Insulin Management: Optimizing Outcomes

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Faculty Disclosure

I have not had any relevant financial relationships during the past 24 months.

Practice Gap & Educational Need

Practice Gap: Increasing options in insulin types, dosing, and delivery can make insulin management challenging for the diabetes care team.

Educational Need: Understanding and managing insulin to balance efficacy, safety, and patient-specific goals are key to meeting diabetes goals.

Objectives

Identify types of insulin available and key characteristics of each type

Evaluate appropriate initiation and titration strategies for insulin management

Apply safe and effective insulin management strategies to patient specific situations

Expected Outcome

Increase knowledge and skills in safely and effectively managing insulin to meet patient-specific goals

Insulin

Mechanism of action: analogue of human insulin (regulates metabolism)

Highest efficacy	Cost varies based on type
Injectable and inhaled	Weight gain
	Hypoglycemia risk
	Dose requirements change with renal dysfunction
	Injection site reactions

American Diabetes Association. Pharmacologic Approaches to Glycemic Treatment: Standards of Medical Care in Diabetes—2022. Diabetes Care. Jan 2022, 45 (Supplement 1) S125-S143
Triplitt CL, Repas T, Alvarez C. Diabetes Mellitus. In: DiPiro JT, Talbert RL, Yee GC, Matzke GR, Wells BG, Posey L. eds. Pharmacotherapy: A Pathophysiologic Approach, 10e. McGraw-Hill; Accessed October 01, 2020.

Clinical 	Evaluate the: • Type of diabetes • Diabetes management skills/technical comfort • Presence of diabetes complications or hypoglycemia with or without symptoms • Physical and cognitive functioning for self-administration/availability of a caregiver
Emotional 	Proactively ask the person with diabetes how they feel about their insulin delivery and address any fears (eg, needle phobia) in an open dialogue
Social 	Lifestyle factors, such as daily routine, physical activity levels, work environment, and access/financial constraints can significantly influence device choices and the viability of certain options over others, such as implementing CGM or using an insulin pen instead of syringes

Insulin: Role in Type 1 Diabetes

Type 1 Diabetes:

- Insulin is essential
- Basal/bolus injections or continuous subcutaneous insulin infusion preferred
- Insulin analogs or inhaled insulin referred over injectable human insulins
- Ideally receive education on how to match mealtime insulin dose to nutritional intake (carbohydrate, fats, protein) and how to modify doses based on glucose levels, trends in glucose, illness, and physical activity

Representative relative attributes of insulin delivery approaches in people with type 1 diabetes

Injected insulin plans	Greater flexibility	Lower risk of hypoglycemia	Higher costs
MDI with LAA + RAA or URAA	+++	+++	$$$
Less-preferred, alternative injected insulin plans			
MDI with NPH + RAA or URAA	++	++	$$
MDI with NPH + short-acting (regular) insulin	++	+	$
Two daily injections with NPH + short-acting (regular) insulin or premixed	+	+	$

Continuous insulin infusion plans	Greater flexibility	Lower risk of hypoglycemia	Higher costs
Automated insulin delivery systems	+++++	+++++	$$$$$
Insulin pump with threshold/ predictive low-glucose suspend	++++	++++	$$$$$
Insulin pump therapy without automation	+++	+++	$$$$

Diabetes Care. 2024;48(Supplement_1):S181-S206. doi:10.2337/dc25-S009

Insulin: Management in Type 1 Diabetes

Typically, 30-50% of total daily insulin should be given as basal insulin

Ratio of basal to bolus will vary based on:

- Carbohydrate consumption
- Age
- Pregnancy
- Puberty stage

Total daily insulin requirements estimated based on weight

- Typical dose 0.4-1 unit/kg/day
- Higher doses typically required with puberty, menses, medical illness
- Metabolically stable: starting dose 0.3-0.5 units/kg/day (split 50/50 between basal and prandial dosing)
- If suspect continued endogenous insulin production (honeymoon period): starting dose lower at 0.2-0.6 units/kg

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Patient Case #1

LR is a 24yo female patient who presents to her primary care provider requesting treatment for a UTI. She reports increased urinary frequency including waking up to urinate overnight 5-6 times. She reports that these symptoms have continued to worsen over the past 2 weeks.

