Clinical Case Discussion

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August 21, 2025

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A 25-year-old man with history of poorly controlled type 1 diabetes, diabetic gastroparesis, and frequent medical noncompliance presents to the ER with 24 hours of nausea, vomiting and “out of control blood sugars”. He denies recent illnesses but admits missing several insulin doses over the last week due to an irregular work schedule.

Meds:
Insulin glargine 10 units SQ qhs
Insulin lispro “sliding scale” which he cannot describe clearly

Social history: He is single and lives with a roommate. He works at a local store. He smokes about ½ ppd. There is no history of alcohol or drug use. He has no health insurance.

On exam, he is a thin, chronically-ill appearing young man.
Vitals: bp 108/60 p 90 RR 34 temp 98.9F O2 sat 98% on RA

HEENT: PERRL; EOMI
oropharynx: dry mucous membranes; no exudate

Neck: supple without adenopathy. No thyromegaly. JVP 6 cm at 45 degrees

Car: r/r/r, tachycardic, without murmur

Lungs: CTA without w/r/r

Abd: scaphoid abdomen with hypoactive bowel sounds; mild generalized tenderness

Extr: No edema; dp pulses 2+ bilaterally. Markedly decreased vibratory sense over both feet.

Na	132
K	6.3
Cl	99
CO2	5
BUN	36
Cr	2.1
Ca	8.3
Glucose	613

Anion Gap = 26

Wbc	11,000
Hgb	13.2
Hct	39
Platelets	201,000
% Neutrophils	87

AST	23
ALT	26
Alk phos	80
T bili	1.4

pH	**pCO2**	**pO2**	**O2 sat**
7.35	15	95	100%

Lipase	34

EKG: Sinus rhythm, rate 90, normal axis, normal intervals, no acute changes

DKA due to non compliance with insulin in the setting of Type 1 diabetes

DKA Etiology

- Acute MI
- Acute CVA
- Sepsis
- Pancreatitis
- New onset type 1 diabetes
- Interruption of SQ insulin in type 1 diabetes or inadequate insulin and dietary regimen
- Glucocorticoid therapy
- SGLT2-I in type 2 diabetes
- Cocaine abuse
- Malfunction of insulin pump

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DKA: Clinical Manifestations

- Rapid onset, usually within 24 hours
- Severe hyperglycemia
- Polyuria
- Polydipsia
- Delirium
- Abdominal pain
- Volume depletion on exam
- Kussmaul respirations: hyperventilation
- Fruity breath odor

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Clinical findings and DKA Severity

	Mild	Moderate	Severe
Plasma glucose (mg/dl)	> 250	> 250	> 250
Arterial pH	7.25 to 7.30	7.00 to 7.24	< 7.00
Serum bicarbonate (mEq/L)	15 to 18	10 to 15	<10
Urine ketones	positive	positive	positive

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Clinical findings and DKA Severity

	Mild	Moderate	Severe
Serum ketones	positive	positive	positive
Beta hydroxybutyrate—enzymatic reaction (< 0.6 mmol/L)	3 to 4	4 to 8	> 8
Effective serum osmolality (mOsm/kg)	variable	variable	variable
Anion gap (mEq/L)	> 10	>12	>12
Mental Status	alert	Alert or drowsy	Stupor or coma

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Sodium Abnormalities in DKA

- Mild hyponatremia

- Correcting plasma sodium for serum glucose concentration:
  - Add 2 meEq/L to plasma sodium for each 100 mg/dl increase in glucose above normal.
  - For example, in a patient with a glucose of 375 mg/dl and a plasma sodium of 130, the corrected sodium level is as follows:
    - 375 is about 275 mg/dl above normal glucose of 100 mg/dl
    - 275 mg/dl x increase of 2 mEq Na/L/100 mg/dl increase in Na = 5.5 mEq/L
    - Therefore, corrected Na is 130 + 5.5 = 135.5 mEq/L

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Water Deficit in DKA

- On average, patients have a **six-liter** water deficit in DKA or 100 ml/kg body weight

Electrolyte Deficits in DKA

Electrolyte	Deficit (mEq/kg body weight)	Deficit in a 70 kg patient (mEq)
Na	7 to 10	600
Cl	3 to 5	300
K	3 to 5	300

