Current Diabetes Reports (2019) 19:163
https://doi.org/10.1007/s11892-019-1278-3

PHARMACOLOGIC TREATMENT OF TYPE 2 DIABETES (HE LEBOVITZ AND G BAHTIYAR, SECTION EDITORS)

Technological Advancements in the Management of Type 2 Diabetes

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Abstract

Purpose of Review The increasing prevalence of type 2 diabetes is driving the boundaries of clinical diabetes care outside of the traditional office setting. The purpose of this paper will be to review recent technological advances in the medical management of people with type 2 diabetes, spanning the spectrum of care from access to healthcare providers/educators, to continual virtual support methods, on-line management tools, and technologically integrated medication delivery systems.

Recent Findings Recent findings support a potential positive impact of technology on access to care, clinical outcomes, convenience, patient well-being, and patient acceptance. This includes the use of Bluetooth-enabled glucose meters, continuous glucose monitors, mHealth apps, smartpens, and insulin pumps. However, there are impediments to the implementation of some technologies due to cost and lack of insurance coverage.

Summary There is evidence to support the use of technology to improve the management and treatment of people with type 2 diabetes. Further research is required to demonstrate the long-term clinical benefit and financial viability of technology in the management of type 2 diabetes.

Keywords Type 2 diabetes · Lifestyle modification · Technology · Glucose sensor · Insulin pump · Smartpen

Introduction

Diabetes rates continue to grow in the USA. The 2017 report on prevalence of diabetes from the Centers for Disease Control and Prevention reports that there are 30.3 million adults affected by diabetes, that is, approximately 1 in every 10 adult individuals aged 18 years or older. Of those individuals affected by diabetes, 95% are diagnosed with type 2 diabetes [1].

In conjunction with the rising tide of diabetes diagnoses in the USA, there is also a continual growth of technology use amongst adults. Statistics from 2018 show a near saturation of technology ownership and use by adults in the USA. Over 58% of adults 18 years of age or older report owning or using tablets; greater than 77% of this same adult population own or use computers. Phone use and ownership percentages are even higher amongst adults in the USA with 91% or more owning or using a smartphone, and 97% or greater using the internet and all other mobile phones [2].

Given the high prevalence of the diagnosis of type 2 diabetes and the growing integration of technology into quotidian life, there is growing interest in leveraging the various technology methods to assist in the education, management, and follow-up care of those living with type 2 diabetes. Incorporating technology into the care of those living with diabetes can complement traditional in-person care by providing additional education and support, particularly when access to care is limited [3].

This article will review various technological methods to improve care for those living with type 2 diabetes, both in terms of outcome measures and quality of life. The methods reviewed will span the spectrum of care, from access to healthcare providers/educators, to continual support methods, management tools, and medication delivery systems.

Telehealth

The growing use of technology by the public and of electronic medical records by providers allows the boundaries of medical

This article is part of the Topical Collection on *Pharmacologic Treatment of Type 2 Diabetes*

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Published online: 20 December 2019

care to move beyond the physical office. This provides an increased opportunity for educators and other diabetes healthcare providers to provide services and remote visits via telehealth.

In some of the more rural parts of the USA, access to adequate care and specialists within diabetes care may be limited. The use of telehealth visits provides access to comprehensive diabetes care, including visits with physician diabetes specialists, registered dieticians, and certified diabetes educators. This allows people with diabetes to continue to learn about their diabetes, follow up on their clinical improvements, and follow up with questions that may promote continued diabetes education and self-management. When studying the use of telehealth visits within a rural population, one study found that there was a significant decrease in hemoglobin A1c (HbA1c) amongst those participating in telehealth visits, as well as a significant increase in the percentage of individuals able to meet HbA1c targets in a 6-month time period. In addition to demonstrating improvement in diabetes control, as measured by a reduction in HbA1c, those individuals participating in telehealth visits were satisfied with the use of the technology for follow-up care [4]. With such high levels of satisfaction and positive outcomes for health, telehealth may provide a viable option for those living with a chronic condition such as type 2 diabetes, a condition that requires continued and engaged self-management in order to maintain glucose control.

