BC Diabetes Foundation

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Continuous Glucose Monitors

Continuous glucose monitors (CGMs, also known as “sensors” or “flash”) are devices that measure the level of glucose (sugar) in the body's water. The body’s water is medically known as “interstitial fluid”. Interstitial fluid glucose is almost exactly the same as blood sugar. CGMs are inserted painlessly and measure the sugar every 1 to 5 minutes, 24/7 for 7-14 days. CGMs mean almost no finger pricking. CGMs allow for the setting of low and high sugar alarms meaning that anxiety levels are dramatically lowered. CGMs have brought about a revolution in the management of diabetes - they empower the user and diabetes care team to provide for better, safer diabetes control and better quality of life, in particular freedom from fear of low blood sugar. CGMs facilitate understanding and mastery of the factors that cause sugar to rise and fall (diet, exercise, emotional state, menstrual state, intercurrent illness, oral medication and insulin to name the main ones). Most importantly for those living with Type 1 diabetes or Type 2 diabetes on intensive insulin therapy, CGM has made possible the artificial pancreas - automated insulin delivery combining an insulin pump and an integrated CGM with fabulous software that keeps the sugar stable just like cruise control maintains the speed of a car whether going up hill or on the flat.

At present on the Canadian market there are three devices (discussed below) all of which involve insertion of a small teflon needle into the skin that is changed every 7-14 days. The needle is connected to a sensor which either

A. automatically sends/pushes the interstitial fluid glucose value via bluetooth to a receiver every 5 minutes 24/7 (Dexcom G6; Medtronic GuardianConnect; and Freestyle Libre 3 expected late 2022) or
B. has data “pulled” from it by the waving of a receiver or smartphone over the sensor/flash glucometer (Freestyle Libre, Freestyle Libre 2, see below).

In the US and other countries (but not yet Canada) an implantable device, the Eversense is available. It is surgically implanted in a simple office procedure that takes around 5 minutes. The current version lasts up to 3 months, the newest version, approved by the FDA 2022-Feb-18 will remains active for up to 6 months. As of 2020-Feb-24 an astonishing 39 CGM devices were under development.

Interstitial fluid glucose vs blood glucose

Although interstitial glucose values tend to lag blood glucose values (because blood levels change before interstitial fluid), glucose values reported by CGMs are usually within 10-15% of the true value. When comparing CGM vs finger poke blood glucose and finding a difference of <30% the "true" value is likely somewhere in between the blood and interstitial fluid values. If the difference is >30% you need to wash your hands carefully & repeat the finger poke &

consider calibrating the CGM (see more on this below). It is a fallacy to assume that finger-poke blood values are always correct (see paragraph below "Resolving differences between CGM and finger-poke blood sugar". Finger-poke is not the gold standard (the "true" value) - the gold standard is a blood glucose value done in a lab from a sample drawn with a needle and syringe, the sample having been placed in a tube containing fluoride to stop glucose metabolism. These differences are minimized by the use of algorithms within the sensor device. There are some special caveats:
1) Values reported below 3.8 tend to be less accurate.
2) Users should be aware that if they correct a low sugar with rapid starch (sugar/pop/juice) CGM levels may still show a trend downwards even while blood sugar is going up.
3) Ascorbic acid (Vitamin C) in a dose of > 500 mg will give falsely high readings with the Freestyle libre for 4-6 hours after ingestion. Chelation therapy may contain Vitamin C and as such may also cause falsely high readings.
4) Acetaminophen (paracetamol, Tylenol) gives falsely high readings within 4-6 hours of ingestion for the Medtronic series of CGMs. It does not affect the Dexcom G6 (an earlier model, the Dexcom G5, was affected by acetaminophen).

Resolving differences of >30% between CGM & finger poke blood sugar.

1) Wherever possible calibrate your CGM. Best time to calibrate is when the blood sugar is stable: when you wake up in the morning or just before going to bed are generally good times. Always wash hands before taking a finger poke and when hand washing isn't possible, wipe the first drop of blood and use the second drop. These two strategies can help avoid a major source of CGM inaccuracy: dirty hands -> inaccurate BG meter readings -> inaccurate CGM calibration -> worse CGM accuracy.
2) Wash your hands and take another fingerpoke reading. Upon a second fingerpoke reading, most clients find the CGM is correct and the first meter value was reading falsely high (from not washing hands!). This strategy has prevented our clients from taking dangerous insulin overdoses on many occasions.

Trend arrow (vs glucose value)

The trend arrow indicates whether the sugar is steady =horizontal line, or rising or falling. Vertical arrows indicate rapid rise or fall; half-up or half-down arrows indicate less rapid trend. While a single interstitial glucose value is not as accurate as the "true" glucose value, because of the trend arrow the user is in a much safer position knowing where the value has been and where it is going. In this context CGM glucose values are widely accepted as being sufficiently accurate to allow for insulin adjustment. Indeed, the extreme clinical effectiveness of the combination of CGM accuracy and trending information, that the artificial pancreas is a reality.

