

METERS, MONITORS, PUMPS

Jennifer Grace Ziliotto McCrudden
RN, MSN, FNP-C, CDE

Medical University of South Carolina
Department of Endocrinology

02/02/2019

I have nothing to disclose.

OBJECTIVES

- ▣ *Identify principles of glucose monitoring.*
- ▣ Discuss self-management blood glucose monitoring (SMBG) and continuous glucose monitoring (CGM).
- ▣ Discuss insulin pumps and integration of continuous glucose monitoring.

DIABETES TECHNOLOGY

STANDARDS OF MEDICAL CARE IN DIABETES - 2019
for the first time has a dedicated section on Diabetes
Technology (DT)

- ▣ NEW FOCUSED section on equipment for monitoring blood sugars and delivery of insulin.
- ▣ In the future this section to include topics:
privacy, cost, telemedicine, expense, software as possibly a
medical device, and DE technology

Why Glucose Monitoring?

- ▣ 2019 ADA guidelines state “key for achieving glycemic targets”
- ▣ Assists the healthcare provider and patient to determine:
 - if glycemic target is being met
 - if the current medical regimen is being effective.
- ▣ Guides:
 - insulin dosages, especially prandial dosages
 - diet
 - exercise
 - prevents hypoglycemia
 - evaluates glycemic response based on exercise and diet.
- ▣ Important to know before driving and during acute illness.

Why Glucose Monitoring?

- ▣ Clinical trials have shown monitoring for patients on insulin beneficial as it assists in intensive glycemic control and reduction in complications from diabetes.
- ▣ 2019 - The ADA considers Continuous Glucose Monitoring (CGM): a “complementary method” in determining glucose levels

TWO MAIN WAYS TO CHECK GLUCOSE LEVELS

1. SELF MONITORING OF GLUCOSE LEVELS - METERS



2. CONTINUOUS GLUCOSE MONITORING - CGM/SENSORS, SCANNERS



METERS

- ▣ SMBG (self monitoring of blood glucose)-important for patients to receive ongoing Diabetic Education to ensure:
 - Proper use of meter.
 - Method of obtaining blood sample.
 - Interpretation of results for possible adjustment of medication, diet, and behavior based on reading.
 - And give support to the patient to avoid obstacles that may prevent patient from achieving goals.

- ▣ Clinical trials have shown positive outcomes for patients on insulin with intensive glycemic control:
 - Decreased risk of complications
 - Lower A1C results
 - Evidence DM1- more checks, lower A1c *

How and When Should SMBG be Used?

- ▣ Pts on insulin/intensive regimen/pump:
 - Before meals, snacks, hs, occasionally post prandial, overnight
 - Before all insulin injections
 - More frequent if glycemic target not met or frequent hypoglycemia, check to see if low, or after low
 - Before driving, exercise
- ▣ Not on insulin:
 - Should begin at diagnosis and be individualized- depending on regimen
 - Should use data to determine goals of FBG or PPBG
- ▣ Assists to modify both medication and behavior
- ▣ Correlation of greater amt SMBG checks and lower A1Cs.

Diabetes Care: 42 (Supplement 1). (2019, January 1). Retrieved from http://care.diabetesjournals.org/content/42/Supplement_1

ADA Glucose Monitoring Recommendations

Intensive insulin regimens- Pumps and MDI

Consider SMBG :

- Before meals
 - Before snacks
 - Before bedtime
 - Before exercise
 - Before critical tasks-ex. Driving
 - Occasional postprandial
 - Hypoglycemia
 - After hypoglycemic treatment until normal range
 - Can be 6-10x/day
 - DM1- correlation between more testing and lower A1c's
- *no direct amount recommended by ADA

Standards of Medical Care in Diabetes 2017. (2017, January 1). Retrieved January 29, 2017 from <http://www.slideshare.net/UtaSukviwatsirikul/standards-of-medical-care-in-diabetes-2017>

ADA Glucose Monitoring Recommendations

There is insufficient data as to when or how often to prescribe SMBG:

- ☐ For those on non intensive insulin regimens or oral agents:
 - but data shows an inverse correlation between frequency and glycemic control. *
- ☐ DM2 w basal and w or wo oral meds
- ☐ FMBG - recommended if on basal insulin for dose titration
- ☐ Some data showing no benefit for checking sugars for those not on insulin UNLESS the data is REVIEWED and integrated into care plans/regimen.

Miller, K. M., Beck, R. W., Bergenstal, R. M., Goland, R. S., Haller, M. J., McGill, J. B., ... & Hirsch, I. B. (2013). T1D exchange clinic network evidence of a strong association between frequency of self-monitoring of blood glucose and hemoglobin A1c levels in T1D exchange clinic registry participants. *Diabetes Care*, 36(7), 2009-2014.*

GLYCEMIC GOALS: ADA AND AACE GUIDELINES (non pregnant)

* Patient dependent	ADA	AACE
FPG	80-130	<110
2 hour PPG (mg/dL)	<180	<=140
A1C	<7.0%	<=6.5%

*pregnancy, hypoglycemia, CVD, life expectancy, disease duration goal could be <6.5% or <8%

GLYCEMIC GOALS in PREGNANCY

Blood Glucose	ACOG/ ADA GDM Goals	ADA Goals - Pregnant Diabetics	AACE Goals
Fasting	<=95 mg/ dL	60-99 mg/ dL	<90-95 mg/ dL
1 hour postprandial	<=140 mg/ dL	100-129 mg/ dL	120-140 mg/ dL
2 hours postprandial	<=120 mg/ dL	100-129 mg/ dL	120-140 mg/ dL

*patient dependent

GLYCEMIC GOALS in PREGNANCY

Due to increase red blood cell turnover in normal pregnancy, A1C is usually lower than those non pregnant.

ADA A1C Recommendations
6% to < 6.5%
< 6 % if less risk of hypoglycemia (possibly on orals)
< 7% if risk for hypoglycemia high

*patient dependent

ADA Recommendations for Glucose Control in Children/Teens

- ▣ The American Diabetes Association recommends the following blood glucose ranges for children with Type 1 diabetes.

Age	Before meals	Bedtime-Overnight	Goal A1c
Birth-6 years	90-130 100-180 *	90-150 110-200 *	<7.5%
6-12 years	90-130 90-180 *	90-150 100-180 *	<7.5%
13-19 years	90-130	90-150	<7.5%

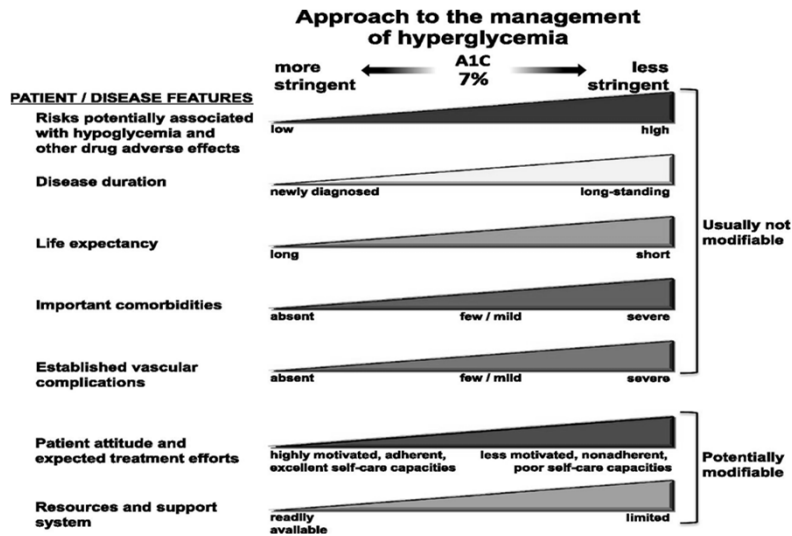
* Old recommendations but can be used to individualize

