VOLUME 07
ISSUE 04

CLINICAL PRACTICE UPDATE IN
ENDOCRINOLOGY & DIABETES

Clinical Pearls Summary 2nd Annual LMC Diabetes "Focus on Pumping"

Missing the Forest for the Trees: What Continuous Glucose Monitoring Can Do For Your Patients

LMC

Editor
Ronnie Aronson
MD, FRCPC, FACE

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Bruce Bode
MD, FACE


Ashleigh Walker
RN, CDE


Megan Skinner
RD, CDE

Log books. Lancets. Meters. Test strips. Tools of the trade for patients with type 1 DM and for those with DM2, using insulin. Frequent self-monitoring of blood glucose (SMBG) has been a standard of care since the DCCT publication in 1993 definitively identified it as a critical portion of optimal management of insulin therapy. Dr. Bruce Bode is Clinical Associate Professor and Diabetes Specialist with Atlanta Diabetes Associates, and recently authored a guide to pumping for patients and healthcare professionals. He joined the LMC Diabetes group for a roundtable discussion on pumping and CGM earlier this year and highlighted his perspective:

- Achieving an A1c under 7% requires monitoring more than four times per day;
- Achieving an A1c under 6.5% requires monitoring up to eight times per day

And yet, despite adhering to these SMBG recommendations, most patients living with diabetes are not achieving target A1C levels. Significant challenges remain, primarily:

1. Hypoglycemia and its associated fears – particularly the fear of nocturnal hypoglycemia.

2. Post-prandial hyperglycemia – a major contributor to persistent A1c elevation – often goes unnoticed as most patients do not monitor their blood glucose after meals.

Dr. Bode's main theme was that we're missing out on the big picture by focusing on these point-in-time blood glucose (BG) readings. We're failing at detecting the patterns happening in the forest by only considering the trees. **Traditional SMBG doesn't tell us where the patient's blood glucose has been, or where it may be headed.** Real-time continuous glucose monitoring (CGM) is the key to seeing the forest beyond the trees.

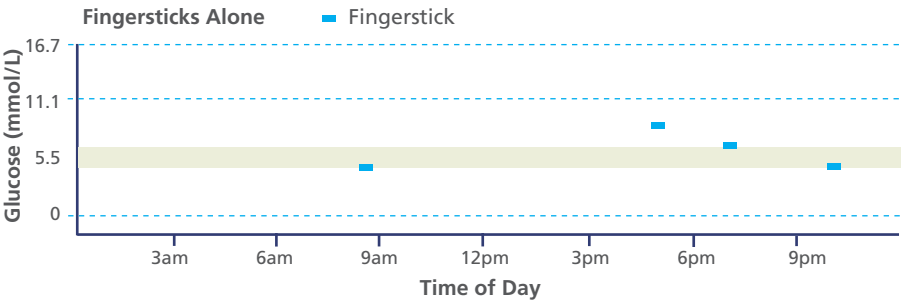
Dr. Bode highlighted that with continuous glucose monitoring systems (CGMS), users benefit enormously from seeing the direction and rate of change of their glucose in real-time, enabling them to take immediate action to prevent hypoglycemia or to manage hyperglycemia. Patients improve their decision-making capabilities once they are able to see the full picture of their glucose patterns, as well as the immediate impact of any nutritional, lifestyle, or medicinal decisions.

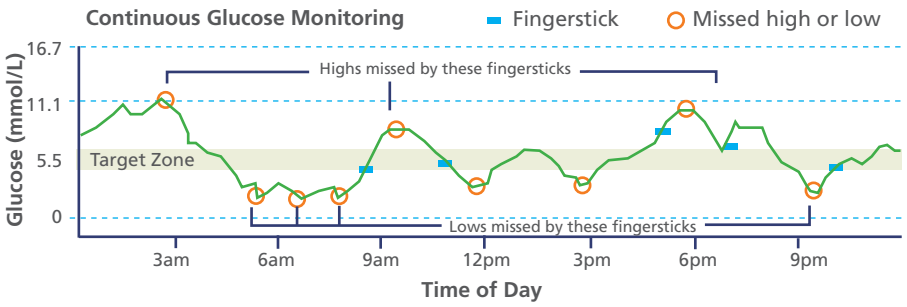
CGM can be particularly valuable in addressing hypoglycemia, as traditional SMBG fails at warning patients of imminent hypoglycemia. Similar value emerges in our many patients who are fearful of overnight hypoglycemia and in our many patients who limit physical activity because of resulting hypoglycemia. With CGMS, patients are more informed as to short-term changes in glucose levels, leading to considerable improvements on quality of life.

