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Review Article

Clinical and economic benefits of continuous blood glucose monitoring devices

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ABSTRACT

The main intervention to reduce the macro-and microvascular complications of diabetes mellitus (DM) remains to achieve better long-term glycemic control. We have discussed the clinical and economic advantages of using continuous glucose monitoring (CGM) devices for type 1 DM and type 2 DM (T1DM and T2DM) based on data from relevant studies in the literature. Our findings show that using these modalities is associated with remarkable outcomes, including reduced HbA1c levels and enhanced glycemic control among patients with T1DM and T2DM. This can enhance the quality of care and life for diabetic patients and intervene against the development of serious complications and hypoglycemia-related adverse events. The cost of routinely using these devices might seem relatively high. However, the estimated cost benefits are usually higher as they can significantly reduce hospitalization rates due to hypoglycemia and the frequency of diabetic therapy malpractices, which are frequently encountered. However, not many studies have reported these outcomes, indicating the need to conduct future relevant studies.

Keywords: Glycemic control, DM, CGM, Management

INTRODUCTION

Diabetes mellitus (DM) is a highly prevalent disorder and one of the commonest disorders worldwide. The prevalence of DM is also steadily increasing, with a significant impact on the affected patients and communities. It is usually associated with various complications that might affect the affected patient's life.[1,2] If not deadly, these complications can significantly impair the quality of life of these patients and pose a significant impact on healthcare settings. Therefore, it is essential to reduce the risk of these events and enhance the quality of care for patients with diabetes to improve their life expectancy and reduce the frequency of morbidities and mortality rates.[3]

The main intervention to reduce the macro-and microvascular complications of DM remains to achieve

better long-term glycemic control.[4-6] However, evidence indicates that achieving this is usually challenging for T1DM and T2DM patients. Nevertheless, many modalities have been reported for achieving such outcomes and enhancing glycemic control in this context. For instance, CGM devices have been reported with many advantages and enhanced compliance.[7] In the present literature review, we will discuss the clinical and economic benefits of using CGM devices in achieving better glycemic control based on evidence from the relevant studies in the literature.

LITERATURE REVIEW

This literature review is based on an extensive literature search in Medline, Cochrane, and EMBASE databases which was performed on 27th December 2021 using the medical subject headings (MeSH) or a combination of all possible related terms, according to the database. To avoid missing potential studies, a further manual search for papers was done through Google Scholar while the reference lists of the initially included papers. Papers discussing clinical and economic benefits of continuous blood glucose monitoring devices were screened for useful information. No limitations were posed on date, language, age of participants, or publication type.

DISCUSSION

Many studies assessed the current literature's clinical and economic benefits of using CGM devices. Most of these studies indicate the favorable events of using these devices for type I and type II patients. For example, a previous randomized controlled trial (RCT) aimed to assess the clinical efficacy of CGM among adult and children patients with T1DM. They all had adequate control of the disease (HbA1c=7-10%) and received CSII. The authors reported that using CGM devices for 26 weeks was significantly associated with better outcomes regarding all glycemic parameters, including a significant reduction in HbA1c levels. The authors furtherly showed that the reported significant reduction in these patients was more significant than the estimated reduction in patients with SMBG aging >25 years ($p<0.001$).[8] Another analysis of the same patient group also indicated that CGM devices correlated with a numerical decrease in the time spent in hypoglycemia compared to the control group. However, these differences were not statistically significant. On the other hand, the authors demonstrated that there was a significant reduction in HbA1c levels in the patient group and time spent out of range ($p=0.003$).[9] Similar favorable outcomes were also reported in the DIAMOND study. The authors compared the outcomes of patients using CGM devices and others receiving diabetic usual care (SMBG $\geq$ four times daily). After 24 weeks from applying these interventions, the authors reported that there was a significant difference regarding the duration of hypoglycemia and HbA1c levels, which were shorter and higher for patients with CGM devices, respectively ($p=0.002$, <0.001).[10]