Comparison of A1C and eAG

A1c	4%	<input type="text"/>	68	eAG
	5%	<input type="text"/>	97	(mg/dl)
	6%	<input type="text"/>	126	
	7%	<input type="text"/>	154	
	8%	<input type="text"/>	183	
	9%	<input type="text"/>	212	
	10%	<input type="text"/>	240	
	11%	<input type="text"/>	269	
	12%	<input type="text"/>	298	
	13%	<input type="text"/>	326	

eAG = Estimated Average Glucose See: <http://professional.diabetes.org/GlucoseCalculator.aspx>

Depicted are patient and disease factors used to determine optimal A1C targets.
****Individually based****



American Diabetes Association Dia Care 2019;42:S61-S70



SMBG and Pattern Management

“Pattern management is a systematic approach to help patients identify patterns in their blood glucose readings to determine whether changes are needed to optimize their glucose control.”

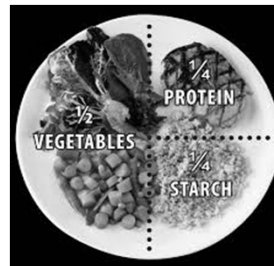
Bergental R, Pearson J, Pearson T: *Pattern Control: A Guide for Adjusting Your Insulin Dose*. Minneapolis, Minn., International Diabetes Center, 1997

PATTERN MANAGEMENT

LOOK!!!!

IS THERE A PATTERN?

- MEAL TIME
- FOOD
- EXERCISE
- WORK
- STRESS
- ILLNESS
- INSULIN ADJUSTMENT
- SKIPPED MEAL
- MISSED MED
- MENSTRUAL CYCLE
- STEROID USE



PATTERN MANAGEMENT

Frequent SMBG taken:

- Review blood glucose levels
- Identifies patterns

	Morning	Lunch	Snack	Dinner	Before Bed
1	266	193	262	104	233
2	394	215	286	212	233
3	151	252		22	133
4	11	95		132	140
5	142	201		270	120
6	157	162		159	232
7	227	239		22	109
8	193	215		235	99
9	198	212	112	130	140
10	112	117		324	247
11	104	242		219	24
12	86	271		204	211
13	94	15		269	104

- Identifies patterns of glucose levels, meals, meal times, exercise, work.
- Can show patterns of hyperglycemia, euglycemia, hypoglycemia daily so changes can be made by both the patient and provider
- Can show insulin resistance, excessive hepatic glucose production, and lack of exogenous insulin coverage.

PATTERN MANAGEMENT- look at last 3-5 days

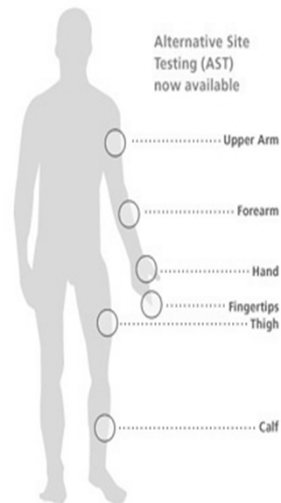
Is there a pattern that:

- happens each day at the same time?
- shows action time of insulin or oral meds?
- shows post meal hyperglycemia?
- shows fasting hyperglycemia?
- shows hypoglycemia?

IF SO-what do we do?

- Correct the hypoglycemia first
- Make small changes to determine what is working- too many changes at one time can be more confusing
- Counsel on meds, exercise, meals

TESTING



- ▣ Fingertips have been the most common area to obtain blood samples
- ▣ Alternate site testing are allowed on some meters:
 - Sites: Upper arm or forearm, palm of the hands, thighs or calves
 - May give reading 20-30 min ago
 - May give slightly lower results due to possible sample venous blood rather than capillary; or when BG changes rapidly.
 - Recommended to be consistent with site, otherwise more fluctuations when switching finger to other site

BG Testing Education

- ▣ Remember to use universal precautions w each patient- change out lancets/gloves
- ▣ Demonstrate how to test, how to use control solution, meter set up, and how to log
- ▣ Logging with date, time, BG, and med/insulin dosage
- ▣ BE SPECIFIC- how many times a day to test and when?

BG Testing

ERRORS can be caused by

- Expired strips
- Wrong strip/wrong meter
- Storage of strips- bathroom or open to air
- Strips defective- bent
- Not enough blood
- Control not performed
- Alcohol/wet hands
- Unclean hands
- Just ate-
- Temperature
- Oxygen - higher level = lower value and vice/versa
 - ▣ Should only use capillary blood samples

Factors that Affect Meter Performance

▪ Hematocrit



Glucose Oxidase Monitors:

High Concentrations:

- Acetaminophen
- Galactose
- Xylose
- L-dopa
- Ascorbic acid
- Uric acid
- Ascorbic acid (Vitamin C)
- Salicylates

Glucose Dehydrogenase Monitors:

Icodextrin

(used in peritoneal dialysis)

American Diabetes Association American Diabetes Association
Diabetes Care 2019 Jan; 42(Supplement 1): S71-S80

Patient Barriers

- ❑ Avoid terms of “good” or “bad” blood sugar results as pt may feel they are “bad” with a “bad” result
- ❑ Painful- help show different areas to obtain BG, check depth level on lancet, be sure lancet has been changed as gets dull
- ❑ Offer timing of checks that may suit there day
ex: work nightshift so “dinner time” may be in morning
- ❑ Log: ask at to keep 3-5 days worth, prior to visit as every day logging can be tedious

*Major barrier: COST!! - no insurance

- ▣ Assist patient in making goals, but realistic goals
- ▣ Stress importance of BG data is intended to help make medical decisions about their regimen - not as judgment of their ability to take care of themselves.
- ▣ Emphasize they are the ones in control and provider can only offer advice.
- ▣ Ask for input of what their goals are what can be done to achieve them.
- ▣ Ask what may be barriers for them and assist with solution.

BG and A1c readings

FALSE HIGH A1C

- ▣ RBC turnover low
- ▣ Pts with iron, Vit B 12, folate deficiency anemia's
- ▣ CKD
- ▣ Thyroid replacement

FALSE LOW A1C

- ▣ RBC turnover rapid
- ▣ Hemolysis or anemia
- ▣ Pts treated for iron, Vit B12, folate def or treatment with erythropoietin
- ▣ CKD

Hypoglycemia Prevention and Treatment

- Prevention! Prevention! Prevention!
- Glucose ≤ 70 - treat 15-20gms- conscious
- “15/15” rule:
 - 15 g of CHO, recheck glucose in 15 minutes
 - Repeat treatment if continued hypoglycemia (with fingerstick) after 15 minutes after initial treatment - want close to 100 mg dL
- Prescribe glucagon if risk of hypoglycemia or clinically significant hypoglycemia = < 54 mg/dL; unconscious
 - Train family members, caregivers in administration.
- Advise those with hypoglycemia or ≥ 1 severe hypoglycemic episode(s) to raise glycemic targets.

