

Conference on ‘Malnutrition matters’

Symposium 6: Young people, artificial nutrition and transitional care The nutritional challenges of the young adult with cystic fibrosis: transition

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Cystic fibrosis (CF) is a complex multisystem disorder affecting mainly the gastrointestinal tract and respiratory system. Intestinal malabsorption occurs in approximately 90% of patients. In the past, malnutrition was an inevitable consequence of disease progression, leading to poor growth, impaired respiratory muscle function, decreased exercise tolerance and immunological impairment. A positive association between body weight and height and survival has been widely reported. The energy requirements of patients with CF vary widely and generally increase with age and disease severity. For many young adults requirements will be 120–150% of the age-related estimated average requirement. To meet these energy needs patients are encouraged to eat a high-fat high-energy diet with appropriate pancreatic enzyme supplements. Many patients are unable to achieve an adequate intake as a result of a variety of factors including chronic poor appetite, infection-related anorexia, gastro-oesophageal reflux and abdominal pain. Oral energy supplements and enteral tube feeding are widely used. Nutritional support has been shown to improve nutritional status and stabilise or slow the rate of decline in lung function. With such emphasis on nutritional intake and nutritional status throughout life, poor adherence to therapies and issues relating to body image are emerging. The median survival of patients with CF is increasing. CF is now considered a life-limiting disease of adulthood rather than a terminal childhood illness. With increased longevity new challenges are emerging that include the transition of young adults with CF to adult services, CF-related diabetes, disordered eating, osteoporosis, liver disease and transplantation.

Cystic Fibrosis: Nutritional management: Transition: Nutritional support

Cystic fibrosis (CF) is the most common lethal inherited genetic condition affecting the Caucasian population. One in twenty-five individuals in the UK are carriers of the gene and the condition is inherited in an autosomally recessive manner, which results in an incidence of one in approximately 2500^(1,2). CF is less common in Oriental and black populations⁽³⁾. It is estimated that 8500 individuals in the UK have CF⁽⁴⁾. The basic defect is in the gene that encodes for the CF transmembrane conductance regulator (CFTR), a chloride channel that allows the exchange of Na and chloride across epithelial cell membranes⁽⁵⁾. Approximately 1500 different genetic mutations that give rise to differing severities of CF have currently been

identified⁽⁶⁾. Class I, II and III mutations are the most severe, giving rise to more typical presentations of CF; class IV and V mutations give rise to milder and atypical disease⁽⁵⁾.

CFTR is a protein that is found in various cell types, including lung epithelium, liver, pancreas, reproductive tract and sweat ducts⁽⁷⁾. The absence of, or a defect in, CFTR results in thick sticky dehydrated secretions that cause blockage and eventual fibrosis in many organs. The widespread presence of CFTR throughout the body helps to explain why CF is a multisystem disorder affecting many organs. However, the two major systems predominantly affected are the respiratory and gastrointestinal

systems. The *CFTR* gene is expressed in the pancreas, where the abnormal mucous secretions lead to progressive organ failure. This progression initially occurs in the exocrine pancreas leading to pancreatic enzyme deficiency, and at a later age the endocrine glands become damaged leading to the development of CF-related diabetes (CFRD) in many patients⁽⁷⁾.

The presence of thick sticky mucous in the lungs results in patients with CF often having chronic and severe respiratory infections. Chronic infection eventually leads to inflammation and irreversible destruction of lung tissue. The respiratory aspect of treatment, which involves intensive antibiotic therapy and physiotherapy, is focused on delaying the development of lung damage. Improvements in respiratory and nutritional management have led to an impressive increase in life expectancy for individuals with CF. CF, which was once considered a life-threatening disease of childhood is now considered a life-limiting disease of adulthood⁽²⁾. The median predicted survival is now 35.2 years⁽⁴⁾ and there are now more individuals with CF aged >16 years in the UK than <16 years⁽⁴⁾.

