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Original Article

Nutritional considerations for a new era: A CF foundation position paper

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ABSTRACT

Objective: To provide interim advice and considerations to the CF Community around CF nutrition in the current era.
Methods: The Cystic Fibrosis (CF) Foundation organized a multidisciplinary committee to develop a Nutrition Position Paper based on the rapidly changing nutrition landscape in CF, due in part to widespread use of cystic fibrosis transmembrane regulator highly effective modulator therapy (HEMT). Four workgroups were formed: Weight Management, Eating Behavior/Food Insecurity, Salt Homeostasis and Pancreatic Enzyme use. Each workgroup conducted their own focused review of the literature.
Results: The committee summarized current understanding of issues pertaining to the four workgroup topics and provided 6 key take-aways around CF Nutrition in the new era.
Conclusion: People with CF (pwCF) are living longer, particularly with the advent of HEMT. The traditional high fat, high calorie CF diet may have negative nutritional and cardiovascular consequences as pwCF age. Individuals with CF may have poor diet quality, food insecurity, distorted body image, and an higher incidence of eating disorders. An increase in overweight and obesity may lead to new considerations for nutritional management, given potential effects of overnutrition on pulmonary and cardiometabolic parameters.

Introduction

Cystic fibrosis (CF) is a chronic genetic disease primarily affecting the respiratory and gastrointestinal tracts. Pancreatic exocrine insufficiency (PI) with malabsorption has dominated the nutritional focus in the past. A high-fat, high calorie diet has been the standard of care for several decades because of the effect of nutritional status on pulmonary function and survival (1,2). This dietary approach may have contributed to poor diet quality devoid of nutrient dense foods and may have increased the incidence of distorted body image (BI) and eating disorders in some peo-

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ple with CF (pwCF) (3). More recently, in the context of introduction of highly effective modulator therapy (HEMT), there has been an increasing prevalence of overweight/obesity in pwCF throughout the world, due in part to improved care, leading to an evolving landscape in disease management and nutritional interventions (4-7). With increasing survival in pwCF globally, the impact of overweight and obesity on CF outcomes, such as pulmonary status, diabetes and cardiometabolic risk, warrants further investigation and updated recommendations for nutrition management. While there is insufficient evidence to develop a formal guideline, the need for guidance led the North American Cystic Fibrosis Foundation (CFF) to organize a multidisciplinary workgroup to develop this position paper.

Methods

A multidisciplinary workgroup, including adult and pediatric physicians from various disciplines, dietitans, a psychologist, social worker, pwCF, and representatives from CFF was formed to consider important nutritional topics in the current era for both children and adults with CF, emphasizing changes in nutritional status following introduction of HEMT. Surveys were distributed by email utilizing SurveyMonkey® to determine topics important to pwCF, their families, and healthcare providers (HCP) at US adult and pediatric care centers. The survey consisted of 20 questions about challenges and concerns around nutrition-related issues in CF. Questions were a combination of drop down and free text formats. 596 responses were received; 422 from CF providers and 155 from pwCF and families. Topics were subsequently selected based on committee and survey input. Four subgroups were formed to cover the following themes: weight management, obesity comorbidities, medical/surgical management of obesity, eating behaviors, body image, food insecurity, salt homeostasis and hypertension; and pancreatic enzymes. Each subgroup conducted a PubMed literature review relevant to their topic. All committee members disclosed conflicts of interest; those with conflicts did not participate in the discussion or writing of the sections where they were conflicted.

The CF Foundation intends for this position paper to summarize evidence, and provide reasonable clinical guidance based on that evidenceto HCPs, pwCF, and other stakeholders, as well as identify areas in need of further research.

Weight management

PwCF fall along the entire spectrum of weight/nutritional status. The effect of different nutritional approaches on mortality across several countries spurred previous changes in dietary recommendations **(**8**).** Historically, emphasis was placed on achieving weight gain/target body mass index (BMI), since optimization of nutritional status has been correlated with improved lung function, decreased hospitalizations for pulmonary exacerbations, and reduced mortality (2,9,10**).** Guidelines have specified minimal BMI goals and annual care center reports in the US have cited center specific data regarding BMI, likely reinforcing the emphasis on weight gain (2). However intake of calorie dense (energy dense) foods for weight gain is no longer a priority for some pwCF as the CF community recognizes the importance of nutrionally rich (nutrient dense) foods for long term health (11). In recent evidence based practice guidelines, McDonald, et al. recommend an age appropriate healthy diet associated with positive health outcomes in the general population (eg fruits, vegetables, legumes, whole grains), adapted to meet individual energy requirements for PwCF **(**12**).**

More recently, with availability of multidisciplinary treatment approaches, earlier diagnosis of CF and PI, widespread use of HEMT, and paralleling anthropometric trends of society at large, the proportion of pwCF who are overweight or obese has increased world-wide. In 2019, before the widespread use of HEMT, up to 23% of pwCF in the US had a BMI that qualified as either overweight or obese (13), Since increased use of HEMT, up to 40% of pwCF in both the US and UK made up these categories in 2021 (44% of men and 36% of women) (5-7,14-16). Likewise, a single center study in Italy reported that 22% of adults with CF were overweight (4). HEMT likely contributes to increase in weight by reducing energy expenditure for breathing, improving smell/taste, enhancing appetite, optimizing fat absorption/intestinal pH (17,18) increasing fat mass (19) and presenting the need to take the medication with fatty foods. In a prospective observational study in pwCF initiating ivacaftor, there was a 5.5% decrease in resting energy expenditure (REE) 3 months after treatment (18). This change in energy balance with HEMT is expected to lead to changes in energy intake recommendations. Given reduced REE, ongoing consumption of the same high-calorie, energy dense foods, which has been traditionally encouraged in PwCF (3) can lead to overnutrition in some pwCF. Nutritional quality of calorie rich but not nutrient dense foods traditionally consumed by pwCF may have long term implications on cardiovascular and metabolic health as pwCF live longer. The role of exercise for cardiovascular health and in maintaining a healthy weight also needs to be emphasized in pwCF. Even though traditionally BMI has been the metric used to categorize weight, it does not account for body composition or genetic predisposition to metabolic derangements, nor does it encompass various cultural norms. BMI, therefore, remains an imperfect surrogate for nutritional status and potential metabolic risk. Nutritional recommendations in CF should be personalized using the individual's available clinical data and the goals of the pwCF; evidence based guidance regarding specific diet recommendations is not yet available. While the considerations on this paper are not intended to serve as nutritional guidelines, it is encouraged to recommend intake of foods associated with optimal cardiometabolic outcomes (fruits, vegetables, lean proteins, low fat dairy, whole grains, legumes) for children and adults that are achieving desired growth or target weight (20). A multidisciplinary approach can be especially helpful in supporting patients in reaching their nutritional goals. Table 1 lists the roles of the team members involved in weight management in pwCF.