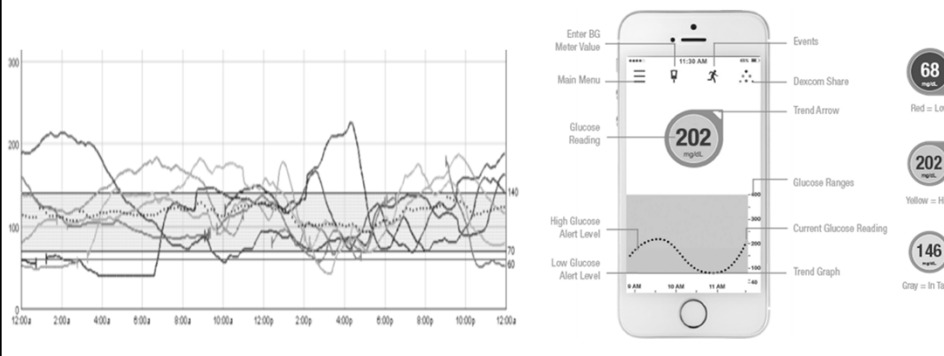
SMBG = self-monitoring of blood glucose.



ADA. *Diabetes Care*. 2015; 38 (suppl.):S11-S63 .

CGM- Continuous Glucose Monitoring

- ▣ Continuous glucose monitoring (CGM) in conjunction with intensive insulin regimens can be a useful tool to lower A1c in selected adults with type 1 diabetes.



CGM-Continuous Glucose Monitoring

- ▣ Measures glucose content of interstitial fluid which correlates to plasma glucose.
- ▣ Accessed through a subcutaneous needle sensor



- ▣ Measurements may not correlate due to lag time- WHY?
 - Glucose moves from vessels and capillaries first then interstitial fluid.

*(some studies showed hypoglycemia readings are less accurate vs. hyperglycemia on older models of CGM)
- ▣ New RCTs has proven 40% reduction of time in hypoglycemic range and decrease in amt of hypoglycemic daily events

CGMS

FDA approved 2 CGM devices for “adjunctive” treatment decisions without SMBG confirmation

- ▣ 12/20/2016 - Dexcom G5
- ▣ 09/27/17 - Freestyle Libre

2019 - ADA renamed eA1c to Glucose Management Indicator GMI so CGM can estimate A1cs.

- ▣ Studies have shown:
 - association of A1c reduction in 8-24 yo w continued use of CGM ≥ 6 day use (0.5%)
 - More use = better glycemic control
 - CONCEPT trial -Evidence now that use is beneficial for reduction in A1c levels for pregnant patients w DM1 and it improve neonatal outcomes
 - ADA states CGM w pregnancy can be used effectively

CGM-Continuous Glucose Monitoring

<u>Personal</u>	<u>Professional</u>
-“Real time” glucose shown	-Blind study
-7-10 day use	-Needs downloading
-Alarms- hypoglycemia and hyperglycemia	-3-5 day use with records of BG, food, medications, exercise
-Predicts BG, shows trends	-No alarms
-self starts	

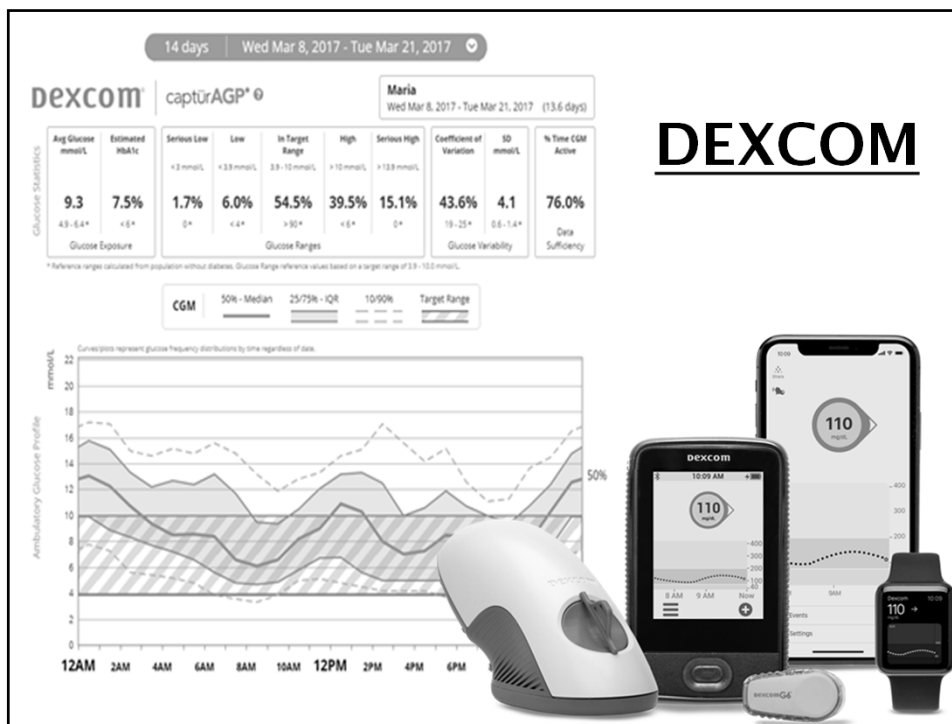
CGMS

FDA – reports for “adjunctive use” for making treatment decisions without SMBG confirmation

- Should be checking if numbers don’t correlate feeling- pre meal, before dosing insulin, before driving, when low

Candidates:

- Frequent hypoglycemia/unawareness
- Over age of 2- 2018 ADA allowing
- On or off insulin
- Motivated patients-will test
- Preconception/pregnancy



DEXCOM



- ❑ Access real time BG readings
- ❑ Trends- 1, 3, 6, 12, 24 hour graph
- ❑ Alarms – personal high/low
- ❑ Calibrate every 12 hours (with any meter-same)- G5
- ❑ Sites abdomen or upper buttocks
- ❑ DexCom Data Manger and Home Clarity software – can be shared w 5 people w follow app
- ❑ Don't use in MRI, CT scan or diathermy
- ❑ Transmits directly to iPhone/ Android, receiver, or iWatch 3series and up
-new transmitter every 3 months
- ❑ Belly and upper buttocks only
- ❑ January 13, 2017-coverage now by Medicare

DEXCOM

G5

- FDA approved for treatment decisions
- Still need to calibrate every 12 hours (2x/day)
- STILL check finger sticks for calibration, unsure of symptoms, possible stacking of insulin, exercise.
- Tylenol/Excedrin Xtra Strength contraindicated -as may falsely raise readings.
- Belly and upper buttocks only
- 7 day use
- Medicare covers - DM1, DM2 if on multiple injections

G6

- FDA approved for treatment decisions without calibration
- STILL check finger sticks for calibration, unsure of symptoms, possible stacking of insulin, exercise.
- Can use Acetaminophen - *maximum dose 1,000 mg q 6hrs
- Change in inserter to make it easier
- 10 day use
- Medicare will start to cover Spring 2019