Malnutrition in cystic fibrosis

Malnutrition in CF is multifactorial and has been reviewed in detail elsewhere⁽⁸⁾. There has been evidence of strong links between improved nutritional status and survival for >30 years. A study that compared patients of two North American CF clinics, one of which treated patients with the then traditional low-fat diet and the second treated patients with a high-fat diet, has found the patients treated with a high-fat diet to be taller and heavier⁽⁵⁾. Importantly, this improvement in nutritional status was deemed to be the main reason for a 9-year survival advantage. Since this early study a poor nutritional status has been shown to independently contribute to prognosis^(9–11). Growth failure⁽⁹⁾ and wasting⁽¹⁰⁾ are both highly significant independent prognostic indicators of survival. In patients with height <5th percentile at age 5 years risk of death is significantly increased (males $P<0.02$, females $P<0.0001$); this increased risk persists at age 7 years (males $P<0.01$, females $P<0.0001$)⁽⁹⁾. Patients with >85% ideal body weight have a better prognosis at 5 years of age than those with <85% ideal body weight ($P<0.0001$)⁽¹⁰⁾.

There is also a positive association between nutritional status and lung function^(12–16). Conversely, malnutrition results in poor growth, impaired respiratory muscle function⁽¹³⁾, decreased exercise tolerance and immunological impairment that results in increased susceptibility to infections⁽¹⁷⁾.

Nutritional management

The aims of the nutritional management of CF are that children and adults should be adequately nourished, have normal weight, height, body composition and pubertal development and have optimal vitamin, antioxidant and essential fatty acid status. With increased life expectancy there are constantly new nutritional challenges emerging. Early identification of conditions such as CFRD that may

impact on nutritional status is extremely important and good diabetic control is increasingly important. Dietary management should also aim to minimise the nutritional risks associated with the development of reduced bone mineral density. It is therefore essential that dietetic management is an integral part of CF care for all patients.

Pancreatic insufficiency usually develops in infancy and approximately 92% of individuals with CF are pancreatic insufficient by 1 year of age⁽¹⁸⁾. Approximately 95% of patients in northern Europe will eventually be pancreatic insufficient as a result of an inadequacy of their own pancreatic enzyme secretions⁽¹⁹⁾. With the introduction of newborn screening within the UK and the early identification of milder mutations the percentage of patients with pancreatic sufficiency may increase. In pancreatic insufficiency there is insufficient pancreatic function to achieve normal digestion and absorption of fat. These patients need to take pancreatic enzyme-replacement therapy in order to prevent the symptoms of fat malabsorption. These symptoms include frequent pale, oily and offensive stools, abdominal pain, poor growth and malnutrition and deficiencies of the fat-soluble vitamins and essential fatty acids.

In individuals with CF malabsorption is secondary to pancreatic insufficiency. However, this representation is oversimplistic, especially if compared with patients with pancreatitis for whom malabsorption is relatively easy to control on low doses of pancreatic enzymes. In patients with CF a host of other factors contribute to malabsorption, including a deficiency of pancreatic bicarbonate that reduces duodenal pH⁽²⁰⁾, an increased loss of bile salts in the stool⁽²¹⁾, an imbalance in the type of bile salts produced⁽²²⁾, abnormal ion transfer in the gut as a result of the basic defect in the *CFTR*⁽²³⁾, impaired mucosal uptake and transport of long-chain fatty acid across the gut wall^(24,25) and altered gut motility⁽²⁶⁾.

All patients who are pancreatic insufficient must take pancreatic enzymes with all food and drinks that contain fat. There are various enzyme preparations available⁽¹⁹⁾. The enteric-coated acid-resistant microsphere and mini-microsphere preparations (e.g. Creon[®] Micro and Creon[®] 10 000 (Solvay Healthcare, Southampton, Hants., UK) and Nutrizym 10[®] (Merck Serono, Feltham, Middx, UK)) are more effective than the older pancreatic enzyme preparations (e.g. Pancrex V[®] (Paines & Byrne Ltd, Staines, Middx, UK) and Cotazym[®] (Organon Pharmaceuticals, West Orange, NJ, USA)). As a result of the multiple factors affecting enzyme efficacy dose requirements can vary between 400 IU/g fat and 5000 IU/g fat⁽¹⁹⁾. The dose of enzymes required with all meals, snacks and drinks is titrated against the fat content of the food. Foods that do not contain fat do not need enzymes. The enzymes must not be crushed or chewed, because their efficacy will be reduced. Enzymes should be given at the beginning, middle and end of the meal, especially if the meal takes >30 min to eat. Doses should be advised individually and re-assessed regularly by the dietitian. The dose is adjusted according to clinical symptoms, appearance of the stools and objective assessment of weight gain, nutritional status, growth and absorption. It is recommended that the total dose of enzymes should not usually be >10 000 IU

lipase/kg body weight per d⁽²⁷⁾. Educating patients about dose adjustment and the timing of pancreatic enzyme-replacement therapy is essential to achieve optimal absorption and a good nutritional status. Individuals with CF should be encouraged to openly discuss any adherence issues or problems they experience with pancreatic enzyme-replacement therapy.

