



Diabetes Pathophysiology

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www.DiabetesEd.net | 2026



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Lecture Objectives

1. Discuss the current impact of diabetes.
2. Describe the pathophysiological pathway associated with the development of diabetes
3. Describe and differentiate between the different types: prediabetes, Type 1, Type 2, and GDM
4. Describe the laboratory tests used for the diagnosis of diabetes
5. State signs of hypoglycemia and prevention.



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CDC Announces



35% of
Americans will
have Diabetes
by 2050

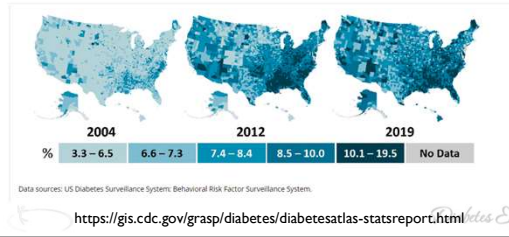
Boyle, Thompson, Barker, Williamson
2010, Oct 22-8(1)29
www.pophealthmetrics.com

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Type 2 Diabetes in America 2026

- ▶ 14.7% with Diabetes - 38 million adults
 - ▶ 25% don't know they have it
- ▶ 38% with Prediabetes – 100+ million adults

Figure 3. Age-adjusted, county-level prevalence of diagnosed diabetes among adults aged 20 years or older, United States, 2004, 2012, and 2019



PreDiabetes is FREAKING ME OUT

DIABETES
40.1 million people have diabetes. That's about 1 in every 8 people. More than 1 in 8 adults with diabetes don't know they have it.

PREDIABETES
115.2 million American adults have prediabetes. More than 8 in 10 adults with prediabetes don't know they have it.

Do I look like I am freaking out?

1. Prevention or Delay of Diabetes and Associated Complications: Standards of Care in Diabetes—2020. American Diabetes Association. <https://doi.org/10.2337/191001>

- ▶ Associated with higher rates of heart attack, stroke, neuropathy and vessel disease

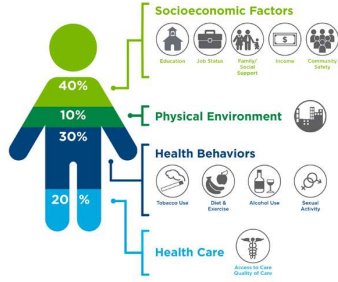
Diabetes Prevalence Stats

- ▶ **For adults in U.S., diabetes prevalence:**
 - American Indians and Alaska Natives – highest rates
 - Non-Hispanic Blacks (17.4%),
 - People of Hispanic origin (15.5%),
 - Non-Hispanic Asians (16.7%)
 - White Individuals (13.6%)
 - ▶ **Education and SES and Location**
 - ▶ Less than high school ed (13.1%)
 - ▶ More than high school (6.9%)
 - ▶ Living below federal poverty (13.1%)
 - ▶ Living at 500% of federal poverty (5.1%)
 - ▶ Rural living (9.5%)
 - ▶ Metropolitan (8.1%)
1. Improving Care and Promoting Health in Populations: Standards of Care in Diabetes—2020. American Diabetes Association. <https://doi.org/10.2337/191001>

Address Barriers to Self Management

- Barriers exist within health system, payer, health care professional & individual.
- Address barriers through innovation, including community health workers, telehealth, other digital health solutions.
- Consider social drivers of health in the target population when designing care.

What Goes Into Your Health?



University Care and Health Systems - Population: Standards of Care
© 2018 University of Michigan Health System
Source: Institute of Medicine (IOM). Committee on the National Academies of Sciences, Engineering, and Medicine. *Disparities in Health: Closing the Racial and Ethnic Gaps*. Washington, DC: National Academies Press; 2016.

