MVH Grand Rounds – Glucose Management
May 2, 2024
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TEXT ATTENDANCE

Please text **2289** to 855-618-2034

to submit your attendance for this grand rounds event.

You have 60 minutes prior, during and 120 minutes after the end of the event to text in your attendance.

The evaluation for this event will be sent once you text your attendance in. You must complete the evaluation to get your CME certificate.

Any questions please contact India Myers (ilmyers@premierhealth.com) or Dana Mackert (dlmackert@premierhealth.com

Miami Valley Hospital Medical Staff Grand Rounds

Presents

Headaches

Presented by Dr. Glen D. Solomon and Dr. Richard Kim

Thursday, June 6, 2024

12:00 – 1:00 PM

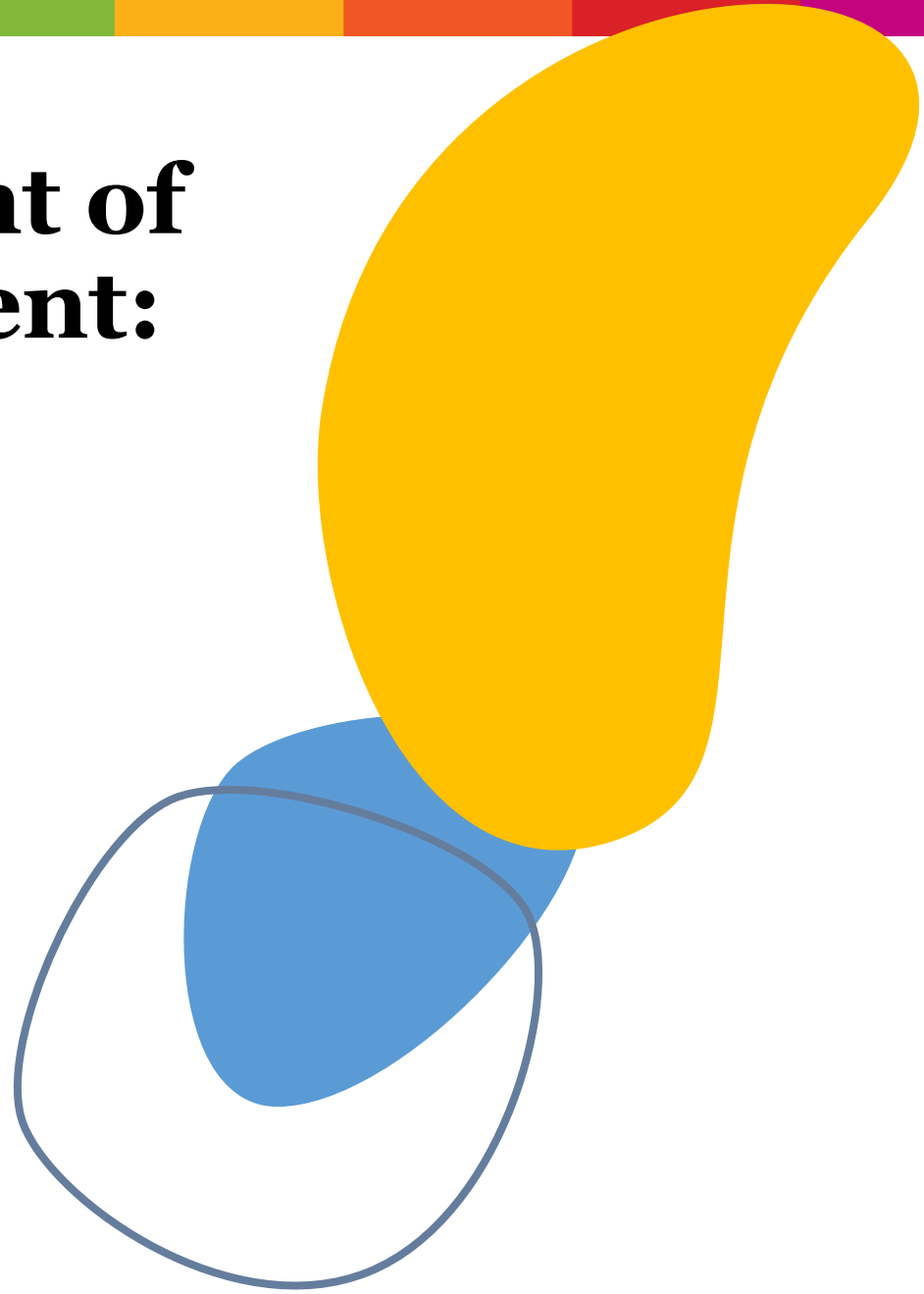
CME Credit Available

Information will be sent out next week!

Glycemic Management of the Hospitalized Patient: A Practical Approach

Maher Al-Samkari D.O.
Miami Valley Hospitalist Group
5/2/2024

*No financial associations or disclosures



Premier Health

Background

First, a bit of history…

Background

- Diabetes is an endocrine disorder of glucose metabolism.
- Practically described in an Egyptian manuscript from 1500 BCE as the ‘Too great emptying of urine’
- Term “diabetes” often attributed to Apollonius of Memphis in 250 BCE (”Siphon”, Greek = ‘Dia’ - through; ‘Betes’ - to go). Mellitus (Latin = honey, sweet).
- Advocated treatment with wheat grains, fruits, and sweet beer.

StatPearls. Treasure Island (FL): StatPearls Publishing; 2024 Jan.

Background

- In modern terms, it is resolved into four (broadly defined) types:
  - Type 1
  - Type 2
  - Gestational
  - Additional subtypes (“LADA,” “Steroid induced,” “CFR DM”).

Suzuki S. [Secondary diabetes]. Nihon Rinsho. 1999 Mar;57(3):637-43. Japanese. PMID: 10199147.

Background

- **Primary and secondary causes are numerous**
    - Endocrine pancreatic insufficiency (surgical, inflammatory)
    - Cushing's Syndrome
    - MODY
    - Mitochondrial Diabetes
- Distinction between subtypes is defined more so by the **primary mechanism of the dysfunction** (Insulin deficiency / resistance) rather than the **process that has led to it, as there may be overlap.**

Nomiyama T, Yanase T. [Secondary diabetes]. Nihon Rinsho. 2015 Dec;73(12):2008-12. Japanese. PMID: 26666145.

Background – Type 1 DM

- Type 1 Diabetes (*formerly* 'Juvenile,' or 'IDDM,') results from the failure of the pancreas to produce insulin.
- This may result from autoimmune destruction of insulin producing islet-cells, or surgical removal of the gland.
- These patients have an **absolute** insulin deficiency, and require insulin to live and comprise <10% of the total diabetic population.
- May have concurrent insulin resistance (either via medication, comorbid disease processes) that can confound glycemic control.

Background – Type 2 DM

- Type 2 Diabetes (*formerly* 'adult-onset' or 'NIDDM') results from resistance of the peripheral tissues to endogenous insulin. This is usually the result of combined **genetic** and **environmental** factors.

- These patients have a **relative** insulin deficiency, and in the outpatient setting management may vary from diet, to oral and injectable non-insulin agents, to insulin alone.

- Comprise 90% of the diabetic population

- Type 2 Diabetics can develop an absolute insulin deficiency which can convey elements of a Type 1 presentation.

Background – Gestational DM

- Gestational diabetes is a distinct entity similar to Type 2.
- Factors related to hormone and metabolic changes in pregnancy potentiate insulin resistance in a patient who may or may not be diabetic otherwise.
- Treated with diet, oral medication, or insulin.

Background –IDDM and NIDDM

- “IDDM” and ”NIDDM” is are terms best avoided
- Low-utility terminology - Doesn’t effectively differentiate between subtypes or the mechanisms at play.
- All human beings are dependent on insulin to live.
- Insulin is not necessarily the end-point of type 2 diabetes.

Background - Statistics

- As of 2021, and estimated 38.4 million Americans, or 11.6% of the population, had diabetes.
- Remains the **8th** leading cause of death in the United States, based on the **104,294** death certificates in which diabetes was listed as the underlying cause of death.
- however given the disease's **contribution** to other co-morbid conditions, this is vastly underreported. In 2021, diabetes was mentioned as a cause of death in a total of **399,401** certificates.

Centers for Disease Control.(2023). National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States. https://www.cdc.gov/diabetes/data/statistics-report/index.html

Background – Statistics 2023(2015)

- $412.9 ($245) billion: Total costs of diagnosed diabetes in the United States in 2012
- $306.6 ($176) billion for direct medical costs
- $106.3($69) billion in reduced productivity
- Avg. medical expenditures among people with diagnosed diabetes were **2.6 times higher** than in the absence of diabetes.

American Diabetes Assoc.(2023). Statistics About Diabetes. https://diabetes.org/about-diabetes/statistics/about-diabetes

Background - The Broad View

- Hyperglycemia, whatever the cause, unequivocally associated with adverse outcomes in hospitalized patients.

- Data derived from observational studies have long demonstrated a strong association between hyperglycemia and complications:

  - **Infection** (due to disrupted WBC function)
  - **Dehydration**, (which will contribute to acute kidney injury)
  - **Prolonged length of stay** (both ICU and medical floor)
  - **Disability after discharge**, and death.

Background - The Broad View

- Variability in responses to hospital interventions are due to several factors:
  - Differences in insulin treatment protocols and implementation
  - Differing glycemic targets.
  - Patient populations (General Floor / Surgical / ICU).
  - Methods for glucose monitoring.
  - Insulin adjustment algorithms.