DEXCOM

Professional use:

Dexcom G4® PLATINUM Professional CGM System

- ☐ Can be blind/unblind study
- ☐ Real-time sugars
- ☐ Reimbursement/Billable for insertion, interpretation
- ☐ Dexcom Studio Software needed

isCGM or INTERMITTENTLY SCANNED CGM

- ❑ 2019 ADA allows use but conflicting research re accuracy vs some other CGMS
- ❑ Sensor is used in arm and have a reader that is scanned over sensor to show readings or now phone app
- ❑ Available 2017 (Europe since 2014)
- ❑ Comparison studies have shown acceptable accuracy in isCGM vs SMBG but shows a slower rise in readings after meals and lower numbers in lower ranges which may have
- ❑ Those not able to or unwilling to check via fingerstick
- ❑ Pts should check via fingerstick if numbers don't match SX
- ❑ * some had allergic reaction to isobornyl acrylate contact dermatitis

isCGM: FREESTYLE LIBRE:



- ❑ 14 day use for 18 yo or older
- ❑ NO calibration due to already factory calibrated
- ❑ FDA requires 1 hour warm up time
- ❑ Measures readings via interstitial fluid every 1 minute, records every 15 minutes, displays last 8 hrs
- ❑ No alarms for low/high readings
- ❑ Lower cost
- ❑ Remove the sensor before MRI, CT scan, X-ray, or diathermy treatment
- ❑ Not approved in pregnant, on HD, or critically ill patients
- ❑ Ascorbic Acid and Salicylic Acid may interfere with the sensor readings

**isCGM:
FREESTYLE LIBRE:**



- ← Sensor:
* inserts into arm
* Size of 2 quarters stacked



- ← Reader:
* Charge every 7 days
* Scans 1 second for reading
* Stores 90 days
* Arrow shows direction of glucose trend
* Low- can be seen in 4 different 6 hr segments
* Can show 7, 14, 30, 90 day data



**LibreLINK: App for
iPHONE**

- * add notes
- * shows last 8 hrs,
- * trend arrow,
- * current glucose reading

LIBRE 10:

- ▣ 10 day sensor use
- ▣ 1st glucose reading 12hrs after application & activation

LIBRE 14:

- ▣ 14 day sensor use
- ▣ 1st glucose reading 1hr after application & activation

eversense

- ❑ 1st FDA approved CGM for 3 month use
- ❑ Implantable sensor that is professionally inserted SQ in upper arm and removed.
- ❑ 40-400 mg/dL readings
- ❑ 18 yo or older
- ❑ * complements not to replace finger sticks
- ❑ Sensor uses a “patented fluorescent, glucose indicating polymer technology” to measure glucose and then sends to its transmitter (activated by LED light, amt of light = glucose)
- ❑ DMS - Diabetes Management System software for healthcare providers - download reports

PARTS : Sensor, smart transmitter, your smart device



*Need to check sugar before treatment. Has NOT replaced finger sticks yet.

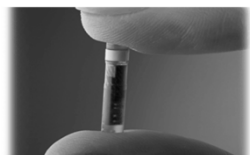
Tetracyclines may falsify readings.

Eversense Sensor. (n.d.). Retrieved from <https://www.eversenseddiabetes.com/eversense-sensor/>

eversense

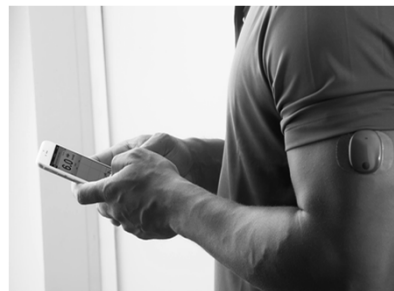
SENSOR:

- ❑ 5mm incision to upper arm with local anesthetic and inserted w custom inserter, under skin, unseen
- ❑ Incision is closed only w steri-strips - resume normal activities right away
- ❑ On body alert by vibrating if high or low, even without transmitter on
- ❑ 24 hr warm up period
- ❑ Calibrate 4 x 1st day (2-12hrs apart) then every day 2x (spaced 10-14 hrs apart)



SMART TRANSMITTER:

- ❑ rechargeable, worn on skin w silicon adhesive that can easily be put on or taken off without restarting sensor.
- ❑ Water resistant - 1 meter for 30 min
- ❑ Warm up:
- ❑ Measures glucose every 5 min even wo mobile device
- ❑ Can be removed from skin



eversense



Eversense -mobile App

Receives data from Smart Transmitter

- ❑ Share w 5 people w “My Circle” feature
- ❑ iPhone, Android, Apple Watch
- ❑ Can track trends, log exercise, meals
- ❑ Can customize alerts, low and high levels
- ❑ Set up predictive alerts to notify of trends of high and low
- ❑ Shows glucose data every 5 min but after 2cd calibration (about 26 hours after insertion)
- ❑ MARDS – 8.8%

MEDTRONIC –iPro 2 CGM

- ❑ Professional CGM
- ❑ Enlite sensor and inserter
- ❑ 6 day use
- ❑ Blind study
- ❑ Multiple patient use of recorder on pumps or MDI
- ❑ Pts can use iPro 2 myLog APP to record sugars, food, insulin amts
- ❑ Download in clinic and can bill



CGM-MEDTRONIC



*Guardian Connect APP to smartphone those on MDI.
Shows readings every 5 min to phone.

Guardian 3 sensor- 530G
pump, 630G pump,
670G pumps- use with
SmartGuard Automode

- ▣ 7 day use
- ▣ Shows readings every 5 minutes
- ▣ Shows data from past 3, 6, 12, 24 hours
- ▣ Abdomen and now arm use (14-75yo)-needs to be at least 1-2" away from pump site

Calibrate- not when low, exercise, just ate

- 2 hour warm up period
- Calibrate at 2 hours, then 6 hours, every 12 hours afterwards (3-4x a day)
- CareLink personal- downloading software
- Automatic suspension of pump when low threshold is met will alarm and suspend up to 2 hours w 530G pump

CGMS BILLING- Professional or Personal use

95250-TECHNICAL

BILL AT TIME OF HOOK UP

- *Done under supervision of provider
- ☐ Subcutaneous sensor for minimum of 72 hours
- ☐ Sensor placement/hookup
- ☐ Calibration of monitor
- ☐ Pt education
- ☐ Disconnection
- ☐ Data download recording

95251-INTERPRETIVE

- *Must be completed by Physician, NP, PA
- ☐ Review
- ☐ Interpret
- ☐ Report data
- ☐ Must be minimum of 72 hours
- ☐ No more than 1 time a month can bill
- ☐ **Does not need to be face to face but report needs to be generated - can be remote

***Currently no Medicare/Medicaid coverage and coverage is insurance specific

INSULIN PUMPS- CSII

INSULIN PUMPS HAVE BEEN IN USE FOR OVER 40 YEARS IN THE U.S.

1963:

-first insulin pump

It was as big as backpack!