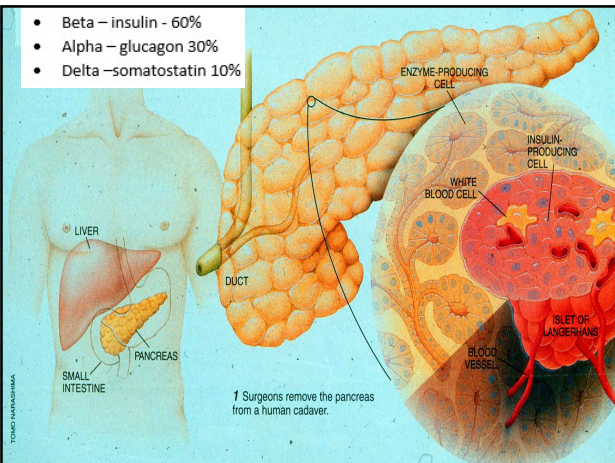
<https://coveragetoolkit.org/health-equity/defining-health-equity/>

Now, let's get to the Nitty Gritty



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- Beta – insulin - 60%
- Alpha – glucagon 30%
- Delta –somatostatin 10%



Hormones Effect on Glucose

Hormone

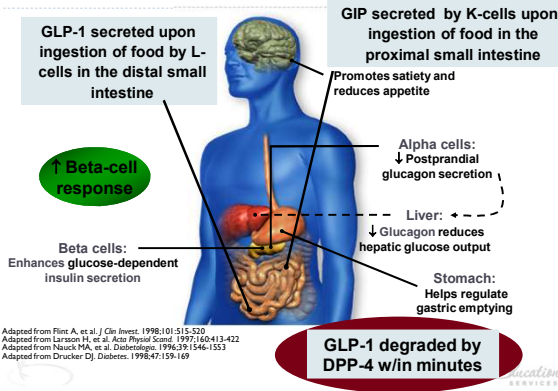
- ▶ Glucagon (pancreas)
- ▶ Stress hormones (kidney)
- ▶ Epinephrine (kidney)
- ▶ Insulin (pancreas)
- ▶ Amylin (pancreas)
- ▶ Gut hormones - incretins (GLP-1 intestinal mucosa, beta cell has receptors)

Effect



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Understanding the Natural Role of Incretins



Pocket Card: GLP-1 & GIP RA

GLP-1 & GIP for Diabetes & Weight Loss

Class/Action	Generic Name	Diabetes Version Dose & Indications	Wt loss Version Max Dose & Indications	Considerations
GLP-1 RA - Glucagon Like Peptide Receptor Agonist *Incretin Mimetic* <ul style="list-style-type: none"> • Increases insulin release with food • Slows gastric emptying • Promotes satiety • Suppresses glucagon 	exenatide 2x day injection	exenatide 5 and 10 mcg		Side effects: N/V, wt loss. Report signs of pancreatitis or ileus, stop med. Black box warning: Avoid if family history medullary thyroid tumor. All FDA approved to reduce risk of CV disease, death, MI, stroke (except exenatide, Saxenda). *Approved for peds 10-17 yrs **Approved for Peds 12-17 years Lowers A1C ~ 0.5 - 1.6% Wt loss: 4-9% (Diabetes versions)
	liraglutide 1x day injection	Victoza† 0.6, 1.2, 1.8mg	Saxenda†† - 3.0mg	
	dulaglutide 1x week injection	Trulicity† 0.75, 1.5, 3.0, 4.5mg		
	semaglutide 1x week injection	Ozempic 0.25, 0.5, 1.0, 2.0mg Tx for CKD	Wegovy†† - 2.4mg High Dose - 7.2mg Tx for MASH	
	semaglutide Daily Oral - fasting w/ H2O	Oral Ozempic 1.5, 4, 9 mg Rybelsus 3, 7, 14 mg	Wegovy - 25mg Oral tablet	
GLP-1 & GIP Receptor Agonist Activates receptors for GLP-1 (see above) & Glucose-dependent Insulinotropic Polypeptide (GIP).	tirzepatide 1x week injection.	Mounjaro† 2.5, 5.0, 7.5, 10, 12.5, 15 mg	Zepbound Max dose 15mg Tx for sleep apnea	Side effects: N/V, wt loss. Report pancreatitis or signs of ileus, stop med. Black box warning: Avoid if family hx of medullary thyroid tumor. *Approved for peds 10-17 yrs Lowers A1C ~ 1.8 - 2.4% Wt loss: 7-14% (Diabetes versions)
	Single dose via prefilled pen or vial. Gradually adjust dose based on shared decision, individual goals.			

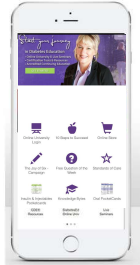
Download Your NEW & Improved CDCES Coach App Today!

Fresh new design with easier navigation.