Electrolyte Deficits in DKA

Electrolyte	Deficit (mEq/kg body weight)	Deficit in a 70 kg patient (mEq)
Phos	5 to 7	400
Mag	1 to 2	100
Ca	1 to 2	100

Leukocytosis with left shift

- Leukocytosis due to:
  - Hypercortisolemia
  - Increased catecholamines

- DKA alone generally does NOT explain a wbc > 25,000 or more than 10% band forms on the differential and should prompt further investigation

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Differential diagnosis of DKA

- Alcoholic ketoacidosis
- Starvation ketoacidosis

Management of DKA

Management of DKA

- IVFs
- Insulin
- Potassium and Phosphate
- Bicarbonate
- Treat the underlying cause!

Management of DKA: Laboratory Monitoring

Check finger stick blood glucose hourly until stable

Check electrolytes, BUN/Cr (ie. chem-8, Mag,Phos) every two to four hours

Serial ABGs NOT indicated

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Management of DKA: IVFs

- Isotonic saline (0.9%) generally 1 liter in the first hour
- Follow volume status clinically
- Once intravascular volume is restored and if sodium level is normal or high, change IVFs to 0.45% saline

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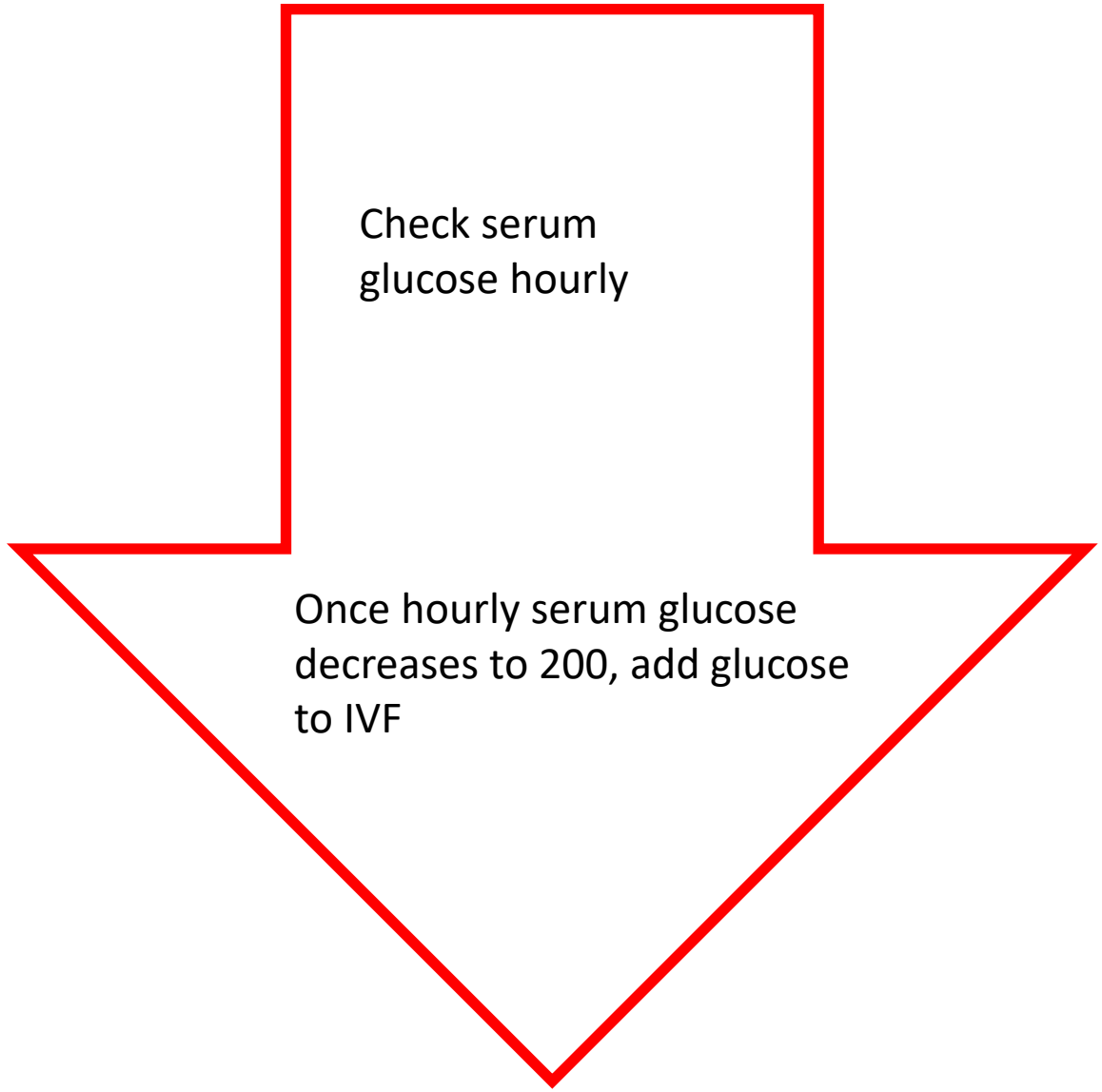
Management of DKA: IVFs