Many other investigations also aimed to assess the efficacy of CGM devices for diabetic patients with a history of severe hypoglycemia and impaired awareness of hypoglycemia. For instance, a previous study compared the outcomes of patients using CGM devices and SMBG with CSII and multiple daily injections of insulin. The authors reported that both groups had similar outcomes regarding reductions in the frequency of hypoglycemic events and improvements in hypoglycemia awareness over 24 weeks.[11] Moreover, another study compared patients using CGM and SMBG after receiving multiple daily injections of insulin or CSII. The included patients were all T1DM and had impaired awareness of hypoglycemia. The authors reported that using CGM devices was significantly associated with a significant reduction in hypoglycemia time, increased normoglycemia time, and reduced severe hypoglycemic events.[12] Another RCT also compared the efficacy of both CGM and SMBG in T1DM patients receiving multiple daily insulin injections. The authors reported that the incidence of hypoglycemic events was significantly reduced by 72% among high-risk patients using CGM devices ($p<0.0001$).[13] It has been further shown that CGM devices might also enhance the therapeutic responses and related outcomes of patients receiving different insulin formulations and other antidiabetic modalities. In this context, a previous study aimed to assess the different aspects of glycemic control by using CGM devices among patients receiving two concentrations of insulin glargine. The authors reported that the patients were randomized to receive a dose of 100 or 300 U/ml of insulin for eight weeks in the morning or evening and vice versa in the following eight weeks. Based on the 24-hour CGM findings, the authors concluded that fewer glucose fluctuations and more consistent glucose readings were significantly associated with administering insulin glargine 300 than 100 U/ml, irrespective of the time of administration. It has also been found that reduced events of confirmed severe nocturnal hypoglycemia were significantly associated with administering 300 than 100 U/ml of insulin glargine.[14] Another CGM-based investigation also indicated the clinical efficacy of these modalities in predicting clinical outcomes among patients with a sodium-glucose co-transporter 2 inhibitor.[15] These findings indicate the clinical efficacy and advantages of using CGM for monitoring glucose levels and related outcomes in diabetic patients.

In addition to the current trials' results, evidence from other studies also indicated that using CGM is also associated with other favorable outcomes. These outcomes might include enhanced quality of life, reduced diabetes-related stress, fear of hypoglycemia, and reduced hypoglycemia and HbA1c levels.[16-18] In addition, another investigation that included patients with T1DM who began to use CGM devices showed that work absenteeism, hospital stay, and hospitalization due to ketoacidosis and/or hypoglycemia was significantly reduced during one year of follow-up.[19] However, among

the different studies in the literature, conclusive evidence is still missing, and the present data is conflicting.

Regarding the use and clinical benefits of CGM devices in monitoring blood glucose levels for patients with T2DM, current evidence indicates that using these devices is associated with enhanced glycemic control among patients receiving multiple daily insulin injections and other antidiabetic modalities.[20,21] However, the current data is limited by the small number of relevant investigations, indicating the need for future investigations. In this context, a previous RCT investigated these outcomes among T2DM patients receiving various insulin therapy regimens (but no prandial insulin). The follow-up period lasted for 52 weeks, and the authors reported a significant reduction in HbA1c levels in patients with CGM devices than with SMBG.[22] This has been furtherly indicated by the results from the DIAMOND trial, which showed that using CGM devices was significantly associated with a reduction in HbA1c levels by 1% more than usual care (0.6%) in T2DM patients receiving multiple daily injections of insulin (p=0.005). However, it should also be noted that the authors reported no significant differences in changes from baseline in insulin dose and time spent in hypoglycemia between the two groups.[10] In another context, data from the DIAMOND study indicate that there was a significant reduction in baseline HbA1c levels in older T2DM and T1DM patients with either CGM or SMBG (p<0.001).[23] Therefore, more recent investigations also aimed to assess the efficacy and benefits of using flash CGM in these patients. For instance, two previous RCTs reported a significant reduction in time spent in hypoglycemia by 43% and 56% for adult T2DM patients receiving insulin therapy, and the latter ratio was estimated for adults ≥65 years when using this modality. The authors furtherly reported that the estimated reduction rate for patients with well-controlled T1DM was 38%.[24,25] It should be noted that the estimated reductions in all of these occasions were more significant in the CGM than the SMBG group, indicating the clinical efficacy and benefits of using CGM devices.