- Forums to connect with your peers
- Instant access to blogs and news
- Quizzes with rationale

One-click access to go-tools tools, including:

- Medication PocketCards
- Cheat Sheets
- ADA Standards of Care
- Free Webinars
- Study materials




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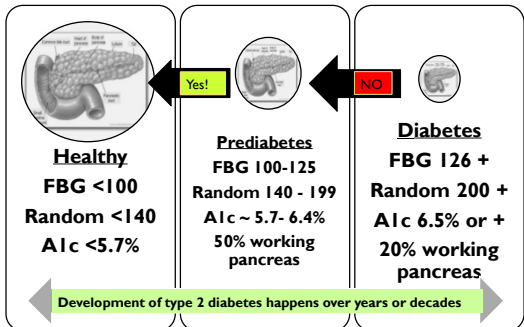
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Signs of Diabetes

- ▶ Polyuria
- ▶ Polydipsia
- ▶ Polyphasia
- ▶ Weight loss
- ▶ Fatigue
- ▶ Skin and other infections
- ▶ Blurry vision
- ▶ Glycosuria, H₂O losses
- ▶ Dehydration
- ▶ Fuel Depletion
- ▶ Loss of body tissue, H₂O
- ▶ Poor energy utilization
- ▶ Hyperglycemia increases incidence of infection
- ▶ Osmotic changes



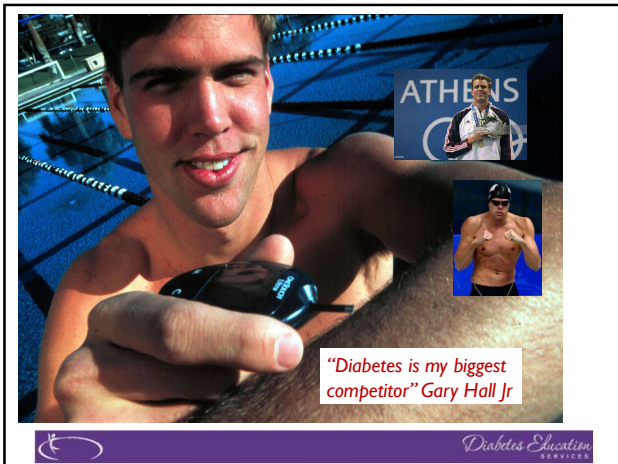
Natural History of Diabetes



<p>Healthy FBG <100 Random <140 A1c <5.7%</p>	<p>Prediabetes FBG 100-125 Random 140 - 199 A1c ~ 5.7- 6.4% 50% working pancreas</p>	<p>Diabetes FBG 126 + Random 200 + A1c 6.5% or + 20% working pancreas</p>
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Development of type 2 diabetes happens over years or decades







Insulin Finally Available - 1922

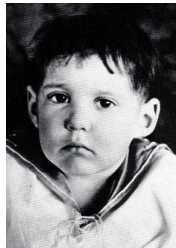


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Miracle of Insulin



Patient J.L., December 15, 1922



February 15, 1923

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Type 1 – 10% of all Diabetes

- Auto-immune pancreatic beta cells destruction
- Most commonly expressed at age 10 - 14
- Insulin sensitive (require 0.5 - 1.0 units/kg/day)
- Expression due to a combo of genes and environment:
 - Autoimmunity tends to run in families
 - Exposure to virus or other environmental factors



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Signs of Type 1 Diabetes

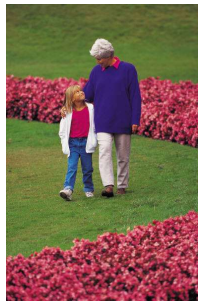
- ▶ Sudden onset of nighttime bedwetting
- ▶ Weight loss, thirst, hunger
- ▶ May present in DKA
 - ▶ Fruity breath
 - ▶ Hypothermic
 - ▶ Poor skin turgor
 - ▶ "Out of it"
 - ▶ Ketone positive (blood or urine)
 - ▶ Other



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How do we know someone has Type 1 vs Type 2?

- ▶ Type 1
 - ▶ Positive antibodies
 - ▶ GAD
 - ▶ IA2
 - ▶ ZnT8
 - ▶ Younger people develop quickly
 - ▶ Older people take longer to develop
 - ▶ Body wt and presentation



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Type 1 Diabetes Features?