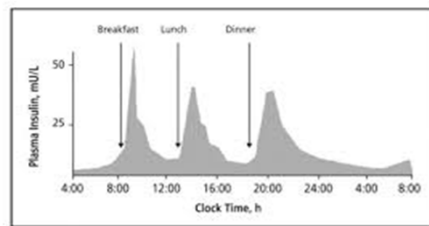


INSULIN PUMPS- CSII

Candidate:

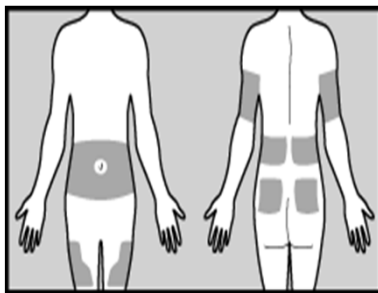
- Self motivated
- Monitors 4-6 times a day
- Self desire for good management
- Has support
- Expectations are realistic
- Insulin sensitive
- Pregnant- as macrosomia is due to hyperglycemic excursions
- Hypoglycemic unawareness

ADA states start can be at time of dx, but insurance co. may want 6 months (honeymoon, DE needed first, pt insulin needs, trouble shooting)



Drawing of normal pancreatic insulin delivery.³

INSULIN PUMPS- CSII



- ❑ Mimics the pancreas
- ❑ Programmed to deliver insulin slowly to the body through a needle or plastic cannula.
- ❑ Analog or U500 can be used
- ❑ Flexible lifestyle and mealtimes
- ❑ **Uses one injection site for 2-3 days**
- ❑ ***Evidence less risk hypoglycemia, DKA complications in youth**

INSULIN PUMPS

BASAL

- ▣ Steady, slow continuous 24 hour insulin delivered by pump to mimic pancreas-basal rate
- ▣ Hourly insulin that works between meals and overnight while suppressing glucose production
- ▣ Multiple basal rates can be programmed hour by hour from as little 0.025 u/hr
- ▣ This will take the place of basal insulin given by injection
ex: NPH, Levemir, Lantus

BOLUS

- ▣ Insulin broken down to cover 2 things
 1. Food coverage -meals, snacks
 - By cho counting, or fixed amt
 - Ex: 1 unit covers every 10 gms of food eaten
 - Ate 60 gms = 6 units
 2. Correction coverage -
 - How much BG drops w 1 unit of rapid acting insulin
 - (Correction factor or sensitivity)
 - Ex: 1:50 - 1 unit drops BG by 50 points

Target and Correction

- Target- BG goal where you want BG to be
- Correction is calculated by:
 $BG - target / sensitivity = \text{amt correction needed}$

Ex:

Target BG: 100

Current BG: 250

Sensitivity : 50

$250 - 100 / 50 = 3$ units correction to get target of 100

BASAL

- ☐ **Type 1 can NOT go without basal insulin**
 - May be off pump for 1-1.5 hours before seeing elevation. BG rises 45 mg/dL/hr after no insulin
 - Can lead to DKA if no basal for a period of time

Time of Day	Basal Level (units/hr)
12 AM - 5 AM	0.70
5 AM - 8 AM	0.90
8 AM - 1 PM	0.60
1 PM - 10 PM	0.50
10 PM - 12 AM	0.60

Clement, et al. Diab Tech Therapeutics 4: 459-466, 2002

BASAL

- ☐ Change basal rates 3-8 hours before you want it to work- think ahead
- ☐ Adjust basal from 0.05 to 0.1 unit/hr but if very sensitive can go up by 0.025u/hr
- ☐ Usually 50-60% of TDD
- ☐ Most Type 1 seem to need 2-4 different rates
- ☐ Basal rates should be similar in rate amts
Ex: 0.5 then increase to 1.2-? BIG JUMP- recheck

BASAL TOO HIGH

Are there lows:

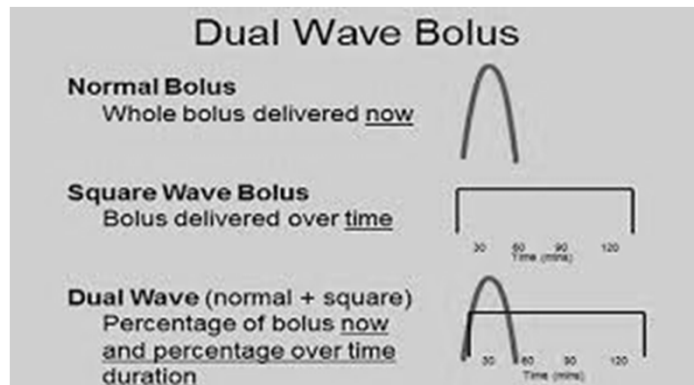
- ▣ when a meal or snack is missed?
- ▣ overnight?
- ▣ before breakfast?
- ▣ lows more than 4 hours after bolus given?
- ▣ with wt loss?
- ▣ when the basal insulin is more than 50-60% of TDD?

BASAL TOO LOW

- ▣ BG elevates with skipped meal.
- ▣ FBG elevated and no bedtime snack.
- ▣ BG frequently elevated.
- ▣ Frequent correction needed.
- ▣ Basal is less than 50-60% of TDD.

BOLUS

- ▣ Can deliver bolus by 3 ways:
 - 1. Normal: delivers all insulin at that time
 - 2. Square-wave: delivers insulin over a period time set by pt - extended
 - ▣ Good with pts w gastroparesis, banquets, high fat meal or grazing over a specific period of time
 - 3. Dual wave : some insulin given now and some over a period of time (part normal and square wave)
 - ▣ Ex: Sugar elevated before banquet meal- can give upfront 70% now (to correct elevated BG) and give the remaining amt over an hour (30% left)
 - ▣ Most pts use for high fat meals like Mexican, PIZZA, french fries – but for how long is not exact



BOLUS “Wizard” or Calculator

- ▣ Allows for exact calculation of insulin rather than fixed dose. ex: 1.85 vs. 2.0
- ▣ Considers amt of cho eaten and current blood sugar when suggesting a dose.
- ▣ Considers “insulin on board” or leftover insulin from previous bolus.
- ▣ Bolus calculation considers:
 - Cho amt, BG before the meal, CHO amt of food, target BG
- ▣ Works only if settings are correct, the cho count was correct, and if BG was entered.

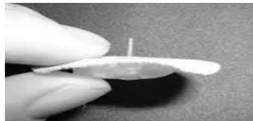
Insulin on Board

- ▣ IOB - unused amount of active insulin
- ▣ Shows how much insulin is left from previous bolus * if pt count cho accurately
 - Helps to avoid stacking
 - Improves bolus accuracy
 - If pt goes low with IOB = hint that settings need to be changed
 - Most set for 3-4 hours but can be changed
 - ▣ Pregnant pt- needs to have correction sooner to avoid PP hyperglycemia
 - ▣ Pt on steroids

PUMP Formulas- for Adults

- ▣ Total daily dose (TDD) =
Wt (kg) x 0.53 = or 25% of total of MDI *
- ▣ Carbohydrate ratio (CIR or 1:C ratio)
500 gms divided by TDD
- ▣ Correction factor = 1700 adults or 1800 children
divided by TDD
- ▣ Basal Insulin = 0.48 x TDD or (approx 50% of
TDD)

*Jeandier N, Rivelineb J-P, Tubiana-Rufi N, et al. Treatment of diabetes mellitus using an external insulin pump in clinical practice. *Diabetes and Metabolism*. 2008;34(4, supplement 1):425-438



PUMP – Infusion sets

Has 2 parts w tubing: insertion sets and reservoir

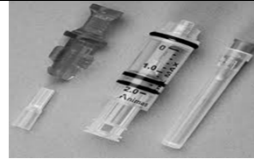
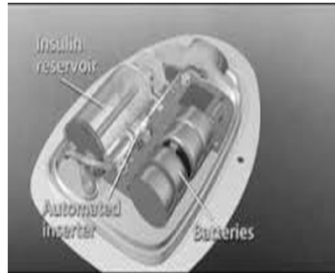
Insertion sets include:

- ▣ Tubing – leads from pump to site on pt
 - 23 inch or 43 inch tubing
- ▣ Catheter or insertion set (part that is “inserted” into the skin metal or plastic)
- ▣ Cannula lengths:
 - 12 mm for larger adults
 - 10 mm for adults
 - 8 mm for children/thin adult
 - 6 mm for infant



Reservoir:

- ▣ Container that holds the insulin inside the pump
 - Can hold 200-480 units of insulin depending on pump.