At this time, coverage for telehealth visits by the Centers for Medicare & Medicaid Services (CMS) is limited based on geographical location. Currently, coverage is primarily limited to rural areas and does not extend to underserved urban populations. As of 2019 regulations, for telehealth visits to be covered, the physical location where the visits take place is also restricted to health care sites. For example, it is currently required that the two-way communication between patient and provider take place within a doctor's office, hospital, rural health clinic, Federally Qualified Health Center (FQHC), hospital-based dialysis facility, skilled nursing facility, or community mental health center. There may be changes in 2020 towards also allowing the visits to take place when the patient is located in the home, but this is yet to be seen (https://www.medicare.gov/coverage/telehealth).

Glucose Meters

Glucose monitoring remains the backbone of diabetes care. In recent years, the capabilities of glucose meters have advanced beyond simple measurement of blood glucose levels. Many meters now contain Bluetooth capabilities and link regularly with phone applications (apps). Examples of meters that will link with apps are Dario Health Smart Meter, One Touch Verio Flex, Accu-chek Aviva Connect Meter, and Contour Next One Smart Meter. This functionality allows users to track not only their glucose values but also their food intake, administration of medication, and physical activity. These data points are then combined into proprietary reports that are downloaded and reviewed by the patient in between visits, and/or shared with a healthcare team at the time of a visit.

There are also companies that now market diabetes education and remote support services that are employed concurrently with glucose meter use. Examples of two of these types of systems and support are One Drop and Livongo. These services provide remote monitoring of patient data and real-time assistance for patients from a certified diabetes educator. When studying individuals using these services for durations of 1 week to 2 years to assist with management of obesity and type 2 diabetes, researchers demonstrated benefits to the primary outcomes of weight loss, weight maintenance, and blood glucose reductions (represented by HbA1c reductions of 0.4% to 1.9%). In addition, the use of these services demonstrated benefits to the secondary outcomes of behavioral changes, patient perception of self-efficacy, and acceptability of the interventions provided with these programs [5•].

With the apparent benefit in multiple studies to induce behavioral change, improve self-efficacy, and improve ability to self-manage their disease, there could be a value for continued research on the long-term benefits of combined glucose monitoring and remote support services. If such research demonstrates feasibility, efficacy, and sustained medical benefit, there could be a greater reliance on remote monitoring with chronic disease management to promote patient engagement and efficacy.

Continuous/Intermittent Glucose Monitoring

Continuous (CGM) and intermittent (flash) glucose monitoring systems have changed the landscape of glucose monitoring over the past few years. These devices measure interstitial glucose, as opposed to capillary blood glucose, automatically throughout the day. They capture and display the data for both "near real-time" use, as well as for longer term trend analysis. Use of these devices has demonstrated improvements in glycemic control in people with type 2 diabetes [6]. Patients place their device every 10 to 14 days, depending on the brand/manufacturer of the device they are using. This schedule alleviates some of the burden placed on patients by daily fingerstick/blood sugar checking. Two of the three available devices are factory calibrated and are approved by CMS for making management decisions.

Intermittent "flash" glucose monitoring, such as the Freestyle Libre, has grown in popularity for patients with type 2 diabetes. Flash devices are approved by CMS for management decisions and promote ascertainment of more glucose information daily with fewer blood glucose readings. Flash monitors allow patients to monitor glucose levels fasting, post-meal, throughout the day, and overnight. Many of these

measures are often not part of the usual diabetes management plan for those living with type 2 diabetes and may reveal previously unrecognized patterns of hyper- or hypoglycemia. For example, review of post-prandial glucose levels can provide opportunities to learn about food choices and portion sizes, as well as lead to an improved understanding of how food choices and glucose levels contribute to HbA1c values. For the healthcare provider, there is an added benefit in care, provided by the ability to monitor glucose trends and patterns throughout the day and night. Such pattern analysis allows more granular adjustments of medications and dosing, often resulting in improved control with a reduction in glycemic variability. For patients with type 2 diabetes who use multiple daily injections of insulin to manage their glucose, these devices can also prove valuable to assess for hypoglycemia. When studying individuals wearing a flash glucose monitor, in this case the Freestyle Libre, there was a reduction in hypoglycemia compared with a control group not using the device. There was also an increase in monitoring through the day which could promote improved overall glucose control as the standard of care is increased monitoring for improved glucose levels [6].