Vitals	
Systolic	117
Diastolic	71
Heart Rate	104
Temp	36.7 C
Resp	18
Height (cm)	160 cm
Weight (kg)	82.1 kg
BMI	32.06 kg/m2
BSA (m2)	1.91 m2

URINE DIP	
POCT Urine Color	Yellow
POCT Urine Clarity	Clear
POCT Specific Gravity, Urine	1.020
POCT Protein, Urine	Negative
POCT pH, Urine	6.5
POCT Glucose Urine	>=1000 !
POCT Bilirubin, Urine	Negative
POCT Ketones, Urine	Negative
POCT Blood, Urine	Negative
POCT Urobilinogen, Urine	0.2
POCT Leukocyte Esterase, Ur...	Negative
POCT Nitrite, Urine	Negative

Patient Case #1

Upon reviewing LR's urine dip, you discuss with LR her risk factors for diabetes. She shares her dad and brother both have T1DM. After hearing her glucose is elevated in her urine, she is now worried she might also have T1DM.

POCT Hemoglobin A1C		10.5
C-Peptide	0.32 ▼	

ZINC TRANSPORTER 8 ANTI...	03/21/25 252.6 ▲
Islet Cell Cytoplasmic Antibo...	03/21/25 1:8 ▲
IA 2 AUTOANTIBODY	03/21/25 >120.0 ▲

Glucose	271 ▲
Sodium	134 ▼
Potassium	4.1
Chloride	99
CO2	23
Creatinine	0.76
Anion Gap	12
BUN	21
BUN/Creatinine Ratio	28
EGFR	112.3
Calcium	9.2
Albumin	4.0
Total Protein	6.9
ALT, Plasma	26
AST, Plasma	28

Patient Case #1

What is an appropriate insulin regimen to start LR on?

Vitals	
Systolic	117
Diastolic	71
Heart Rate	104
Temp	36.7 C
Resp	18
Height (cm)	160 cm
Weight (kg)	82.1 kg
BMI	32.06 kg/m2
BSA (m2)	1.91 m2

Insulin: Role in Type 2 Diabetes

Type 2 Diabetes:

- Insulin initiation should be considered regardless of duration of disease or current diabetes therapies if:
  - Symptoms of hyperglycemia present
  - A1c > 10%
  - Glucose ≥ 300mg/dL
- If there's no evidence of insulin deficiency, GLP-1 RA or GIP/GLP-1 RA preferred over insulin
- Combination therapy of insulin + GLP-1 RA or GIP/GLP-1 RA recommended
- Insulin dose should be reassessed with addition or dose escalation of any non-insulin diabetes therapies
- Generally, non-insulin diabetes therapies can be continued when initiating insulin therapy especially if demonstrated glycemic and/or metabolic effects

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Insulin: Management in Type 2 Diabetes

Initiation:

- Basal insulin: 10 units daily OR 0.1-0.2 units/kg per day
- Prandial insulin:
  - Can start with one dose with largest meal
  - 4 units before meal or 10% of basal dose
  - May consider reducing basal insulin dose by 10% if A1c <8%

Titration:

- Basal insulin: Consider self titration of 2 units every 3 days until fasting glucose at goal
- If hypoglycemia: decrease by 10-20% if no clear cause