Fat-soluble vitamins

Exocrine pancreatic insufficiency and altered bile salt metabolism are two factors contributing to fat malabsorption and fat-soluble vitamin deficiency in most individuals with CF. Biochemical evidence of fat-soluble vitamin deficiency has been found as early as 2 months of age in untreated screened infants with CF⁽²⁸⁾. All patients should have plasma levels of the fat-soluble vitamins A, D and E, total cholesterol, vitamin E:cholesterol and a prothrombin time checked at least annually^(29,30). Ideally, this check should be carried out at a time of clinical stability. Retinol-binding protein, plasma Zn levels and C-reactive protein should be measured at the same time to help in the interpretation of plasma vitamin A levels^(29,31). Vitamin K status is more difficult to assess. Plasma vitamin K levels alone are unreliable for assessment of vitamin K status^(32,33). Vitamin K deficiency of the liver and bone may occur independently. Prothrombin levels are the easiest way to assess vitamin K deficiency; however, they do not always correlate with plasma vitamin K levels⁽³⁴⁾. Although it is not widely available, protein induced by vitamin K absence or antagonist-II levels are a more sensitive measure of vitamin K status of the liver⁽³⁵⁾. Under-carboxylated osteocalcin is the most accurate method of assessing vitamin K adequacy for bone metabolism but it is not used routinely in clinical practice.

All patients with pancreatic insufficiency should receive supplementation with the fat-soluble vitamins A, D and E. There is little international consensus about the need for routine vitamin K supplementation, although it is likely that all patients with CF need routine vitamin K supplementation for optimal bone health. Optimal supplementary doses of the fat-soluble vitamins have not been adequately established and vary from country to country^(29,30). Frequent and serial monitoring of serum vitamin levels is essential⁽²⁸⁾ and doses should be adjusted based on these results. Patients who are pancreatic sufficient need to be monitored annually to ensure that plasma vitamin levels are adequate. Most, if not all, patients who are pancreatic sufficient will require supplementation with vitamin D to achieve adequate levels for optimal bone health.

For adults, starting doses for supplementation are (/d): vitamin A 1200–3000 µg, vitamin D 10–20 µg and vitamin E 100–400 mg⁽³⁰⁾.

Vitamin A

Vitamin A deficiency may cause night blindness in older patients⁽³⁶⁾ and can progress to severe xerophthalmia if not checked⁽³⁷⁾. Vitamin A is also important because of its role in the maintenance of mucus-secreting epithelial cells.

Low vitamin A levels are associated with poorer clinical status, impaired lung function^(38,39) and lower weight standard deviation scores and bone mineral density⁽³⁸⁾. As patients become older there is an increasing disparity in vitamin A levels between patients with CF and controls, suggesting an association with disease progression⁽³⁸⁾. High serum levels of vitamin A⁽⁴⁰⁾ have been reported in individuals with CF and are especially common following transplantation⁽⁴¹⁾.

Vitamin D

Risk factors for suboptimal vitamin D levels include: fat and vitamin D malabsorption⁽⁴²⁾; low vitamin D-binding protein⁽⁴³⁾; poor adherence with prescribed vitamin supplements; inadequate sunlight exposure as a result of hospitalisation, illness or through advice about photosensitivity from antibiotic therapy. Vitamin D deficiency may cause rickets⁽⁴⁴⁾ and osteomalacia^(45,46). Clinical evidence of overt vitamin D deficiency is rare but suboptimal levels for optimal bone health remain common despite standard and high-dose vitamin supplementation regimens^(47–52).

