are increased in CF due to the increased losses in the sweat. Most children and adults consume enough salt eating a typical Western diet, but infants require extra salt, since the sodium content of breast milk, infant formulas and weaning foods is low (1/8 - 1/4 teaspoon per day).

(Suggested Vitamin and Mineral Supplementation: See Summary of Nutritional Recommendations)

Pancreatic Enzymes: Why and How Much?

Approximately 85% of CF patients have pancreatic insufficiency and inadequate levels of digestive enzymes, which leads to malabsorption of nutrients, especially fat. Plugs of thick mucus reduce the quantity of digestive enzymes released from the pancreas into the gut. Enzyme replacement therapy is the first step taken to correct maldigestion and malabsorption. The quantity of enzymes to be taken with food depends on the degree of pancreatic insufficiency, the quantity of food eaten, the fat and protein content of the meal and the type of enzymes used. Enzymes, when prescribed by a doctor, should be taken only just before and during the meal. Dosage is adjusted according to individual symptoms and needs. It is important not to chew or crush the capsules, since this will damage the coating around the tiny microspheres inside the capsules and decrease their effectiveness.

For infants and children unable to swallow capsules, the capsules can be opened and the microspheresmixed with a soft acidic food such as apple juice. It should not be mixed with foods that have a pH greater than 6, such as dairy products, because the coating surrounding the microspheres will dissolve and the enzymes exposed to the acidity of the stomach, which will inactivate them.

Nutritional Care and Management for Children and Infants:

The rapid growth periods of infancy and childhood can only be maintained if a child's nutrient intake is optimal. Insufficient intake leads to impaired growth and malnutrition. The provision of adequate energy and other nutrients to a child with CF is therefore very important. In meeting their requirements, it should be born in mind that children have limited stomach capacity and appetites and as such meeting nutrient requirements presents a difficult challenge. It is therefore necessary to modify and plan the diet carefully to ensure adequate intake of food. The best way to monitor weight gain and detect malnutrition in children early, is to use the “Road to Health" card (curves that illustrate the growth pattern of a child) or BMI (Body Mass Index: kg/m² - weight in kg divided by height in meters squared) in older children.

Special Hints to Feed Babies and Toddlers with CF:

Milk feeds:

Although breast milk is the best, it may not be adequate for some CF infants with increased requirements. Breastfeeding and/or formula feeding can be supplemented with extra carbohydrate or oil (MCT - medium chain trygliserides or sunflower oil if not available) if the infant is not growing well. Offer the milk feed every 2-3 hours or more frequently on demand and if the infant finishes all the feed, then offer more. Pancreatic enzymes may be opened and mixed with small amounts of acidic foods such as apple juice, fruit juice or pureed fruit and given before each milk feed. Never mix the enzymes into the feed. The amount of enzymes will vary from child to child and will need to be changed depending on the frequency and consistency of the infant's stools, bowel movements and weight gain. It is very important to check the infant's mouth and between the gums after a feed to ensure that there are no microspheres caught there, since they may cause mouth ulcers.

Weaning:

CF infants are often ready for solids earlier than usual due to an increased appetite and 3-4 months is a reasonable age to start weaning. Infants should be started with one feed per day. Increase the solids according to the infant's appetite and increase the pancreatic enzymes accordingly. It is generally advised that weaning foods be introduced in small amounts and one at a time, starting with cereals, porridge with milk, puréed vegetables or fruit and progressing to a mixed diet in mashed form. The sequence in which these foods are introduced is not important. However, introducing one individual food at a time helps parents to identify any allergies or intolerance to a particular food. Commercial infant foods may be chosen for convenience, but eating nutritious food from the family pot is also a good and less costly alternative. The frequency of feeding should gradually increase from two to four meals per day by about six months of age to four to six meals per day including snacks and in addition to milk feeds when the infant is older than six to seven months of age. The quantity of milk in the diet should not be reduced to less than 600 ml per day when the infant is weaned.

Toddlers:

The amount of food the child requires depends on a variety of factors including gender, size and activity. The rate of growth at this age is slower than in the first year of life and this is associated with a decrease in appetite, which may further fluctuate on a daily basis. Coping with a CF child during this period can be particularly frustrating. Behavioural intervention which targets both nutrition education and behavioural management has been found to be effective in achieving an increased food intake and weight gain of 1.48 kg over 9 weeks in children. It also teaches parents to utilize child behaviour-management techniques to motivate children to increase their daily energy intake.

It should be kept in mind that young children can only manage a small amount of food at a time. It is recommended for the child to receive 5 to 6 smaller meals daily. These include mid-morning,

mid-afternoon and bedtime snacks. A general rule, which can be followed, is to offer a minimum of one tablespoon of each food for every year of age and thereafter to offer more food according to appetite.

Most children with CF need extra sodium chloride (table salt), especially during hot weather. The extra salt should be added to solid feeds (1/8 to 1/4 teaspoon per day). It is important to give plenty of fluids at all times but especially in hot weather, since these children perspire excessively in hot weather conditions. Diluted fruit juice given between meals is best, if it is affordable, since it also supplies vitamins and minerals as well as carbohydrates.