Often require higher daily doses ~1 units/kg

Typically lower risk of hypoglycemia

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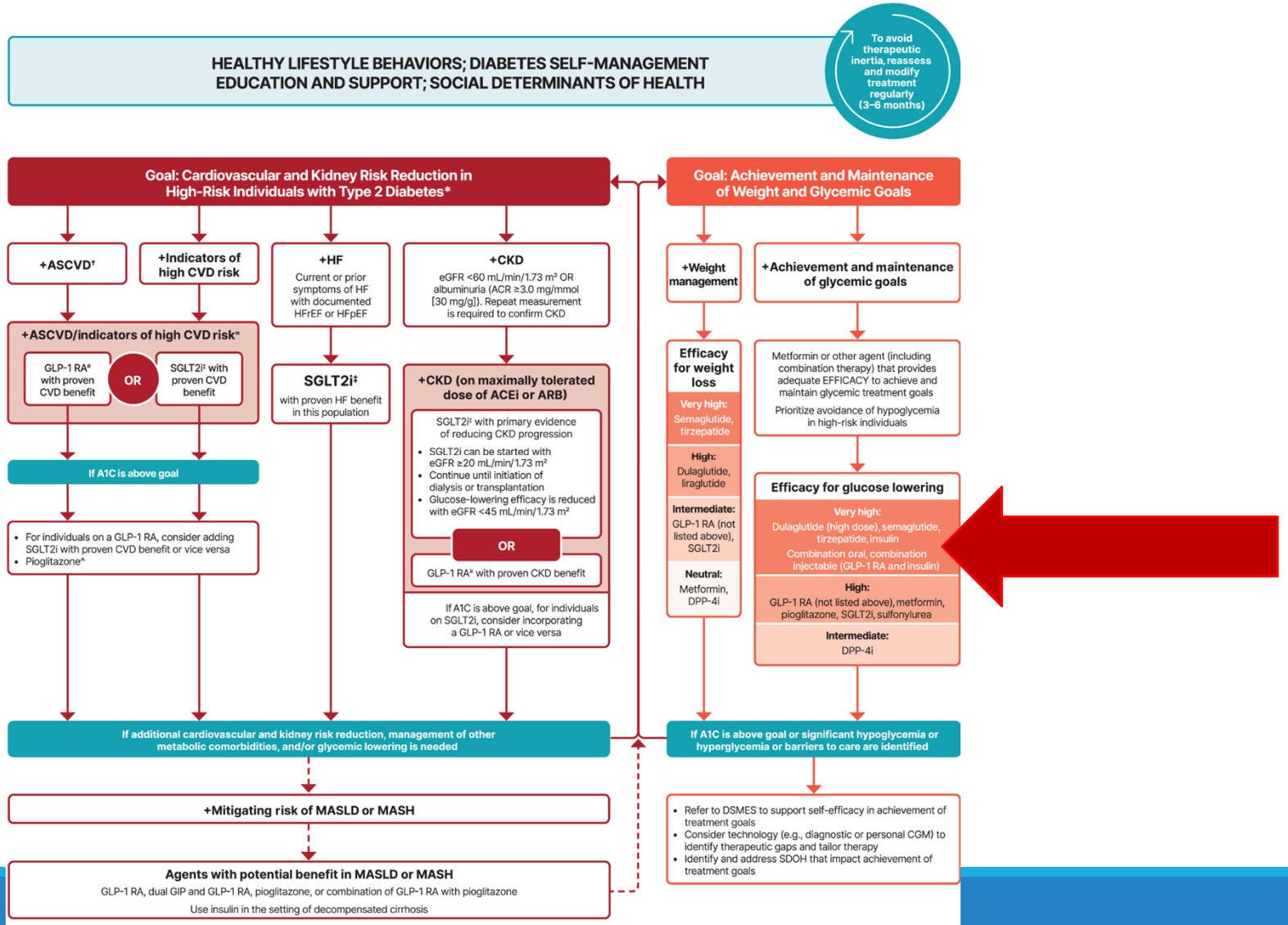
Use of Glucose-Lowering Medications in the Management of Type 2 Diabetes



Diabetes Care.
2024;48(Supplement_1):S181-S206.
doi:10.2337/dc25-S009

Insulin: Role in Type 2 Diabetes

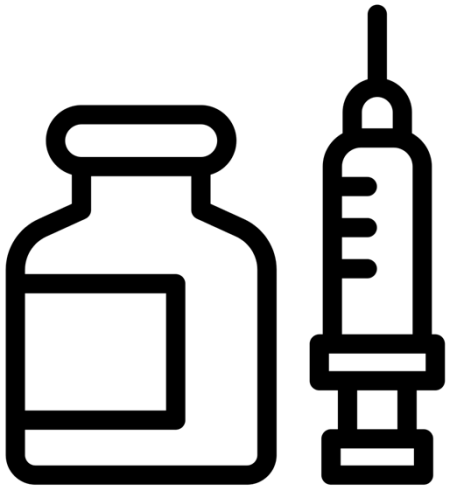
Important to have ongoing conversations with patients about the progression of the disease

Avoid discussing as a threat or punishment for patients

May be beneficial to maintain glycemic goals long term

May also be beneficial for acute management of glucose in specific situations:

- Hospitalization
- Acute Illness
- High dose glucocorticoid utilization
- Pregnancy or planning pregnancy



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Insulins

* Concentrated product available
† Biosimilar/follow-on product available

Glargine/Lixisenatide

Degludec/Liraglutide

Pre-Mix Basal Insulin/GLP-1 agonists

Intermediate-acting (NPH)

Long-acting (glargine*†, detemir)

Ultra-long acting (degludec*)

Basal

Short-acting (regular)

Rapid-acting (lispro*†, glulisine, aspart, inhaled)

Ultra-rapid acting (aspart)

Bolus/Prandial

NPH/regular 70/30

Lispro 50/50

Lispro 75/25

Aspart 70/30

Pre-Mix

Concentrated human regular insulin (regular U-500*)

U-500

Utilizes prandial insulins to deliver continuous basal rates and boluses

Combined pump and sensor systems

Pumps

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Generic	Brand	Dosage Form
Insulin degludec	Tresiba	U100 vial, pen U200 pen
Insulin glargine	Lantus, Basaglar, Semglee, Toujeo	U100 vial, pen U300 pen
Insulin NPH	Humulin N, Novolin N	U100 vial, pen

Basal Insulins

Role: limit hyperglycemia overnight and between meals by counteracting hepatic glucose production

Monitoring dose: fasting glucose, between meal glucose patterns

Most convenient insulin initiation in type 2 diabetes

Necessary to have basal coverage in all patients with type 1 diabetes

Hypoglycemia risk:

- U100 glargine and determine less likely to cause hypoglycemia including nocturnal hypoglycemia compared to NPH
- U300 glargine and degludec have lower nocturnal hypoglycemia risk than U100 glargine

Be careful to avoid overbasalization!