Background - The Broad View

Triage glucose testing essential for all admissions.

Identification of those patients with known diagnosis and their degree of control.

Identification of those patients with previously unknown diagnosis.

Appropriate glucose goals based on the care setting.

Avoidance and treatment of hypoglycemia.

Establishing appropriate post-discharge care.

The Initial Approach

- Endocrine Society guidelines recommend all patients with a **BG greater than 140 mm/dL** be monitored with bedside POC testing initially.

- Should include all previously normoglycemic patients receiving therapies such as **corticosteroids, octreotide, enteral and parenteral nutrition**.

American Diabetes Assoc.(2023). American Association of Clinical Endocrinologists and American Diabetes Association Consensus Statement on Inpatient Glycemic Control

Assessing Control

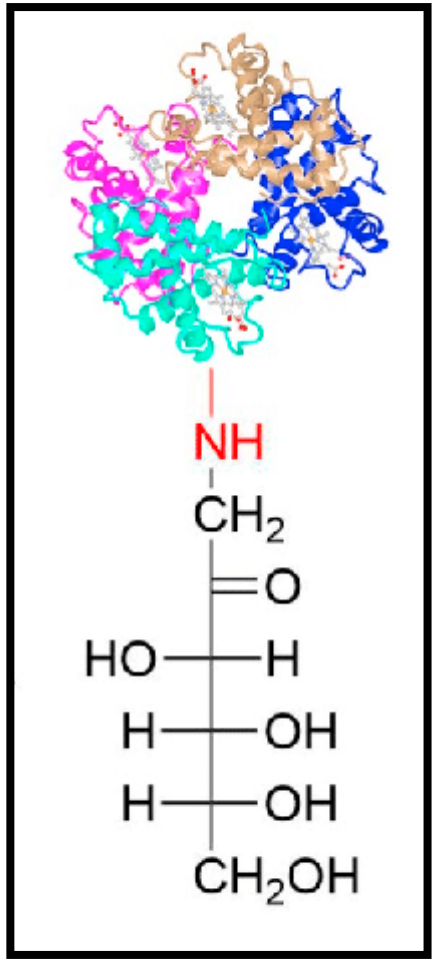
- Glycosylated hemoglobin should be component, not a replacement for adequate glycemic control history.
- Additionally, HbA1C is of **lower utility** in patients with chronic renal / liver disease, and patients with hereditary blood dyscrasias
- Sporadically may be inaccurate due to anomalies within the hb molecule.
- Fructosamine levels (essentially glycosylated albumin) can provide a less precise picture of glycemic control.

BMC Endocr Disord. 2023; 23: 24.

Assessing Control

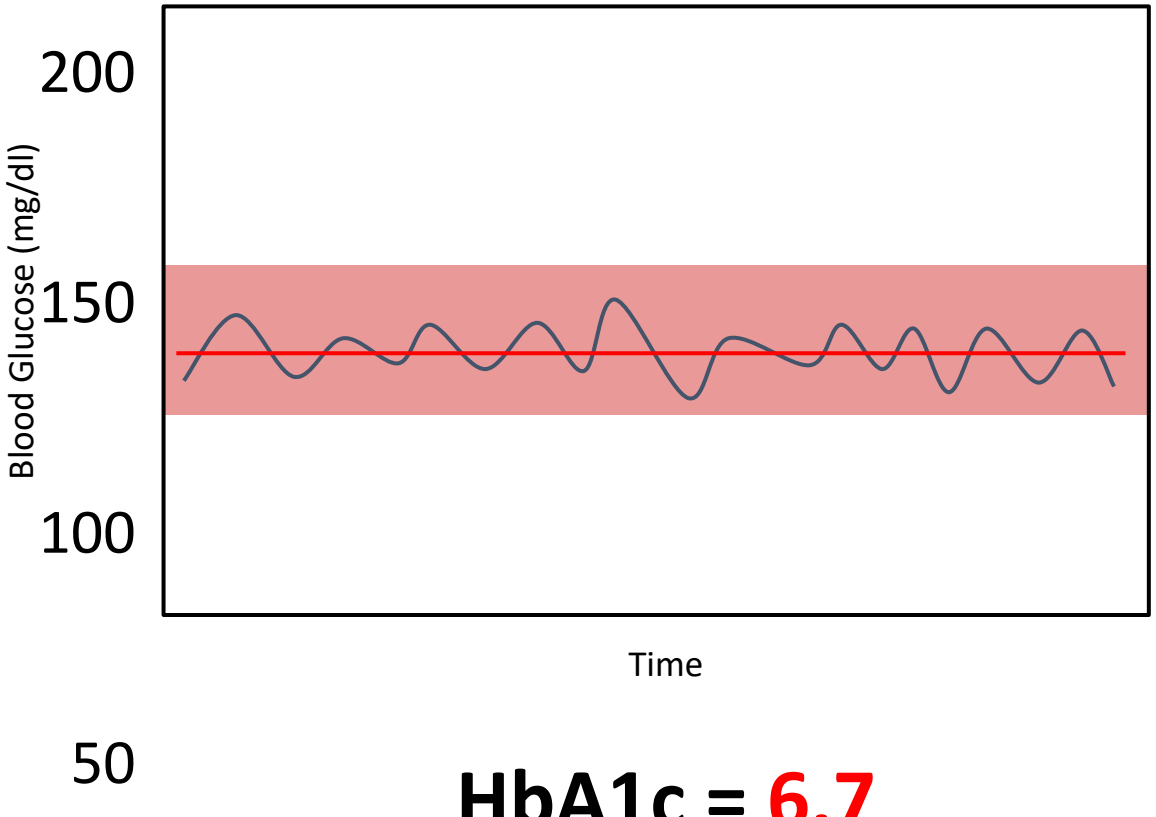
- HBA1c can be viewed as a **coarse measure** that conveys an average. Thus a 'desirable' value can mask variability.

- Multiple potential confounders:
  - Chronic kidney disease
  - Liver disease
  - Anemia (Chronic, Fe deficiency, thalassemia, hemoglobinopathies, genetic variations)
  - Blood transfusions

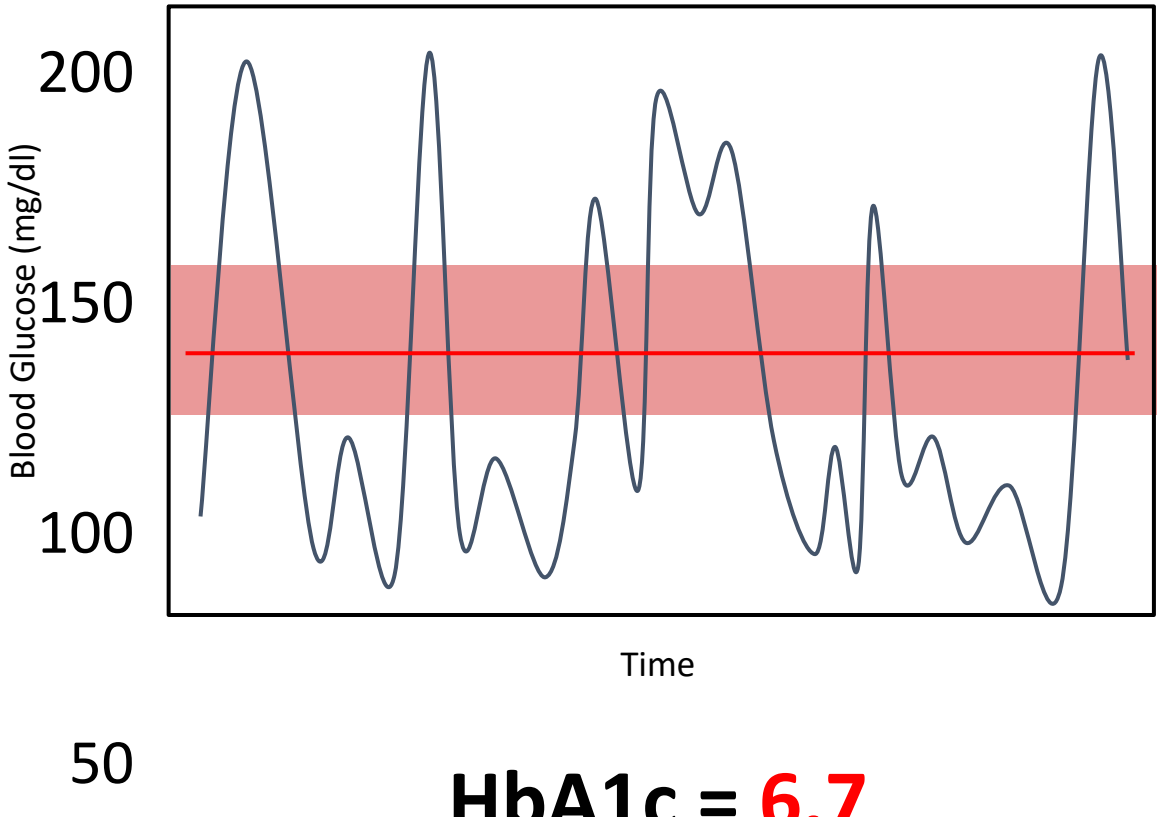


Hörber, et al. Harmonization of immunoassays for biomarkers in diabetes mellitus. February 2019. Biotechnology Advances 39(4)

Assessing Control



HbA1c = 6.7



HbA1c = 6.7

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Treatment

The Tools at our Disposal …

(Sometimes) Control is an Illusion

- The most efficient approach in the hospital setting is trying to control for as many variables as possible.
- As clinicians, we have no control over the disease process.
- As clinicians, we wield some influence over bedside management and patient behavior.
- As clinicians, we wield key influence over the dosages and timing of medications and the diet*.