Obesity comorbidities

Obesity is associated with worsened cardiovascular outcomes in the general population, but data are limited in pwCF. Increasing prevalence of obesity in pwCF, along with consumption of high fat and high sugar foods starting in early life, may contribute to cardiovascular disease and other comorbidities as pwCF live longer (9). Arterial stiffness has been shown to be increased in children with CF, in association with inflammatory markers (21,22). Median blood levels of cholesterol and systemic hypertension have been reported to be higher in pwCF who are overweight compared with individuals who are normal weight and underweight (4).

Compared with healthy age matched controls, pwCF had similar total body adiposity and BMI, but higher visceral adiposity, correlating with sugar consumption and higher fasting blood glucose (23), and increased odds of frailty (24). Additional studies have demonstrated increased insulin resistance in pwCF who are overweight and obese compared with those who are of normal weight or are underweight (4,9,14,25-27). As pwCF develop overweight and obesity, insulin resistance may play a more significant role in cystic fibrosis related diabetes (CFRD) pathophysiology. Treatment of CFRD may be changing with the introduction of HEMT. Elexacaftor-tezacaftor-ivacaftor (ETI) has been shown to

Table 1
Interdisciplinary Team's role in weight management and food insecurity assessment.

Collaboration between team members is essential to address all issues and ensure consistent messaging.	
Team Member	Role in Weight Management and Food Insecurity Assessment
Patient and Family	1. Provide input on food preferences, cultural food practices, and access to nutrient-dense foods 2. Participate in shared decision making
Dietitian	1. Perform diet recalls identifying opportunities for optimizing dietary intake 2. Recommend strategies to enhance diet quality 3. Review labs and provide recommendations on micronutrients (both deficiency and excess) 4. Evaluate for manifestations of malabsorption and adjustment of pancreatic enzyme dosage 5. May perform body composition measurements in the clinic (bioelectrical impedance analysis), and alternative measures of nutritional assessment (skin fold thickness, hand-grip strength etc.) 6. Provide education for PwCF and family 7. Provide supportive counseling around body image and weight stigma 8. Screen for food insecurity
Social Worker/ Clinical Psychologist/Mental Health Coordinator	1. Provide psychosocial support around body image and weight stigma and implementing behavioral change strategies 2. Screen for depression, anxiety, disordered eating, and food insecurity 3. Provide resources and interventions for patients with positive screening 4. Follow up after the clinical visit to ensure resources provided were helpful
Pulmonologist/ Physician/Advanced Practice Providers (primary care physician may play a shared role for certain conditions)	1. Evaluate/provide referral for CF-related comorbidities which may increase with obesity (eg CFRD) 2. Evaluate/provide referral for obesity-related comorbidities such as obstructive sleep apnea, hypertension, and cardiovascular disease 3. Reinforce importance of healthy diet and exercise with PwCF, assess access to adequate nutrient rich foods
Gastroenterologist	1. Evaluate and manage gastrointestinal comorbidities of obesity (e.g., gastroesophageal reflux disease, cholelithiasis, hepatic steatosis) 2. Evaluate and manage CF-related or obesity related liver disease 3. Evaluate pancreatic function and manage pancreatic insufficiency 4. Managing gastrointestinal/hepatic manifestations of E/T/I (85)
Nurse Coordinator/Research Nurse	1. Encourage communication between the PwCF and the team, facilitate coordination between team members in issues related to weight management.
Endocrinologist/ Obesity Specialist	1. Evaluate and manage dyslipidemia 2. Evaluate the need for medical/surgical management for obesity 3. Discuss the effect of medical/surgical management of obesity on CF-related diabetes and malabsorption
PhysicalTherapist/ Physiotherapist	1.Measure functional ability: stamina, endurance, and ADLs 2.Provide customized exercise program aimed at integrating physical activities into a healthy lifestyle and optimize lean body mass
Pharmacist	1. Assess drug-nutrient and drug-drug interactions, including weight loss drugs.

reduce random blood glucose and hemoglobin A1C in pwCF (6). In children with CFRD, one study demonstrated improved glycemic control after initiation of ETI, with some children able to reduce or discontinue insulin (28) Overnutrition in CF has also been shown to be associated with obstructive sleep apnea (OSA) and a higher mean apnea/hypopnea index (29).

A single center retrospective study of 134 adults recently showed elevation of blood pressure a median of 12.2 months after initiation of elexacaftor/tezacaftor/ivacaftor (6). Clinicians should be aware of the potential cardiovascular complications associated with the legacy, high fat/high calorie CF diet, particularly in the setting of HEMT and increasing life span for pwCF. Clinicians' recommendations on nutrition should take into consideration that the median percent predicted FEV1 was higher, and exacerbations were lower, in pwCF who were overweight compared with pwCF who were normal or underweight (4,14) with a possible plateau as BMI increases, suggesting that increased BMI association with improved lung function can plateau at higher BMI values. Further studies of the adverse cardiometabolic effects of obesity and the effect of a "heart healthy" diet on CF outcomes are urgently needed. Lipid screening should follow guidelines in the general population until further CF specific data becomes available. The role of exercise in potentially circumventing obesity comorbidities in pwCF also requires further investigation.

Medical/Surgical management

Medical management of undernutrition in pwCF has been outlined in previously published guidelines (12,30) and may involve a variety of approaches, including enteral nutrition (2,31). Since overnutrition and obesity are a relatively recent phenomenon in pwCF globally, there is a paucity of data on optimal diet, effective lifestyle, pharmacological and surgical management. Current guidelines detailing strategies for weight loss in the general population offer some guidance, but caution is required in extrapolating these recommendations to pwCF. In the general population with obesity, lifestyle modifications including diet, exercise and behavior change mangement are typically the first recommendation, and pharmacological therapy is indicated when BMI is >30 kg/m^2, or >27 kg/m^2 with obesity-related comorbidities (32). Medical therapy is considered when individuals do not lose 5% of their body weight in 3 months despite changes in diet and physical activity. Pharmacotherapy approved for treatment of obesity in the general population may be associated with worsening malabsorption, drug-drug interactions, or exacerbation of underlying gastrointestinal symptoms in pwCF and should be used with caution (32). Shared decision making is vital when discussing and considering weight management options and strategies with the pwCF, as there are no data on the safety of efficacy of these therapies in this patient population.