- Watch for high bedtime to morning glucose differentials (dropping ≥50mg/dL overnight)
- Hypoglycemia (with or without symptoms)
- High glucose variability
- Should evaluate if prandial hyperglycemia appropriately addressed

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Generic	Brand	Dosage Form
Insulin aspart	Novolog	U100 vial, cartridge, pen
Insulin aspart – faster acting	Fiasp	U100 vial, cartridge, pen
Insulin glulisine	Apidra	U100 vial, pen
Inhaled insulin	Afrezza	Inhalation cartridge
Insulin lispro	Humalog	U100 vial, cartridge, pen U200 pen
Lispro-aabc	Lyumjev	U100 vial, pen U200 pen
Insulin regular	Humulin, Novolin	U100 vial, pen

Bolus Insulins

For type 2 diabetes:

- Consider starting with singled prandial insulin dose with largest meal
- Can be intensified further based on patient specific needs

Can maintain metformin, GLP-1 RA or GLP-1/GIP RA, SGLT2i, TZD unless adverse effects

Should discontinue sulfonylureas, meglitinides, and DPP-4i

Frequent titrations often required

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Generic	Brand	Dosage Form
Insulin aspart 70/30	Novolog 70/0	U100 vial, pen
Insulin lispro 50/50	Humalog 50/50	U100 vial, pen
Insulin lispro 75/25	Humalog 75/25	U100 vial, pen
Insulin NPH/regular 70/30	Humulin 70/30, Novolin 70/30	U100 vial, pen

Premixed Insulins

May be options for simplification of regimen

Allows for:

- Simpler dosing
- Less confusion by only using one insulin product
- Often less costly
- Basal and bolus coverage in one product

Increases risk for hyperglycemia and hypoglycemia if:

- Inconsistent sleeping and eating schedule
- Inconsistent carbohydrate intake
- Inconsistent timing of doses

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Choosing an Insulin Regimen

BASAL-BOLUS

More flexible

Better for erratic meal schedules

Better for variability in meal nutrition

Ability to titrate to patient specific needs

Risk of hypoglycemia if patient does not eat with short acting insulin

PREMIXED

Can be less expensive, especially with no insurance coverage

OTC options available

Typically twice daily dosing (less injections)

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POP QUIZ:
What type of regimen is best for…

Patient with T1DM who recently moved to the area and is no longer able to use their insulin pump because of an insurance change

Patient with an A1c of 9.5% and currently taking metformin, semaglutide, and empagliflozin (all at max doses)

Patient with T2DM resistant to multiple daily injections with recent A1c of 13%

Patient with T2DM currently on metformin and tirzepatide who is hoping to conceive pregnancy within the next 3 months and most recent A1c of 8.5%

Patient with T2DM who works as a nurse and flips between night shift and day shift

Patient with T2DM, HFrEF planning a 30 day religious fast with an A1c of 8.4% currently taking metformin, dulaglutide and unable to take an SGLT2i due to recurrent genital infections

Concentrated Insulin

May allow for fewer injections

May be more comfortable to inject due to smaller volume

Insulin regular U500 (Humulin R U500)

- Consider in patients utilizing >200 units/day
- Distinct pharmacokinetics
- Similar onset to insulin regular U100
- Blunted, prolonged peak compared to insulin regular U100
- Characteristics more like premixed insulin
- Used BID or TID QAC
- Available in pens and 20 mL vial (need U500 syringes for vial)

All other concentrated insulin only available in pens to minimize risk of errors

Insulin glargine U300 (Toujeo)

- Longer duration than glargine U100
- Slightly less efficacious than glargine U100

Insulin degludec U200 (Tresiba)

- Similar pharmacokinetics to degludec U100

Insulin lispro U200 (Humalog U200)

- Similar pharmacokinetics to lispro U100

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Patient Case #2

JS is a 67 yo male with history of T2DM, HTN, CVA and HLD. His current insulin regimen is as follows:

- Insulin glargine U300 (Toujeo) 120 units daily
- Insulin lispro 50 units TID QAC

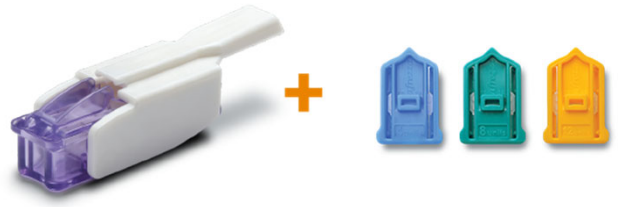
Today's A1c is 8.4%

The patient reports most days he only takes 2 doses of his mealtime insulin because he is often at friends or neighbors homes for lunch and always forgets to bring the insulin with him.