A plasma level >30 ng/ml or 75 nmol/l is recommended for the general population⁽⁵³⁾ and the recommendation is the same (at all times of the year) for individuals with CF^(54,55). As vitamin D is usually given in combination with vitamin A (as multivitamin preparations or vitamin A and D capsules) care should be taken when increasing the dose of supplement as a high intake of vitamin A may contribute to poor bone mineralisation⁽⁵⁶⁾. A separate vitamin D preparation may be required.

Vitamin E

Severe vitamin E deficiency may cause neurological problems in older patients with CF⁽⁵⁷⁾. It may also contribute to anaemia and correction of vitamin E deficiency improves Hb levels⁽⁵⁸⁾. Vitamin E may be important in controlling the progression of lung disease as it is an important antioxidant. Vitamin E reduces the effects of free radicals produced by infection and chronic inflammation, thus helping to protect cell membranes from oxidative damage.

More recently, it has been suggested that vitamin E plays a role in cognitive function. The prevention of prolonged vitamin E deficiency by neonatal screening and early active nutritional intervention in infants with CF is associated with better cognitive function⁽⁵⁹⁾. With modern intervention and monitoring high plasma vitamin E levels have been reported in patients with pancreatic insufficiency⁽⁶⁰⁾ and are especially common following transplantation⁽⁴¹⁾. This finding emphasises the need for regular nutritional assessment and surveillance.

Vitamin K

Individuals with CF are at risk of vitamin K deficiency as a result of pancreatic insufficiency and bile salt deficiency causing fat malabsorption. Additional risk factors include CF-related liver disease, frequent antibiotic therapy,

inadequate dietary intake and short-gut syndrome resulting from bowel resection⁽³²⁾.

Vitamin K deficiency and subclinical vitamin K deficiency (as shown by elevated protein induced by vitamin K absence or antagonist-II levels) are common^(33,61). It occurs in all patients with CF-related liver disease, is common in individuals with CF who are pancreatic insufficient and is found in about one-third of patients who are pancreatic sufficient. There is increased attention to the role of vitamin K in bone health in individuals with CF⁽⁶²⁾. A cause-and-effect relationship between vitamin K deficiency and low bone mass in CF has not been proved⁽⁶¹⁾, but subclinical vitamin K deficiency may be important in the development of CF-related low bone mineral density.

With improved treatment, earlier intervention, increased survival and the emergence of new co-morbidities overt deficiency of the fat-soluble vitamins is now rare in CF. The emphasis is moving from preventing deficiency to achieving optimal levels for a number of health outcomes, and with this shift optimal surveillance for toxicity as well as adequacy will be needed⁽⁶³⁾.

Nutritional support

International consensus reports recommend constant monitoring of nutritional status and growth with staged nutritional intervention for individuals with CF who have or are at risk of nutritional failure and malnutrition^(29,30). The actual extent of nutritional failure for initiating interventions varies between these reports^(29,30). It is recommended that individuals with CF have access to a CF specialist dietitian at every outpatient clinic visit, inpatient admission and at the time of annual review^(64,65).

Preventative nutritional counselling is recommended for all patients regardless of their nutritional and clinical status. If a patient's weight gain or nutritional status is inadequate or appetite poor, oral dietary supplements are introduced to help to improve energy intake. Supplements are prescribed on an individual basis dependent on the patient's age, preferences and requirements. Supplements should be taken in addition to normal food to increase total daily energy intake and should not replace a meal. It is essential that pancreatic enzyme-replacement therapy is given with all fat-containing supplements. A UK multi-centre longitudinal study has shown that their use can promote weight gain⁽⁶⁶⁾ and improvements in protein and energy intake^(67,68). The efficacy of the short-term use of oral energy supplements in the acute situation, and the long-term use in adults or those with advanced lung disease, has not been fully assessed⁽⁶⁹⁾.

If preventative nutritional counselling and/or oral dietary supplements fail to prevent or reverse poor nutrition or nutritional decline, enteral tube feeding is the final recommended stage of nutritional support. The European and UK nutrition consensus documents give specific recommendations on when enteral tube feeding should be initiated^(29,30). These criteria are taken as an indication of the need to introduce enteral tube feeding, but a more comprehensive global nutritional and clinical assessment may prompt or delay intervention. Some of the additional

Table 1. Examples of objective and subjective factors taken into consideration when assessing patients for the introduction of enteral tube feeding

Objective criterion	Subjective criterion
Previous weight history	Psychosocial implications
Rate of weight loss	Emotional acceptance
Control of malabsorption	Patient and/or carer workload
Respiratory function	
Frequency of respiratory exacerbation	
Clinical disease severity	
Transplant status	
Liver disease	
Diabetic status	

factors that may be taken into consideration are summarised in Table 1.