Table 2
Definitions.

Disordered eating behaviors or disturbed eating attitudes and behaviors (EABs)*	Restrained eating; emotional eating; disinhibited eating; night eating; binge eating; weight, shape, and eating concerns; strict dieting; and controlling one's body weight and shape through inappropriate compensatory behaviors (i.e. purging) that do not warrant an eating disorder diagnosis (*Diagnostic and Statistical Manual of Mental Disorders).*
Chronic health conditions (CHC)	A health condition with a biological, psychological, or cognitive basis, expected to last for at least one year, with symptoms that may limit function and activities, and requiring medical care or related services.
Diet-related chronic health condition or diet-treated chronic illness (DR...-CHC)	A CHC with prescribed dietary regimens with pressures to comply, leading to the development of destructive attitudes towards food, body weight, and unhealthy eating habits. (i.e. CF, IBD, IBS, T1DM)
Eating disorder (ED)*	Clinically meaningful behavioral or psychological pattern with eating or weight, associated with distress, disability, or with substantially increased risk of morbidity or mortality.
Anorexia nervosa (AN)*	Restriction of energy intake relative to requirements leading to a significantly low body weight in context of age, sex, developmental trajectory, and physical health; Intense fear of gaining weight or becoming fat, even though underweight.
Binge-Eating Disorder (BEN)*	Recurrent episodes of binge eating characterized by: 1. Eating, in a discrete period of time, an amount of food that is definitely larger than most people would eat during a similar period of time and under similar circumstances, and 2. A sense of lack of control over eating during the episode.
Bulimia nervosa (BN)*	Recurrent inappropriate compensatory behaviors and binge eating both occur. Recurrent inappropriate compensatory behavior in order to prevent weight gain, such as self-induced vomiting, misuse of laxatives, diuretics, or other medications, fasting, or excessive exercise;
Food insecurity	Lack of consistent access to affordable, nutritious food
Weight Neutral Approaches	Focus on optimizing other health outcome measures rather than promoting weight loss to treat overweight and obesity

* Definitions obtained from The Diagnostic and Statistical Manual of Mental Disorders, 5th Edition.

FDA approved medications for weight loss are detailed in the Endocrine Society Clinical Practice Guidelines (32). While there is lack of data on safety and efficacy of pharmacotherapy use for weight loss in pwCF, limited, anecdotal clinical experience has shown that such therapies can be used safely and effectively, when selected carefully and in consultation with medical providers with expertise in using these medications in this patient population.

Bariatric surgery is considered in non-CF individuals with BMI $\geq$40 kg/m^2 and or BMI 35 to 39.9 kg/m^2 with at least one obesity-related comorbidity when diet, exercise, and pharmacotherapy do not augment weight loss (33). There have been some reports of pwCF undergoing weight loss surgery, however there is insufficient data regarding the safety and efficacy of bariatric surgery in pwCF, specifically as it relates to malabsorption and GI symptoms.

Weight stigma/weight neutral approaches

Weight stigma, discriminatory acts directed at individiuals because of their weight or size, is a common experience for overweight and obese individuals and is associated with disordered eating patterns and negative health behaviors (34-37). Weight neutral approaches (WNAs) focus on optimizing other health outcome measures rather than promoting weight loss to treat overweight and obesity. In the general population, WNAs are an alternative to traditional weight management and produce sustainable positive health benefits. These benefits include improvement in cholesterol levels, waist to hip ratios, physical activity, diet quality, and self-esteem, while also producing weight loss and reduction in BMI (38,39). While no studies on WNAs exist in CF, these alternative methods are becoming popular in the general population–particularly in individuals who struggle with body image (BI) issues, eating disorders, and weight stigma. CF care teams should be aware of these methods and should consider WNAs for pwCF who struggle with BI issues or disordered eating (40,41).

Eating behaviors/eating disorders

Access to healthy food is an important contributor to eating behaviors; this is especially relevant when people experience food insecurity (FI). Adherence to intense dietary regimens to maintain weight can be demanding and time-consuming and may contribute to maladaptive attitudes towards food, body weight, and eating habits. Increased concern about body weight and dietary prescriptions may precipitate disordered eating, negatively affect mental and physical health, and lead to eating disorders (ED) (42). Table 2 lists definitions of commonly used terms relevant to eating disorders. In a case-control study, adults with a diet-related chronic health condition (DR-CHC) including CF were significantly more likely to use "inappropriate compensatory eating behaviors" to manage weight, including excessive exercise and medication misuse, than peer controls (43). Despite endorsement of disordered eating practices (42) and that CF can be defined as a DR-CHC, only few studies report the prevalence of ED in pwCF (44,45) (46). From these studies, youth with CF and disordered eating were more likely to exhibit anorexia nervosa symptoms than binge-eating disorder or bulimia nervosa symptoms (46). While a minority of adults with CF report disordered eating attitudes and behaviors (EABs), they do overwhelmingly report pressure from others to eat (47). A recent study demonstrated that in 52 adolescents and young adults with CF, there was a clinically significant number who screened positive for an ED on a standardized ED assessment (41). Through semi-structured interviews, HCP identified the most common EABs in PwCF as misusing PERT, food restriction, binge eating, and skipping meals. Like the general population, ED is present in both males and females with CF, but is more common in females (46). A CF-specific screening tool for assessing EABs has been developed with promising psychometrics in detecting ED however it has not yet been studied for validity or reliability (48). There is need for an evidenced-based, brief, and easy-to-implement screening tool with low participant burden to better identify EABs (44).

Body image

PwCF are at high risk of malnutrition, leading to visible body changes such as short stature, low weight, and pubertal delay. Body shape and size are sensitive topics for many young adults and can be even more complex for pwCF, as CF care has traditionally emphasized one's body mass index (BMI) and weight *gain*. PwCF using enteral tube feedings are less satisfied with their BI than those without tube feedings (47). Moreover, gender differences in BI have been identified for young adults with CF: females overestimate weight and males underestimate weight (49,50). A mixed-method study utilizing interviews and questionnaires examined

Table 3
Resources for body image/disordered eating.