*debatable in some situations

Non-Insulin agents

- This includes **oral** agents such as metformin, DPP-IV inhibitors (Januvia), TZDs (Actos), SGLT2 Inhibitors (Invokana, Jardiance), sulfonylureas (Glipizide).

- This includes **Injectable** noninsulin therapies such as GLP-1 agonists (Bydureon, Victoza) as well, which have limitations similar to oral therapies.

- **But have no fear, as most of these are inappropriate in the vast majority of hospitalized patients.**

Non-Insulin agents

- Are usually **ineffective** as monotherapy in the acute setting (IE, you have to use insulin anyway).
- Patients often subject to drastic fluid shifts which can have a profound effect upon renal and hepatic function and thus the metabolism of these agents.
- PO intake in the hospital setting is also often unpredictable and inconsistent due to patient variables (pain, nausea) or NPO status (for procedures / testing), putting patients further at risk of hypoglycemia.

Non-Insulin agents

- **Metformin** - contraindicated in the setting of renal and hepatic dysfunction, and may cause life-threatening lactic acidosis if given after recent exposure to radiocontrast dye.
- **Sulfonylureas** (Glyburide, Glipizide) - may result in profound hypoglycemia, especially in the setting of renal dysfunction.
- **TZD's** (Actos) - Also contribute to hypoglycemia, and have been associated with edema and decompensation of underlying CHF.
- All other noninsulin agents are associated with hypoglycemia if PO intake is compromised, and if used in tandem with rapid acting insulin.

Non-Insulin agents

- **SGLT2 Inhibitors** (Jardiance) have emerged as the latest agent in guideline-directed therapy in heart failure.

- Note that their use is specific to this population of patients, and are not intended as agents to be utilized for traditional inpatient glycemic control. **In patients who do not have CHF, these agents should be discontinued on admission.**

- Regardless, their metabolic effect must be taken into account for those patients being treated for both disease processes.

Int J Heart Fail. 2023 Apr; 5(2): 82–90.

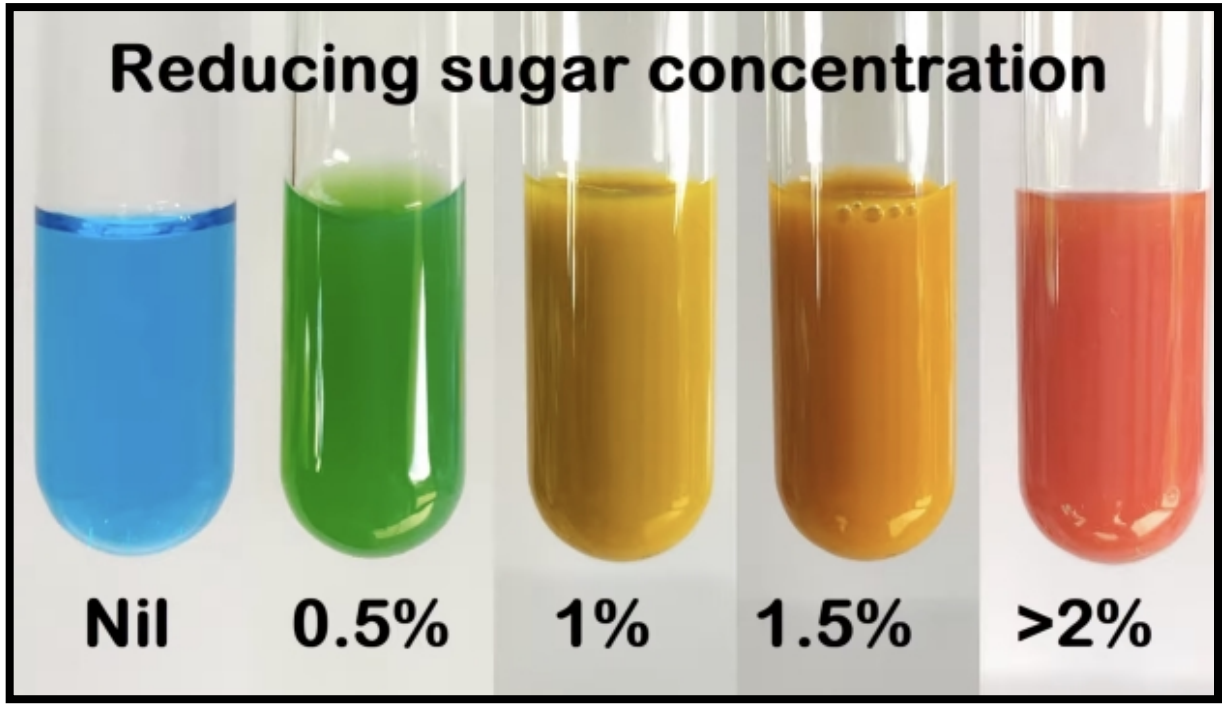
Non-Insulin agents

- Discontinuation of non-insulin agents, with few exceptions, should be the standard of care when admitting or managing a hospitalized patient.
- Patients who are imminently to be discharged, conversely, **may** be considered for transition to oral / injectable therapy on a case-by-case basis.
- As always, therapy is individualized – we avoid placing patient at risk for convenience' sake.

“Sliding-Scale Insulin”

- Prior to POC / SBG testing, utilized a Fehling’s / Benedict’s test of urine for glycosuria.

- Required boiling urine in solutions containing Copper Sulfate, which would change color depending upon the concentration of glucose.



https://www.youtube.com/watch?v=qdMjKVJVIOs

“Sliding-Scale Insulin”

- Original treatments developed using this test referred to as “Rainbow Scale” or “Rainbow Coverage”.

- Regular insulin was the only insulin available.

1934 Sliding Scale by Elliot Joslin

Urine Color	Amount of Regular Insulin to administer
Blue	0 units
Green	5 units
Yellow	10 units
Orange	15 units

Golightly LK, Jones MA, Hamamura DH,et al. Management of diabetes in hospitalized patients: Efficacy and effectivess of sliding-scale insulin therapy.*Pharmacotherapy* 2006;26(10):1421-1432

“Sliding-Scale Insulin”

- Traditionally those in which **prolonged** insulin administration is governed by elevated blood sugars above predetermined thresholds alone.
- Classically, it was often given without regard for when the patient last received insulin.
- Despite a lack of evidence for their use in the last 40 years, they persist in our hospitals nationwide.

Am Fam Physician. 2010;81(9):1130-1135 / https://www.aafp.org/pubs/afp/issues/2010/0501/p1130.html

“Sliding-Scale Insulin”

- Sliding scale insulin has been actively discouraged by:
  - AAFP
  - American Diabetes Association
  - Society of Hospital Medicine
  - American Association of Clinical Endocrinologists
  - Endocrine Society
  - American Geriatrics Society

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Am Fam Physician. 2010;81(9):1130-1135 / https://www.aafp.org/pubs/afp/issues/2010/0501/p1130.html

“Sliding-Scale Insulin”

- It has long been recognized that this approach is not proactive, as “SSI” does not factor in carbohydrate intake (discrete meals, tube feeds, or TPN).
- In short, this approach is reactive, ineffective, and potentially harmful.
- Paradoxically, even if the clinician is using appropriate basal-bolus-therapy, many are still documenting “sliding scale” or “SSI”

“Sliding-Scale Insulin”

- Sliding Scale insulin is not corrective insulin.
- New documentation standards applied to more stringent billing criteria will see higher scrutiny paid to notes containing these terms, and potentially will need to be eliminated entirely in the near future.
- Patients are savvy and have immediate access to their records. The term “sliding scale” or SSI may carry the connotation that the clinician has poor understanding of the disease process and best treatment practices.

“Sliding-Scale Insulin”

About 42,800,000 results (0.39 seconds)

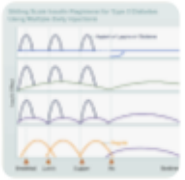
The American Diabetes Association (ADA) warn that using only sliding scale insulin for treatment is ineffective for most people. It can increase the risk of both high and low blood sugar and of complications if the person needs surgery. Most doctors advise against using this approach.

Google

Diabetes Education Online
https://dtc.ucsf.edu › ... › Type 2 Insulin Rx

Sliding Scale Therapy - Diabetes Education Online - UCSF

Sliding scales are less effective in covering a pre-meal high blood sugar, because the high blood glucose correction and food bolus cannot be split.



Today's Geriatric Medicine
https://www.todaysgeriatricmedicine.com › archive

Sliding-Scale Insulin: An Ineffective Practice

Sliding-Scale Insulin: An Ineffective Practice ; **Kidney failure**. 44% of all new cases are related to diabetes ; Nerve damage. 60% to 70% of diabetics with mild to ...

National Institutes of Health (NIH) (.gov)
https://pubmed.ncbi.nlm.nih.gov › ...