There are no randomised controlled trials that have assessed the efficacy or possible adverse effects of enteral tube feeding in CF⁽⁷⁰⁾. However, enteral tube feeding has been shown to improve weight gain and nutritional status^(71,72) and to stabilise⁽⁷³⁾ or slow the rate of decline in respiratory function^(74,75). Improvement in respiratory function has been shown following 1 year of enteral tube feeding⁽⁷⁶⁾. Improved nutritional status may also contribute to increased quality of life⁽⁷⁷⁾. Early discussion about enteral tube feeding and early introduction of enteral tube feeding is essential, as early intervention is associated with improved outcome^(74,78). Those patients with advanced disease may benefit less^(78,79). Although patients may express concerns about body image⁽⁸⁰⁾, positive attitudes to gastrostomy placement including increased quality of life have also been reported⁽⁷⁷⁾.

Feeds are usually administered overnight and patients are encouraged to eat normally through the day. Most patients tolerate whole-protein polymeric feeds with a high energy density. Enteral tube feeding may precipitate hyperglycaemia requiring insulin therapy⁽⁸¹⁾ irrespective of the carbohydrate content of the feed⁽⁸²⁾. This tendency is exacerbated if the patient is also receiving corticosteroids; therefore, the introduction of enteral tube feeding should be closely monitored to assess its effects on nocturnal glycaemia.

Cystic fibrosis-related diabetes

With increased longevity CFRD has emerged as the most common co-morbidity in CF^(83,84). The reported prevalence varies depending on the screening and diagnostic criteria used⁽⁸⁵⁾. The prevalence of CFRD increases with age, with 26% of 10–20 year olds⁽⁸⁶⁾ and 50% of 30 year olds⁽⁸⁷⁾ being reported as having CFRD. In addition, glucose intolerance is common in both adolescent and adult patients with CF⁽⁸⁴⁾ and glucose tolerance status⁽⁸⁸⁾ and insulin resistance can fluctuate. Consequently, patients may be glucose intolerant or diabetic for a period of time and then revert to normal again⁽⁸⁸⁾. This fluctuation requires a unique approach to diagnosis and management.

Conventional measures of glucose status used in the diagnosis of diabetes in the general population are often unreliable in CFRD. Fasting glucose levels do not reliably identify CFRD⁽⁸⁹⁾ even if impaired fasting glucose is used as an indication for an oral glucose tolerance test⁽⁹⁰⁾. HbA_{1c} has been used as a screening test but has been shown to be unreliable in the diagnosis of CFRD⁽⁸⁸⁾ as levels are often normal at the time of diagnosis of CFRD. Symptoms are unreliable as the onset of CFRD is insidious and patients are usually asymptomatic. The 2 h oral glucose tolerance test is the recommended screening test for CFRD^(85,88,91). Importantly, CFRD is distinct from type 1 or type 2 diabetes but has features of both. It is associated with insulinopenia and insulin resistance^(92,93). Ketoacidosis is unusual but can occur, especially if there has been a long period of symptomatic hyperglycaemia before diagnosis⁽⁸⁶⁾.

There are many factors specific to CF, including acute and chronic respiratory infection and inflammation, increased energy expenditure, malabsorption, abnormal intestinal transit time, malnutrition, glucagon deficiency, CF-related liver disease, overnight tube feeding and steroid use, that may contribute to fluctuations in glucose tolerance status.

CFRD mainly occurs in individuals with the most severe CF mutations, all of which are associated with exocrine pancreatic insufficiency^(94–96), and it is more common in those patients who are homozygous for the delta F508 genotype⁽⁹⁷⁾. Patients with milder genetic mutations associated with pancreatic sufficiency are less likely to develop CFRD^(5,95,98). Other risk factors for the development of CFRD include increasing age^(94,96,97), female gender^(94,96,97), more severe pulmonary disease^(96,97), liver disease^(94–96), use of corticosteroids^(95,96), use of enteral tube feeding⁽⁹⁹⁾ and organ transplantation^(95,100,101).