Other resources
https://cfreshc.org/SRH-Guide/body-image/
National Eating Disorders Association: https://www.nationaleatingdisorders.org/
https://thebodypositive.org/
https://benourished.org/about/
https://www.intuitiveeating.org/
More Than a Body. Lindsay Kite and Lexie Kite
No Weigh! A Teen's Guide to Body Image, Food and Emotional Wisdom. By Signe Darpinian, Wendy Sterling, Shelley AggarwalR
aising Body Positive Teens. By Signe Darpinian, Wendy Sterling, Shelley Aggarwal
Body Image and Cystic Fibrosis Booklet, CF Trust, updated 2019
Intuitive Eating. Fourth Edition. By Evelyn Tribole and Elyse Resch

perspectives of adolescents and young adults with CF with their HCPs on BI communication (51). Both pwCF and care providers agreed that BI is an important topic that should be discussed comfortably and supportively.

Treatment advances in CF care may introduce new issues of concern for BI disturbance. BI concerns in pwCF previously revolved primarily around low body weight, but recently began to include weight gain and larger body size. Although these changes may be positive for many pwCF, they have led to physical and psychological challenges while other pwCF grapple with severe disease. It is unclear what the impact of HEMT, gender and race/ethnicity have on BI issues in pwCF and how to appropriately screen and intervene. To assist pwCF in navigating this evolving landscape with the least risk of harm, it is imperative for CF clinicians to feel comfortable discussing, identifying and appropriately referring for concerning EABs. Table 3 lists resources for body image screening and education.

The importance of constructive language to promote discussion should be emphasized (https://uconnruddcenter.org/). Soliciting word preference and employing supportive and empowering language absent of blame and shame can markedly improve conversations regarding weight between pwCF and CF HCP.

Food insecurity in the cystic fibrosis population

Food insecurity (FI), an important social determinant of health, is defined as the lack of consistent access to affordable, nutritious, and healthy foods and is a global problem (52,53). In 2019, up to 33% of pwCF in the US were impacted by FI, which was triple the national average (54). It is pervasive in the CF community regardless of employment status or income level. PwCF and their families may be more vulnerable to FI due to financial challenges of CF impacting their ability to purchase food. As such, food security has increasingly become a key focus of many CF care centers. In pwCF, FI has unique implications due to the specific diet requirements in a multisystemic chronic disease and the importance of adequate nutrition for optimizing growth and respiratory health. However, there exists a paradox of a higher risk of obesity within food insecure households, possibly due to easier access to high calorie and low nutrient-dense foods (55). This may become an increasing concern within the CF community, particularly as HEMT are increasingly available for more pwCF and obesity is emerging as a co-morbidity. While in the past, CF care has primarily focused on the total number of calories consumed, there is a need to shift focus to the quality of calories and micronutrients (56).

Screening and subsequent intervention, as outlined in Fig. 1, will help identify and address patient-specific concerns regarding FI. To achieve goals of increasing food security in the CF community, decreasing the perceived stigma, and starting conversations that allow families to discuss their unique needs (54), consider screening pwCF for FI at every visit. Refer families experiencing FI to local, national, and federal programs; regular follow up is important to ensure interventions meet the family's need. Resources to support CF clinicians have been developed by the CF Foundation Food Security Committee and are in the My.CFF resource library (my.cff.org) or available by email at sdoh@cff.org (2).

Salt homeostasis and hypertension

Excessive salt loss in sweat can lead to inadequate levels of sodium in pwCF at all ages, but particularly in infants and children (2,57). Adequate salt intake is needed for optimal growth in infants and children (58). While specific salt intake recommendations may vary based on dietary need, level of physical activity and climate, current guidelines suggest increased intake in all pwCF to compensate for loss of sodium in sweat (2,59-61).

In adults with CF, increased salt intake continues to be recommended to reduce the risk of electrolyte imbalances such as hyponatremia (2,59), however this recommendation will need to be revisited given the reduced loss of sodium and chloride in the sweat of pwCF taking HEMT. Despite high levels of salt intake, essential hypertension was historically not a common co-morbidity among pwCF (62,63). This may be due to the lower rates of hypertension risk factors, such as obesity and metabolic syndrome, previously observed in pwCF. Additionally, studies show that the sodium and water depletion caused by CFTR dysfunction may lead to lower-than-expected blood pressure in pwCF (64). With improved life expectancy, increasing prevalence of overweight, and the availability of CFTR modulators with their effect on salt homeostasis, hypertension may be increasing in pwCF. 7.2% of adult pwCF had a diagnosis of hypertension in 2021 (65). Moderate increases in systolic and diastolic blood pressure were observed in clinical trials for ETI, and case reports of newly diagnosed hypertension have been published (66,67). While increases in blood pressure may be partly related to increase in weight, reduced salt losses in the setting of HEMT along with the legacy high salt diet in PwCF, may contribute to the modest increases in reported blood pressures. The true effect of HEMT on salt homeostasis is yet to be elucidated. Therefore, blood pressure should be monitored, and previous recommendations regarding salt intake should likely be modified for pwCF taking HEMT. Currently, there is a lack a data to make specific suggestions about salt intake in those PwCF and hypertension or those pwCF who have normal sweat testing after treatment with HEMT, necessitating clinical judgement or use of individualized dietary sodium recommendations (53). Another unique population are those post organ transplant where immunosuppression is itself a risk factor for hypertension, highlighting the importance of personalized care in pwCF (68,69). Recent guidelines for sodium intake in the general population can be considered in establishing recommendations for individual patients (https://nap.nationalacademies.org/catalog/25353/dietary-reference-intakes-for-sodium-and-potassium).