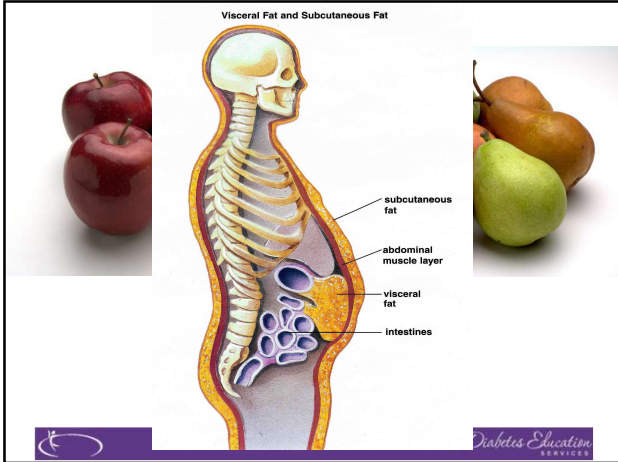
- ▶ For JR, a 28 admitted to the ICU with a blood glucose of 476 mg/dl, pH of 7.1, anion gap of 15. Recently lost 13 pounds.

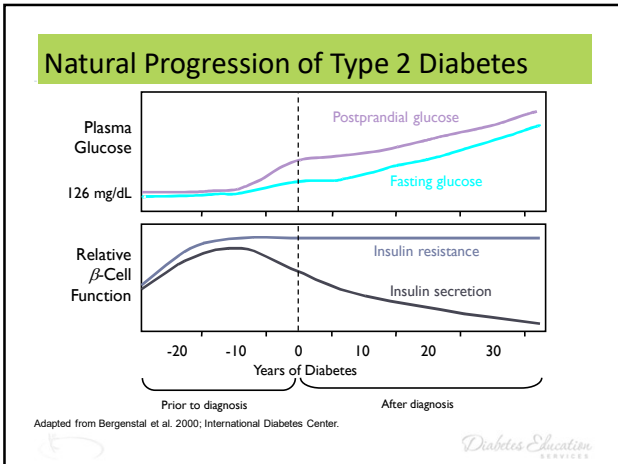
Type 1 Most Discriminative Features

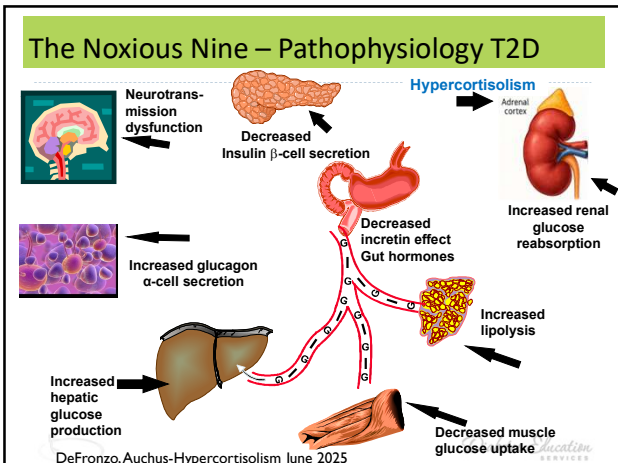
- Younger than 35 years at diagnosis
- Lower BMI (<25 kg/m²)
- Unintentional weight loss
- Ketoacidosis
- Glucose 360 mg/dl or greater.

Misdiagnosis is common and can occur in ~40% of adults with new type 1 diabetes

Diagnosis and Classification of Diabetes: Standards of Care in Diabetes—2026 







What is Type 2 Diabetes?

- ▶ Complex metabolic disorder
(Insulin resistance and deficiency)
with social, behavioral and environmental risk factors unmasking the effects of genetic susceptibility.

New Diagnosis?
Call 800 – DIABETES to
request "Getting Started Kit"
www.Diabetes.org



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What is Type 2 Diabetes?

- ▶ Type 2 diabetes is associated with insulin secretory defects related to
 - ▶ genetic predisposition,
 - ▶ epigenetic changes (how genes are expressed)
 - ▶ inflammation, and
 - ▶ metabolic stress.



- ▶ Future classification schemes for diabetes will likely focus on the pathophysiology of the underlying β -cell dysfunction.