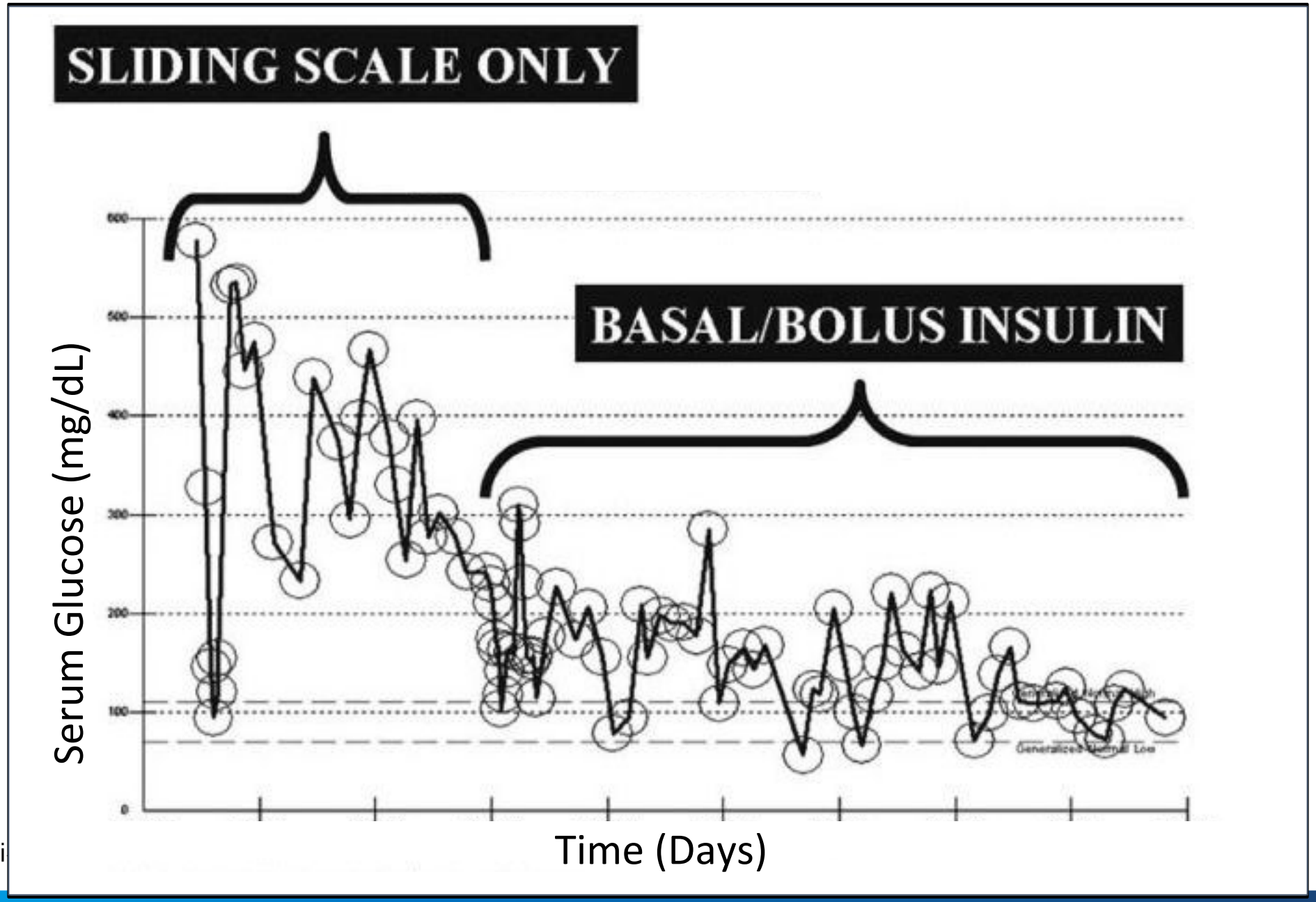
Sliding scale insulin use: myth or insanity?

by GE Umpierrez · 2007 · Cited by 189 — Several studies have revealed **evidence of poor glycemic control and deleterious effects in** sliding scale insulin use. To understand its wide…

MDedge
https://cdn.mdedge.com › files › 6005JFP_Scale

It's time to abandon the sliding scale

by R Guthrie · 2011 · Cited by 12 — The sliding scale is **usually dependent on blood glucose levels obtained by bedside monitoring,13** tested every 6 hours. Hospital- ized patients often…

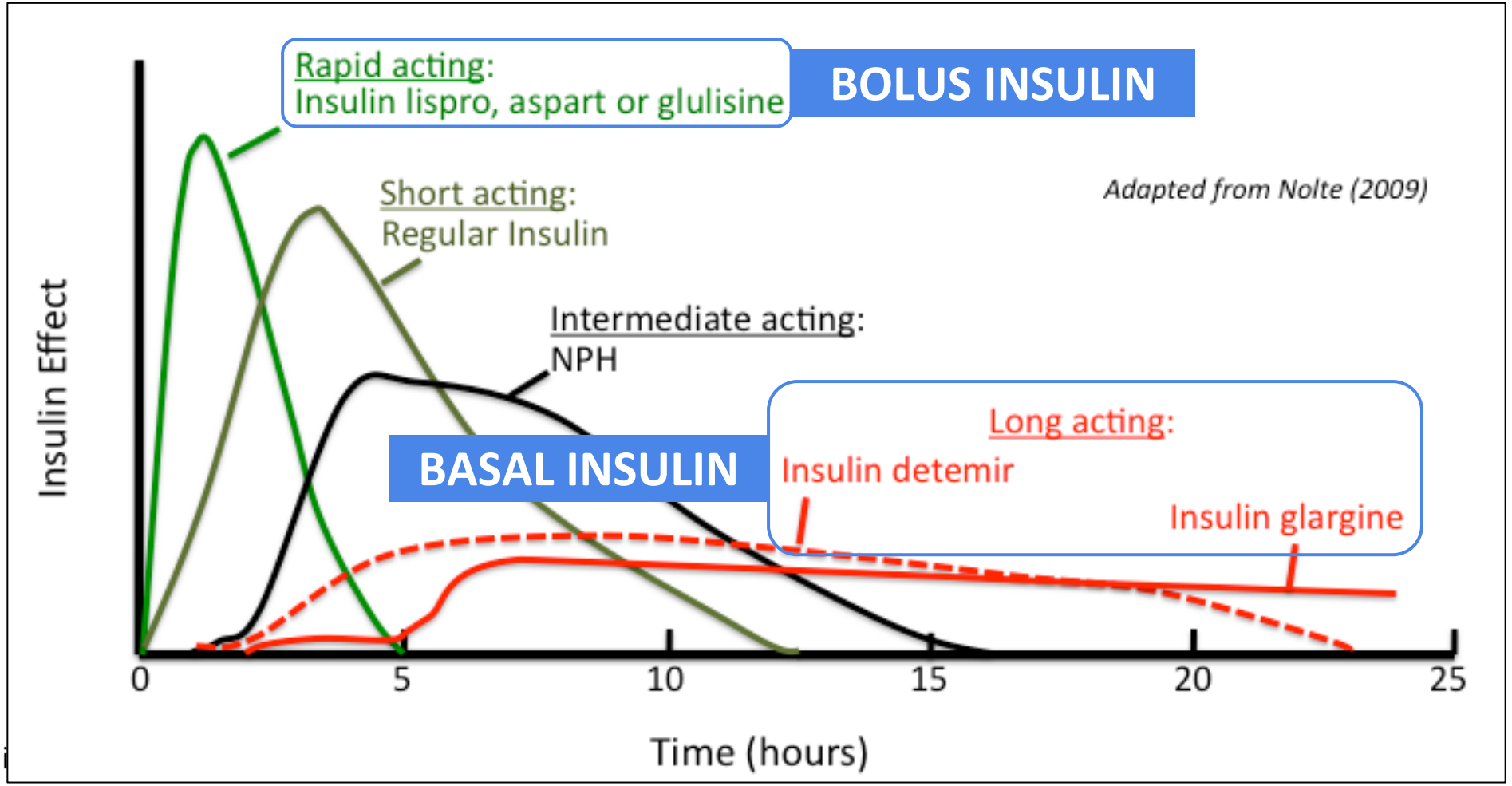

SLIDING SCALE ONLY
BASAL/BOLUS INSULIN
Serum Glucose (mg/dL)
600
500
400
300
200
100
0
Time (Days)

The Basal-Bolus Concept

- **Basal: Intermediate or long acting insulin** is given to provide steady plasma insulin levels which can account for the patient's **endogenous** glucose production. Irrespective of current diet but may be dictated by nutritional status.

