Glycaemic control in cystic fibrosis-related diabetes using personal management plans based on continuous glucose monitoring

Paula Dyce

Citation: Dyce P (2014) Glycaemic control in cystic fibrosis-related diabetes using personal management plans based on continuous glucose monitoring. *Diabetes Care for Children & Young People* **3**: 12–5

Article points

1. Cystic fibrosis-related diabetes (CFRD) is the most common comorbidity for people with cystic fibrosis.
2. CFRD is notoriously difficult to manage.
3. Personal management plans were created with input from key members of the multidisciplinary team and given to 11 study participants.
4. This study demonstrates the efficacy of using personal management plans based on continuous glucose monitoring to help patients manage CFRD.

Key words

- Continuous glucose monitoring
- Cystic fibrosis-related diabetes
- Personal management plan

Authors

Paula Dyce is Advanced Nurse Practitioner for Cystic Fibrosis-Related Diabetes, Liverpool Heart and Chest Hospital

Improved survival rates for people with cystic fibrosis (CF) and the increasing prevalence of cystic fibrosis-related diabetes (CFRD) has led to an increase in the popularity of new methods to aid glucose control for this patient group, such as continuous glucose monitoring. A study at a large regional adult CF unit that has used continuous glucose monitoring (CGM) for more than 3 years tested the efficacy of implementing personal management plans based on CGM readings, and diet and exercise diaries. Eleven people with CFRD were given a personal management plan that was created in collaboration with an advanced nurse practitioner, a dietitian and others in the multidisciplinary team. All underwent repeated CGM after an interval of at least 6 months when glycaemic status and clinical parameters (HbA_{1c}, lung function and weight) were re-evaluated. All parameters improved after using the personal management plans.

Cystic fibrosis (CF) is the UK's most common genetically inherited disease and it affects about 9000 people (Cystic Fibrosis Trust, 2013). Advances in medicine have meant that patients suffering from CF are living longer. It is now common for people with CF to live into adulthood and the mean survival rate today is about 42 years (Cystic Fibrosis Trust, 2013). This has meant that there is an increased risk of developing complications of the disease.

The most common complication is cystic fibrosis-related diabetes (CFRD) and it occurs in 40–50% of people with CF (Moran et al, 2009). The prevalence of CFRD increases with age with the average age of onset being 18–21 years (Moran et al, 1998). It is predicted that 70–90% of all adult CF patients will have some degree of glucose intolerance by the time they are 40 years of age (Lanng et al, 1995).

While CFRD shares the characteristics of type 1 and type 2 diabetes, it is unique and needs to be managed differently (Moran et al, 1999). CFRD is thought to be a mixture of insulin deficiency and insulin resistance, making diagnosis and management of this complex condition challenging. Like type 1 diabetes, CFRD occurs in young people, is associated with insulin insufficiency and can be treated with insulin injections. Like type 2 diabetes, CFRD is associated with insulin resistance, has an insidious onset and ketoacidosis is rare.

CFRD has been associated with worse lung function and poorer nutritional status when compared with people with CF who do not have diabetes (Lanng et al, 1995). CFRD has also been linked to up to a six-fold increase in early mortality (Rodman, 1986). It is incredibly important, therefore, to achieve timely and effective diagnosis and treatment for CFRD.

Treatment of CFRD can prove difficult as there are many variables that have an impact upon blood glucose levels. For example, one of the most common problems associated with CF is pulmonary exacerbation leading to infection, for which corticosteroid treatment is common.

Insulin is used to treat CFRD patients as oral agents have previously proved to be ineffective owing to malabsorption (Onady and Stolfi, 2005). People with CF are often malnourished and a healthy weight is difficult to maintain. Pancreatic insufficiency often causes people with CF to struggle to maintain and increase weight, and they will require 150% of the calories needed by people without CF. Dietary advice for people with CF, therefore, directly conflicts with advice given to people with type 1 and type 2 due to these additional calorific requirements.

With improving survival in people with CF and the increasing prevalence of CFRD, newer screening and management methods, such as continuous glucose monitoring (CGM), are becoming more popular for this patient group (O'Riordan et al, 2009). At the author's large regional adult CF unit (*n*=280), CGM has been used for more than 3 years to diagnose and manage CFRD, and the specialist diabetic service has recently been developed to include an advanced nurse practitioner (ANP), a specialist CF dietitian and a clinical psychologist. Since the development of the CGM service, personal management plans (PMPs) are now used for the patients to facilitate self-management and the practice has been audited to measure the efficacy of the service.

Methods

Eleven individuals (6 men; 5 women) with poorly-controlled CFRD (defined by frequent hypoglycaemic attacks [at least one per day <3.5 mmol/L] and/or post-prandial serial glucose monitoring [>12 mmol/L] and associated patient reports of erratic sugar control) were given CGM for 3 to 5 days. CGM consists of a transmitter with a sensor that is attached to the person's arm or abdomen. Interstitial glucose readings are sent to a receiver every minute via Bluetooth technology. The individuals were also asked to complete a food and exercise diary in as much detail as possible for each of the days the monitor was attached. The food and exercise diary is a locally developed booklet that is used with all people undertaking CGM. It is a self-reporting tool, which requires the patient to list all food and drink along with any exercise undertaken for the period that CGM is used. The diary is broken down into sections throughout the day.