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Life Study – Mrs. Jones

MJ is 62 years old, with a BMI of 36 and complains of feeling tired and urinating several times a night. Has a urinary tract infection. Her A1c is 8.3%, glucose 237.

MJ is hypertensive with a history of gestational diabetes. No ketones in urine.

- ▶ What are risk factors and signs of diabetes?
- ▶ You find a few moments to teach and MJ asks you some questions.



What Do You Say? Mrs. Jones asks you

- ▶ What is type 2 diabetes?
- ▶ Will this go away?
- ▶ Will I get complications?
- ▶ Will I need to take diabetes medication for the rest of my life?
- ▶ How come I got diabetes?
- ▶ Do I have to check my blood sugars?



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Comparison of Type 1 & Type 2

	Type 1	Type 2
Obesity	x	xxx
Insulin dependence	xxx	30%
Respond to oral agents	0	xxx
Ketosis	xxx	x
Antibodies present	xxx	0
Typical Age of onset	teens	adult
Insulin Resistance	0	xxx



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Pre Diabetes & Type 2- Screening Guidelines (ADA 2026 Clinical Practice Guidelines)

1. Start screening all people at age 35.
2. Screen at any age if BMI \geq 25 (Asians BMI \geq 23) plus one or > additional **risk factor**:

- ▶ First-degree relative w/ diabetes
- ▶ Member of a high-risk ethnic population
- ▶ Habitual physical inactivity
- ▶ History of heart disease
- ▶ Check more frequently if taking high risk meds; antiretrovirals, 2nd generation antipsychotics or steroids, thiazide diuretics, statins
- ▶ History of pancreatitis, prediabetes, GDM, periodontal disease



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Diabetes 2 - Who is at Risk?

(ADA Clinical Practice Guidelines)



Screening in dental practices can help detect diabetes. ~30% of dental patients over age of 30, have some degree of dysglycemia.

Risk factors cont'd

- ▶ HTN - BP > 140/90
- ▶ HDL < 35 or triglycerides > 250
- ▶ History of Gestational Diabetes Mellitus
- ▶ Polycystic ovary syndrome (PCOS)
- ▶ Other conditions assoc w/ insulin resistance:
 - ▶ Elevated BMI, acanthosis nigricans (AN)

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Acanthosis Nigricans



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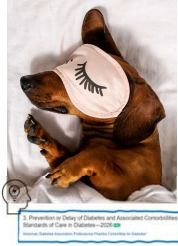
Acanthosis Nigricans (AN)

- ▶ Signals high insulin levels in bloodstream
- ▶ Patches of darkened skin over parts of body that bend or rub against each other
 - ▶ Neck, underarm, waistline, groin, knuckles, elbows, toes
 - ▶ Skin tags on neck and darkened areas around eyes, nose and cheeks.
- ▶ No cure, lesions regress with treatment of insulin resistance

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Sleep quality and Diabetes Risk

- ▶ Sleep quality “an individual’s self-satisfaction with all aspects of sleep experience.”
- ▶ Sleep modulates important metabolic, endocrine, cardiovascular processes.
- ▶ Poor sleep quality associated with 40% increased risk of developing type 2 diabetes
- ▶ Night owls have 2.5 higher odds for type 2 than early birds (chronotype)



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Quick Self-Assessment

- ▶ LS arrives late for appointment and says they forgot their log book. LS has only been taking their metformin a couple times a week and has gone back to getting fast food each morning for breakfast.
- ▶ What feelings would this evoke?
 - ▶ LS doesn't care
 - ▶ Non-compliant
 - ▶ Lazy
 - ▶ Better scare them
 - ▶ Exasperation
 - ▶ Other?

curiosity

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Language of Diabetes Education

- | Old Way | New Way |
|---------------------------|--|
| ▶ Control diabetes | ▶ Manage |
| ▶ Test BG | ▶ Check |
| ▶ Patient | ▶ Participant |
| ▶ Normal BG | ▶ BG in target range |
| ▶ Non-adherent, compliant | ▶ Focus on what they are accomplishing |
| ▶ Refuse | ▶ Decided, chose |

American Diabetes Association, Diabetes Care
The Use of Language in Diabetes Care and Education, 2017

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ADA 2026 ABC Goals

A1c less than 7% (individualize)

- Pre-meal BG 80-130
- Post meal BG <180
- Time in Range (70-180) 70% of time

Blood Pressure
<130/80
<120/80 for high risk



Cholesterol

- Statin therapy based on age & risk status
- If 40+ with ASCVD Risk, decrease LDL by 50%, LDL <70
- If 40+ with ASCVD, decrease LDL by 50%, LDL <55



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Where are we on this continuum?