Dr. Bode began by reviewing the studies that have shown that real-time CGM can safely improve glycemic control. The Medtronic Paradigm Veo pump is the first to have a low-glucose suspend (LGS) feature – the pump will automatically suspend insulin delivery if the sensor detects a preset glucose threshold. For many healthcare professionals, the notion of complete insulin suspension can raise concerns over diabetic ketoacidosis (DKA). However, when the LGS feature was studied in the recent ASPIRE trial, Dr. Bode and other researchers found it could effectively reduce nocturnal hypoglycemia without any unwanted hyperglycemia. The new Enlite sensor (Medtronic™) has been shown to detect up to 96% of hypoglycemic events, is 69% smaller in size than its predecessor and up to 26% more accurate.

The 2013 Canadian Diabetes Association Clinical Practice Guidelines (CPGs) recommend real-time CGM in patients living with type 1 diabetes as a way to improve glycemic control and reduce hypoglycemia. In particular, Dr. Bode pointed out the value of CGM for patients with persistent A1c levels above target, labile BG values, hypoglycemia unawareness, or employment considerations. The CPGs recommend incorporating CGM within a structured educational program to facilitate and encourage behaviour change in order to improve glycemic control. **Interestingly, we find that CGM is a powerful stand-alone agent for creating behaviour change simply by showing patients the reaction to their daily decisions, in real-time.**

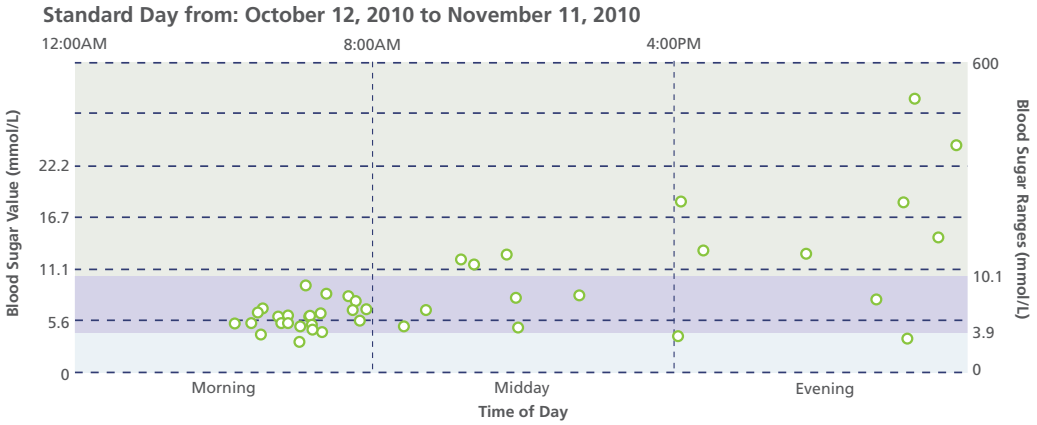
In this special issue of Clinical Practice Update, we will review the patient cases that Dr. Bode analyzed, and we'll try to share our further learnings in how CGM can reduce hypoglycemia, improve glycemic variability, and enhance quality of life for patients living with this challenging and demanding chronic disease.