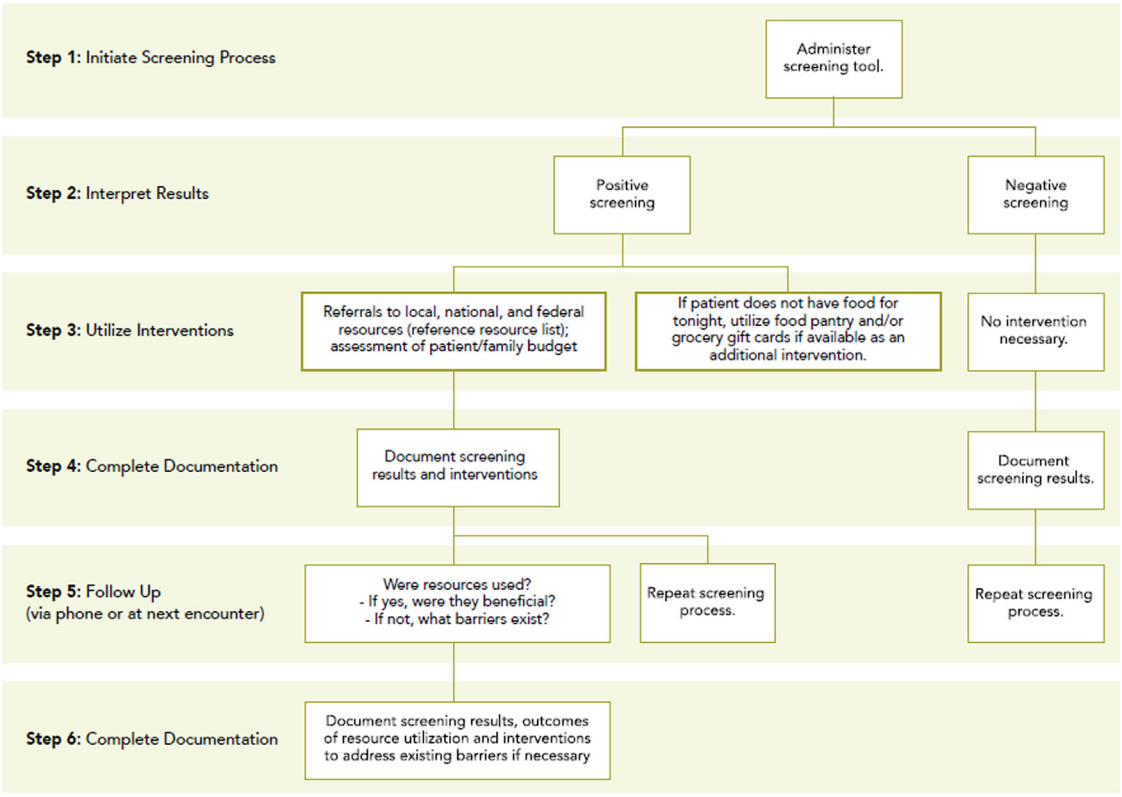

Fig. 1. Sample algorithm of screening for food insecurity, developed as a part of the FI QI change package. (Reprinted with permission from the CF Foundation Food Security Committee.).

Pancreatic enzymes

Approximately 85% of pwCF have PI, primarily due to progressive damage of pancreatic acinar cells and mucus buildup in the pancreaticobiliary ductal system (70). The majority are diagnosed with PI within the first year of life, typically by fecal elastase (60,71-73). The therapeutic mainstay for PI is pancreatic enzyme replacement therapy (PERT) (70,74).

Once diagnosed, PI was considered a lifelong condition. Fortunately, emerging data suggests that HEMT may improve or even reverse PI in some children with CF. This is supported both by physiologic studies showing that luminal pH in the small intestine improves with modulators, and data from both observational case series and HEMT clinical trials demonstrating improvement and even normalization of fecal elastase levels in some children, but not in older pwCF, after initiation of HEMT (17,75-78). Further studies are needed to better understand the true impact of CFTR modulators on PI and other aspects of the pancreaticobiliary system, including evaluation for recovery and maintenance of pancreatic exocrine function and the effect of HEMT on nutritional/vitamin deficiencies throughout life. Development of standards and/or algorithms for adjusting PERT with modulator therapy, ideally evidence based, would also be of benefit in nutritional care of pwCF. Until more data are available, checking a fecal elastase after modulator initiation in children up to age 5 may be helpful if a change in pancreatic status is clinically suspected, and as clinically appropriate in other age groups. Continued monitoring and clinical assessment may be warranted since recovery of pancreatic function after HEMT may take several years (76).

For pwCF using enteral tube feeds, using an inline enzyme cartridge with immobilized lipase has been shown to be safe and effective for digesting nutrients and promoting weight gain. This data has become available since publication of the CFF Enteral Feeding Guidelines in 2016 (31,79–82).

Fat-soluble vitamin supplementation is an important aspect of CF nutritional care. There is currently insufficient new data regarding use of supplemental fat-soluble vitamins in pwCF being treated with HEMT. Vitamin levels should be monitored and adjusted as appropriate, as has been the current practice until further evidence based guidelines become available (1,60,61,83,84).

Conclusion

Nutritional priorities in CF have evolved over time, particularly with the introduction of widely used HEMT. Individuals not taking HEMT may still require intensive efforts to optimize caloric intake. For those on HEMT, the traditional high fat, high calorie CF diet may have negative nutritional consequences as pwCF age and following population-based guidelines may be more appropriate. Individuals with CF may have poor diet quality, food insecurity, distorted body image, and an increased incidence of eating disorders. The relationship between pulmonary and cardiovascular outcomes and nutritional status will need to be better defined as the CF population ages. FI is a concern in pwCF from all socioeconomic sectors and screening should be part of standard care in CF. As overweight and obesity increase in the CF population, clinicians may see more obesity related comorbidities. As a result of the changing landscape of CF nutrition, an individualized, multidisciplinary care center approach is of utmost importance.

Further study is needed in the post HEMT era to better define optimal treatments in pwCF in many areas including diet makeup, vitamin monitoring/supplementation, pancreatic function, sodium needs, treatment of overweight and obesity. As part of the shared decision-making process, care decisions regarding individual patients should be made using a combination of this guidance, the

associated benefit-risk assessment of treatment options from the clinical team, the patient's individual and unique circumstances, as well as the goals and preferences of the patients and families that the team serves.

Table 4
Key Take-Aways.

- Nutrition care should be individualized using clinical data and goals of pwCF. Although prevalence of overweight and obesity is increasing, undernutrition is still a concern for some pwCF.
- Clinicians should be aware of the potential cardiovascular complications associated with the legacy, high fat/high calorie CF diet, particularly considering increasing life span. Lipid screening should follow guidelines in the general population until further CF specific data is available.
- Food insecurity is a concern in pwCF from all socioeconomic sectors and screening should be part of standard care in CF (see Fig. 1).
- There is a lack of data to make specific suggestions about salt intake in those pwCF and hypertension. Regular monitoring of blood pressure is encouraged.
- Some data suggest that there is the potential for return of pancreatic function in some children taking HEMT. Fecal elastase should be monitored if a change in pancreatic status is suspected.
- Inline enzyme cartridges are safe and effective for digesting nutrients and promoting weight gain in pwCF with enteral tube feeds.

Credit author statement

Amanda Leonard: Conceptualization; Data curation; Methodology; Project administration; Supervision; Roles/Writing - original draft; Writing - review & editing.

Declaration of Competing Interest

A. Stein: Reported that he is a speaker and consultant with Abbvie, and a speaker for Pfizer and Takeda, but has no conflicts related to this manuscript

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S. Hempstead: Reported employment by the Cystic Fibrosis Foundation

References

[1] Yankaskas JR, Marshall BC, Sufian B, Simon RH, Rodman D. Cystic fibrosis adult care: consensus conference report. Chest 2004;125(1 Suppl):1S–39S.

