Inpatient Hyperglycemia: Do this, Don't do That

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Disclosures:

- None

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Objectives – to discuss:

- Approach to insulin management in the hospital:

  – Subcutaneous insulin regimens

  – Intravenous insulin infusions

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Hyperglycemia in the Hospital

- Diabetes:
  - Previously diagnosed
  - Previously undiagnosed

- Hyperglycemia without diabetes diagnosis
  - Diabetes diagnosed on follow-up
  - Prediabetes with overt hyperglycemia during acute physiologic stress
  - Hyperglycemia due to physiologic stress without underlying metabolic abnormality
    - normal follow-up testing

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Identifying Hyperglycemia in the Hospital

- **Hyperglycemia in the hospital is defined as an admission or in hospital BG > 140 mg/dl.**

- HbA1c testing can be useful to:
  - assess glycemic control prior to admission
  - assist with differentiation of newly diagnosed diabetes from stress hyperglycemia
  - designing an optimal regimen at the time of discharge
- HbA1c $\geq$ 6.5% = diabetes
- HbA1c 5.7%-6.4% = prediabetes

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AACE/ADA Target Glucose Levels in Hospitalized Patients

- ## ICU setting:

Not recommended <110	Acceptable 110-140	Recommended 140-180	Not recommended >180

- ## Non-ICU setting:

Pre-Meal < 140	Random < 180

Hypoglycemia = BG <70 mg/dL
Severe hypoglycemia = BG <40 mg/dL

Moghissi ES, et al; AACE/ADA Inpatient Glycemic Control Consensus Panel. *Endocr Pract.* 2009;15(4).
http://www.aace.com/pub/pdf/guidelines/InpatientGlycemicControlConsensusStatement.pdf.

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Recommendations for Managing Hyperglycemia in the Inpatient Setting