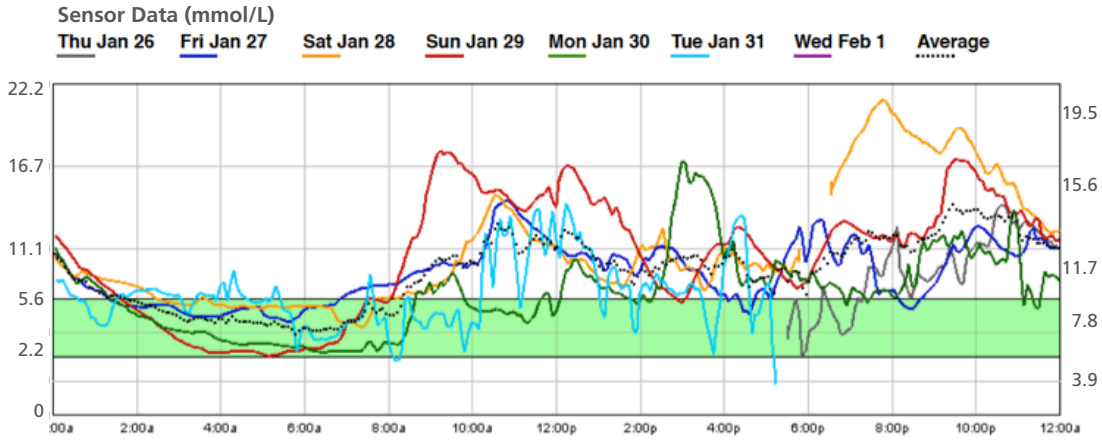


CASE STUDY 1 - HENRY			Objective data
	• 64 y.o. male • Type 2 DM since age 37 • On pump since 2000	• Gastric bypass surgery 2006; BMI 48 to 29 • A1c 7.9%	• 26 units/day (0.35 units/kg) • 69% basal; 31% bolus • SMBG 1.5/day • Mean BG 8.3 ± 5.4mmol/L

Glycemic variability often goes undetected when patients are selectively monitoring at times when a target glucose level is expected, and there are numerous barriers to frequent SMBG for many people living with diabetes. This case scenario illustrates the additional value CGM has in filling in the gaps throughout the day.



This patient was checking their blood glucose predominately in the morning, and occasionally during the afternoon & evening period. The blood glucose values in the morning were always in target (6.5-6.8 mmol/L) and therefore, the patient did not see the benefit of checking more frequently.



The patient agreed to try CGM to gain a better understanding of the blood glucose patterns and trends. The most obvious finding for this patient was a very high standard deviation – a measure of Henry's glycemic variability. Dr. Bode recommends targeting a standard deviation of less than half of the mean blood glucose, and in this example, the standard deviation of 5.3 mmol/L was more than 50% of the average blood glucose (8.3 mmol/L). **Without the assistance of CGM, we would not have been able to see the extent of this patient's glycemic variability.**

The CGM data also clearly showed that the patient was often going to bed with blood glucose levels around 11-12 mmol/L and waking up in the morning close to 6.5 mmol/L. More and more healthcare professionals are now analyzing their patients' "BEAM score", which looks at the difference between the bedtime (BE) and morning blood glucose (AM) level. As highlighted by Dr. Bode, the BEAM score

should be less than 2.5 mmol/L (for example, in this case scenario, the BEAM score would be approximately 5.5 mmol/L). Addressing only the evening hyperglycemia by increasing the dinner bolus without also reducing the overnight basal coverage would put the patient at risk of nocturnal hypoglycemia. CGM can be instrumental in supporting patients and caregivers to mitigate fears of hypoglycemia as well as tackling glycemic variability.