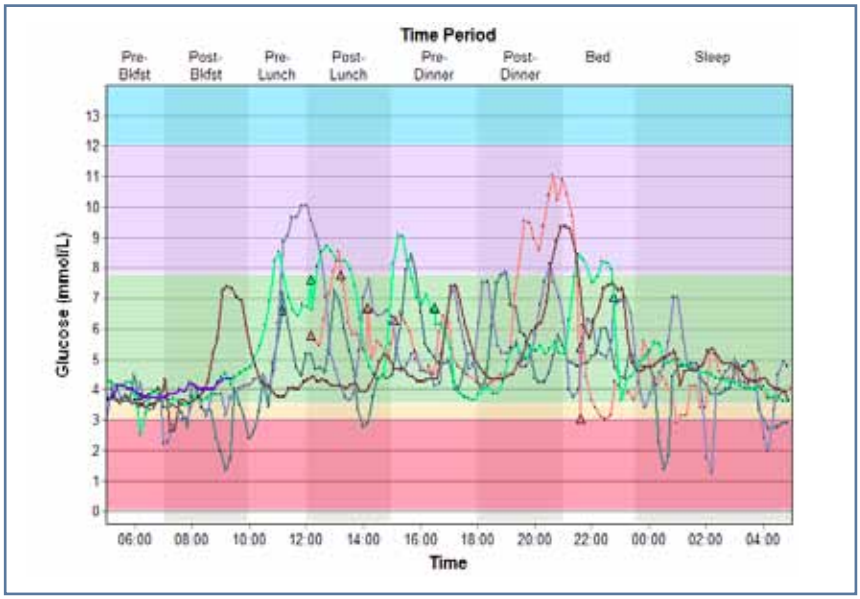

Figure 1. Example of one of the participant's glucose trace recorded by continuous glucose monitoring with day-by-day trends plotted (each of the coloured lines represents a different day of the week).

The CGM data was uploaded to a computerised software package that displayed the glucose readings. The ANP or CF-nurse specialist, together with the specialist dietitian, analysed the results alongside the food and exercise diary. Any queries relating to the diary were discussed with the participant, and the data provided was mapped to the CGM results graph.

The CGM provided a glucose trend for each day of the week (*Figure 1*). Dietary intake and exercise could be tracked against each of the timelines. Once the data was collected, the individual was invited to attend clinic to discuss the results and create a PMP using a collaborative approach between participant, dietitian and/or clinical psychologist, and nurse. Participants and their families were involved in each aspect of the decision-making process from diagnosis, including treatment options and dietary considerations. The patients were given their PMP based on CGM data and the food and exercise diaries.

After analysing the data, compliance and coping strategies were also discussed with both the individual and the CF team. If deemed appropriate, our CF clinical psychologist engaged in joint sessions with the ANP and participant, either in a home or clinical setting. The participants were given individualised advice following the CGM analysis pertaining to

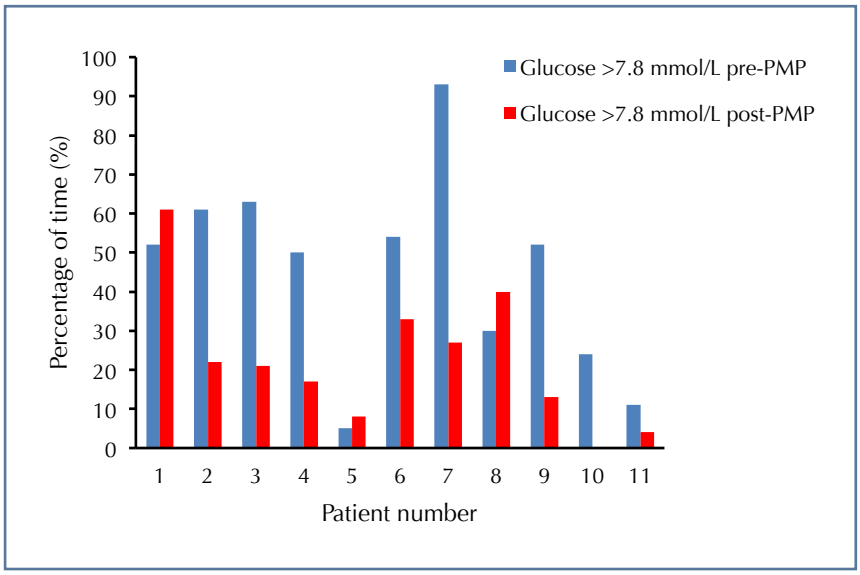

Figure 2. Percentage of time when interstitial glucose levels were >7.8 mmol/L before and after implementing a personal management plan (PMP) based on continuous glucose monitoring.

insulin titration or type. Dietary advice was also given along with exercise plans to enable and empower individuals to control their blood glucose levels.