Pre-breakfast	Pre-lunch	Pre-dinner	Bedtime
195	220	251	297
208	195	299	305
211	185	301	254
197	241	284	273
281	199	361	251
193	231	250	301
225	204	296	251

How would you adjust JS's insulin regimen?

Inhaled human insulin



Monomers of regular human insulin

Studied in T1DM

Pharmacokinetics similar to injectable rapid acting insulin

May have faster onset, shorter duration, better A1c reduction, and weight reductions compared with injectable rapid acting insulins

May cause decline in lung function

- Contraindicated in chronic lung disease
- Not recommended in those who smoke or recently stopped smoking
- Requires spirometry prior to starting and after initiation

Units per meal	How to write	NDC # and contents of 1 box[$]
4–16	• Inhale 4-16 units by mouth at mealtime and additional units as needed for glucose control • **Max total daily dose:** 48 units=1 box; 96 units=2 boxes (360 cartridges); 144 units=3 boxes (540 cartridges) • 30-day supply • **Refills:** 12	NDC 47918-0902-18 [60] 4-Unit Cartridges [60] 8-Unit Cartridges [60] 12-Unit Cartridges Total: 180 cartridges
4–12	• Inhale 4-12 units by mouth at mealtime and additional units as needed for glucose control • **Max total daily dose:** 36 units=1 box; 72 units=2 boxes (360 cartridges); 108 units=3 boxes (540 cartridges) • 30-day supply • **Refills:** 12	NDC 47918-0880-18 [90] 4-Unit Cartridges [90] 8-Unit Cartridges Total: 180 cartridges
8–20	• Inhale 8-20 units by mouth at mealtime and additional units as needed for glucose control • **Max daily dose:** 60 units=1 box; 120 units=2 boxes (360 cartridges); 180 units=3 boxes (540 cartridges) • 30-day supply • **Refills:** 12	NDC 47918-0898-18 [90] 8-Unit Cartridges [90] 12-Unit Cartridges Total: 180 cartridges

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https://afrezzahcp.com/dosing/

Insulin pumps

Small computerized, wearable device using **rapid acting insulin** to deliver both **basal and bolus insulin coverage**

Basal coverage given continuously measured in units/hr

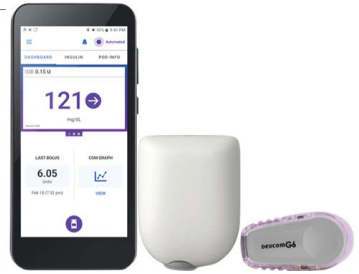
Bolus doses given to cover nutritional intake and correction insulin for hyperglycemia

Automated Insulin Delivery (AID)

Also known as hybrid or advanced hybrid closed-loop

3 components:

- Continuous glucose monitor (CGM)
- Insulin pump
- Algorithm that adjust insulin delivery in response to CGM value and trend



danatech. Automated insulin delivery, a quick overview. https://www.adces.org/danatech/insulin-pumps/insulin-pumps-101/automated-insulin-devices-faq#:~:text=What%20is%20AID%3F,the%20CGM%20value%20and%20trend.
ADA. Consumer Guide. https://consumerguide.diabetes.org/collections/pumps

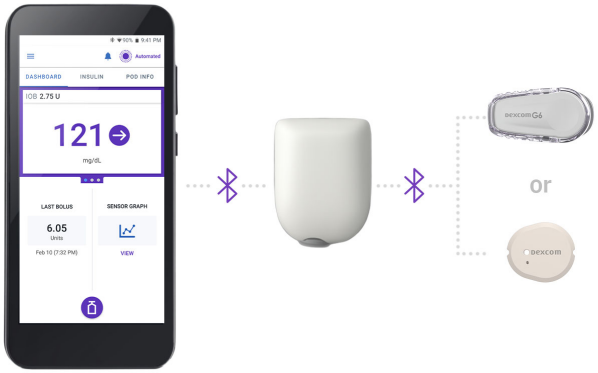
Automated Insulin Delivery (AID)

Advantages

Improve time in range

Reduce hypoglycemia

Reduce burden of diabetes



Considerations

2 devices must be worn

$$$ with variable coverage

Need troubleshooting skills

Need back up plan in case of pump failure

User must pre-bolus for food and adjust for exercise, stress or illness

User must troubleshoot when glucose not as expected or out of range

User/provider must trust the system to make adjustments

danatech. Automated insulin delivery, a quick overview. https://www.adces.org/danatech/insulin-pumps/insulin-pumps-101/automated-insulin-devices-faq#:~:text=What%20is%20AID%3F,the%20CGM%20value%20and%20trend.