PUMP TRAINING

EDUCATION IS KEY!!!

CDE, RD: crucial for ongoing education on CHO counting, management of BG, problem solving, and how to manage: exercise, sick days, travel, or if pump malfunctions.

Education includes:

- Pre pump education - testing 4 times a day, CHO counting
- Pump start up
- Follow up, management, and ongoing education with support.

Insulin Pump Problems

- ▣ Site or tubing occlusion, or bubbles in tubing – may lead to DKA
 - BG >250 x2 row need to change all tubing, reservoir, and insulin and give injection.
 - Monitor BG frequently and urine ketones
 - Contact provider if nausea/vomiting, ketones
- ▣ Illnesses, medications
- ▣ Site infections, tape sensitivities, hematoma, not changing site every 2-3 days
- ▣ Pump malfunctions
- ▣ *Cost, insurance coverage

Insulin Pump Problems

- ▣ Increase or decrease in insulin needs- wt loss/gain
- ▣ Patient understanding
- ▣ Patient adherence – not changing site, not checking BG, not utilizing CHO wizard, forgetting to bolus
- ▣ Settings are incorrect
- ▣ Mechanical support # usually on back of pump

“The Pump is only as good as the user who uses it!”

Emergency Kit With Pumps

- ▣ Blood sugar testing equipment- meter, strips, lancets, batteries
- ▣ Site and reservoir sets
- ▣ Back up insulin-analog and basal
 - Syringes or pens
- ▣ Glucagon Emergency Kits - hypoglycemia
- ▣ Snacks
- ▣ Medic Alert
- ▣ Written settings/regimen if pump malfunctions
- ▣ Contact information if emergency
- ▣ Providers name and number

INSULIN PUMPS

Following slides are from a non-biased website for comparisons of insulin pumps

- ▣ Focus on the most common seen at MUSC:
 - T-Slim, Medtronic, Omnipod, and V-Go (Accucheck/ Animas - out of business)

All pumps basically do the same thing:

delivers insulin via basal, bolus

- Bells and whistles are different

Ex: waterproof, battery vs. rechargeable, tubing/ no tubing, delivery increments, amt of insulin held, CGM combination and now iPhone/ share compatible

Tandem t-slim X2 with BASAL IQ



- ❑ Integrated with Dexcom G6
- ❑ predicts blood sugars 30 min ahead and will suspend pump if expects sugar to drop below 80 mg/dL
- ❑ Self resumes insulin once sugar begins to rise
- ❑ Suspends up to 2 hours in 2.5 hr period
- ❑ On and off every 5 min if needed
- ❑ Shows red bar when suspended

Tandem t-slim X2

- ❑ Integrated with Dexcom G5 - can not use Basal IQ feature
- ❑ 2 hour warm up period
- ❑ Enter 1 blood sugar every 12 hours to calibrate
- ❑ Software upgrade can be down easily for G6
- ❑ Requires charging 1-2x/week- full battery lasts 1 week
- ❑ Automatic update



Tandem t-slim

Advantages:

- ❑ Modern, high-tech look, touch screen
- ❑ Rechargeable
- ❑ Compact, thin dimensions
- ❑ Rapid numeric entry, fastest bolus entry
- ❑ Cartridges hold 300u (t:slim); 480u (t:slimX2)
- ❑ Can calculate boluses up to 50 units (60 on Flex version)
- ❑ Site-change reminder can be customized day & time
- ❑ Carb counting calculator
- ❑ Temp basal up to 250%, 72 hrs
- ❑ Missed bolus reminders customizable by day of week
- ❑ Alert for high temperatures which may spoil insulin
- ❑ Compatible w/leur-lock infusion sets
- ❑ Minimal insulin movement with altitude change

Possible Drawbacks:

- ❑ Basal & bolus settings in same time slots; may take several steps to edit
- ❑ Requires charging 1-2x/week- full battery lasts 1 week

2018 New Insulin Pump Comparisons and Reviews. (n.d.). Retrieved from <https://integrateddiabetes.com/2018-new-insulin-pump-comparisons-and-reviews/>

Tandem T-slim G4 and G5



Combines Dexcom G4 Platinum CGM and also G5.
Can see BG readout on pump and with transmitter can share data to iPhone

Advantages

- ❑ Can program through clothing from a few feet away
- ❑ Discrete pump size - use arms, thighs, abdomen, back
- ❑ No tubing
- ❑ Simple, automated cannula insertion minimizes pain, reduces "human errors",
- ❑ Forced pod change reduces chances for lipodystrophy & absorption problems
- ❑ Only pump without tubing - needs PDM to deliver boluses
- ❑ Pump is fully watertight -25 feet 1 hr
- ❑ Freestyle meter built into handheld programmer
- ❑ Can customize programming text without PC linkup
- ❑ Large color screen w/ full-sentence text and graphing capability
- ❑ Only 2 parts; convenient for travel
- ❑ Can use Dexcom but separately now

Omnipod



2018 New Insulin Pump Comparisons and Reviews. (n.d.). Retrieved from <https://integrateddiabetes.com/2018-new-insulin-pump-comparisons-and-reviews/>

OMNIPOD -DASH



- ❑ Due out Jan 2019
- ❑ New Android PDM platform can be used on phone as well
- ❑ "Find my PDM" feature
- ❑ Remote - bolus
- ❑ Share status with up to 12 people
- ❑ Phone APP will have widget can see both CGM and insulin delivery together
- ❑ Calorie King food diary w 80,000 items for easy cho look up
- ❑ Contour Next One meter to automatically transfer sugar into DASH PDM
- ❑ Bluetooth technology
- ❑ CHO ratios <1gm
- ❑ Won't have built in meter - switching to Contour Next One

Omnipod

Possible disadvantages

- ❑ Somewhat bulky programmer and pod creates a “bulge” on the skin under clothes
- ❑ Cannot enter boluses or make setting changes without programmer- basal delivery only
- ❑ Only one cannula orientation/length; may not work for all body types
- ❑ Max reservoir volume 200u; minimum fill amount 85u
- ❑ Pod stops working after 72 hours (plus grace period)
- ❑ “Disconnection” requires complete pod replacement
- ❑ Must suspend when changing basal settings
- ❑ Temp basal limited to 12 hours max
- ❑ Insulin-to-carb ratios in whole-numbers increments only
- ❑ Loss (or malfunction) of remote/PDM renders pod non-programmable (delivers basal only)
- ❑ DASH pods only w DASH PDM
- ❑ Not integrated w CGM yet but has Widget