Isotonic saline (0.9%) generally
1 liter in the first hour

Follow volume status clinically and watch serum sodium level

Once intravascular volume is restored

Serum sodium high or normal

0.45% saline

Serum sodium low

0.9% saline

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Management of DKA: Insulin

- Use intravenous regular insulin
- Initiate insulin IF serum K > 3.3 mEq/L

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Management of DKA: Insulin

Insulin alone will decrease glucose by 50 to 70 mg/dl per hour

IVFs alone will decrease glucose by 35 to 70 mg/dl per hour

Expect insulin combined with IVFs to decrease glucose by a maximum of about 140 mg/dl per hour

Serum K > 3.3 mEq/L?

No → Supplement K to achieve level > 3.3 mEq/L

Yes ↓

Regular insulin 0.1 unit/kg IV bolus ↓

Regular insulin 0.1 unit/kg per hour IV infusion

Check blood glucose hourly while on insulin infusion

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Management of DKA: Potassium

- Replace K IF serum K < 5.3 and UOP at least 50 ml/hr
- Almost all patients with DKA have a total body potassium deficit
  - Glucose-related osmotic diuresis
  - Secondary hyperaldosteronism
- On presentation, about 2/3 of patients with DKA have a normal K level; about 1/3 have an elevated K

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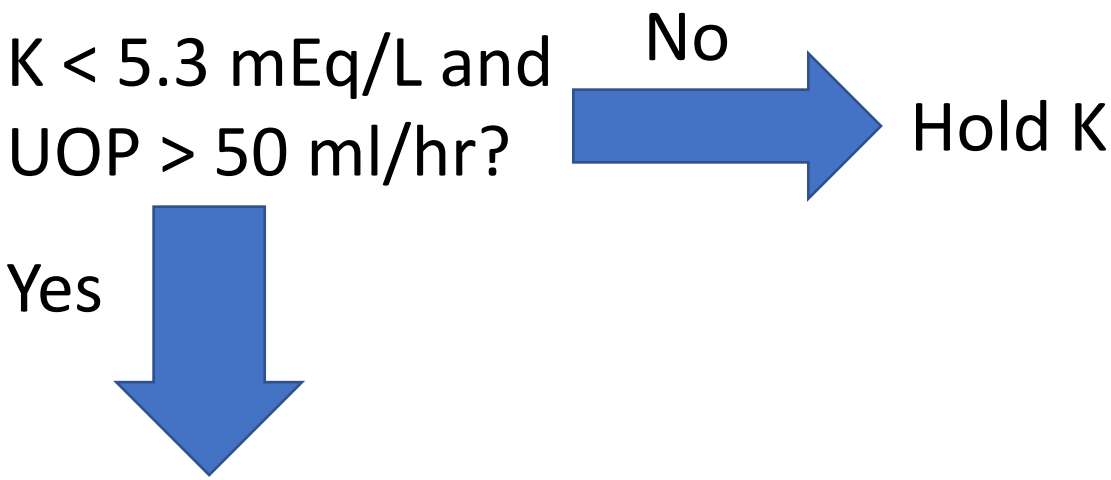
Management of DKA: Potassium