Early detection and treatment of CFRD is important as there is increased morbidity in the pre-diabetic state. Insulin deficiency leads to poorer pulmonary outcome⁽¹⁰²⁾. The early diagnosis and intervention in CFRD can have a profound impact on patient well-being, protecting against weight loss and deterioration in lung function⁽¹⁰³⁾. The negative impact of diabetes on pulmonary status in CF appears to be greater in female patients than in males^(104,105). Women with CFRD have a survival disadvantage⁽¹⁰⁴⁾. The negative impact of diabetes on nutritional decline appears to be more pronounced in those patients who are still growing during the pre-diabetic years⁽⁹⁹⁾. This factor is particularly important as these patients are likely to be going through the difficult phase of transition from paediatric to adult services. CFRD is associated with a more rapid rate of decline in lung function even before diagnosis^(103,106), although this decline can be prevented through the use of intensive nutritional intervention⁽⁹⁹⁾.

The importance of early detection and good control of CFRD cannot be overemphasised. Microvascular complications are increasingly recognised in patients with CFRD^(107–111). Although macrovascular complications have not yet been reported, with the increasing life expectancy of individuals with CF the risk of these complications developing will be minimised with good control.

The primary aim of treatment in CFRD is to maintain nutritional status, and the maintenance of a high-fat high-energy diet is important. Insulin therapy is the treatment of choice to help maintain an adequate energy intake. All patients should receive individualised dietary review and advice at the time of the diagnosis of CFRD. They should usually maintain a high-energy diet and the insulin dose should be tailored to their individual requirements.

Individuals should be advised not to limit their intake of refined carbohydrates, or high-fat foods^(91,112). Many individuals are aware of the dietary restrictions (reduced fat, high fibre, low sugar, low salt, controlled energy) that are part of the treatment of type 1 and type 2 diabetes and these restrictions are directly opposed to the requirements for CFRD (a high-fat high-energy high-protein diet with an increased Na content). Many individuals with CF have erratic eating habits and their insulin regimen should be tailored to their pattern of eating. They should not decrease their carbohydrate intake but should be encouraged to eat regular meals with similar carbohydrate content each day. If this approach compromises their total energy intake, carbohydrate counting may be valuable, enabling them to eat as much as they can. If a patient is receiving bolus nasogastric or gastrostomy feeds over a few hours they can be covered with soluble insulin^(84,91). Intermediate or long-acting insulin will be required for overnight feeds. Relatively large doses of insulin may be required for feeds, and patients and carers must be made aware of the risk of severe hypoglycaemia if the insulin is given and the feed then not being delivered or if the feed is discontinued^(84,91).

The additional burden of CFRD needs to be acknowledged in patient management and care. In addition, there needs to be consideration of transition to a second care provider, that of the Diabetes Service, which may be less well established.

Bone health

Reduced bone mineral density is well documented in adolescents and adults with CF^(113,114). Most patients with severe CF-related lung disease have reduced bone mass^(115,116). Recent reports suggest that defective bone mineralisation occurs in early childhood in individuals with CF^(51,117). Prevalence data vary depending on the population studied and method of assessment used.

The aetiology of low bone mineral density in CF is a complex interaction of multiple factors that include the effect of the CFTR mutation itself, poor nutritional status including low BMI, deficiency of the fat-soluble vitamins D and K, poor Ca intakes, disease severity, recurrent chest infections with raised levels of circulating pro-inflammatory cytokines, delayed puberty, secondary hypogonadism, CFRD, reduced weight-bearing exercise and physical inactivity, treatment with corticosteroids or other drugs that cause bone loss such as depot medroxyprogesterone acetate and immunosuppressive therapy⁽⁵⁴⁾.