Real-time continuous glucose monitors may also be beneficial for patients with type 2 diabetes, especially those on more intensive insulin management including multiple daily injections with long acting and mealtime dosing. Like the Freestyle Libre flash device, the Dexcom real-time continuous glucose monitor is also approved by CMS for management decisions. As with the use of a flash glucose monitoring, use of continuous glucose monitors promotes ascertainment of more glucose information daily with fewer blood glucose readings. Unlike flash monitors, these systems provide alerts to patients when glucose levels reach preset levels for low and high glucose levels. This allows in-the-moment behavior changes and a reduction in the risk of high and especially low glucose levels. The use of these devices may also allow education and management recommendations by Diabetes Care and Education Specialists and providers in order to guide patients on appropriate management to respond to alerts. In addition to the Dexcom continuous glucose monitor, the Medtonic Guardian Connect CGM will allow real-time monitoring of glucose and also has the capability to link to an additional app on an iPhone that uses technology from IBM Watson to make recommendations based on glucose trends and patterns. Real-time continuous glucose monitors have been shown to reduce HbA1c levels compared with those not wearing devices, without increasing the frequency of hypoglycemia or negatively impacting the patients' feeling of quality of life while wearing a device [7•].

In addition to personal use of continuous or intermittent glucose monitoring, many practices now offer short-term professional glucose monitoring using these same systems. In this context, the devices are owned by the medical practice, are placed by staff in the provider's office, and are worn by the patient for 7–14 days (depending on the device). Patients are requested to log food intake, medication dosing, and physical activity during the time they are wearing the device. They return to the practice at the end of the monitoring period to have the device removed and downloaded, and then participate in an interpretation session with their diabetes care and education specialist. Professional glucose monitoring provides added, more in-depth insight for patients who do not require continuous use of such devices or who prefer not to wear one on a daily basis.

Apps to Promote Wellness

There are a growing number of apps available for use on personal cellphones that are not specific to diabetes management, but that can be incorporated into patient care. These apps promote behavior change regarding food intake and physical activity engagement. These two areas of self-management can be tracked, monitored, and reviewed in visits and may assist in glucose levels being in range and an eventual HbA1c reduction. Often these apps can link to show both areas in one reporting feature, such as can be found with MyFitnessPal and Lose It, in combination with Fitbit and MapMyRun. The act of tracking physical activity, in one study with those living with type 2 diabetes, showed an increase in engagement in 30 min of activity daily. As a result, the group with increased activity had a non-significant decrease in HbA1c compared with a control group that did not track their activity levels [8]. There are many unpaid versions of calorie/food tracking apps available for individuals living with type 2 diabetes as well as the general public. These apps can assist in assessing caloric intake and food choice as it relates to weight and blood glucose control. The use of these freely available apps has not yet been studied specifically with the type 2 diabetes population. At present, research in the area of behavior change in relation to food tracking has been connected to tracking methods of both food and physical activity and also often includes the concept of health coaching, either in person or remotely as discussed in an earlier section of this article. This may indicate the importance of dietary education and follow up on choices for continued modifications rather than relying purely on tracking of food intake.