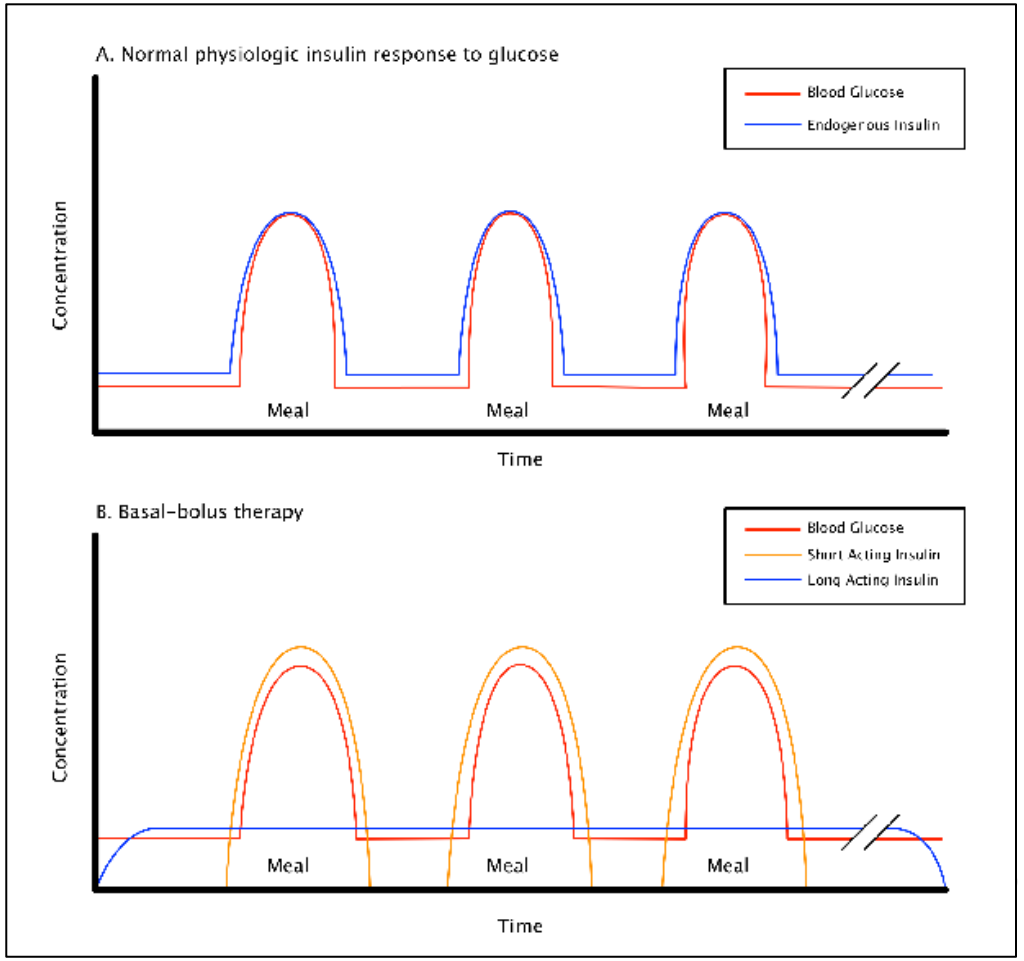
- **Bolus: Short or rapid-acting insulin**, meanwhile, is given immediately before (or at) meal-times, to cover prandial rises in serum blood glucose as the result of carbohydrate intake.

The Basal-Bolus Concept



The Basal-Bolus Concept

- The utilization of these insulins **together** mirrors the physiologic action of the pancreas in-between and, in response to, meals.



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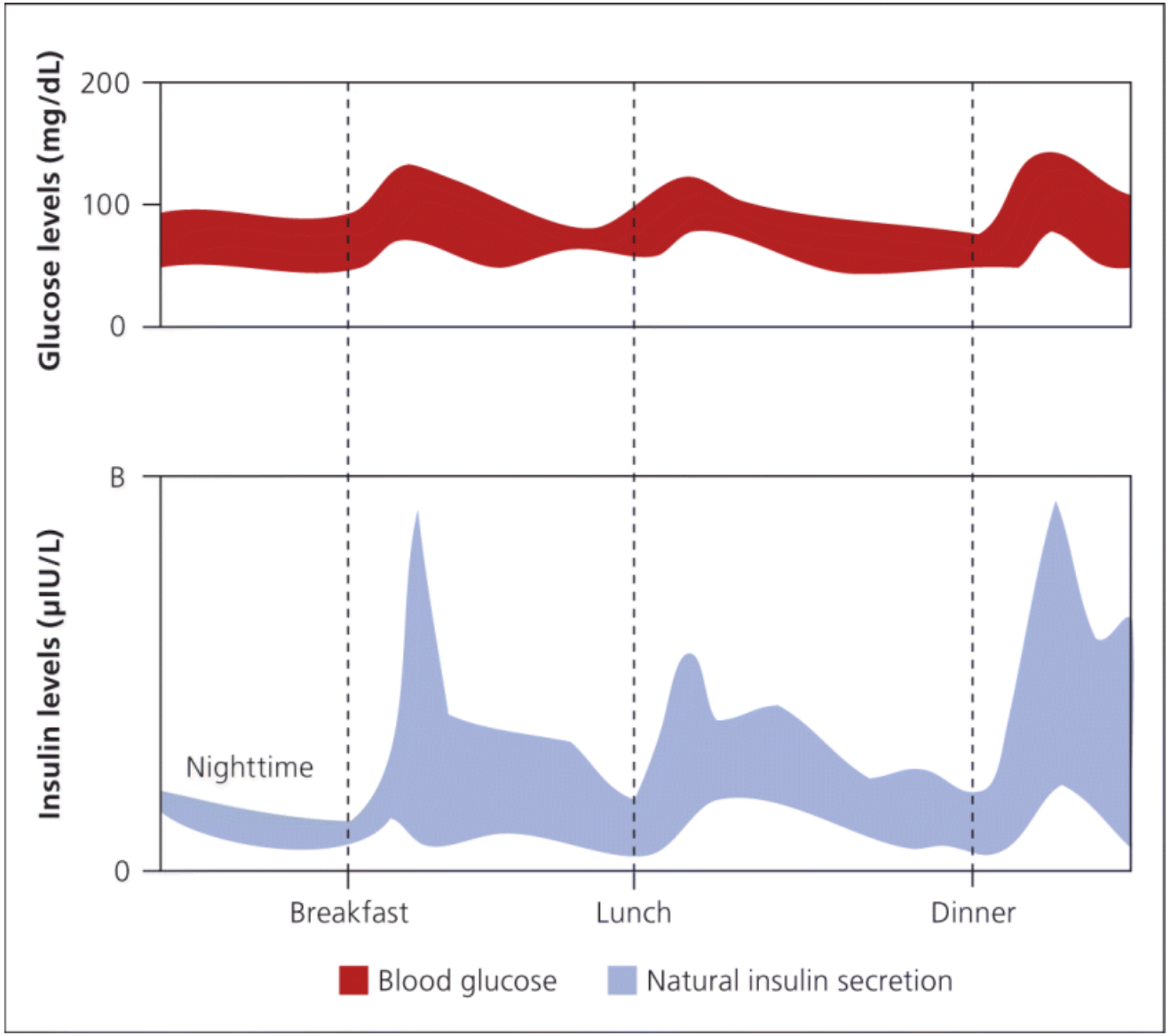

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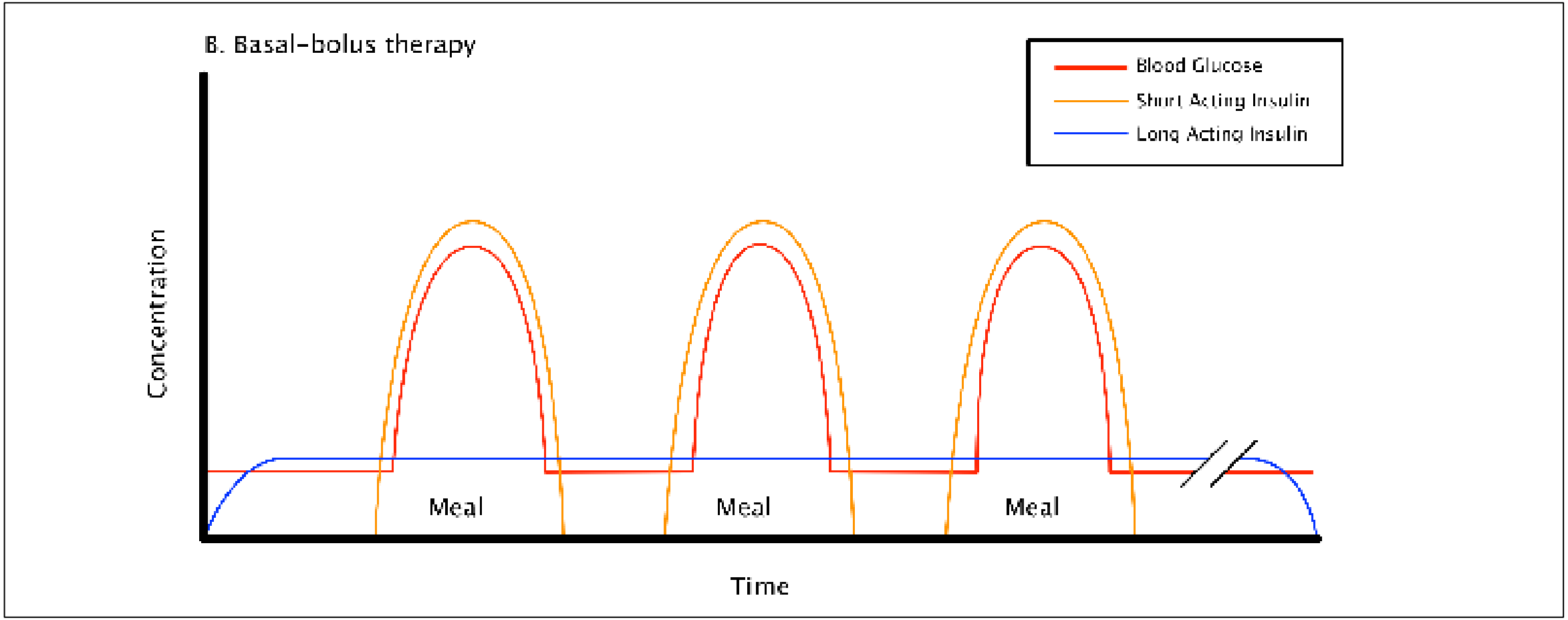
AAFP.(2023). Insulin Management of Type 2 Diabetes Mellitus. https://www.aafp.org/pubs/afp/issues/2011/0715/p183.html


B. Basal-bolus therapy
Blood Glucose
Short Acting Insulin
Long Acting Insulin
Concentration
Meal
Meal
Meal
Time

The Basal-Bolus Concept

- Basal insulins, such as glargine and detemir, are “relatively” peakless, and provide a predictable insulin level for up to 24 hours.