Bone mineral acquisition in childhood and especially during the pubertal growth spurt, in adolescence, is a major determinant of adult bone health. Of the peak bone mass

Table 2. A six-step programme for transfer between the paediatric and adult cystic fibrosis (CF) units⁽¹³⁷⁾

Step	Programme
1	At 14 years of age the patient's named paediatric CF nurse specialist makes a home visit to discuss a number of issues, which include the transition programme, any worries or concerns about transferring to the adult unit, fertility, sexuality or contraception. The nurse, patient and family also discuss a move towards more patient responsibility for treatment, which involves addressing the concerns of the parents and caregivers as well as those of the patient
2	The young adult patient is transferred at approximately 15 years of age to the 'transition' clinic, which takes place monthly in the paediatric CF unit outpatient department. Both paediatric and adult consultants attend but the allied health professionals in the clinic are from the adult team. This approach helps the young adult and family to get to know the adult team in familiar surroundings with their paediatrician present
3	The paediatric CF nurse specialist takes the young adult and their family to visit the adult unit and to meet other members of the adult CF team
4	Before the first outpatient appointment at the adult unit all young adults and their families are offered a joint home visit by their named paediatric CF nurse specialist and the adult CF nurse specialist. This visit allows the opportunity to ask any last questions and to address concerns before transfer. The young adult will receive a letter from the adult consultant welcoming them to the adult CF unit
5	The young adult is transferred to the adult unit at a minimum age of 16 years. Transfer is planned to fit in with other important life events (e.g. in August when exams have finished and before college starts), and when the adolescent is physically, medically and socially prepared for transfer. Individual paediatric multidisciplinary specialists brief their colleagues on the adult team about each patient before they transfer
6	Transfer is not a discrete event, but is a gradual process. After transfer to the adult unit the young adult and family can contact their named paediatric CF nurse to discuss any concerns or ask any questions. After 6 months the family are contacted by their paediatric nurse to see how they have settled down

$\geq 90\%$ is achieved by the end of the pubertal growth spurt⁽¹¹⁸⁾. It is therefore essential that prevention strategies to attain and maintain normal bone status begin from diagnosis, but even greater emphasis on these issues occurs during adolescence. A multidisciplinary approach to prevention is essential and should include optimising respiratory status and encouraging regular weight-bearing exercise. Dietetic management focuses on optimising weight gain and growth and optimising intakes of nutrients that support bone development such as Ca, vitamin D and vitamin K.

Ca is the major mineral in the skeleton. Reduced Ca intake in childhood is linked with an increased risk of osteoporosis in adult life and an increased Ca intake may improve bone mineral density⁽¹¹⁹⁾. Girls with CF have marked endogenous faecal Ca loss⁽¹²⁰⁾ and lower bone Ca accretion rates during pre- and late puberty than girls without CF⁽¹²¹⁾. Dietetic supervision is essential to ensure an adequate Ca intake.

Vitamin D intake and blood levels should be reviewed at least annually. Low blood vitamin D levels remain common in individuals with CF despite the use of standard ($\geq 20 \mu\text{g}/\text{d}$) and high-dose replacement regimens⁽⁴⁷⁻⁵²⁾. There is now increased attention on the role of vitamin K in bone health⁽⁶²⁾. Vitamins K and D together may postpone fracture risk by 10 years in the non-CF population⁽¹²²⁾. Evidence is accumulating that all patients with CF should receive vitamin K supplements (see earlier discussion of vitamin supplementation).

Other nutritional challenges

In addition to the clinical challenges to achieving a good nutritional status in young adults with CF, there are also social pressures. Societal pressure on young women to

remain thin and strive to achieve 'size zero' may compromise optimum nutritional management. Clinically, the aim is for a BMI of $22 \text{ kg}/\text{m}^2$ in females and $23 \text{ kg}/\text{m}^2$ in males⁽¹²³⁾. In addition, nationally there is an emphasis on a low-fat high-fibre 'healthy eating' regimen that is in direct contrast to the high-fat high-energy dietary recommendations for CF of 120–150% of estimated average requirements for energy with 40% of total energy coming from fat^(124,125).

In view of the importance of nutrition there is often persistent emphasis on weight gain from diagnosis, which may result in issues relating to body image and eating behaviour. Adolescents with chronic illnesses have been reported to be at greater risk for patterns of eating disorders or disordered eating behaviour than other adolescents^(126,127). Reports in relation to individuals with CF are conflicting^(80,128,129). In the author's experience of adolescents and young adults with CF, eating behaviour and attitudes, body satisfaction and self-esteem are similar to those of their healthy peers. Males perceive themselves as heavier than they are but also wish to be heavier still. Females with CF see themselves as thinner than they are but are happy with their perceived body image. Females with CF actually reported fewer problems than their healthy peers⁽¹³⁰⁾.