[2] Turck D, Braegger CP, Colombo C, Declercq D, Morton A, Pancheva R, et al. ESPEN-ESPGHAN-ECFS guidelines on nutrition care for infants, children, and adults with cystic fibrosis. Clin Nutr 2016;35(3):557–77.

[3] Sutherland R, Katz T, Liu V, Quintano J, Brunner R, Tong CW, et al. Dietary intake of energy-dense, nutrient-poor and nutrient-dense food sources in children with cystic fibrosis. J Cyst Fibros 2018;17(6):804–10.

[4] Gramegna A, Aliberti S, Contarini M, Savi D, Sotgiu G, Majo F, et al. Overweight and obesity in adults with cystic fibrosis: an Italian multicenter cohort study. J Cyst Fibros 2022;21(1):111–14.

[5] Szentpetery S, Fernandez GS, Schechter MS, Jain R, Flume PA, Fink AK. Obesity in cystic fibrosis: prevalence, trends and associated factors data from the US cystic fibrosis foundation patient registry. J Cyst Fibros 2022;21(5):777–83.

[6] Petersen MC, Begnel L, Wallendorf M, Litvin M. Effect of elexacaftor-tezacaftor-ivacaftor on body weight and metabolic parameters in adults with cystic fibrosis. J Cyst Fibros 2022;21(2):265–71.

[7] Registry CFTUCF. 2021 Annual Data Report. 2021.

[8] Corey M, McLaughlin FJ, Williams M, Levison H. A comparison of survival, growth, and pulmonary function in patients with cystic fibrosis in Boston and Toronto. J Clin Epidemiol 1988;41(6):583–91.

[9] Bonhoure A, Boudreau V, Litvin M, Colomba J, Bergeron C, Mailhot M, et al. Overweight, obesity and significant weight gain in adult patients with cystic fibrosis association with lung function and cardiometabolic risk factors. Clin Nutr 2020;39(9):2910–16.

[10] Calella P, Valerio G, Brodlie M, Donini LM, Siervo M. Cystic fibrosis, body composition, and health outcomes: a systematic review. Nutrition 2018:131–9 55-56.

[11] Snowball JE, Flight WG, Heath L, Koutoukidis DA. A paradigm shift in cystic fibrosis nutritional care: clinicians' views on the management of patients with overweight and obesity. J Cyst Fibros 2023.

[12] McDonald CM, Alvarez JA, Bailey J, Bowser EK, Farnham K, Mangus M, et al. Academy of nutrition and dietetics: 2020 cystic fibrosis evidence analysis center evidence-based nutrition practice guideline. J Acad Nutr Diet 2021;121(8):1591–636 e3.

[13] Registry CFFP. 2019 Annual Data Report. 2020.

[14] Harindhanavudhi T, Wang Q, Dunitz J, Moran A, Moheet A. Prevalence and factors associated with overweight and obesity in adults with cystic fibrosis: a single-center analysis. J Cyst Fibros 2020;19(1):139–45.

[15] King SJ, Tierney AC, Edgeworth D, Keating D, Williams E, Kotsimbos T, et al. Body composition and weight changes after ivacaftor treatment in adults with cystic fibrosis carrying the G551 D cystic fibrosis transmembrane conductance regulator mutation: a double-blind, placebo-controlled, randomized, crossover study with open-label extension. Nutrition 2021;85:111124.

[16] Registry CFFP. 2021 Annual Data Report. 2022.

[17] Gelfond D, Heltshe S, Ma C, Rowe SM, Frederick C, Uluer A, et al. Impact of CFTR modulation on intestinal pH, motility, and clinical outcomes in patients with cystic fibrosis and the G551D mutation. Clin Transl Gastroenterol 2017;8(3):e81.

[18] Stallings VA, Sainath N, Oberle M, Bertolaso C, Schall JI. Energy balance and mechanisms of weight gain with ivacaftor treatment of cystic fibrosis gating mutations. J Pediatr 2018;201:229–37 e4.

[19] Edgeworth D, Keating D, Ellis M, Button B, Williams E, Clark D, et al. Improvement in exercise duration, lung function and well-being in G551D-cystic fibrosis patients: a double-blind, placebo-controlled, randomized, cross-over study with ivacaftor treatment. Clin Sci (Lond) 2017;131(15):2037–45.

[20] McDonald CM, Bowser EK, Farnham K, Alvarez JA, Padula L, Rozga M. Dietary macronutrient distribution and nutrition outcomes in persons with cystic fibrosis: an evidence analysis center systematic review. J Acad Nutr Diet 2021;121(8):1574–90 e3.

[21] Eising JB, van der Ent CK, Teske AJ, Vanderschuren MM, Uiterwaal C, Meijboom FJ. Young patients with cystic fibrosis demonstrate subtle alterations of the cardiovascular system. J Cyst Fibros 2018;17(5):643–9.

[22] Buehler T, Steinmann M, Singer F, Regamey N, Casaulta C, Schoeni MH, et al. Increased arterial stiffness in children with cystic fibrosis. Eur Respir J 2012;39(6):1536–7.

[23] Bellissimo MP, Zhang I, Ivie EA, Tran PH, Tangpricha V, Hunt WR, et al. Visceral adipose tissue is associated with poor diet quality and higher fasting glucose in adults with cystic fibrosis. J Cyst Fibros 2019;18(3):430–5.

[24] Anderson MR, Kolaitis NA, Gao Y, Kukreja J, Greenland J, Hays S, et al. A nonlinear relationship between visceral adipose tissue and frailty in adult lung transplant candidates. Am J Transplant 2019;19(11):3155–61.

[25] Coderre L, Fadainia C, Belson L, Belisle V, Ziai S, Maillhot G, et al. LDL-cholesterol and insulin are independently associated with body mass index in adult cystic fibrosis patients. J Cyst Fibros 2012;11(5):393–7.

[26] Nowak JK, Szczepanik M, Wojsyk-Banaszak I, Madry E, Wykretowicz A, Krzyzanowska-Jankowska P, et al. Cystic fibrosis dyslipidaemia: a cross-sectional study. J Cyst Fibros 2019;18(4):566–71.

[27] Rhodes B, Nash EF, Tullis E, Pencharz PB, Brotherwood M, Dupuis A, et al. Prevalence of dyslipidemia in adults with cystic fibrosis. J Cyst Fibros 2010;9(1):24–8.