K < 3.3 mEq/L

Add 20 to 40 mEq KCL
to each liter of IVFs

K between 3.3 and 5.3 mEq/L

Add 20 to 30 mEq KCL
to each liter of IVFs

Goal: Maintain K between 4 and 5 mEq/L

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Management of DKA: Phosphate

- Patients with DKA are often total body phosphate depleted

- If severe hypophosphatemia develops (ie. < 1 mg/dl) then can add 20 to 30 mEq/L sodium phosphate can be added to each liter of IVF, particularly in the setting of
  - Cardiac dysfunction
  - Hemolytic anemia
  - Respiratory depression

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Management of DKA: Phosphate

- For non-severe hypophosphatemia, intravenous phosphate replacement is **not** recommended
  - No benefit demonstrated in randomized trials
    - Duration of DKA
    - Dose of insulin required
    - Rate of fall of serum glucose
    - Morbidity
    - Mortality
  - Risks of phosphate repletion
    - Hypocalcemia
    - hypomagnesemia

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Management of DKA: Bicarbonate

- General NOT recommended EXCEPT in severe metabolic acidosis:
  - Arterial pH < 6.9
  - Decreased cardiac contractility and vasodilation with decreased tissue perfusion

- If bicarbonate is used:
  - 1 ampule of 7.5% sodium bicarbonate = 44.6 mEq of HCO3 ion
  - Given 2 ampules (about 100 mEq)
  - If K < 5.3 mEq/L, also administer 20 mEq KCL as administration of bicarbonate will drive K intracellularly

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Resolving DKA

- Anion gap < 12
- Normal mental status
- Effective plasma Osmolality < 315 mOsm/kg

Effective P_{osm} = [2x Na (mEq/L)] + [glucose (mEq/L) /18]

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Complications of DKA

- Cerebral edema, especially in children

- Clinical manifestations: 12 to 24 hours after starting treatment for DKA
  - Headache
  - Decreased responsiveness
  - Seizures
  - Incontinence
  - Pupillary changes
  - Respiratory arrest

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Complications of DKA: Cerebral edema

- Mortality rate 20 to 40%

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Complications of DKA: Cerebral edema

- Prevention:
  - Gradual replacement of sodium and free water deficits in hyperosmolar patients who are not in hypovolemic shock
  - Do not exceed a change in sodium level of 0.5 mEq/L per hour

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Complications of DKA: Cerebral edema

- Prevention:
  - In the first three hours of treatment, do not exceed 15 to 20 ml of 0.9% saline/kg lean body weight per hour
    - Calculating lean body weight:
      - Female LBW (kg) = (0.65 X Height (cm)) – 50.74
      - Male LBW (kg) = (0.73 X Height (cm)) – 59.42

    - Example: for a male patient who is 6 feet tall = 72 inches = 183 cm

    LBW = 74 kg; **administer normal saline no faster than 1100 to 1400 ml/hr**

    - Example: for a female patient who is 5ft 5 inches tall = 65 inches = 165 cm

    LBW = 57 cm; **administer normal saline no faster than 850 to 1100 ml/hr**

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Transitioning patients to SQ insulin

- Once a patient is able to eat, start a subcutaneous insulin regimen or if a patient normally uses an insulin pump, restart the pump.

- Best time to transition from IV insulin is before a meal

Transitioning patients to SQ insulin

- Give basal insulin and prandial insulin SQ at the same time and have the patient eat.

- To prevent recurrent DKA, **continue insulin infusion for at least two hours after first basal insulin injection** is given then taper infusion to off