However, invasive nutritional support and the presence of CFRD may confound this outcome. No difference has been found between patients with CFRD and adults with CF who do not have CFRD in relation to actual, perceived or desired BMI^(80,131). However, those with CFRD, especially females, report a greater number of problems concerning food and eating behaviours. In addition, both males and females with CFRD are less satisfied with their body appearance than controls. Patients treated with insulin report greater problems with food and eating behaviours and feelings of lower self-worth than those taking oral

medication⁽¹³¹⁾. Both males and females receiving nutritional interventions (oral supplements or enteral tube feeds) have been found to have appropriate eating behaviours and a desire to gain weight; females receiving nutritional intervention report more dieting behaviour, greater preoccupation with food and feeling more pressure to eat than controls⁽⁸⁰⁾. Adults with CF receiving nutritional interventions, especially tube feeding, have been found to be less satisfied with their body image, report lower self-esteem and poorer quality of life⁽⁸⁰⁾.

The burden of treatment and transition

Increasing and improved survival has occurred as a result of more aggressive management of CF and the introduction of new therapies. Thus, many young adults with CF have a complex regimen of care aimed at both prevention and treatment. For most young adults this regimen requires at a minimum pancreatic enzyme-replacement therapy at every meal and snack, supplemental vitamins, prophylactic oral antibiotic therapy, inhaled and nebulised therapies and oral anti-inflammatory medication. On the other hand, the patient with more complex care may require treatment of co-existing liver disease, insulin therapy for co-existing CFRD, bisphosphonate treatment for CF-related low bone mineral density, O₂ therapy and/or non-invasive ventilation, intravenous antibiotic therapy and enteral tube feeding. With the increasing number and complexities of these therapies there may, for some patients, be a point at which the perceived treatment burden outweighs the benefit of any new or additive therapy, and this situation may affect patient adherence. It is also important to acknowledge that, because of the constant emphasis placed on eating, food and nutritional status, for many individuals with CF eating, which is viewed as just another treatment, is problematic. Understanding and improving adherence in the young adult with CF remains a major challenge.

Adolescents and young adults with chronic conditions share the same social, developmental and emotional needs as their healthy peers. There are many transitions that the young healthy adult has to go through, and these transitions help the individual to become increasingly self sufficient. In addition, individuals with a chronic illness such as CF need to make a transition within the healthcare system from paediatric to adult care.

The National Service Framework for Children, Young People and Maternity Services⁽¹³²⁾ has highlighted the importance of ensuring safe and effective transition; ensuring a seamless transfer is one of the greatest challenges facing both children's and adult services⁽¹³³⁾. With continually-improving survival increasing numbers of adolescents and young adults with CF are making the transition from paediatric to adult care. This transition is a hugely important milestone for the patient and the family and must be handled sensitively.

This transfer process is a challenge for the patient themselves, for their parents, caregivers and for both the paediatric and adult teams caring for the patients. Patients should be transferred to an adult clinic at approximately the age of 16 years, but the exact timing must be flexible,

depending on the health of the patient and individual variations in physical and emotional development⁽¹³⁴⁾.

Different transitional models exist⁽¹³⁵⁾ but successful transition planning and programmes are crucially dependent on collaboration between children's and adult services⁽¹³⁶⁾. It is important that transition is viewed as a process and not a single event. As CF is a multisystem disorder transition may be from more than one service provider, e.g. Liver Service, Endocrine Service as well as the CF Service, and hence may be complex.

A six-step programme for transfer between the paediatric and adult CF Units that aims to reduce any patient anxiety⁽¹³⁷⁾ is shown in Table 2; audit and evaluation of this process are ongoing.

Summary

The nutritional challenges of the young adult with CF are complex. In addition to clinical and nutritional challenges there are many social challenges. Transition to adult care remains a stressful and trying time for patients, parents and caregivers but has to be addressed, as with increasing longevity more patients and families will experience the process. Despite CF being the most common lethal inherited genetic condition affecting the Caucasian population, it remains relatively rare, with approximately 8500 individuals with CF in the UK⁽⁴⁾. Nevertheless, increasing numbers reach adulthood and go through the transitional process. Ensuring a seamless transfer is one of the greatest challenges facing both children's and adult services⁽¹³³⁾.

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