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A hard truth

- ▶ Exercise alone doesn't cause weight loss
- ▶ But...
 - ▶ It helps keep weight off
 - ▶ Decreases visceral adiposity
 - ▶ Decreases CV Risk

IT TAKES 524 BURPEES
TO BURN OFF 1 LARGE FRIES
BURPEES SUCK, SO CHOOSE WISELY!
@G.HEALTH



- ▶ To combat the rise in body weight, we need to change the food environment
- ▶ "You cannot outrun an unhealthy diet".




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Diabetes is also associated with

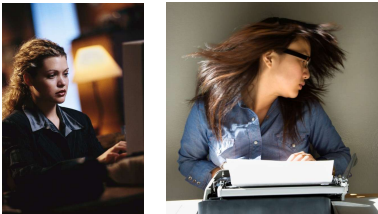
- ▶ Steatosis
- ▶ Obstructive sleep apnea
- ▶ Cancer; pancreas, liver, breast
- ▶ Alzheimer's & Dementia
- ▶ Depression, Distress and Anxiety



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Other Types of Diabetes

- ▶ Gestational
- ▶ Other specific types of diabetes



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Diabetes in Pregnancy Background

- ▶ Prevalence of diabetes in pregnancy is increasing
- ▶ Definitions
 - ▶ Pre-gestational diabetes: pre-existing type 1 or type 2 diabetes in pregnancy
 - ▶ Gestational diabetes: diabetes diagnosed in the 2nd or 3rd trimester of pregnancy



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Gestational DM ~ 9% of all Pregnancies

- ▶ Detected at 24-28 weeks of pregnancy (most insulin resistant phase)
- ▶ Rates are increasing:
 - ▶ Women getting pregnant later
 - ▶ Higher rates of obesity
- ▶ 50% chance of getting diabetes post delivery
- ▶ Offspring at greater risk of insulin resistance and diabetes



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Specific type of diabetes due to other causes

- ▶ Medications:
 - ▶ Steroids
 - ▶ Anti-retroviral meds,
 - ▶ Antipsychotic meds
 - ▶ Transplant meds
 - ▶ Checkpoint inhibitors
- ▶ Exocrine pancreas disease:
 - ▶ Cystic fibrosis
 - ▶ Type 3c
 - ▶ Pancreatitis
- ▶ Monogenic diabetes syndromes
- ▶ Agent Orange

2. Diagnosis and Classification of Diabetes: Standards of Care in Diabetes—2026

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Hypoglycemia prevention

- ▶ 72 yr old, thin, lives alone, A1c 7.3%. History of MI, stroke. DM for 12 yrs, takes glyburide 10mg BID. Limited income. Creat 1.4.
- ▶ What strategies to Prevent hypo?



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Hypoglycemia Symptoms

- ▶ **Autonomic**
 - ▶ Anxiety
 - ▶ Palpitations
 - ▶ Sweating
 - ▶ Tingling
 - ▶ Trembling
 - ▶ Hypoglycemic Unawareness
- ✱ **Neuroglycopenia**
 - Irritability
 - Drowsiness
 - Dizziness
 - Blurred Vision
 - Difficulty with speech
 - Confusion
 - Feeling faint



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Treatment of Hypoglycemia

- ▶ If blood glucose **70mg/dl** or below:
 - 10-15 gms of carb to raise BG 30 - 45mg/dl
- ⦿ Retest in 15 minutes, if still low, treat again, even without symptoms
- ⦿ Follow with usual meal or snack
- ⦿ If BG less than 40, allow recovery time
- ⦿ Severe hypo may require glucagon



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Hypoglycemia: Identify, Treat, & Prevent

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Step 1

Identify your signs of hypoglycemia or low blood sugar:

- Sweaty
- Shaky
- Hungry
- Can't think straight
- Headache
- Irritated, grouchy
- Other

Step 2

If have signs of hypo, treat with carbs until glucose reaches 70+, then eat usual meal.