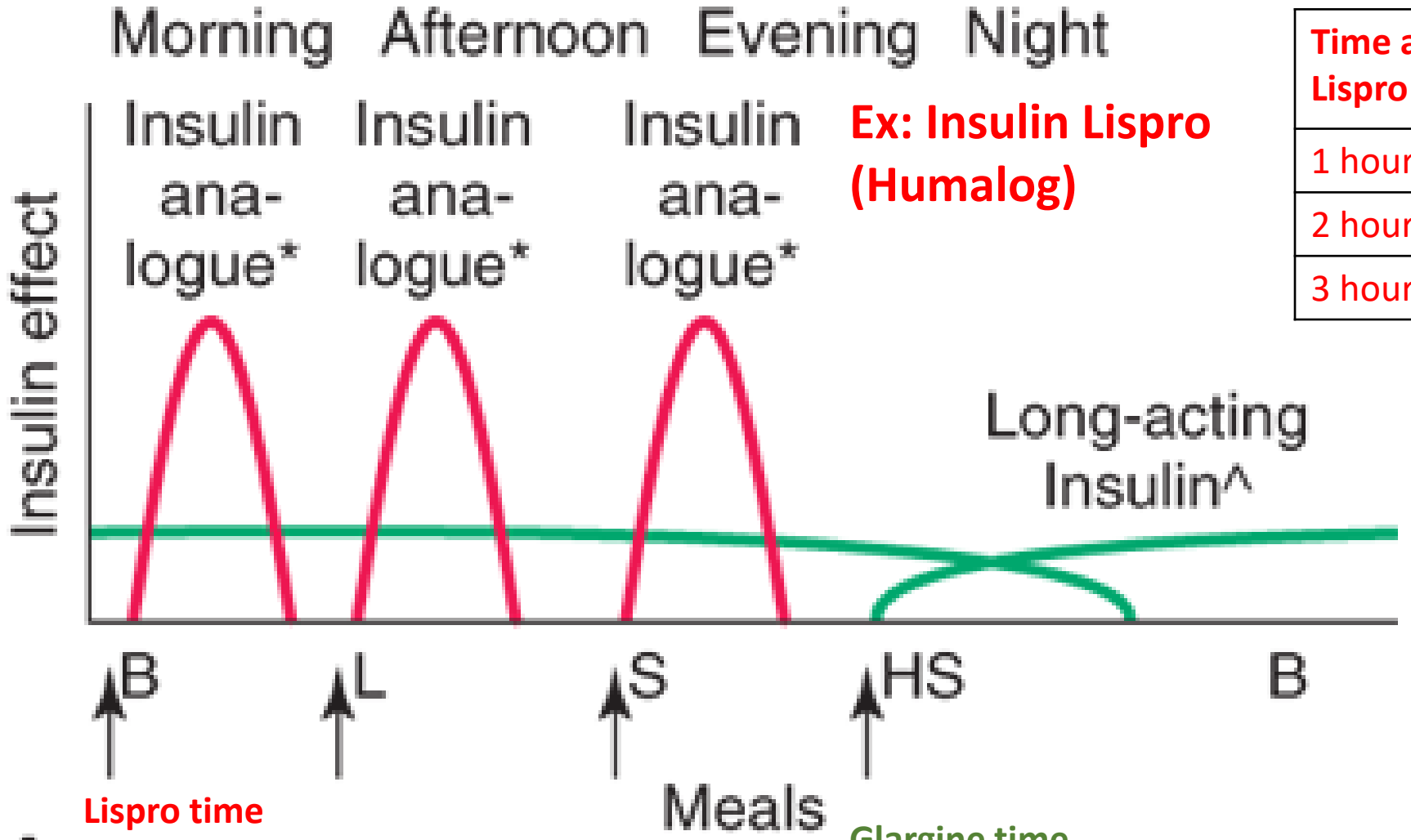
Transitioning patients to SQ insulin

Transitioning patients to SQ insulin in Type 1 Diabetes

Glycemic Targets

- Premeal (ie fasting) blood glucose 80-130 mg/dL
- Postprandial blood glucose < 180 mg/dL 1-2 hours after eating
- HgbA1C < 7%

Insulin glargine (Lantus) + Insulin Lispro (Humalog) Regimen



Ex: Insulin Lispro (Humalog)

Time after SQ Lispro	% Metabolized
1 hour	60%
2 hours	80%
3 hours	About 100%

Ex: Insulin glargine (Lantus)

A

Lispro time of onset 3 to 15 minutes

Glargine time of onset Two hours

Glargine is "peakless" and lasts about 24 hours

Source: J.L. Jameson, A.S. Fauci, D.L. Kasper, S.L. Hauser, D.L. Longo, J. Loscalzo: Harrison's Principles of Internal Medicine, 20th Edition