2018 New Insulin Pump Comparisons and Reviews. (n.d.). Retrieved from <https://integrateddiabetes.com/2018-new-insulin-pump-comparisons-and-reviews/>



Advantages:

- ❑ Large, secure, long-established company
- ❑ Pump comes with integrated Enlite CGM or Guardain 3 system (670G); data displayed on pump screen
- ❑ Automatic basal shutoff when low glucose detected by sensor (may help prevent severe hypos)- SmartGuard Technology
- ❑ Minimed Connect App
- ❑ Quick/simple bolus programming
- ❑ Slim/streamlined attachable clip
- ❑ Optional remote control (@ addl. cost)
- ❑ Accepts radio communication from multiple blood glucose meters
- ❑ Easily downloadable to online Carelink program
- ❑ Can set I:C ratios in .1g increments
- ❑ Generates insulin/carb/BG statistics



Medtronic



630G →

← 530G



- ❑ Oct 2018- no longer selling
 - ❑ NO color screen
 - ❑ Enlite sensor 7 days
 - ❑ Water resistant 3.2 feet for 30 min
 - ❑ Stores 40 min of missed data
 - ❑ 16 yo/older
 - ❑ Mobile monitoring
 - ❑ SmartGuard technology automatically stops insulin sugar reaches a preset low limit, and you don't respond to alerts for up to 2 hrs.
 - ❑ Shows readings every 5 min.
- ❑ Color screen
 - ❑ Enlite sensor 7 days –now with Guardian 3 sensor/transmitter
 - ❑ Waterproof 12 feet 24 hrs
 - ❑ Stores 10 hrs of missed data
 - ❑ 16 yo/older
 - ❑ SmartGuard technology automatically stops insulin sugar reaches a preset low limit, and you don't respond to alerts- for up to 2 hrs.
 - ❑ Contour Next Link 2.4 meter
 - ❑ Remote bolus w meter
 - ❑ Predictive alert can let you know 30 min before a low/high
 - ❑ Shows readings every 5 min

MEDTRONIC 670G – FIRST CLOSED LOOP HYBRID INSULIN PUMP



- ❑ ONLY insulin pump “CLOSED LOOP” which self regulates basal rates to control blood sugars.
- ❑ DM1 only, 14 yrs and older
- ❑ Not for children < 7 yrs old or < 8 units insulin/day
- ❑ NEW GUARDIAN 3 SENSOR – 7 day use
- ❑ AUTO MODE option– every 5 minutes adjusts insulin/basal amt based on sensor blood sugars
- ❑ SUSPEND BEFORE LOW – automatically suspends pump 30 minutes before reaching preset low threshold number, then automatically resumes to avoid rebound hyperglycemia when recover
- ❑ CONTOUR NEXT 2.4 METER – remote, meter, and used to calibrate directly to pump. ONLY USE THIS METER WITH THIS PUMP.



MEDTRONIC 670G

NOT intended for those that:

- ▣ Are under 7
- ▣ Use less than 8 units/day
- ▣ Pregnant
- ▣ Impaired kidney function
- ▣ U100 insulin only
- ▣ Only use blood sugars from Contour Next 2.4 meter
- ▣ No alternate site testing to be used to calibrate
- ▣ Don't calibrate if blood sugars rapidly changing ex. Low, exercise
- ▣ Recommended to calibrate 3-4 times a day; at least every 12 hrs

MEDTRONIC 670G



- ▣ No set basal - adjusts background basal based on CGMS
- ▣ No set correction
- ▣ Target set 120
 - Temp target 150 - exercise
- ▣ Only can change CHO ratio (usually needs to be more aggressive) and Insulin on Board time
- ▣ Day starts at 12 MN
 - Learns pattern 2-3 days
- *NEW FINDINGS*
 - Action time not as important
 - For manual mode divide total basal on automode by 24 hours for manual mode basal
 - Target suggested 100-150
 - Calibrate vs enter BG now
 - ▣ Sensor vs transmitter

NEW!!! Medtronic 670G with Guardian Sensor 3



NOT intended for those that:

- Are under 7
- Use less than 8 units/day
- Pregnant
- Impaired kidney function

- ☐ First "Hybrid Closed Loop System"
- ☐ Will automatically increase/decrease basal insulin based on CGM readings and suspend insulin based on low threshold
- ☐ New Sensor w 7 day use, need to calibrate 3x day
- ☐ 14 years and older w DM1
- ☐ *NO basal-pump gives minute amt of boluses making up for bolus
- ☐ *Usually need to change cho ratios, IOB to be more aggressive
- ☐ Waterproof 12 feet-24hrs

MiniMed Guardian Connect

- ☐ Remote monitoring Info from pump to Uploader then transfers info to iPhone/iPod and CareLink automatically
- ☐ HCP can get access
- ☐ Alerts 10-60 min before low, see trends right on phone (iphone only for now)
- ☐ Sugar IQ app - shows patterns/trends of how food, exercise, daily routines



MiniMed

Possible Disadvantages:

- ❑ Not water-tight- but new 630G is
- ❑ Must purchase CGM system along with pump –MEDICARE NOT COVERED
- ❑ Must use their infusion set tubing
- ❑ Must purchase CGM system along with the pump
- ❑ Must pay for loaner/backup pumps
- ❑ Holds 180 units; 300-unit version is slightly larger
- ❑ Insulin-on-board only deducted from correction boluses
- ❑ CGM system accuracy, longevity, transmission range, ease of use considered inferior to competitors
- ❑ CGM & pump alerts may not be loud enough for some to hear- many alarms = ALARM FATIGUE
- ❑ Data from pump/CGM not downloadable to any program other than Carelink & Carelink Pro
- ❑ Much more button pushing

2018 New Insulin Pump Comparisons and Reviews. (n.d.). Retrieved from <https://integrateddiabetes.com/2018-new-insulin-pump-comparisons-and-reviews/>

V-Go: Patch Pump

V-Go option	Preset basal rate	+ On-demand bolus dosing	= Total available insulin
VGO® 20 <small>DISPOSABLE INSULIN DELIVERY</small>	20 Units/24 hr (0.83 U/hr)	+ Up to 36 Units in 2-Unit increments*	= 56 Units
VGO® 30 <small>DISPOSABLE INSULIN DELIVERY</small>	30 Units/24 hr (1.25 U/hr)	+ Up to 36 Units in 2-Unit increments*	= 66 Units
VGO® 40 <small>DISPOSABLE INSULIN DELIVERY</small>	40 Units/24 hr (1.67 U/hr)	+ Up to 36 Units in 2-Unit increments*	= 76 Units

❑ Valeritas V-Go

- For DM 2 only
- 1 Day use only
- Preset basals (can't be changed)
- On demand boluses – 2 unit @ click, analog insulin only

Wear it on back of arm, abdomen, back or thigh.