Dexcom G6

The Dexcom G6 is the state of the art CGM in Canada today (though is equaled by the Freestyle Libre 3, see below, available now in Europe but not yet in Canada). A free Dexcom G6 can be obtained by registering online for individuals who state that they have "Type 1 diabetes" or have "Type 2 diabetes on insulin therapy". The Dexcom G6 is the combination of a sensor that lasts 10 days and a transmitter that lasts 110 days. The Dexcom G6 is sold in

community pharmacies for the following prices: $289 for a box of 3 sensors + $29 for a transmitter. The Dexcom G6 is covered by BC Pharmacare subject to the BC Pharmacare deductible; until you have hit the Family Deductible threshold it will cost $10/day. Once that threshold is hit it will be $3/day until the Maximal Family Deductible is reached after which it will come at no charge For consumers who do not qualify for BC Pharmacare the Dexcom G6 can also be purchased online.

In emergency situations the life of the Dexcom G6 sensor can be extended beyond the usual 10 days to 14-20+ days with this hack. The hack must be implemented no less than 2 hours before expiry. You will need a regular finger poke test-strip to slide under the narrow end of the sensor.

Dexcom allows for analytics and sharing of data with HCPs through its Clarity app.

The Dexcom G6 can also be used without a smartphone or internet connection using a Dexcom G6 Receiver (similar to the reader for the Freestyle Libre and Libre 2, see below). For clients with BC Pharmacare coverage and proof of purchase of Dexcom G6 these can be obtained at no cost by calling 1-844-832-1810, choosing option #1, providing their name & address and emailing proof of purchase to ca.accounts@dexcom.com.

To run the Dexcom G6 you need an app - your choices are 1) the manufacturer's app: Dexcom G6 from Google Play or the Apple app store or 2) open source software. Android users who prefer open source software or for whom the Dexcom G6 app is incompatible may consider installing first BYODA ("build your own Dexcom app") and if unsuccessful xDrip. iPhone users familiar with TestFlight (reinstallation of the app every 3 months is required) or for whom the Dexcom app is a challenge should consider installing xDrip4io5 after installing TestFlight.

If you are using or planning to use Dexcom with Nightscout follow these Dexcom installation instructions.

Freestyle Libre

The Freestyle Libre ("Libre") measures sugar every minute, costs approximately $4.55/day (with this 25% off coupon), requires no blood glucose testing for calibration (ie no finger pokes!) and lasts 14 days. There are now three generations of the Freestyle Libre (FSL): the FSL (original), the FSL2 and the FSL3 (expected by me in Canada in late 2022, Health Canada has a mind of its own). The FSL and the FSL 2 require that the sugar value be "pulled" from the sensor by scanning it with a device. Device options include a stand-alone Reader or a smartphone equipped with NFC (iPhone 7+, most non-entry-level Android phones) running the app Librelink (for FSL) and Libre 2 (for FSL2). The sensor must be scanned a minimum of every 8 hours otherwise there will be data loss. For the FSL3 no scanning is required.

The advantage of the FSL2 over the FSL is that the FSL2 allows for the setting of low and high sugar alarms (your phone will sound or vibrate). The advantage of the FSL3 other than not requiring scanning is that it is easier to apply & is only ⅓ the size.

FSL, FSL2 & FSL3 users running Librelink (or Libre 2 or Libre 3 apps) on their smartphones can perform analytics through a desktop app, Libreview - Libreview also offers a convenient way of sharing data with health care providers (HCP). To share with your HCP, from within Librelink go to Settings, choose Connected Apps then Libreview and enter your HCPs Practice ID. An effective low-tech way to share your FSL results with your HCP is by taking screenshots from the app or photos from the reader. The most informative views are Daily Patterns, Time-in-Target, Average Glucose & Sensor usage.

The retail price of a sensor for the FSL and FSL2 (and the FSL3 when it arrives) is identical: $89 in Costco & Naz's pharmacies and more in others. The Reader for the FSL is $49 and can be bought in pharmacies. Every person living with diabetes qualifies for one free FSL & Reader courtesy of the manufacturer by registering for a one hour online educational webinar - it will be shipped to the address you enter within a couple of days. If you are purchasing a FSL or FSL2 at a retail pharmacy this coupon will get you approximately 30% off. A prescription is not required unless you have coverage through extended medical insurance (covered by 95% of plans, subject to the plan not being a "cheap" one).

For Android phone users: the original FSL can be calibrated using the app Glimp. For both the FSL & FSL2 the life of the sensor can be extended beyond the usual 14 days using the app iDroplet providing the FSL/FSL2 is started with an app other than Librelink (Glimp for FSL and xDrip for FSL & FSL2).

Here is a testimonial on the Libre from a BCDiabetes patient with Type 2 diabetes diabetes. He found the biggest benefit was learning which foods his body could handle and which foods it couldn't……

Medtronic Guardian Connect

Recent Medtronic insulin pumps ("Minimed") have their own excellent CGM, the Guardian series (Enlite and Smartguard) which push glucose values to their 630G and 670G/770G Minimed pumps respectively. Note the Minimed 670G & 770G pumps includes the option of automated basal insulin delivery which provides hybrid closed-loop functionality. The manufacturer recommends the CGM sensor be changed every 6 days. When used with a Medtronic pump, the Guardian series of sensors are available at $99/month with a commitment for an annual subscription that can be cancelled at any time (after one month for instance).

Medtronic's standalone CGM is the Guardian Connect. BCDiabetes has test-driven a number of them and found them to do the job well and to be comparable to the Dexcom 6 other than having a more challenging insertion, shorter life (7 days vs 10 days), running only on iOS (Android expected within 12 months) and having bluetooth challenges. Pricing is identical to the Dexcom G6 at $10/day with a 12 month subscription (unfortunately the $99/month pricing is not available - only available when used in combination with a Medtronic pump.
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