- Sugary drink, 4-8oz
- Piece of fruit
- Raisins, handful
- Glucose tabs, 4+
- Honey/glucose gel
- Skittles candy, 15+

Step 3

Have glucagon rescue meds available.

In case of severe hypo, identify someone (ahead of time) who can get medical help & give a glucagon rescue medication.

Notify your provider of low blood sugar events.

Hypoglycemia Levels:

Level 1 – Glucose less than 70
 Level 2 – Glucose less than 54
 Level 3 - Severe, needs assistance

Identify Causes of Hypo & Problem Solve to Prevent Future Episodes

- » Low carb meal
- » Extra activity
- » Drinking alcohol
- » Delayed, missed meal
- » Too much insulin/meds
- » Insulin timing

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Glucagon Rescue Medications for Diabetes-Related Hypoglycemia

Name/Delivery	Supplied	Dose Range		Age / Route / Storage
		Adult	Peds / Age WT Dosing	
Glucagon Emergency Kit Injection requires mixing glucagon powder	1mg / 1mL vial + syringe	1mg	0.03mg/kg or < 6yrs or < 25 kgs 0.5mg ≥ 6yrs or > 25kgs 1mg	All ages approved SubQ or IM admin Expires in 2 years at room temp.
Baqsimi Nasal glucagon powder	3 mg intranasal device	3 mg	< 4 yrs: not recommended 4 yrs or older 3mg dose	Approved Age 4+ Nasal admin Expires ~ 2 years at room temp (keep in shrink-wrapped tube).
Gvoke Injectable liquid stable glucagon solution	0.5mg or 1.0mg in -Prefilled syringe -HypoPen auto-injector -Kit with vial and syringe	1 mg	< 2yrs: not recommended 2- 12 yrs < 45kg 0.5mg ≥ 45kg 1mg 12 yrs or older 1mg	Approved Age 2+ SubQ admin in arm, thigh, abdomen Expires in 2 years at room temp (keep in foil pouch).
Dasiglucagon (Zegalogue) Stable liquid glucagon analog	0.6mg/0.6mL Prefilled syringe Autoinjector	0.6mg	< 6yrs: not recommended 6 yrs or older 0.6mg	Approved Age 6+ SubQ in abdomen, buttocks, thigh outer upper arm Expires in 1 year at room temp. (store in red protective case).

*All raise BG 20+ points. Can cause nausea, vomiting. After admin, roll person on side. Seek medical help. If no response after 1st dose, give 2nd dose in 15 mins. When awake, give oral carbs ASAP when safe to swallow. Please consult package insert for detailed info.
 All PocketCard content is for educational purposes only. Please consult prescribing information for detailed guidelines.
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Glucagon Emergency Kit



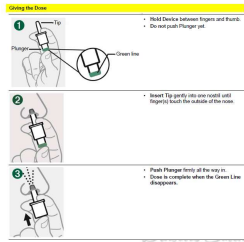
Store 68-77 degrees prior to reconstitution, single use only

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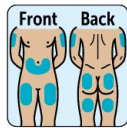
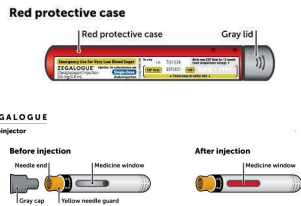
Nasal Glucagon - Baqsimi



- ▶ Approved for ages 4 +
- ▶ Absorbed nasally
- ▶ No reconstitution or refrigeration needed
- ▶ Kept in temps up to 86
- ▶ Raises BG 67-73 mg/dl
- ▶ Don't use in those with
 - ▶ Pheochromocytoma
 - ▶ Insulinoma
- ▶ See package insert



Dasiglucagon (Zegalogue)



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80 /20 Rule – Perfect Not Required

▶ Words of wisdom from my diabetes educator:
“You don't have to be perfect, Mom!”

Certified diabetes educator (and daughter!):
 Beverly Thomassian, RN, MPH, CDE, BC-ADM, president of Diabetes Education Services, Chico, CA



Patient (and mom!):
 Becky Dyck, 73
 Resident:
 Chico, CA

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Key points

- ▶ At the center of diabetes is someone living with it everyday.
- ▶ Focus on their successes
- ▶ Coach and support



Thank You



- ▶ bev@diabetesed.net
- ▶ www.DiabetesEd.net



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