A previous investigation that included both T1DM and T2DM reported that using flash CGM in these patients was significantly associated with more reduction in HbA1c levels than SMBG. Moreover, it has been shown that more remarkable differences were observed among T1DM patients.[26] Favorable events were also reported by a previous large investigation, which included 50,000 participants. Using flash CGM approaches, the authors reported a positive correlation between time spent in euglycemia and a negative correlation between time spent in hypo-and hyperglycemia.[27] On the other hand, another investigation (namely the I HART CGM) reported that among adult patients with T1DM with an increased risk of developing hypoglycemia, there was a significant positive impact over hypoglycemia when switching from flash to real-time CGM. According to the authors of this study, the frequency of time spent on hypoglycemia reduced from 5% to 0.8%.[28] Therefore, these findings indicate that it is important that data collection regarding blood glucose levels should be frequently collected to optimize blood glucose levels and reduce the incidence of hypoglycemia for diabetic patients. However, it should be noted that the economic burden of such approaches is the main barrier and should be considered when drawing such interventions.

The cost-efficacy of using CGM devices has been remarkably variant across the different studies in the literature. However, overall, evidence shows that the annual costs of these devices usually range between 2,500 and 6,000$, and the estimated cost for buying the flash CMG device is 100$. Moreover, the monthly costs of buying sensor kits for the device usually range between 120 and 200$. It should all be noted that other devices might have higher costs than this, and the cost usually differs between countries based on each manufacturer and economic and political variations. Evidence also indicates that battery replacement usually costs around 600$ per year.[29] Unfortunately, not many studies in the literature have estimated the cost-efficacy of CGM devices for T2DM patients. Therefore, the frequency of buying these devices and supporting their use by healthcare authorities is questionable and needs further research. However, some studies indicated the cost-efficacy and favorable clinical outcomes in their diabetic populations. For instance, the previous DIAMOND RCT indicated that using CGM devices was significantly associated with remarkable cost-effectiveness during the six months of the trial.[30] Another study in England also aimed to assess the cost-effectiveness of CMG devices for patients with T1DM. The authors reported that using these devices was significantly associated with net favorable outcomes. Despite the high costs of using these devices, the authors demonstrated that they were remarkably low secondary to the reduced use of insulin pumps, decreased HbA1c-related complications, reduced SMBG strip usage, and decreased hypoglycemia-related costs and adverse events.[31] On the other hand, another Swedish investigation demonstrated that using flash monitoring devices was more significantly associated with enhanced cost-efficacy than using either CGM or SMBG.[32] Therefore, it is essential to conduct further investigations to adequately estimate the cost-effectiveness of these modalities and enhance reporting guidelines. Besides, there are some limitations to be considered among the relevant trials in the literature. For instance, it has been shown that most of the included patients in these trials are recruited with high adherence rates to the treatment regimens. However, real-world data show that these rates are significantly lower in T1DM and T2DM patients. Therefore, these differences should be considered, affecting the outcomes and reporting quality. Moreover, there are some barriers to using CGM. These include patient annoyance secondary to interference with daily life, body image issues, insertion pain, frequent alarms, inadequate cost/reimbursement, and limited accuracy of the devices.[33] Accordingly, further studies are needed to

overcome these limitations and enhance the quality of these devices and the quality of care of diabetic patients.

CONCLUSION

We have discussed the clinical and economic advantages of using CGM devices for T1DM and T2DM based on data from relevant studies in the literature. Our findings show that using these modalities is associated with remarkable outcomes, including reduced HbA1c levels and enhanced glycemic control among patients with T1DM and T2DM. This can enhance the quality of care and life for diabetic patients and intervene against the development of serious complications and hypoglycemia-related adverse events. The cost of routinely using these devices might seem relatively high. However, the estimated cost benefits are usually higher as they can significantly reduce hospitalization rates due to hypoglycemia and the frequency of diabetic therapy malpractices, which are frequently encountered. However, not many studies have reported these outcomes, indicating the need to conduct future relevant studies.

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