- Onset of action usually within 3-4 hours of administration

The Basal-Bolus Concept

- Rapid acting bolus insulins (such as lispro, aspart, glulisine) more closely mimic short term physiologic responses to meals / elevated blood sugar.
- Onset of action within 15 minutes
- Peak tends to occur within 30-40 minutes
- Last ~ 4 hours

The Basal-Bolus Concept

- Traditionally, a patient's **total daily dose** of insulin is estimated as evenly distributed between their basal and bolus regimens (**50/50 or 40/60**) although there are often exceptions to this.

- It is important to stress that long-acting basal insulin should **never** be used to treat **prandial** glucose excursions: only a single missed meal or snack can thus result in potentially dangerous hypoglycemia.

The Basal-Bolus Concept

- In many circumstances, if it is being dosed correctly, basal insulin does not necessarily need to be held even if a patient is not eating for a planned test or procedure.

- As many patients are admitted to the hospital on excessive basal insulin, however, adjustments are advisable if this is the concern.

Clinical Confounders

Dietary indiscretion
Labile Renal Function
Labile Hepatic Function
Steroids
Inconsistent or Absent Meals
Improper POC Glucose Assessments
Concurrent Disease processes
Physiologic Differences

Simple Concept, Complex Situation

- It may be tempting to hold insulin at a normal blood glucose due to the fear of hypoglycemia.
- Unfortunately, this usually leads to the recurrent cycle of hyper-hypoglycemia throughout the following day.
- Type 1 diabetics in particular have no endogenous insulin production; holding a basal dose, even overnight, places them at risk of DKA during their hospitalization (a “never event”).

Simple Concept, Complex Situation

- Basal insulin should also be given **even if** the patient's blood glucose at bedtime is in less than 100 mg/dL
- If the patient is at risk of or has had frequent hypoglycemia on the same dose, however, it is essential to **adjust** the dose.
- Repeat serial monitoring overnight is also recommended.

Simple Concept, Complex Situation

- A dose reduction of a patient's basal insulin may still be appropriate in certain scenarios:
    - **Prior prolonged starvation** (*limited glycemic reserve*)
    - **Prolonged NPO status**
    - **Renal/Hepatic impairment** (*limited reserve & clearance*).
    - **History of frequent AM hypoglycemia** on their current regimen (*Basal dose is too high*)

Feeding Basal Insulin

- Unfortunately, it is still not uncommon to encounter patients who state they must eat a “HS snack” at bedtime to avoid mid-night or early morning lows.
- Alternatively, you may encounter patients who administer basal insulin on a “sliding scale” based on their HS blood glucose.
- Occasionally you will encounter patients on basal monotherapy.
- This is known in some diabetic social circles colloquially as ‘feeding your insulin’.

Feeding Basal Insulin

- In the outpatient setting, it leads to **weight gain** and **poor control,** with worsening long-term outcomes.

- In the hospital setting, it often leads to **hypoglycemia** as it relies upon meals to be available in a timely and consistent fashion, when we know categorically this is impossible in the hospital setting.

- In short, it represents an unacceptable risk and is best avoided.

What to do

- Decrease **the basal insulin dose** *before* it is given. Follow with a POC glucose around **2 AM** (or **3-4 hrs** or so after basal insulin has been given).

- At **that** point, if the patient's POC glucose is <100 mg/dL, provide a **single carb snack (or 12.5 g dextrose if NPO)**, with serial monitoring.

- This is different from the ubiquitous "HS Snack" as it is a **controlled intervention.**

What to do

- Interventions such as this can not only ensure the patient has a safer and potentially shorter hospital stay, it may also lower the risk of morbidity and complications after discharge.

What Harm Can a Snack Do?

The Snack That Eats Like a Meal

25g carbs

12g carbs

6g carbs

25g carbs

Equates to 68g of carbohydrate or 5 CARB Servings
= A Meal

Corrective Insulin

- **Not to be confused with "sliding scale" insulin**, remains a necessary component of inpatient diabetes management.

- **Its purpose is as an adjunct** to basal/prandial therapy, to best tailor a regimen to a patient's individual needs.

- **Can be used *temporarily*** in the absence of basal / bolus but only in specific and documented circumstances.

What About Steroids?

- Steroids often more profoundly effect postprandial, rather than fasting, blood glucose.
- Their effect on the basal insulin requirement is minimal.
- It is therefore key to focus on treating with higher prandial doses of insulin, not higher basal doses.

Cheng, et al. (2021). Insulin management in hospitalized patients with diabetes mellitus on high-dose glucocorticoids: Management of steroid-exacerbated hyperglycemia. https://doi.org/10.1371/journal.pone.0256682

What About Steroids?

- An asymmetric approach is key: an increase in the preprogrammed boluses, coupled with an adjustment of the correction algorithm based on impaired insulin sensitivity.

Insulin Pumps

- **Electronic device** that provides a continuous basal insulin (usually rapid-acting)
- By design, allows the user the means to manually bolus insulin as needed for meals and/or to treat hyperglycemia.
- The basal rate can be programmed to vary at predetermined intervals to allow for tight titration of the daily insulin dose.

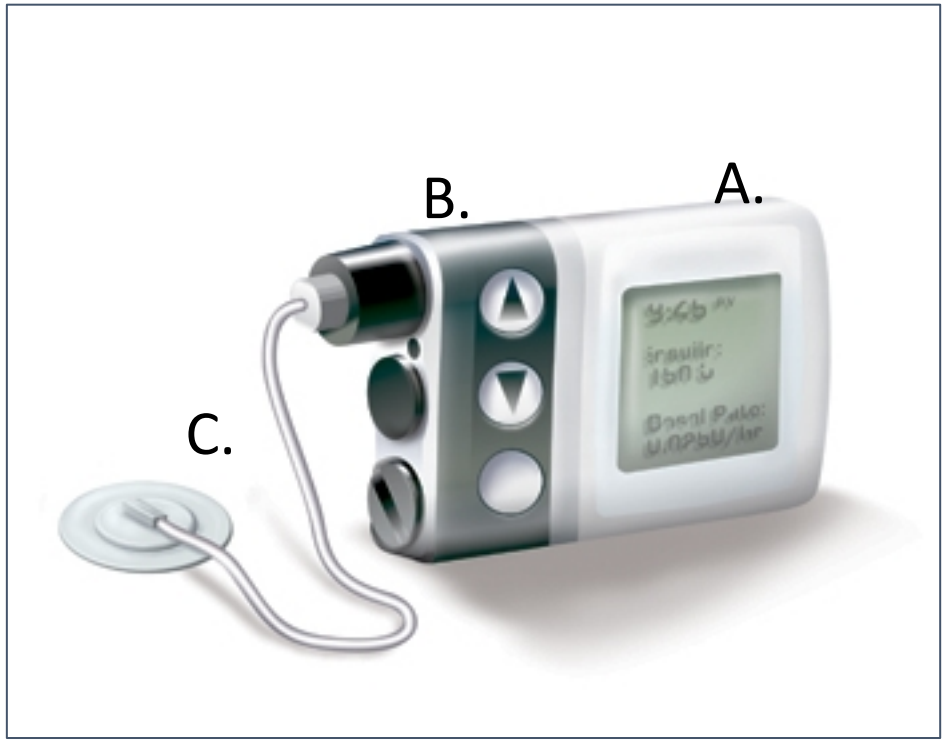
Insulin Pumps

- Boluses are administered via a **pre-programmed insulin-to-carb ratio and insulin sensitivity factor**, calculated against **user-entered** carbohydrate numbers at mealtimes.

- These metrics are traditionally determined over the course of several visits with the patient's endocrinologist until a safe and effective regimen is established.

Insulin Pumps

- Consists of 3 components:
  a. The **pump module.**
  b. An insulin **reservoir**.
  c. A **disposable infusion set**, including a cannula for subcutaneous insertion and a tubing system to interface the insulin reservoir.



Insulin Pumps

- A common misconception is that the pump provides an ‘autopilot’ for insulin management. In truth, it is a facet of intensive, patient-managed diabetes therapy.

- Because it is subject to the patient’s control, carries additional risk in any circumstances in which said patient’s judgement may be **impaired**.

    - Includes the setting of severe acute illness, delirium, or administration of medications such as narcotics.

    - Steroids may also hinder adequate control.

Insulin Pumps

- If the patient is not at risk, they must be placed on a ‘pump protocol’
- The patient agrees they will not alter their basal rate in any way without informing the clinician.
- They must inform their nurse or clinician upon administration of a bolus.
- It is important that the patient be provided with supplies for their pump, including replacement reservoirs, infusion sets, and insulin.