Evaluating efficacy of insulin regimen

A1c

Glucose log

CGM data

Basal insulin: fasting glucose

Prandial insulin: postprandial glucose excursions

Hypoglycemia
- Frequency
- Severity
- Timing

Evaluating efficacy of insulin regimen

All the data is worthless without understanding how the patient is utilizing their insulin including:

- When they take their injections (time, relationship to meals or other activities)
- How often they are missing doses (intentional or unintentional)
- How often are they giving extra doses (intentional or unintentional)
- If they are self adjusting doses (increasing or decreasing in response to glucose values and/or symptoms)
- What insulins they are actually using (people have random stuff in their refrigerators)
- Storage of insulin
- Injection technique
- How they manage hyperglycemia
- How they manage hypoglycemia

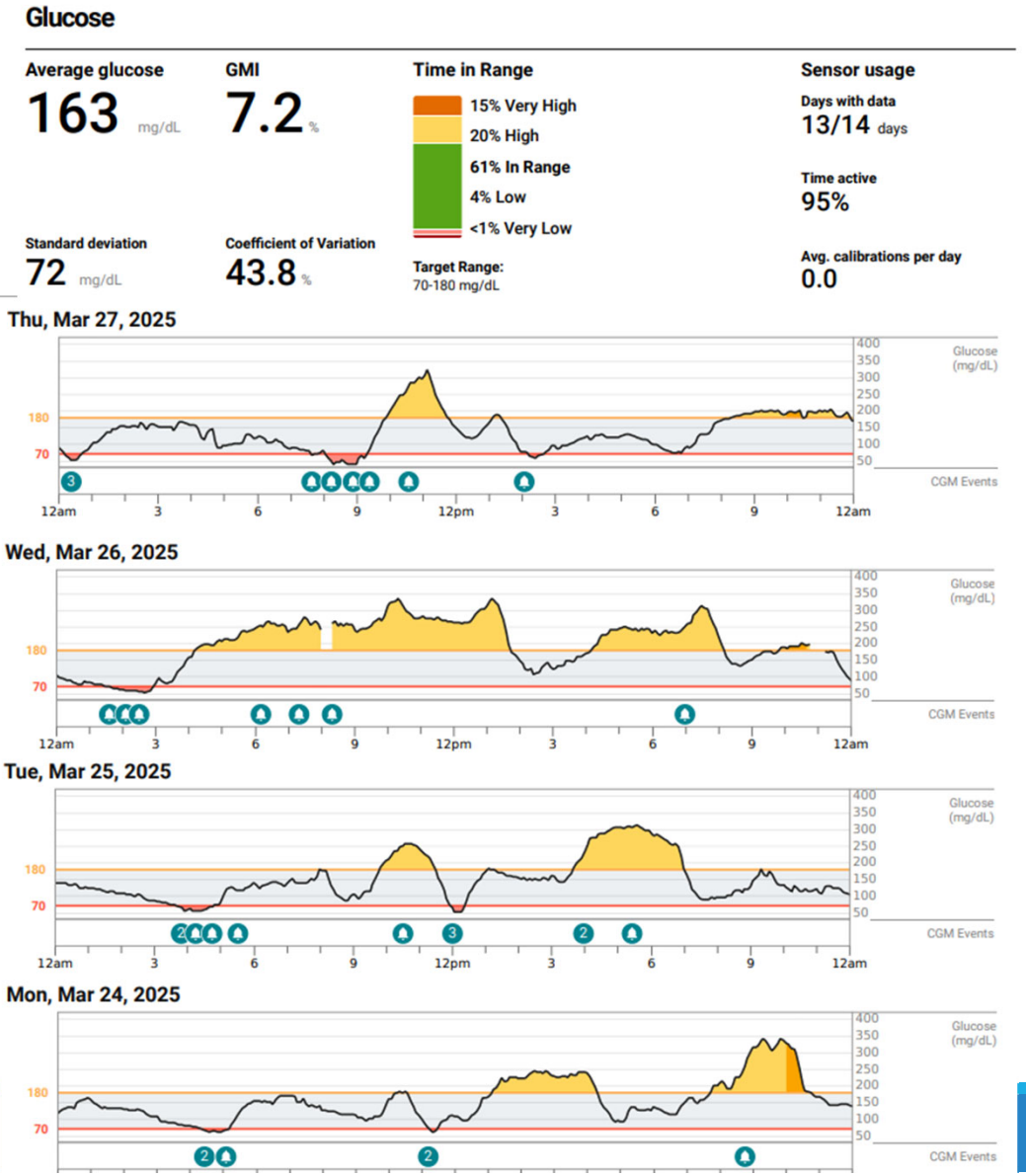
Patient Case #3

SR presents for a 3 month follow up for type 2 diabetes. He reports overall things are going well with his glucose management but has become frustrated with an increasing number of highs and lows despite his A1c being near goal. He's not sure if he needs more or less insulin, but thinks an adjustment should be made. Due to his history of pancreatitis and CKD4, he is not currently able to take any non-insulin agents.

Current diabetes medications:

- Insulin glargine 46 units once daily in the evening
- Insulin lispro 10 units before all meals

How would you adjust LR's insulin regimen?



Insulin: Administration Technique Education

Injection

Appropriate sites of administration

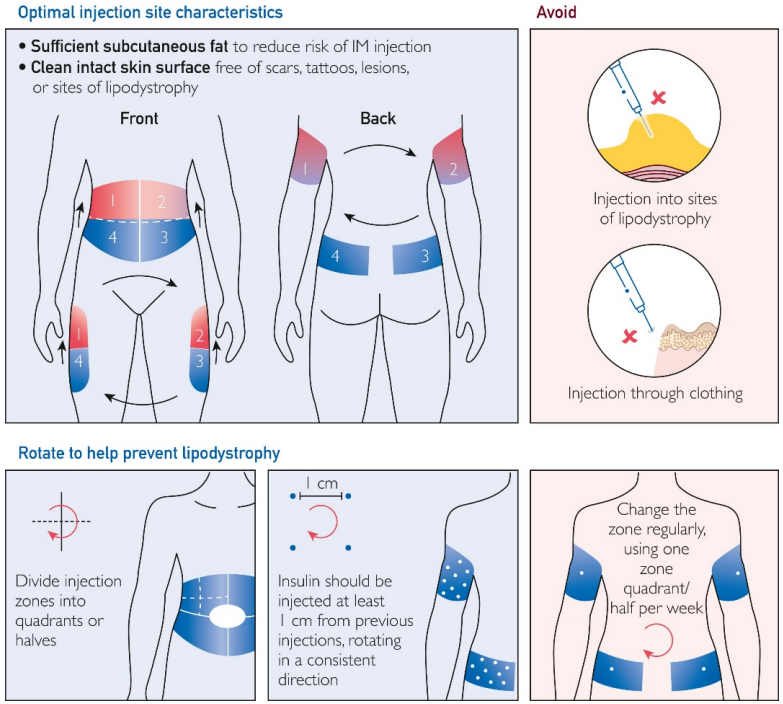
Appropriate care of site to prevent infection and complications