✓ Check Yourself

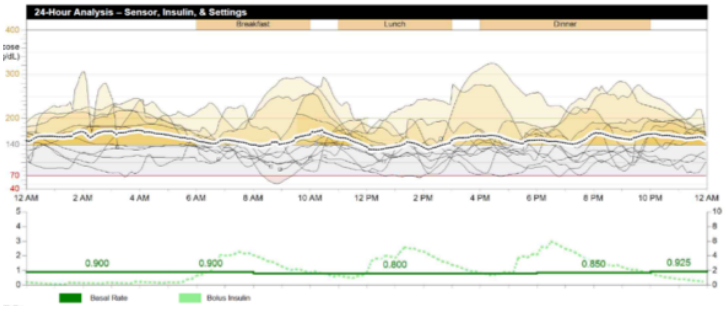
	Consider aiming for a standard deviation of less than half of the average blood glucose level
	Calculate the BEAM score to target a value of less than 2.5 mmol/L

CASE STUDY 2 - Maria

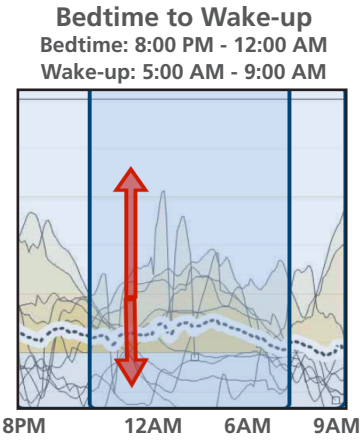
- 30 y.o. female
- weight 74 kg
- Medtronic pump for 2 years, CGM for past 8 months
- A1c 7.1% (recently reduced from 8.2%)
- Now advised that an A1c <6% was needed prior to pregnancy.

Dr. Bode emphasized that our goal should be seeing the big picture when reviewing CGM reports, with less focus on individual day-to-day BG levels. Many healthcare providers admit they feel overwhelmed with the amount of information produced from insulin pump therapy management software; particularly with CGM-augmented pump users.

Dr. Bode recommended starting with the 24-Hour Overlay Report. In this case, we see wide variability with the average blood glucose above target at 10mmol/L. If a pattern doesn't easily stand out, Dr. Bode structures his analysis by first reviewing overnight blood glucose control, then evaluating prandial and post-prandial time periods, and finally, looking for events preceding hypoglycemia and hyperglycemia.

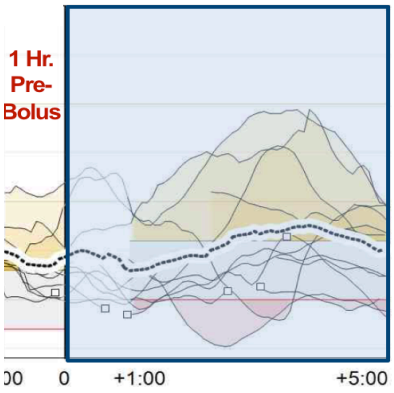


1. Start with Overnight



With most of the nights showing hyperglycemia, one might consider increasing the overnight basal rates for correction – but this move would possibly increase her frequency of nocturnal hypoglycemia. In cases such as this, seek out more information regarding the possible causes of variability in discussion with the patient, and review other CareLink reports to gain further insight.

2. Evaluate Prandial & Post-Prandial Glucose Control



Though some variability is noticeable, her blood glucose is staying relatively flat coming into meals and post-meals. Her insulin:carb ratio (ICR) therefore appears adequate here for breakfast, and additional reports showed the same stability at lunch and dinner. Dr. Bode doubted that more intensive carb counting would bring down her A1c to pregnancy targets.