Insulin Pumps

- Insulin pumps must be removed if patient is undergoing MRI.
- If the pump is to be **off for more than 2 hours**, they need to be transitioned to an alternative regimen (BBC)
- If the patient is **uncontrolled** on their pump regimen, they need to be transitioned to an alternative regimen (BBC)
- Even if the patient is self-monitoring, nursing must independently validate and document POC glucose levels and insulin being administered.

Insulin Delivery Devices

- Gained traction in the outpatient setting as a convenient means of managing basal-bolus therapy.

- Disposable “pods” consist of a spring-loaded reservoir mechanism that delivers a basal rate using mechanical tension, and a user-initiated click-bolus mechanism.

Insulin Delivery Devices

- These devices **have no electronic components.**
- These have no means of cataloging if insulin delivery was successful, or when they were activated, or when insulin was last given.
- In essence, these are not pumps. They are glorified pens.
- As such, they have no place in the hospital setting. They are not covered by pump protocols, and must be removed / replaced with basal-bolus insulin or insulin drip upon admission.

Continuous Glucose Monitors

- Have seen wide adoption in the outpatient setting due to lower costs and ease of use.
- Convenient, but with that convenience bring their own set of quirks and problems.

Continuous Glucose Monitors

- An off-the-shelf CGM is calibrated for outpatient use, but this likely does **not** meet the equipment standard for a hospitalized patient.
- Nurses will require appropriate training to become familiar with the technology and **must still validate results at the standard intervals**.
- Now seeing adoption within our hospital system for specific clinical scenarios (ICU patients on insulin drips).

J Diabetes Sci Technol. 2015 Sep; 9(5): 1006–1015.

Continuous Glucose Monitors

- There is a very real serum-versus-interstitial delay between readings, which may be the result of local blood flow, local tissue perfusion, permeability of the interstitial fluid, and more.

- As such the CGM value may not necessarily be reflective of the actual POC blood sugar.

Continuous Glucose Monitors

- One 5 phase, 2 year study found this discrepancy was present for as little as **4 and much as 9 minutes** utilizing one commonly available brand.

- Some CGMS also utilize **predictive algorithms** to prevent hypoglycemia, which can result in inappropriate interventions and alarm fatigue.

- As always, approach with caution and be skeptical of outlying or discordant values.

J Diabetes Sci Technol. 2015 Sep; 9(5): 1006–1015.

DKA / HHS

Worst Case Scenarios …

DKA and HHS

- Represent the complication of the underlying metabolic derangements inherent in diabetes taken to its physiologic extreme (a medical emergency).
- Are two distinct entities governed by different physiologic processes.
- Despite this, however, many of the underlying causes and, in turn, elements of their management, are the same.

DKA and HHS

- Diagnostic Critera for DKA and HHS:

Lab Value	DKA	HHS
Blood Sugar	>250	>600
pH	<7.25	Variable (usually >7.3)
Beta-hydroxybuterate level	>0.3	Variable (usually >0.3)
Serum Bicarbonate	<18	Variable (usually >18)
Anion Gap	>10	Variable

Why is the distinction important?

- Though the initial approach for each presentation is similar, their management outcomes differ.
- DKA is often ‘over-diagnosed’ as many times patients with HHS or simple hyperglycemia are admitted without a gap and without acidosis as ‘DKA’.
- This can have an effect upon root cause identification, inpatient morbidity, length of stay, patient satisfaction, billing discrepancies and more.

Diabetic Ketoacidosis

- Results from **absolute** deficiency of insulin (Most type 1's, some type 2's)
- In response, the body switches to burning fatty acids and producing **acidic ketone bodies** that cause most of the symptoms and complications.
- The lack of insulin also leads to increased release of glucose by the liver.
- High glucose levels spill over into the urine, taking water and solutes (such as sodium and potassium) along with it via osmotic diuresis.
- This leads to progressive polyuria, dehydration.

Diabetic Ketoacidosis

- The lack of insulin leads to the release of free fatty acids from adipose tissue, which are converted into the acidic **ketone** bodies acetoacetate and β-hydroxybutyrate.
- The preponderance of ketone bodies, however, results in **acidemia**, and over time turn the blood acidic (metabolic **acidosis**).
- Hence, the term **ketoacidosis.**
- **DKA can thus be seen as a the end result of profound starvation and dehydration.**

Hyperosmolar Hyperglycemic State

- Results from the relative shortage of insulin (all Type 2's)
- Elevated serum glucose results in elevated serum osmolality
- This drives a pronounced urination, resulting in severe dehydration and hemoconcentration which further drives hyperosmolarity and osmotic diuresis.
- Otherwise referred to as HONK (HyperOsmolar Non-Ketotic state), highlighting the fact that ketones are usually **not** significantly elevated and do not drive an underlying anion-gap metabolic acidosis.

Hyperosmolar Hyperglycemic State

- The osmotic derangements can lead to a severe encephalopathy/obtundation (or “coma”) not generally seen in DKA.
- Neurologic presentation can include neuromuscular flaccidity, tremor, and even seizures.
- **HHS can thus be seen as the result of profound hyperglycemia, hyperosmolarity and severe dehydration.**

DKA/HHS Treatment

- 5 steps for success:
  - Fluids
  - Fluids
  - Fluids
  - Insulin

(Did I mention fluids?)

DKA/HHS Treatment

- Underlying causes may include:
  - Noncompliance / previously undiagnosed disease
  - Infection
  - Acute MI / Stroke
  - Polysubstance abuse
  - Medications (antipsychotics, SGLT2 Inhibitors)

DKA/HHS Treatment

- Volume replacement is key:
  - **~6-10 liters fluid deficit usually needs to be replaced**.
  - Must be given judiciously in older patients, patients with ESRD on dialysis, and any who may have underlying or known CHF.
  - Is most often overlooked element of therapy (in my experience) leading to longer LOS.

DKA/HHS Treatment

- Electrolyte replacement is essential:
  - Due to **pH-driven extracellular shifts** (DKA) and / or **hemoconcentration** (DKA and HHS), serum potassium levels on presentation are usually **transiently** or **spuriously** normal or elevated (**Hidden Hypokalemia**).
  - Exposed when circulating extracellular potassium shifting back into the cells due to insulin's effect (K+ goes with glucose) and the increase in pH,and/or the concentration is diluted (as in HHS).

DKA: Treatment Pearls

- When the serum glucose has dropped below 200-250 mg/dL, dextrose must be added to maintain euglycemia while halting the ketogenesis driving the acidosis

- It is important to emphasize that the primary goal of a DKA insulin protocol is to **correct the acidosis, dehydration, and electrolyte derangement, not simply to correct hyperglycemia.**

DKA: More than “closing the gap”

- As previously noted, the anion gap is but one of many factors that **must** be considered when determining if DKA has resolved:
  - Correction of anion gap (calculated from BMP)
  - Correction of acidosis (may require ABG/VBG)
  - Correction of dehydration (may be limited by cardiac or renal status)
  - Correction of serum CO2 to prevent rebound (calculated from BMP)
  - Correction of hypokalemia
  - Correction of hypophosphatemia (if applicable)
  - Patient able to eat or obtain nutrition (if applicable)

Non DKA Insulin Drips

- In a more perfect world, patient management would be straightforward and predictable.
- Unfortunately, as we see higher acuity patients with greater and greater frequency, that demand closer observation and a greater commitment of time.
- While, ideally, we would prefer these patients be treated with subcutaneous insulin for the entirety of their hospital stay, this is often not the case.

Non DKA Insulin Drips

- Titratable drips can be used to **correct hyperglycemia** in a patient who cannot be managed on subcutaneous basal-bolus insulin.

- Indications for initiating an insulin drip include:

    - Severe or recurrent hyperglycemia and/or hypoglycemic episodes
    - Severe hypertriglyceridemia (including pancreatitis)
    - Prolonged hyperglycemia (glucotoxicity)
    - Critical illness / hemodynamic instability
    - Patients on vasoactive drugs (epinephrine)
    - Patients receiving high-dose steroids
    - Patients undergoing surgery
    - Severe generalized edema

Non DKA Insulin Drips

- The **fastest, safest**, and **most efficient** means to establish euglycemia in a patient with refractory hyperglycemia.
- Can be used to ascertain a more accurate estimate of a patient's basal requirement.
- Initiation will **shorten the patient's hospital stay** and improve patient experience.

Non DKA Insulin Drips

- Patients on the non-DKA insulin drip **may receive mealtime insulin** boluses while on the drip if they are eating reliably.
- Though it is not required, it can decrease the amount of adjusting which may be necessary.
- The drip acts as both the **basal and corrective insulin** components of the patient's insulin regimen.
- Separate correction should be the only thing that is **always** held when a patient is on an insulin drip.

Transitioning

The Next Logical Step …

Transition Tips – Read the Room

- Be wary of resuming basal-heavy regimens (IE, large doses of basal and correction only.)
- Remember, if these patients have some semblance of control on these regimens, it is may be because they feed their insulin at home.
- Insulin drips, especially Non-DKA drips can provide invaluable data with regards to patient's actual insulin needs.

Transition Tips – Take A Moment

- Many transitions (especially late-night transitions) usually lead to the patient being placed on their home regimen due to a paucity of glycemic data.

- Unfortunately, many of our patients are here because their home regimen may in fact be inadequate, excessive, or dangerous

  .