Practical guidelines to increase intake:

- Avoid force-feeding and excessive coaxing. Such struggles are fruitless and will most likely lead to a life-long aversion to certain foods.
- Make food fun. Allow the child to help with simple tasks e.g. measuring or stirring while preparing food (which is not hot or boiling)
- Ensure relaxed mealtimes. Serve food at the table in an atmosphere conducive to eating.
- Serve appropriately spaced meals. The child shouldn't be too tired before meals, or in-between snacks given too close (within 1½ hours) to the main meals.
- Offer a variety of foods, including favourites. Give new foods at the beginning of the meal while the child is hungry. No fuss should be made if the new item is rejected. That new item can be re-introduced a few days later, perhaps prepared differently or mixed with a favourite food. It is also not unusual for children to suddenly reject previously favourite foods.
- Avoid using favourite foods as reward for eating e.g. promising pudding if all the vegetables are eaten. This will not make the vegetable more popular and is liable to lead to manipulation and a negative attitude to that food item. If a reward is to be used at all, it is better to use non-food alternatives, e.g. a story, games, favourite TV program or other favourite activities.
- Allow sufficient time for the toddler to complete the meal. In particularly difficult eaters, it may be necessary though to set a time limit (around 20 minutes) in which the meal should be completed. Attempts at attention seeking, refusals and undesirable behavior should be ignored.
- Add fat liberally to food e.g. add oil or soft margarine to porridge, vegetables, gravies, pasta and puddings.
- Allow the child to feed him- or her-self. It is to be expected that mealtimes will be messy, but this should be tolerated to allow the child to acquire the necessary feeding skills.
- Children usually prefer that individual food items do not touch each other on the plate. Casseroles and mixed dishes, except pizza and spaghetti, are usually not popular. Children favour bright colours and smooth or crunchy textures instead of soggy vegetables or lumpy mash potatoes.

Summary of Nutritional Recommendations for Adult and Children with CF:

Nutrients	Children	Adults
Energy	130-150% of the RDA for age	130-150% of the RDA for age
Fat	35 - 40 % of total energy	35 - 40 % of total energy
Protein	Minimum RDA for age	Minimum RDA for age and sex
EFA	Include good sources of omega 3 and 6: Omega-3 fatty acids abundant in fish such as salmon, mackerel, herring, tuna, snoek, trout, sardines and pilchards. Omega-6 is a group of unsaturated fatty acids found primarily in animal protein (see above in text) and plant oils. (Supplement according to blood lipid profile and under medical supervision.)	Include good sources of omega 3 and 6: Omega-3 fatty acids abundant in fish such as salmon, mackerel, herring, tuna, snoek, trout, sardines and pilchards. Omega-6 is a group of unsaturated fatty acids found primarily in animal protein (see above in text) and plant oils. (Supplement according to blood lipid profile and under medical supervision.)
Vitamin A	Supplements: Infants: 0-12 months: 450 RE Children 1 – 3 years: 1500 RE Children: 4 - 8 years: 1500 – 3000 RE Children > 8 years 3000 RE	Supplements: 1-2 x RDA for age: Females older than 13 years: 700 - 1400 RE Males older than 13 years: 900 - 1800 RE
Vitamin E	Supplements: Infants: 0-12 months: 40-50 IU per day Children: 1-3 years: 80-150 IU per day	Supplements: 1-2 x RDA for age: Females older than 13 years: 15 - 30 mg / day

	Children: 4 - 8 years: 100- 200 IU per day Children : > 8 years: 200-400 IU per day	Males older than 13 years: 15 – 30 mg / day
Vitamin D	Supplements: Infants: 0-12 months: 10µg per day Children 1 - 13 years: 10 – 20 µg per day	Supplements: 1-2 x RDA for age: Adults 9- 50 years; 5 – 10 µg / day
Vitamin K	Supplements: Infants: 0-12 months: 2.5 - 5.0 mg weekly Infants and children receiving long-term antibiotics: 2.5 - 5.0 mg weekly	Supplements: Adults receiving long term antibiotic therapy or with liver disease: 2.5 - 5.0 mg twice weekly
Sodium (salt)	Infants: 1/8 - 1/4 daily with milk feeds	Excessive sweating or profuse diarrhoea: 250 mg - 2 g, 2 - 3 times daily
Water soluble vitamins	At least RDA	At least RDA

RDA: Recommended Daily Allowances
Adapted from Krause's Food and Diet Therapy: 10th Edition; Consensus Conferences, Concepts in CF care, March 28-29, 2001

More Practical guidelines to increase energy intake for adults and older children:

- CF often adversely affects nutritional intake, due to poor appetites, placing children at risk for malnutrition. Six smaller meals per day are indicated instead of three meals.
- The meals should be appetizing in appearance and taste and provide enough fat, energy and protein.
- Commercially available high energy and protein drinks (balanced in terms of micro-and macronutrients) may be used effectively to meet the increased requirements.
- Household ingredients, such as sugar, vegetable oil, peanut butter, eggs and dry milk powder can be used in porridge, soups, gravies, casseroles or milk based drinks to increase the protein and energy content without adding to the bulk of the meal.
- At least 500 - 750 ml of milk or yogurt should be consumed daily to ensure adequate intakes of vitamin D and calcium.
- At least 5-6 portions of fruit and vegetables should be eaten per day. Pure fruit juice can be used to decrease the bulk of the diet. Approximately 1/2 a glass of fruit juice is equal to one portion of fruit.
- Alcohol should be avoided.
- Adequate fluid intake is important due to increased losses (at least 6-8 glasses per day).
- A good multivitamin and mineral supplement, providing 100 - 200% of the recommended daily intake, is advisable since it will be most unlikely that a person with CF will be able to meet the increased requirements for vitamins and minerals with diet alone (due to a poor appetite). It is important to monitor the required levels of supplementation to ensure that the supplemental dosages for fat-soluble vitamins (see table above) are met. Supplements however should preferably be given after consulting an expert health professional.

For further, personalized and more detailed information, please contact NICUS or a dietitian registered with the Health Professions Council of South Africa.

References from the scientific literature used to compile this document are available on request.

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