Smartpens

For those patients with type 2 diabetes requiring multiple daily injections of insulin, there are now advanced "smart" insulin pens that can track the timing, dosing, and administration of short-acting prandial insulin (https://www.companionmedical.com/inpen). These smartpens can be

used to dispense "standing" doses of prandial insulin. In addition, they contain bolus-dose calculators that can provide insulin dose recommendations for patients who are carb counting. The smartpens link to cellphone apps and provide exportable logbooks that may be easily shared with and reviewed by a patient's medical team. One such pen now in use is the InPen. In addition, the memory feature of these devices may also be of particular benefit for patients who need assistance remembering when they last took a dose of the short-acting insulin. Basic smart pens that have a memory function built into the insulin pen also exist. This function records the last dose of insulin administered, as well as the timing of the last injection (https://www.novologpro.com/administration-options/insulin-pens.html).

Insulin Pump Therapy

For some individuals with type 2 diabetes, oral and injectable medications may not provide adequate control of glucose levels. There may also be other medical conditions that make certain oral agents an inappropriate choice. In these instances, patients with type 2 diabetes may be prescribed insulin injections once a day, or they may be prescribed multiple daily injections (MDI), to provide long-acting and mealtime dosing. In addition to using a continuous glucose monitor for monitoring trends when on multiple injection therapy, these patients may benefit from the use of an insulin pump to ease management.

There are several insulin pump options to transition to for patients using multiple daily injections. The use of these devices can vary from a more "basic" methodology of delivery with fixed dosing or more advanced features such as using programmed carbohydrate ratios and insulin sensitivity factors with hourly programmed basal rates that can be different throughout the day.

When evaluating a "patch" pump with no tubing that has a fixed hourly basal rate and set bolus dosing capabilities, the VGo, researchers found that while patients using the patch pump had similar glycemic control as those using MDI, there were lower costs and lower total daily doses of insulin for those using the pump method [9]. The lower costs may be associated with the lower total daily dose of insulin used. The total daily dose may be able to be reduced due to more efficacious absorption of insulin when delivered in smaller amounts throughout a 24-h period thereby reducing the amount needed.

A more standard pump therapy, which uses a tube and allows for hourly basal rate adjustments and various carbohydrate ratios and sensitivity factors through the day, also shows a reduction in total daily dose of insulin compared with those using MDI. Tandem, Insulet, and Medtronic all make insulin pumps such as this that may be covered by insurance for use in type 2 diabetes management. This type of therapy is also shown to reduce HbA1c with the ability to maintain this HbA1c reduction for a 6-month period of time. Conclusions were drawn that these results could be due to a variety of benefits of using insulin pump therapy. These include (1) improved adherence to insulin therapy when using an insulin pump, (2) a delivery method that is more physiologic and that allows for delivery of more precise doses, and (3) the achievement of reduced variability in glucose levels throughout the day due to the ability to adjust settings based on the personalized needs of the individual patient [10•].

With these insulin delivery methods providing assistance in adherence to therapy, improvement in costs, reduction of variability, and HbA1c reduction, there may be a benefit for continued observation and study of the long-term use of these devices to promote reaching HbA1c targets.

Conclusion

With the continued growth of both type 2 diabetes and technology use in the USA, there is a logical effort being undertaken by various groups to incorporate technology into the monitoring, medication delivery, education, and management of this chronic disease.

Healthcare teams also benefit from the use of these technology methods and are better able to assist their patients to achieve the recommended level of glucose control. Providers have a better ability to fine tune insulin dosing with insulin pump therapy and to monitor glucose throughout a full day with the reports that can be generated from a continuous glucose monitor. For those medical professionals without access to a diabetes care and education specialist on staff, the use of telehealth services and/or remote monitoring from glucose meter and app companies may also aid patients in management of their diabetes. These remote services help provide patients the knowledge they need and more in-the-moment feedback to be able to make appropriate changes to behavior and self-management, allowing them to reduce hypoglycemia, hyperglycemia, glucose variability, and HbA1c.

It will likely be helpful in the future for healthcare teams to incorporate some of these delivery systems, such as telehealth services, if insurance covers them more widely for those living with type 2 diabetes.

Compliance with Ethical Standards

Conflict of Interest Abigail Kennedy Grant and Lauren Golden declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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