[28] Park J, Walsh A, Kerr S, Woodland C, Southward S, Deakin M, et al. Improvements in glucose regulation in children and young people with cystic fibrosis related diabetes following initiation of Elexacaftor/Tezacaftor/Ivacaftor. Horm Res Paediatr 2023.

[29] Shakkottai A, Irani S, Nasr SZ, O'Brien LM, Chervin RD. Risk factors for obstructive sleep apnea in cystic fibrosis. Pediatr Pulmonol 2022;57(4):926–34.

[30] Stallings VA, Stark LJ, Robinson KA, Feranchak AP, Quinton H. Clinical Practice Guidelines on G, et al. Evidence-based practice recommendations for nutrition-related management of children and adults with cystic fibrosis and pancreatic insufficiency: results of a systematic review. J Am Diet Assoc 2008;108(5):832–9.

[31] Schwarzenberg SJ, Hempstead SE, McDonald CM, Powers SW, Wooldridge J, Blair S, et al. Enteral tube feeding for individuals with cystic fibrosis: cystic Fibrosis Foundation evidence-informed guidelines. J Cyst Fibros 2016;15(6):724–35.

[32] Apovian CM, Aronne LJ, Bessesen DH, McDonnell ME, Murad MH, Pagotto U, et al. Pharmacological management of obesity: an endocrine Society clinical practice guideline. J Clin Endocrinol Metab 2015;100(2):342–362.
[33] Mechanick JI, Youdim A, Jones DB, Timothy Garvey W, Hurley DL, Molly McMahon M, et al. Clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient–2013 update: cosponsored by American Association of Clinical Endocrinologists, the Obesity Society, and American Society for Metabolic & Bariatric Surgery. Surg Obes Relat Dis 2013;9(2):159–91.
[34] Puhl R, Suh Y. Stigma and eating and weight disorders. Curr Psychiatry Rep 2015;17(3):552.
[35] Puhl RM, Himmelstein MS, Pearl RL. Weight stigma as a psychosocial contributor to obesity. Am Psychol 2020;75(2):274–89.
[36] Puhl R, Suh Y. Health consequences of weight stigma: implications for obesity prevention and treatment. Curr Obes Rep 2015;4(2):182–90.
[37] Tomiyama AJ, Carr D, Granberg EM, Major B, Robinson E, Sutin AR, et al. How and why weight stigma drives the obesity 'epidemic' and harms health. BMC Med 2018;16(1):123.
[38] Mensinger JL, Calogero RM, Stranges S, Tylka TL. A weight-neutral versus weight-loss approach for health promotion in women with high BMI: a randomized-controlled trial. Appetite 2016;105:364–74.
[39] Ulian MD, Benatti FB, de Campos-Ferraz PL, Roble OJ, Unsain RF, de Morais, Sato P, et al. The effects of a "health at every size((R))"-based approach in obese women: a pilot-trial of the "health and wellness in obesity" study. Front Nutr. 2015;2:34.
[40] Darukhanavala A, Merjaneh L, Mason K, Le T. Eating disorders and body image in cystic fibrosis. J Clin Transl Endocrinol 2021;26:100280.
[41] Kass AP, Berbert L, Dahlberg S, Bern E, Sabharwal S, Leonard J, et al. Eating disorders in adolescents and young adults with cystic fibrosis. Pediatr Pulmonol 2022;57(11):2791–7.
[42] Quick VM, Byrd-Bredbenner C, Neumark-Sztainer D. Chronic illness and disordered eating: a discussion of the literature. Adv Nutr 2013;4(3):277–86.
[43] Quick VM, McWilliams R, Byrd-Bredbenner C. Case-control study of disturbed eating behaviors and related psychographic characteristics in young adults with and without diet-related chronic health conditions. Eat Behav 2012;13(3):207–13.
[44] Quick V, Chang G. Health care provider's experiences, practices, and recommendations for interventions and screening of cystic fibrosis patients with disordered eating: a qualitative analysis. Chronic Illn 2021;17(4):377–90.
[45] Stacey D, Vandemheen KL, Hennessey R, Gooyers T, Gaudet E, Mallick R, et al. Implementation of a cystic fibrosis lung transplant referral patient decision aid in routine clinical practice: an observational study. Implement Sci 2015;10:17.
[46] Conviser JH, Fisher SD, McColley SA. Are children with chronic illnesses requiring dietary therapy at risk for disordered eating or eating disorders? A systematic review. Int J Eat Disord 2018;51(3):187–213.
[47] Abbott J, Conway S, Etherington C, Fitzjohn J, Gee L, Morton A, et al. Perceived body image and eating behavior in young adults with cystic fibrosis and their healthy peers. J Behav Med 2000;23(6):501–17.
[48] Randlesome K, Bryon M, Evangeli M. Developing a measure of eating attitudes and behaviours in cystic fibrosis. J Cyst Fibros 2013;12(1):15–21.
[49] Walters S. Sex differences in weight perception and nutritional behaviour in adults with cystic fibrosis. J Hum Nutr Diet 2001;14(2):83–91.
[50] Tierney S. Body image and cystic fibrosis: a critical review. Body Image 2012;9(1):12–19.
[51] Helms SW, Christon LM, Dellon EP, Prinstein MJ. Patient and provider perspectives on communication about body image with adolescents and young adults with cystic fibrosis. J Pediatr Psychol 2017;42(9):1040–50.
[52] https://www.who.int/news/item/06-07-2022-un-report–global-hunger-numbers-rose-to-as-many-as-828-million-in-2021 2021;Pages.
[53] Declercq D, Peremans L, Glorieus M, Weygaerde YV, Schaballie H, Van Braeckel E, et al. Urinary sodium/creatinine ratio is a predictor for fractional sodium excretion and related to age in patients with cystic fibrosis. J Cyst Fibros 2022;21(2):e136–ee40.
[54] Corbera-Hincapie MA, Atteih SE, Stransky OM, Weiner DJ, Yann IM, Kazmerski TM. Experiences and perspectives of individuals with cystic fibrosis and their families related to food insecurity. Nutrients 2022;14(13).
[55] !!! INVALID CITATION !!! (49, 50).
[56] !!! INVALID CITATION !!! (51-53).
[57] Arvanitakis SN, Lobeck CC. Metabolic alkalosis and salt depletion in cystic fibrosis. J Pediatr 1973;82(3):535–6.