Sample Insulin Regimen for a Patient with Type 1 Diabetes

Step	Example for a 70 kg-pt with average insulin sensitivity and normal kidney function
Determine target blood glucose range	• 80 to 130 mg/dl before meals • < 180 mg/dl two hours after meals
Determine total daily insulin requirement = 0.5 units/kg actual body weight	35 units total
Calculate basal insulin requirement: long-acting basal insulin dose = 50% of total daily insulin requirement	Insulin glargine 17 units SQ qhs **Glargine: Good Rx $108.91/vial Walmart**

Sample Insulin Regimen for a Patient with Type 1 Diabetes

Step	**Example for a 70 kg-pt with average insulin sensitivity and normal kidney function**
Determine how to calculate insulin needed to correct elevated glucose to keep glucose in the desired range: correction dose	Correction dose ("sliding scale") Regular dose = (blood glucose -125)/40
Determine how to calculate insulin needed to "cover" the carbohydrates eaten at meals: carbohydrate dose	1 unit of insulin lispro per 10 grams of carbohydrate to be eaten
Prandial insulin dose (ie. total amount of short-acting insulin given around meals) = correction dose + carbohydrate dose	Total prandial insulin lispro = (blood glucose -125)/40 + 1 unit per 10 grams of carbohydrate to be eaten

Insulin Lispro Good Rx: $27.23/vial Walmart

Sample Insulin Regimen for a Patient with Type 1 Diabetes

Complete insulin prescription
Insulin glargine 17 units SQ qhs Insulin lispro with meals = (blood glucose – 125)/40 + 1 unit per 10 grams of carbohydrate to be eaten

Complete insulin prescription without need to make calculations
Insulin glargine 17 units SQ qhs Insulin lispro 2 units qac with titration as needed

Keep Costs of Insulin and Diabetes Supplies in Mind for your patient . . . .sample regimen

Item—Walmart Pharmacy	**Cost**
Relion Premier Classic	$9.00
Relion Prime test strips	$17.88/box of 100
Relion lancing device	$5.92
Relion lancets	$2.72/box of 200
Insulin lispro	$27.23/vial (1000 units)
Insulin glargine	$108/vial (1000 units)
Insulin syringes	$20.00/box of 100

Initial Total cost = $190.75

Monthly cost after first month = $155

Osteopathic Considerations in Type 1 Diabetes

Osteopathic Considerations in Type 1 Diabetes

- The impact of OMT on type 1 diabetes is still under study

- Some information from case report of OMT improving symptoms of gastroparesis

Case Report: OMT in management of diabetic gastroparesis

- 49-year-old man with type 1 diabetes and known gastroparesis
- PMH: Head trauma, R sided rib fractures in MVA 10 years ago
- Hospitalized every six to eight weeks with n/v and dehydration from gastroparesis flare
- No relief with metoclopramide or multiple other medications
- Six OMT sessions scheduled
- Before starting OMT and after finishing six OMT treatments, patient completed the Gastroparesis Cardinal Symptom Index (GCSI) to assess symptoms

J Am Osteopath Assoc. 2015;115(7):452-458

Case Report: OMT in management of diabetic gastroparesis— Examples of OMT used to treat somatic dysfunction found over the six sessions

- Balanced ligamentous tension (BLT) for the
  - Thoracic inlet
  - Abdominal diaphragm
  - Pelvic diaphragm
- Suboccipital release
- Rib raising

- Gastroparesis Cardinal Symptom Index score improved from 13 to 8
- Hospitalizations for n/v, dehydration decreased from once every 6 to 8 weeks to once in 6 months.
- Relief of gastroparesis symptoms and improved quality of life

J Am Osteopath Assoc. 2015;115(7):452-458

Prevention of DKA

- Treat the underlying cause leading to the DKA
- Stop metformin
- Session or sessions with diabetes educator and dietician
- Prescribe an insulin regimen a patient **can understand and follow**
- Prescribe an insulin regimen patients **can afford**
- Close outpatient follow up to ensure chronic diabetes control
- Consider OMT for diabetes complications such as gastroparesis

Questions?

Thank you!