Rotation of sites

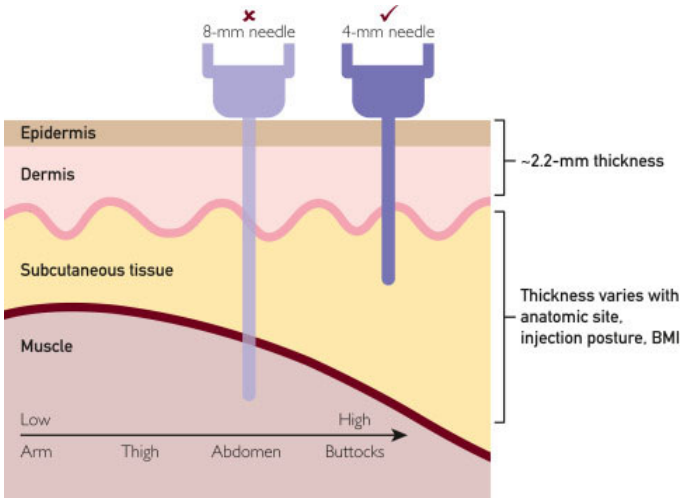
Avoidance of IM insulin delivery

Avoid reusing needles

Reassessing administration technique should be done during routine follow up



Syringes and Pen Needles



Ensure appropriate length of needle

Ensure appropriate quantity ordered to match number of injections daily

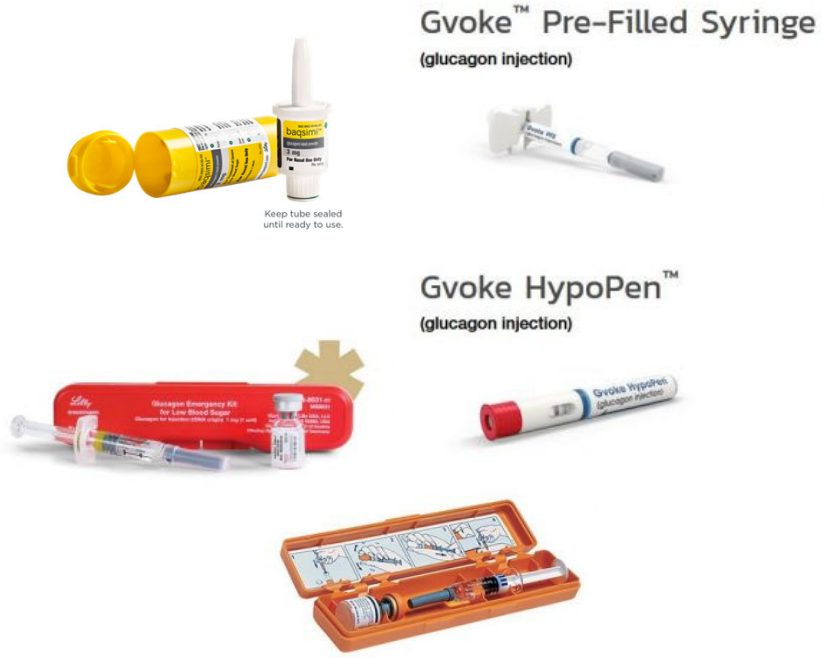
Example: patient taking insulin glargine BID and insulin lispro TID QAC:

pen needle, diabetic 31G X 5 MM misc

Reference Links: • Lexidrug
Product: INSULIN PEN NEEDLE 31G X 5 MM MISC
Sig Method: Specify Dose, Route, Frequency | Taper/Ramp | Combination Dosage | Use Free Text
Dose: 1 each
Route: Does not apply
Frequency: 5 times daily
Duration: Doses | Days | 30 days | 2 months | 1 year
Starting: 4/24/2025 Ending: First fill:
Dispense: Days/Fill: Full (0 Days) | 30 Days | 90 Days
Quantity: 150 each Refill: 11 | 0 | 1 | 2 | 3 | 11
Total Supply: **360 Days**

Glucagon

- Should be prescribed to all people with diabetes on insulin
- Family, caregivers, school personnel should know location and how to administer
- Preparations that do not require reconstitution are preferred
- Clinicians should routinely review patient access to glucagon

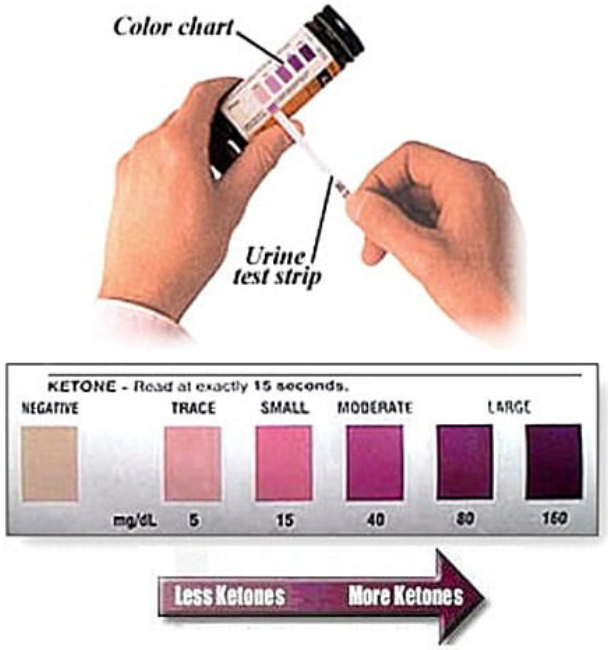


Diabetes Education Services. https://diabetesed.net/glucagon-rescue-meds-options/.
Diabetes Care. 2024;48(Supplement_1):S181-S206. doi:10.2337/dc25-S009

Ketone Monitoring

Provide educations and monitoring plan for those at risk:

- SGLT2 inhibitors
- Type 1 diabetes
- Ketogenic eating pattern
- History of DKA



Reinfield J. MantraCare. https://mantracare.org/diabetes/treatment/ketone-strip-test/.
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Key Points

- Diverse choice in insulin regimens allows for tailoring to patient-specific clinical goals and preferences
- Objective glycemic data and patient insulin utilization behaviors are important in supporting safe and effective insulin management decisions

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