METERS, MONITORS, PUMPS

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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
1. SELF MONITORING OF GLUCOSE LEVELS – METERS

2. CONTINUOUS MONITORING - CGM/SENSORS, SCANNERS

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

**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.


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**GLYCEMIC GOALS: ADA AND AACE GUIDELINES**

*(non pregnant)*

<table>
<thead>
<tr>
<th><em>Patient dependent</em></th>
<th>ADA</th>
<th>AACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPG</td>
<td>80-130</td>
<td>&lt;110</td>
</tr>
<tr>
<td>2 hour PPG (mg/dL)</td>
<td>&lt;180</td>
<td>&lt;=140</td>
</tr>
<tr>
<td>A1C</td>
<td>&lt;7.0%</td>
<td>&lt;=6.5%</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Blood Glucose</th>
<th>ACOG/ADA GDM Goals</th>
<th>ADA Goals - Pregnant Diabetics</th>
<th>AACE Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasting &lt;=95 mg/dL</td>
<td>60-99 mg/dL</td>
<td>&lt;90-95 mg/dL</td>
<td></td>
</tr>
<tr>
<td>1 hour postprandial</td>
<td>&lt;=140 mg/dL</td>
<td>100-129 mg/dL</td>
<td>120-140 mg/dL</td>
</tr>
<tr>
<td>2 hours postprandial</td>
<td>&lt;=120 mg/dL</td>
<td>100-129 mg/dL</td>
<td>120-140 mg/dL</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Age</th>
<th>Before meals</th>
<th>Bedtime-Overnight</th>
<th>Goal A1c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth-6 years</td>
<td>90-130</td>
<td>90-150 *</td>
<td>&lt;7.5%</td>
</tr>
<tr>
<td>6-12 years</td>
<td>90-130</td>
<td>90-150 *</td>
<td>&lt;7.5%</td>
</tr>
<tr>
<td>13-19 years</td>
<td>90-130</td>
<td>90-150 *</td>
<td>&lt;7.5%</td>
</tr>
</tbody>
</table>

* Old recommendations but can be used to individualize.

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**Comparison of A1C and eAG**

<table>
<thead>
<tr>
<th>A1c</th>
<th>eAG (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4%</td>
<td>68</td>
</tr>
<tr>
<td>5%</td>
<td>97</td>
</tr>
<tr>
<td>6%</td>
<td>126</td>
</tr>
<tr>
<td>7%</td>
<td>154</td>
</tr>
<tr>
<td>8%</td>
<td>183</td>
</tr>
<tr>
<td>9%</td>
<td>212</td>
</tr>
<tr>
<td>10%</td>
<td>240</td>
</tr>
<tr>
<td>11%</td>
<td>269</td>
</tr>
<tr>
<td>12%</td>
<td>298</td>
</tr>
<tr>
<td>13%</td>
<td>326</td>
</tr>
</tbody>
</table>

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**

**Approach to the management of hyperglycemia**

- **Patient/Disease Features**
  - Risks potentially associated with hypoglycemia and other drug adverse effects
  - Disease duration
  - Life expectancy
  - Important comorbidities
  - Established vascular complications
  - Patient attitude and expected treatment efforts
  - Resources and support system

- **A1C**
  - More stringent (7%)
  - Less stringent

- **Potential modifications**
  - Usually not modifiable
  - Potentially modifiable


**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.”
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

• 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)

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**

<table>
<thead>
<tr>
<th>FALSE HIGH A1C</th>
<th>FALSE LOW A1C</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBC turnover low</td>
<td>RBC turnover rapid</td>
</tr>
<tr>
<td>Pts with iron, Vit B 12, folate deficiency anemia's</td>
<td>Hemolysis or anemia</td>
</tr>
<tr>
<td>CKD</td>
<td>Pts treated for iron, Vit B12, folate def or treatment with erythropoietin</td>
</tr>
<tr>
<td>Thyroid replacement</td>
<td>CKD</td>
</tr>
</tbody>
</table>
**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.

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**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.
**Continuous Glucose Monitoring (CGM)**

- 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 amount 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

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

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
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

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**DEXCOM**

Professional use:

Dexcom G4<sup>®</sup> 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

**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

LibreLINK: App for iPhone
- add notes
- shows last 8 hrs,
- trend arrow,
- current glucose reading
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.