[58] Haycock GB. The influence of sodium on growth in infancy. Pediatr Nephrol 1993;7(6):871–5.
[59] Declercq D, Van Braeckel E, Marchand S, Van Daele S, Van Biervliet S. Sodium status and replacement in children and adults living with cystic fibrosis: a narrative review. J Acad Nutr Diet 2020;120(9):1517–29.
[60] Lahiri T, Hempstead SE, Brady C, Cannon CL, Clark K, Condren ME, et al. Clinical practice guidelines from the cystic fibrosis foundation for preschoolers with cystic fibrosis. Pediatrics 2016;137(4).
[61] Cystic Fibrosis F, Borowitz D, Robinson KA, Rosenfeld M, Davis SD, Sabadosa KA, et al. Cystic fibrosis foundation evidence-based guidelines for management of infants with cystic fibrosis. J Pediatr 2009;155(6 Suppl):S73–93.
[62] Lieberman J, Rodbard S. Low blood pressure in young adults with cystic fibrosis: an effect of chronic salt loss in sweat? Ann Intern Med 1975;82(6):806–8.
[63] Super M, Irtiza-Ali A, Roberts SA, Schwarz M, Young M, Smith A, et al. Blood pressure and the cystic fibrosis gene: evidence for lower pressure rises with age in female carriers. Hypertension 2004;44(6):878–83.
[64] Zhang YP, Ye LL, Yuan H, Duan DD. CFTR plays an important role in the regulation of vascular resistance and high-fructose/salt-diet induced hypertension in mice. J Cyst Fibros 2021;20(3):516–24.
[65] Registry CFFP. 2020 Annual Data Report. 2021.
[66] Gramegna A, De Petro C, Leonardi G, Contarini M, Amati F, Meazza R, et al. Onset of systemic arterial hypertension after initiation of elexacaftor/tezacaftor/ivacaftor in adults with cystic fibrosis: a case series. J Cyst Fibros 2022;21(5):885–7.
[67] Middleton PG, Mall MA, Drevinek P, Lands LC, McKone EF, Polineni D, et al. Elexacaftor-tezacaftor-ivacaftor for cystic fibrosis with a single Phe508del allele. N Engl J Med 2019;381(19):1809–19.
[68] Sikma MA, van Maarseveen EM, van de Graaf EA, Kirkels JH, Verhaar MC, Donker DW, et al. Pharmacokinetics and toxicity of tacrolimus early after heart and lung transplantation. Am J Transplant 2015;15(9):2301–13.
[69] Morrison RJ, Short HD, Noon GP, Frost AE. Hypertension after lung transplantation. J Heart Lung Transplant 1993;12(6 Pt 1):928–31.
[70] Singh VK, Schwarzenberg SJ. Pancreatic insufficiency in Cystic Fibrosis. J Cyst Fibros 2017;16(Suppl 2):S70–SS8.
[71] Daftary A, Acton J, Heubi J, Amin R. Fecal elastase-1: utility in pancreatic function in cystic fibrosis. J Cyst Fibros 2006;5(2):71–6.
[72] Barben J, Rueegg CS, Jurca M, Spalinger J, Kuehni CE. Swiss cystic fibrosis screening G. Measurement of fecal elastase improves performance of newborn screening for cystic fibrosis. J Cyst Fibros 2016;15(3):313–17.
[73] Caras S, Boyd D, Zipfel L, Sander-Struckmeier S. Evaluation of stool collections to measure efficacy of PERT in subjects with exocrine pancreatic insufficiency. J Pediatr Gastroenterol Nutr 2011;53(6):634–40.
[74] Somaraju URR, Solis-Moya A. Pancreatic enzyme replacement therapy for people with cystic fibrosis. Cochrane Database Syst Rev 2020;8(8):CD008227.
[75] Rosenfeld M, Cunningham S, Harris WT, Lapey A, Regelmann WE, Sawicki GS, et al. An open-label extension study of ivacaftor in children with CF and a CFTR gating mutation initiating treatment at age 2-5 years (KLIMB). J Cyst Fibros 2019;18(6):838–43.
[76] Hutchinson I, McNally P. Appearance of pancreatic sufficiency and discontinuation of pancreatic enzyme replacement therapy in children with cystic fibrosis on ivacaftor, 18. Ann Am Thorac Soc; 2021. p. 182–3.
[77] Nichols AL, Davies JC, Jones D, Carr SB. Restoration of exocrine pancreatic function in older children with cystic fibrosis on ivacaftor. Paediatr Respir Rev 2020;35:99–102.
[78] Munce D, Lim M, Akong K. Persistent recovery of pancreatic function in patients with cystic fibrosis after ivacaftor. Pediatr Pulmonol 2020;55(12):3381–3.
[79] Hendrix SJ, Flume PA, First ER, Stone AA, Van Buskirk M. Improvements in anthropometric measures and gastrointestinal tolerance in patients with cystic fibrosis by using a digestive enzyme cartridge with overnight enteral nutrition. Nutr Clin Pract 2022;37(2):344–50.
[80] Sathe MN, Patel D, Stone A, First E. Evaluation of the effectiveness of in-line immobilized lipase cartridge in enterally fed patients with cystic fibrosis. J Pediatr Gastroenterol Nutr 2021;72(1):18–23.
[81] Stevens J, Wyatt C, Brown P, Patel D, Grujic D, Freedman SD. Absorption and safety with sustained use of RELiZORB evaluation (ASSURE) study in patients with cystic fibrosis receiving enteral feeding. J Pediatr Gastroenterol Nutr 2018;67(4):527–32.
[82] Freedman S, Orenstein D, Black P, Brown P, McCoy K, Stevens J, et al. Increased fat absorption from enteral formula through an in-line digestive cartridge in patients with cystic fibrosis. J Pediatr Gastroenterol Nutr 2017;65(1):97–101.
[83] Tangpricha V, Kelly A, Stephenson A, Maguiness K, Enders J, Robinson KA, et al. An update on the screening, diagnosis, management, and treatment of vitamin D deficiency in individuals with cystic fibrosis: evidence-based recommendations from the Cystic Fibrosis Foundation. J Clin Endocrinol Metab 2012;97(4):1082–93.
[84] Borowitz D, Baker RD, Stallings V. Consensus report on nutrition for pediatric patients with cystic fibrosis. J Pediatr Gastroenterol Nutr 2002;35(3):246–59.
[85] Hadjiliadis D, Khoruts A, Zauber AG, Hempstead SE, Maisonneuve P, Lowenfels AB, et al. Cystic fibrosis colorectal cancer screening consensus recommendations. Gastroenterology 2018;154(3):736–45 e14.