Other clinical parameters were measured before the participants began to use their PMPs. Their HbA_{1c}, FEV_1 (lung function expressed as a percentage of predicted forced expiratory volume) and weight were all recorded at this time. The percentage of time that individuals' interstitial glucose level was >7.8 mmol/L was recorded. This level is particularly pertinent in CFRD, as a previous study has shown that when levels are above this threshold for more than 4.5% of time the patient can develop pulmonary decline (Hameed et al, 2011).

Pulmonary function tests are routinely carried out at every patient visit to determine lung capacity and clinical status. Forced expiratory volume in 1 second (FEV_1) is measured using a spirometer machine that is calibrated by pulmonary function technicians every day to ensure accuracy. It assesses pulmonary function by measuring the volume of air that the patient is able to expel from the lungs after a maximal inspiration. Normal values for lung function are based on age, gender, and height, and the measurement is converted into the FEV_1 value.

After an interval of at least 6 months, the clinical parameters were again measured in order to analyse the efficacy of the PMPs.

Results

The 11 participants were given a PMP that included education and support from the ANP/CF nurse specialist, specialist CF dietitian and/or clinical psychologist. After 6 months of following this PMP, CGM was again used and the other clinical parameters were again measured. The percentage of time that glucose levels were above 7.8 mmol/L was noted. Eight individuals had a significant decrease in the percentage of time that glucose was >7.8 mmol/L, with a mean of 45% pre- and 22% post-intervention. This was statistically significant (P=0.01) (*Table 1* and *Figure 2*).

Pre- and post-PMP weight was analysed, with a positive trend being noted as 6 individuals had gained weight following the intervention. One remained the same weight and the remaining four had lost a small amount of weight. The mean weight of the group was 64.4 kg pre-PMP and 65.1 kg post-PMP (*Table 1*).

HbA_{1c} was also assessed and 7 participants had improved levels post-PMP. However, it has been

Table 1. Clinical parameters measured before and after implementation of personal management plans (n=11).

	At initial CGM (mean±SD)	At repeat CGM (mean±SD)	Significance
Time interstitial glucose levels >7.8 mmol/L (%)	45±26	22±18	P=0.01
Weight (kg)	64.4±16	65.1±14	P=0.79
FEV_1 (%)	47±23	50±26	P=0.44
HbA_{1c} (mmol/mol)	57±16	50±7	P=0.1

CGM=continuous glucose monitoring; SD=standard deviation

suggested that HbA_{1c} in CFRD provides limited value as it can be prone to false negatives due to the increased red cell turnover (Brennan et al, 2006; Godbout et al, 2008).

When we looked at pulmonary function tests (FEV_1), the mean pre-PMP result was 47% and post-PMP was 50%. However, further analysis showed that one individual's lung function had risen by 22% and continued to rise up to 12 months after his PMP was carried out.

Each participant was reviewed by the ANP and specialist dietitian, and 5 individuals had input from the clinical psychologist relating to motivation and coping strategies. The impact of treatment burden and the effect of having to deal with a secondary condition cannot be underestimated for people with CFRD, and we have found the input of the clinical psychologist to be invaluable.

Information provided by the CGM post-PMP supported a change in insulin dose for 8 individuals, and the insulin type was changed in 3. Four participants received a home visit from the ANP, who was accompanied by the clinical psychologist on three of them. The primary aim was to provide psychological support and clarity regarding their PMPs. These visits were particularly beneficial owing to time constraints in the hospital setting. Those visited had more complex CF, more difficult social circumstances or were finding it difficult to cope.

Conclusion

We have demonstrated the benefit of creating a PMP for the control of CFRD when underpinned by the use of serial CGM. This interprofessional approach enhances patient information and knowledge, and people have reported feeling better informed about their secondary condition. We have now incorporated individualised PMPs in our routine practice and recommend this approach in order to address the complexities of CFRD management.

The use of CGM has become a pivotal element of patient care, and it is currently being integrated into annual screening for all people with CF regardless of their diabetic and clinical status.

This service is unique in that it is completely nurse-led. The ANPs and most of the CF-nurse specialists are non-medical prescribers, and our findings have been that CGM enables clear guidance for diagnosis and management, as well as aiding decisions regarding insulin type and dosage. The dietetic team jointly review the data with the nursing team and provide valuable information for decisions regarding dietary advice. This ensures complete analysis of all aspects for the CGM service, and an interprofessional approach.

Most importantly, patients and their families are involved in each aspect of the decision-making process, from diagnosis. Many patients are unaware of elevated glucose levels throughout the day and night. Consequently, the use of CGM mapped against their food and exercise diaries allows people with CFRD and their families to understand how they can manage their glucose levels. The visual aids have been a great educational tool that have helped to improve understanding and empower individuals to self manage their condition. Using CGM can allow clearer explanation and guidance for both staff and patients, and it can be recommended that this approach should be taken in order to address the complexities of CFRD management.

The limitation of this review was the small number of patients that were given a PMP. Further investigations into the efficacy of the approach should be taken, perhaps by using a multicentre study or carrying out a randomised controlled trial. ■

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"The use of continuous glucose monitoring has become a pivotal element of patient care and it is currently being integrated into annual screening for all people with cystic fibrosis regardless of their diabetic and clinical status."