- In addition, patients being transitioned at odd hours may have the following dose is mis-timed, which may lead to **hyper/hypoglycemia, patient/staff confusion as well as prolonged hospitalization.**

Transition Tips – A Useful Shortcut

- Non-DKA drips that are maintained in fasting hours on stable patients may be used to more accurately calculate the patient's real basal insulin requirement.

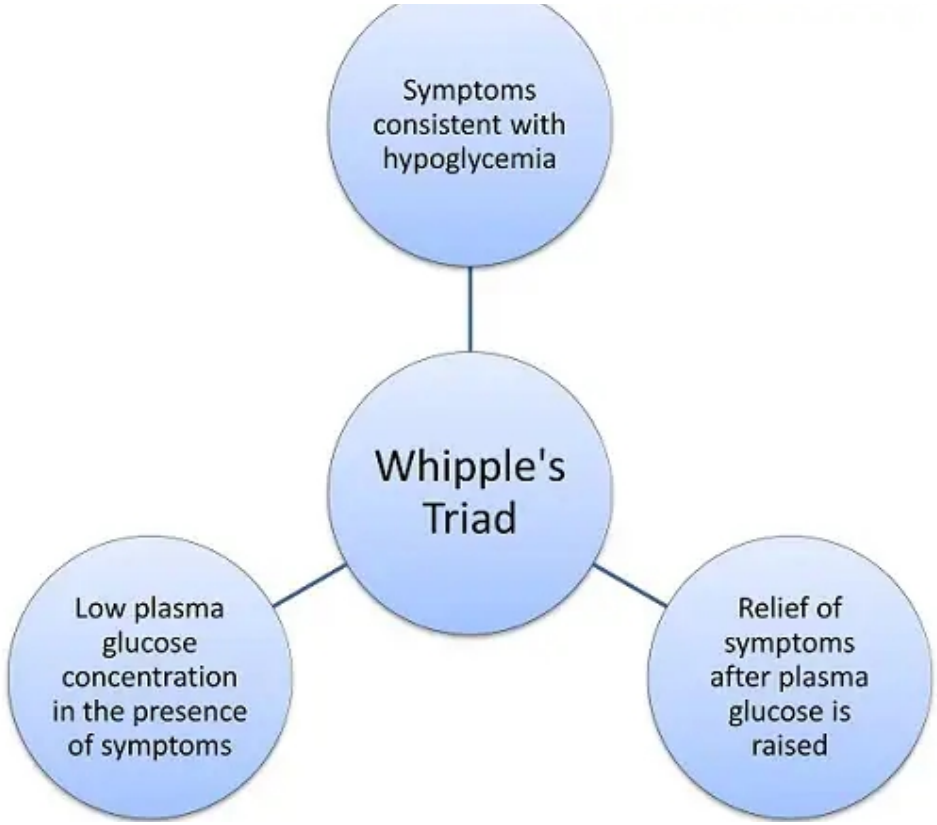
- This information can be used to easily estimate their prandial and correctional insulin needs.

Hypoglycemia

Hypoglycemia requires a low blood sugar, but a low blood sugar is not hypoglycemia.

Hypoglycemia

- Defined by **Whipple's Triad**:
  - Patient identified to have a low blood glucose + symptoms
  - Patient presents with neuroglycopenic or sympathomimetic symptoms
  - Symptoms resolve with the correction of glucose



Mayo Clinic. Hypoglycemia: Overcoming a diagnostic limitation. Feb. 07, 2023.

Hypoglycemia Testing

- Often we are presented with patients that have unexplained hypoglycemia.
- Causes are broad and varied, and may include a combination of concurrent issues.

Insulinoma
Adrenal insufficiency
Starvation
Critical illness
Hepatic dysfunction / Cirrhosis
EtOH use
Exogenous insulin
Malignancy

Hypoglycemia Testing

- A careful history is always the first step, as well as considering the appropriate differentials.

- Often, biochemical testing frequently comes into play, and unfortunately is often fraught with error.

Hypoglycemia Testing

- Most often, these tests are performed to isolate insulinoma:
  - C-peptide ($170)
  - Insulin Level ($120)
  - Proinsulin level ($140)
  - Sulfonylurea screen ($190)

Hypoglycemia Testing

- Biochemical values, however, are of low utility without proper clinical context.

- Levels are often drawn **after** the hypoglycemia has been treated, or without confirmation of the POC glucose value (which is, itself, subject to error).

- Often, patient testing is performed while the patient is on a dextrose drip, which will actually stimulate an increase the values being scrutinized, potentially leading to misdiagnosis and further invasive testing or even surgery.

Hypoglycemia Testing: Context is Key

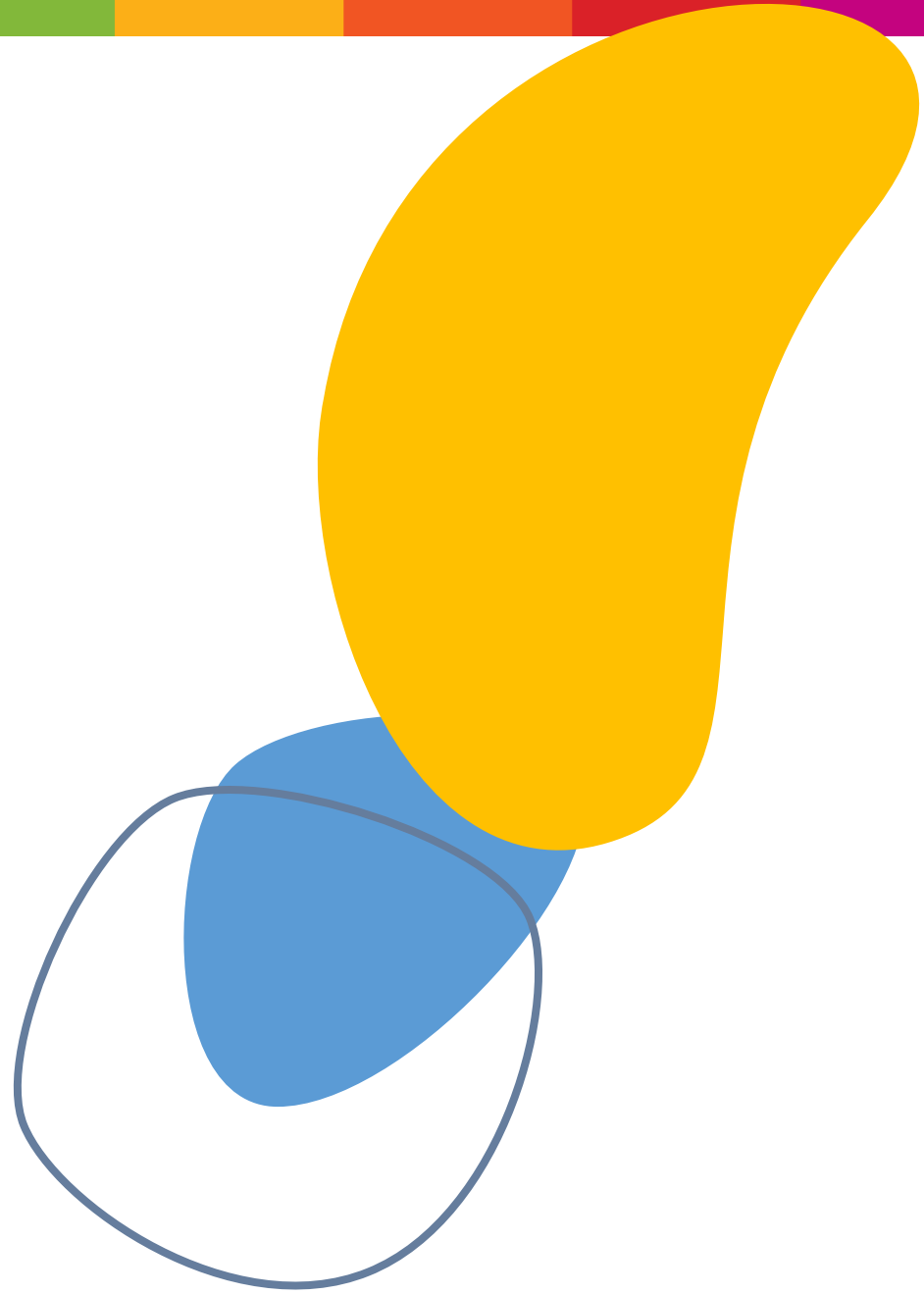
- For hypoglycemic labs to be of clinical value, the **serum** glucose must be below established ranges to be validated:
  - If signs and symptoms of hypoglycemia are present: <55 mg/dL
  - If signs and symptoms are not present: ≤45 mg/dL
- Serum glucose must be drawn at the same time as hypoglycemia labs to reinforce this context, as POC can be off by as much as +/- 15 mg/dL.

Cryer, et al. (2009). Evaluation and management of adult hypoglycemic disorders: an Endocrine Society Clinical Practice Guideline. J Clin Endocrinol Metab. 2009;94(3):709.

Questions?

Additional Sources

- http://care.diabetesjournals.org/content/41/Supplement_1/S144
- http://care.diabetesjournals.org/content/41/Supplement_1/S51



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You have 60 minutes prior, during and 120 minutes after the end of the event to text in your attendance.

The evaluation for this event will be sent once you text your attendance in. You must complete the evaluation to get your CME certificate.

Any questions please contact India Myers (ilmyers@premierhealth.com) or Dana Mackert (dlmackert@premierhealth.com