3. Look for Events Preceding Hypoglycemia & Hyperglycemia

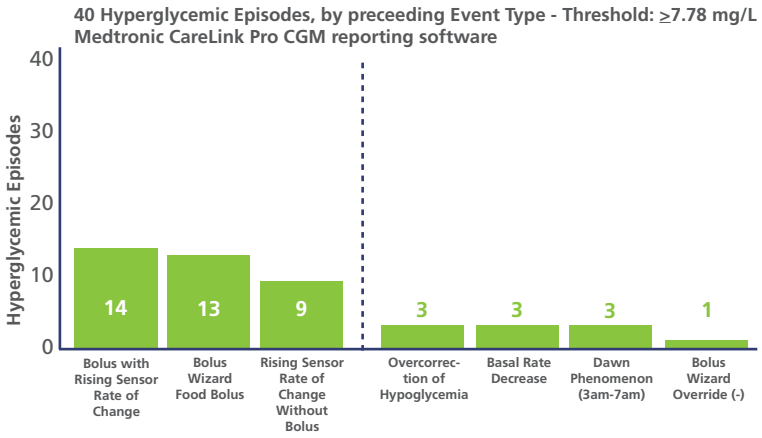
DATA EVALUATION

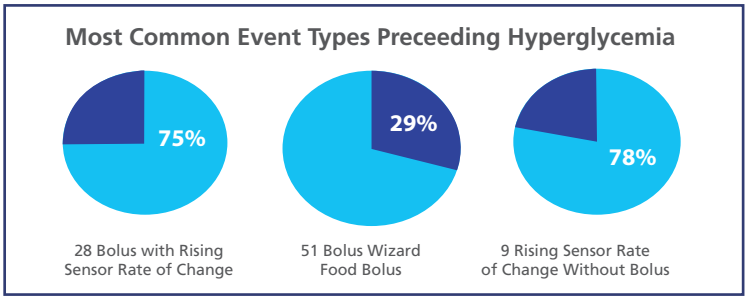
- 28 boluses w/rising rate of change
  Patient is high 2 hours after 75% of those boluses
- 51 food boluses
  29% of time 2-hour post-meal glucose was high
- 9 rising rate of change events where the patient did not bolus
  78% of the time a high glucose started within 3 hours

CONSIDERATIONS

- Correction boluses do not seem to bring patient into target

WHY?





Event Type Descriptions

Event Types	%	Description
Bolus with Rising Sensor Rate of Change	35	Consider counseling your patient to modify bolus amounts when sensor glucose values are rising (upward arrow is present)
Bolus Wizard Food Bolus	32	Consider assessing the Bolus Wizard settings, counseling your patient on accurate carbohydrate counting, and/or the timing of insulin delivery with respect to carbohydrate intake.
Rising Sensor Rate of Change Without Bolus	22	Consider counseling your patient on bolus use with meals and/or correcting rapid glucose excursions.

The Medtronic CareLink Pro CGM reporting software now has built in tools which specifically analyses both hypoglycemic and hyperglycemic events. Dr. Bode felt it was more prudent to focus on patterns of hyperglycemia since Maria spends less than 7% of the time in hypoglycemia. We can see that after administering a bolus with a rising rate of change on her sensor, she ends up with high blood glucose 75% of the time. Essentially, when her blood glucose was above target before giving a bolus, it appeared to stay above target. Dr. Bode's assessment was that either her correction factor needed to be adjusted, or her blood glucose targets were set improperly.

Carbohydrate Ratio
(g/U)

TIME	Ratio
0:00	8.0

Insulin Sensitivity
(mmol/L per U)

TIME	Sensitivity
0:00	2.7

Blood Glucose Target
(mmol/L)

TIME	Low	High
0:00	5.3	6.7
8:00	5.6	7.8

Looking at her settings, her overnight blood glucose target is lower than her daytime target. As Dr. Bode highlighted, she would never reach an A1c of <6% with her targets set for a range of 5.6-7.8 mmol/L during the day. He recommends a target of 5 mmol/L when planning pregnancy up to the 2nd trimester, then lowering to 4-4.5 mmol/L in order to optimize glucose control.

✓ Check Yourself

	Use the 24 hour sensor tracing to prioritize the most significant glucose trends.
	Analyze the overnight period first, move on to prandial & post-prandial control, and finally look at events preceding hypoglycemia & hyperglycemia.
	Ensure blood glucose targets are logical and appropriate.