V-GO: Patch Pump

3 Options:

V-Go 20 - 20 unit basal 24 hr (0.83 U/hr)

V-Go 30 - 30 unit basal 24 hr (1.25 U/hr)

V-Go 40 - 40 unit basal 24 hr (1.67 U/hr)

*All on demand bolus same amt of 36 units in 2 unit increments every 24 hours however

(18 clicks a day = 36 units bolus daily only)



Initiation of V-GO

Patient's body weight

≤220 lb

x 0.45 kg/lb x 0.5 U/kg

Basal rate
V-Go 20
Units/24 hours

Bolus dosing
3 clicks/meal
1 click = 2 Units

20 basal-18 bolus (IUs)
~53%/47% basal-bolus

>220 lb

Basal rate
V-Go 30
Units/24 hours

Bolus dosing
4 clicks/meal
1 click = 2 Units

30 basal-24 bolus (IUs)
~56%/44% basal-bolus

Snacks

1-2 clicks/snack

Celebrities with Diabetes

- | | |
|------------------------------------|---------------|
| ▣ Tom Hanks -actor | ▣ Type 2 |
| ▣ Nick Jonas -singer | ▣ Type 1 |
| ▣ Halle Berry - actress | ▣ Type 1 |
| ▣ Kris Freeman-
Olympian skier | ▣ Type 1 |
| ▣ Salma Hayek - actress | ▣ Gestational |
| ▣ Paula Deen - chef | ▣ Type 2 |
| ▣ Anne Rice - author | ▣ Type 1 |
| ▣ Mary Tyler Moore -
actress | ▣ Type 1 |
| ▣ Nicole Johnson - Miss
America | ▣ Type 1 |
| ▣ Morgan Freeman -
actor | ▣ Type 2 |

Learning Assessment Question #1

- ▣ True/false: The FDA has approved Continuous Glucose Monitoring devices for adjunctive treatment decisions without SMBG confirmation.

True

Learning Assessment Question #2

- ▣ Which of the following is a continuous glucose monitoring (CGM) system?
 - a) Dexcom G6
 - b) Freestyle Libre
 - c) Omnipod Dash
 - d) V-Go
 - e) A and B

Thank
you



Miss Idaho wears an insulin pump

References

- 2018 New Insulin Pump Comparisons and Reviews. (n.d.). Retrieved from <https://integrateddiabetes.com/2018-new-insulin-pump-comparisons-and-reviews/>
- 6. Glycemic Targets: Standards of Medical Care in Diabetes?2019. (2019, January 1). Retrieved from <https://doi.org/10.2337/dc19-S006>
- Eversense Sensor. (n.d.). Retrieved from <https://www.eversenseddiabetes.com/eversense-sensor/>
- Insulin Pump Therapy Is Associated with Lower Rates of Retinopathy and Peripheral Nerve Abnormality. (2016, April 6). Retrieved from <https://doi.org/10.1371/journal.pone.0153033>
- Mary Ann Liebert | Error. (n.d.). Retrieved from <https://doi.org/10.1089/dia.2018.0115>
- Battelino, T., Phillip, M., Bratina, N., Nimri, R., Oskarsson, P., & Bolinder, J. (2011). Effect of Continuous Glucose Monitoring on Hypoglycemia in Type 1 Diabetes. *Diabetes Care*, 34(4), 795-800. doi:10.2337/dc10-1989
- Christiansen, M. P., Klaff, L. J., Brazg, R., Chang, A. R., Levy, C. J., Lam, D., ... Bailey, T. S. (2018). A Prospective Multicenter Evaluation of the Accuracy of a Novel Implanted Continuous Glucose Sensor: PRECISE II. *Diabetes Technology & Therapeutics*, 20(3), 197-206. doi:10.1089/dia.2017.0142
- Heinemann, L., Freckmann, G., Ehrmann, D., Faber-Heinemann, G., Guerra, S., Waldenmaier, D., & Hermanns, N. (2018). Real-time continuous glucose monitoring in adults with type 1 diabetes and impaired hypoglycaemia awareness or severe hypoglycaemia treated with multiple daily insulin injections (HypoDE): a multicentre, randomised controlled trial. *The Lancet*, 391(10128), 1367-1377. doi:10.1016/s0140-6736(18)30297-6
- Karges, B., Schwandt, A., Heidtmann, B., Kordonouri, O., Binder, E., Schierloh, U., ... Holl, R. W. (2017). Association of Insulin Pump Therapy vs Insulin Injection Therapy With Severe Hypoglycemia, Ketoacidosis, and Glycemic Control Among Children, Adolescents, and Young Adults With Type 1 Diabetes. *JAMA*, 318(14), 1358. doi:10.1001/jama.2017.13994
- Miller, K. M., Beck, R. W., Bergenstal, R. M., Goland, R. S., Haller, M. J., & McGill, J. B. (2013). Evidence of a Strong Association Between Frequency of Self-Monitoring of Blood Glucose and Hemoglobin A1c Levels in T1D Exchange Clinic Registry Participants. *Diabetes Care*, 36(7), 2009-2014. doi:10.2337/dc12-1770
- Wong, J. C., Foster, N. C., Maahs, D. M., Raghinaru, D., Bergenstal, R. M., Ahmann, A. J., ... Adi, S. (2014). Real-Time Continuous Glucose Monitoring Among Participants in the T1D Exchange Clinic Registry. *Diabetes Care*, 37(10), 2702-2709. doi:10.2337/dc14-0303

Type 1 diabetic:

Lantus : 24 units in morning 9am

Novolog:

- 6 units with breakfast

-8 units with lunch

-12 units with dinner

Upon questioning:

-Eats oatmeal for breakfast with glass of milk

-Eats usually sandwich for lunch

-Big dinner: low cho, high protein and mostly veg.

-No snack before bed

Pattern Management CASE 1

Time	Monday	Tuesday	Wend
Before breakfast	193	186	215
Before lunch	287	198	227
Before dinner	162	147	142
Before bed	125	102	119

Type 1 diabetic:

Lantus : 24 units in morning 9am

Novolog:

- 6 units with breakfast

-8 units with lunch

-12 units with dinner

Is there a Pattern?:

-elevated in the am

-elevated pre lunch

-good pre dinner, bedtime

What are the Solutions?:

-Increase lantus

-Split lantus-?

-Increase breakfast dose

-Teach CHO counting

-Give correction scale

**Pattern
Management
CASE 1**

Time	Monday	Tuesday	Wend
Before breakfast	193	186	215
Before lunch	287	198	227
Before dinner	162	147	142
Before bed	125	102	119

Type 2 diabetic:

Metformin 1000 mg po bid

Glipizide 10 mg po bid

CASE 2

Upon questioning:

-Eats only "Nabs" for lunch, not hungry

-Has been weeding in garden

-Feels shaky around 80

-Gets meals on wheels

Time	Monday	Tuesday	Wend
Before breakfast	60	83	74
Before lunch	100	68	83
Before bed	81	79	103

Type 2 diabetic:

Metformin 1000 mg po bid

Glipizide 10 mg po bid

CASE 2

What are the Problems?:

- Hypoglycemia - too many
- Exercise
- On sulfonylurea and not eating consistently
- One meal a day guaranteed
- Too much medication

What are some Solutions?:

- Increase intake especially with lunch, exercise
- Snack with exercise/gardening
- Decrease glipizide or stop it depending on A1c

Time	Monday	Tuesday	Wend
Before breakfast	60	83	74
Before lunch	100	68	83
Before bed	81	79	103