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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 - mobile App**

- Receives data from Smart Transmitter
- Share with 5 people with “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 2nd calibration (about 26 hours after insertion)
- MARDs – 8.8%

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**MEDTRONIC – iPro 2 CGM**

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

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

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

<table>
<thead>
<tr>
<th>95250-TECHNICAL</th>
<th>95251-INTERPRETIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BILL AT TIME OF HOOK UP</td>
<td>*Must be completed by Physician, NP, PA</td>
</tr>
<tr>
<td>*Done under supervision of provider</td>
<td></td>
</tr>
<tr>
<td>□ Subcutaneous sensor for minimum of 72 hours</td>
<td>□ Review</td>
</tr>
<tr>
<td>□ Sensor placement/hookup</td>
<td>□ Interpret</td>
</tr>
<tr>
<td>□ Calibration of monitor</td>
<td>□ Report data</td>
</tr>
<tr>
<td>□ Pt education</td>
<td>□ Must be minimum of 72 hours</td>
</tr>
<tr>
<td>□ Disconnection</td>
<td>□ No more than 1 time a month can bill</td>
</tr>
<tr>
<td>□ Data download recording</td>
<td>□ **Does not need to be face to face but report needs to be generated – can be remote</td>
</tr>
</tbody>
</table>

***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!
**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)

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**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 = amt correction needed

  Ex:
  - Target BG: 100
  - Current BG: 250
  - Sensitivity : 50

  \[
  250 - 100 / 50 = 3 \text{ units correction to get target of 100}
  \]
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

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Basal Level (units/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 AM – 5 AM</td>
<td>0.70</td>
</tr>
<tr>
<td>5 AM – 8 AM</td>
<td>0.50</td>
</tr>
<tr>
<td>8 AM – 1 PM</td>
<td>0.60</td>
</tr>
<tr>
<td>1 PM – 10 PM</td>
<td>0.50</td>
</tr>
<tr>
<td>10 PM – 12 AM</td>
<td>0.60</td>
</tr>
</tbody>
</table>


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)


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.

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.

PUMP TRAINING

EDUCATION IS KEY!!!
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
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
- 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

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 -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

Advantages:
- Large, secure, long-established company
- Pump comes with integrated Enlite CGM or Guardian 3 system (670G); data displayed on pump screen
- Automatic basal shut off 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

- Color screen
- Enlite sensor 7 days –now with Guardian 3 sensor/transmitter
- 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.

 meld

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- Enlite sensor 7 days –now with Guardian 3 sensor/transmitter
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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**

- 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

**NOT intended for those that:**
- Are under 7
- Use less than 8 units/day
- Pregnant
- Impaired kidney function

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**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

V-Go: Patch Pump

- **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

<table>
<thead>
<tr>
<th>Patient's body weight</th>
<th>Basal rate</th>
<th>Bolus dosing</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤220 lb</td>
<td>V-Go 20</td>
<td>3 clicks/meal</td>
</tr>
<tr>
<td>≥220 lb</td>
<td>V-Go 30</td>
<td>4 clicks/meal</td>
</tr>
</tbody>
</table>

2x basal-18 bolus (IU) ~53%/47% basal-bolus
3x basal-24 bolus (IU) ~56%/44% basal-bolus

Snacks
1-2 clicks/snack
Celebrities with Diabetes

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

- Type 2
- Type 1
- Type 1
- Type 1
- Gestational
- Type 2
- Type 1
- Type 1
- Type 1
- 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

Miss Idaho wears an insulin pump
### References


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### 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

<table>
<thead>
<tr>
<th>Pattern Management</th>
<th>CASE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time</strong></td>
<td>Monday</td>
</tr>
<tr>
<td>Before breakfast</td>
<td>193</td>
</tr>
<tr>
<td>Before lunch</td>
<td>287</td>
</tr>
<tr>
<td>Before dinner</td>
<td>162</td>
</tr>
<tr>
<td>Before bed</td>
<td>125</td>
</tr>
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**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

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<td>125</td>
<td>102</td>
<td>119</td>
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**Type 2 diabetic:**
Metformin 1000 mg po bid
Glipizide 10 mg po bid

Upon questioning:
- Eats only “Nabs” for lunch, not hungry
- Has been weeding in garden
- Feels shaky around 80
- Gets meals on wheels

**CASE 2**

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</tr>
</thead>
<tbody>
<tr>
<td>Before breakfast</td>
<td>60</td>
<td>83</td>
<td>74</td>
</tr>
<tr>
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<td>100</td>
<td>68</td>
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<td>103</td>
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CASE 2

Type 2 diabetic:
Metformin 1000 mg po bid
Glipizide 10 mg po bid

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

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