CASE STUDY 3 - Diana

- 30 y.o. female
- Type 1 DM
- A1c ranging 6.0-6.5%; used to be 10.0%

Objective data

- 61% basal; 39% bolus
- BG target range of 5-8mmol/L

Modern CGM systems include integrated alerts and alarms to notify users of changes in glucose levels, as well as to maintain their glucose within target ranges. In Diana's case, her CGM target range was set between 5-8 mmol/L, and she often complained of excessive alarms throughout the day. The sensor would alarm at breakfast for the patient's glucose level of approximately 4 mmol/L as this was below her selected target range. Her post-prandial spikes approached 10 mmol/L and would also result in an alarm. This pattern repeated for all three meals throughout the day, leading to a lot of frustration for the patient. **Dr. Bode highlighted the need to expand the target range to reduce the frequency of alarms and in turn, assist with the patient being successful on CGM.**

We further found that Diana was frequently requiring two boluses for each of lunch and dinner, as she tried to react to the elevated post-prandial glucose levels with additional correction boluses. This over-reaction was also resulting in hypoglycemia four to five hours later, before her next meal. As stated by Dr. Bode, "whenever you go low four to five hours after bolusing, you need to look at the basal." Therefore, this patient would need to lower her basal enough to bolus safely – the patient's ICR was lowered from 1:10 to 1:8 to give more insulin with meals and the basal was also reduced by 10-20%. In fact, in Diana's case, the basal/bolus ratio was high at 61% basal versus 39% bolus; **Dr. Bode argued that the basal percentage should always be 50% or less in most patients to reduce the risk for hypoglycemia.**

Another major advantage of the sensor, as discussed by Dr. Bode, was the timing of the meal bolus in relation to the blood glucose trend going into that particular meal. Diana had post-prandial spikes in her BG levels – not uncommon for many patients, particularly those who are often eating simple carbohydrates (i.e. cereal, fruit or juice). Dr. Bode pointed out that "timing is everything" and suggested giving a bolus 20 minutes ahead of the meal to lower post-prandial hyperglycemia. It is important to note that advanced dosing can only be safely done if someone is wearing CGM, because CGM can demonstrate which blood glucose trend is predominating going into the meal.

✓ Check Yourself

	Sensor alerts & alarms should mean something
	Consider redistributing the insulin between basal and bolus
	Aim for the basal percentage to be less than 50%
	Timing is everything: bolus 20 minutes ahead to lower post prandial hyperglycemia

CASE STUDY 4 - Sal

- 60 y.o. male
- DM2 for 22 years, after 1st MI
- weight 101 kg, BMI 31
- 2010: A1c 11.7%, with low C-peptide, placed on Medtronic pump
- 2012: A1c 9%, started CGM & Victoza
- 2013: A1c 6.8% with hypoglycemia

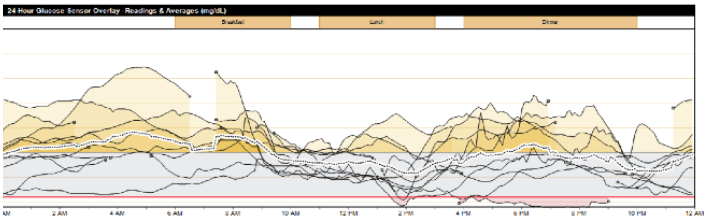
Objective data

- 72% basal, 28% bolus
- BG target of 5 mmol/L
- ICR 1:4

Pump therapy allows patients to deliver specialized boluses based on the macronutrient composition of any particular meal. When a pump is augmented by CGM, patients are able to evaluate the optimal way to match their specialized bolus to the effects of combination meals on their glucose levels.

The patient revealed that sometimes after eating, his sensor will alert him of a low blood sugar – which he does not treat, as he notices his blood sugar will continue to rise on its own, a pattern evident on his tracing. Dr. Bode proposed that this was related to the delayed stomach emptying effects of Victoza, and suggested the patient make use of the dual wave bolus for his meals, particularly higher fat meals, as well as any snacking later at night. He recommended starting with 50% of his bolus delivered up front, and then to give the remaining 50% over two or three hours.

He also discussed the idea of bolusing for



macronutrients other than carbohydrates – "the pizza factor". Many of us working in diabetes are aware of the influence of higher protein or fat meals on blood sugars, and this effect would also be exacerbated by any higher fat choices for snacking, such as ice cream, potato chips, or nuts. The pizza factor suggests adding an extra 30% of the carbohydrate total to cover any additional glucose conversion from amino or fatty acids, and utilizing the dual-wave bolus accordingly. He has found this to be successful in his patient practice, though currently there are no standard best practices published. As with many blood sugar concepts, trial and error is the best approach. Dr. Bode emphasized the fact that patients using CGM are able to test out specialized boluses for the variety of food in their diet.

✓ Check Yourself

	Utilize CGM to gain the most insight on specialized boluses

INTEGRATING CGM INTO PRACTICE

Dr. Bode highlighted the importance of integrating CGM into every diabetes clinic, and also shared that within his practice he could see a patient on sensor augmented pump therapy faster than a patient on multiple daily injections. More than 70% of Dr. Bode's type 1 patients are on an insulin pump and he has worked tirelessly to incorporate modern diabetes technology into his practice.

Dr. Bode shared some essential strategies to help with the implementation of CGM within everyday practice, including the importance of having the clinic equipped to download any patient device. Within Dr. Bode's practice, the medical

assistants know how to download all the various devices and therefore, there is no delay when a patient is on pump therapy. He also highlighted the value of CGM reports when used in conjunction with the A1c value for patient appointments. **For example, if a patient has an A1c of 6.5%, the focus of the appointment should be on looking for patterns of hypoglycemia to ensure patient safety. Alternatively, if a patient has an A1c of 11%, then the reports are used as a teaching tool with the patient to encourage behaviour change.**

Another key point which Dr. Bode mentioned is that the practitioner has to be effective with their time, and therefore an appropriate length of time to spend analyzing the reports is between 3-5 minutes for each patient. Dr. Bode understands that it will take time and practice for practitioners to be efficient at reading the reports, but eventually it will be "like reading an EKG as a cardiologist." He also found it helpful for his team to go on a pump and sensor to appreciate the value of this technology and understand how beneficial it can be for their patients in everyday life. With the ongoing advancements in diabetes care, clinics are only going to be successful with CGM if downloading, analyzing, and interpreting the patient reports are built into their clinic infrastructure.

FUTURE OF CGM

Dr. Bode mentioned that CGM could be "the standard of care in all people with diabetes in five years, including type 2; it will replace intermittent point of care testing." Many employers are considering CGM-augmented pump therapy as a requirement for certain jobs, particularly if the job involves public safety. For example, a flight attendant would benefit tremendously from wearing a CGM augmented pump with low glucose suspend, as they are responsible for the safety of the passengers. Dr. Bode predicts that, in the future, "if you are riding machinery or you are a taxi driver, or running an automobile, or anything that can cause harm to someone… you'll be required wear a sensor." Low alerts and LGS from CGMS enable patients to safely work, drive, and exercise while still aiming for optimal glucose control.

Lastly, the concept of using glucose sensing to drive continuous insulin delivery was also highlighted by Dr. Bode. The holy grail in insulin therapy has always been a closed-loop delivery system. New pumps, sensors and software, with features like low glucose suspend, are clearly leading the way. Currently in late phase testing is a suspend feature that reacts to a downward trend of blood glucose – before the patient has to actually experience a low blood glucose. Anticipating hypoglycemia and reacting is a fundamental first step of a true closed-loop system.

CONCLUSION

Supporting self management and individualizing patient care are both essential in working with patients who have diabetes. As Dr. Bode stressed, CGM is a behavioural modification tool which helps the patient to understand where they are and where they are going. For example, it could help patients identify and manage the various effects of stress, meals, exercise, and medications on their blood glucose levels. Real-time CGM improves glycemic awareness within the user and allows the patient to gain a better understanding into how their decisions within everyday life affect their glucose levels.

It has been proposed that **more patients utilizing CGM could have a substantial improvement on both the time devoted to, and cost-effectiveness of, diabetes management, while also facilitating care plans to be more individualized.** As healthcare professionals, time is very valuable and integrating the use of CGM into the practice environment can provide essential insight into the patient's experience even before they step into your office.

Supported by educational grants from Medtronic.