Antihyperglycemic Therapy

Insulin

Non-Insulin Antihyperglycemic Drugs

Moghissi ES, et al; AACE/ADA Inpatient Glycemic Control Consensus Panel. *Endocr Pract.* 2009;15(4).
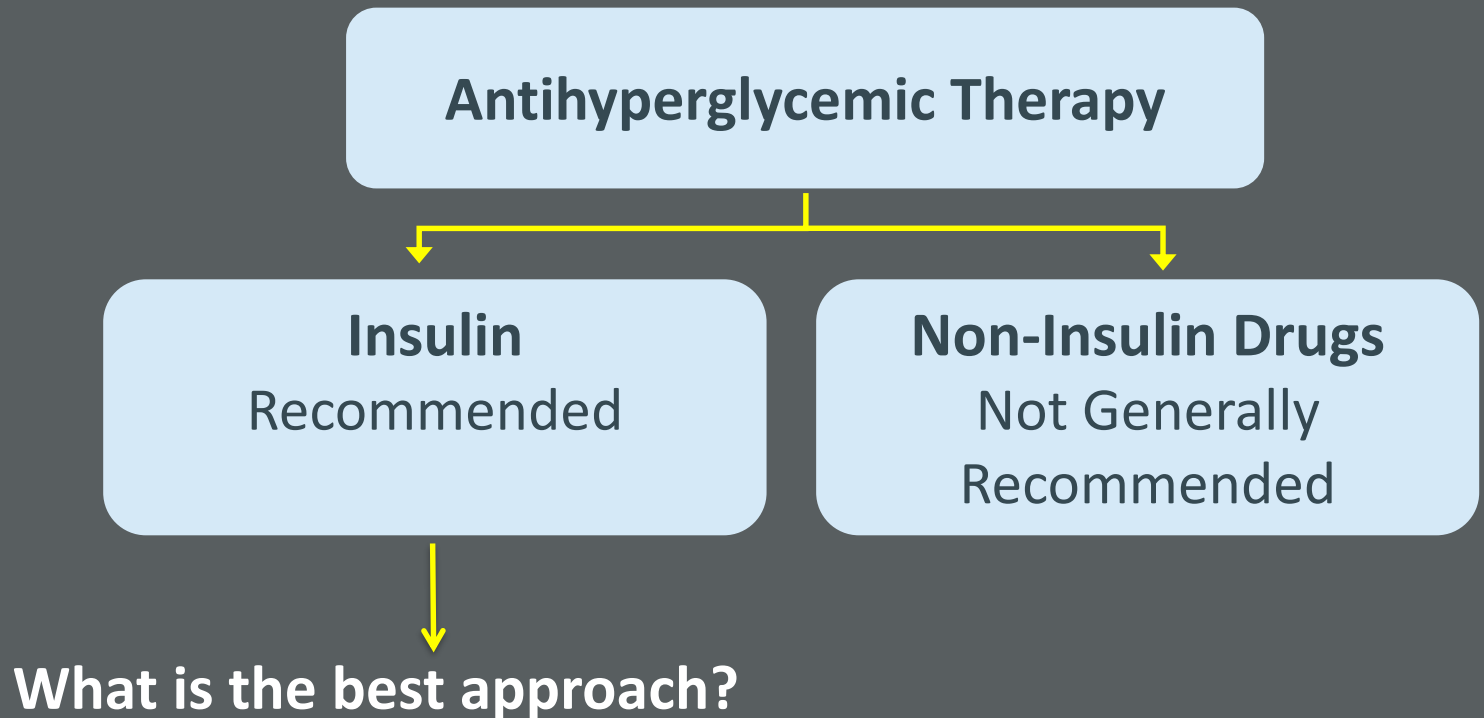http://www.aace.com/pub/pdf/guidelines/InpatientGlycemicControlConsensusStatement.pdf.
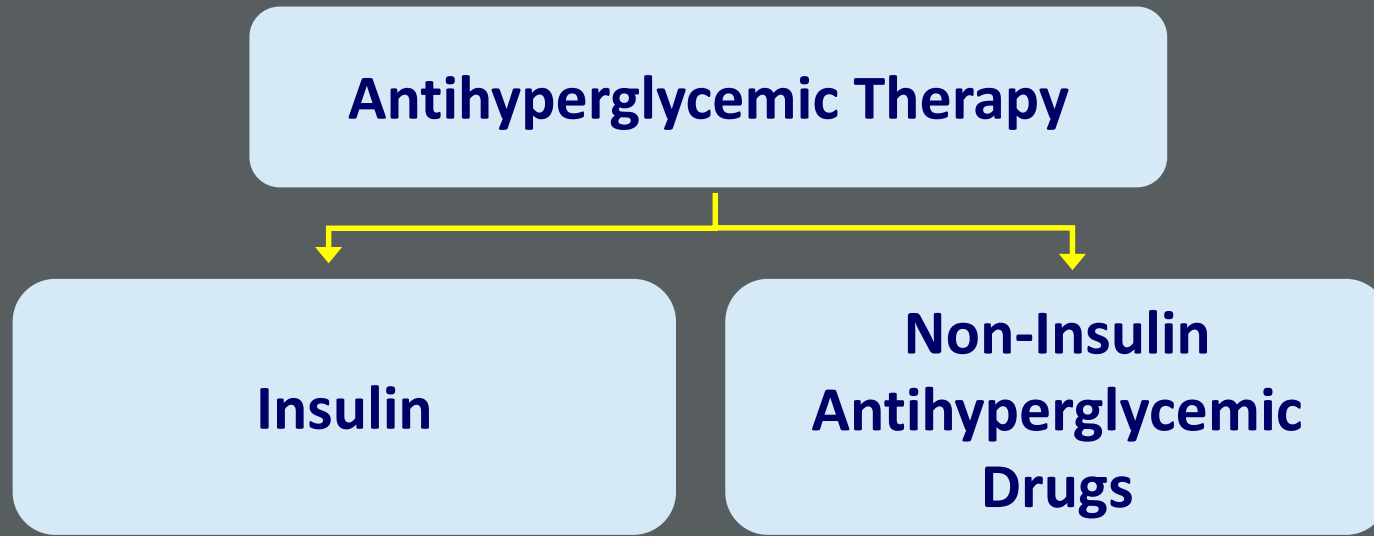
Non-insulin therapies in the hospital?

➤ Sulfonylureas can cause hypoglycemia

➤ Metformin contraindicated in setting of decreased renal blood flow and with use of iodinated contrast dye

➤ Thiazolidinediones associated with edema and CHF

➤ α glucosidase inhibitors are weak glucose lowering agents

➤ DPP-4 inhibitors not very effective in the inpatient setting for patients with CBG >180

➤ GLP1-agonists can cause nausea and have a greater effect on postprandial glucose

➤ SGLT-2 inhibitors have potential risk of UTI and euglycemic DKA, and can contribute to mild volume depletion

Moghissi ES, et al. AACE/ADA Inpatient Glycemic Control Consensus Panel. *Endocr Pract.* 2009

Recommendations for Managing Inpatient Hyperglycemia

Antihyperglycemic Therapy

Insulin
Recommended

Non-Insulin Drugs
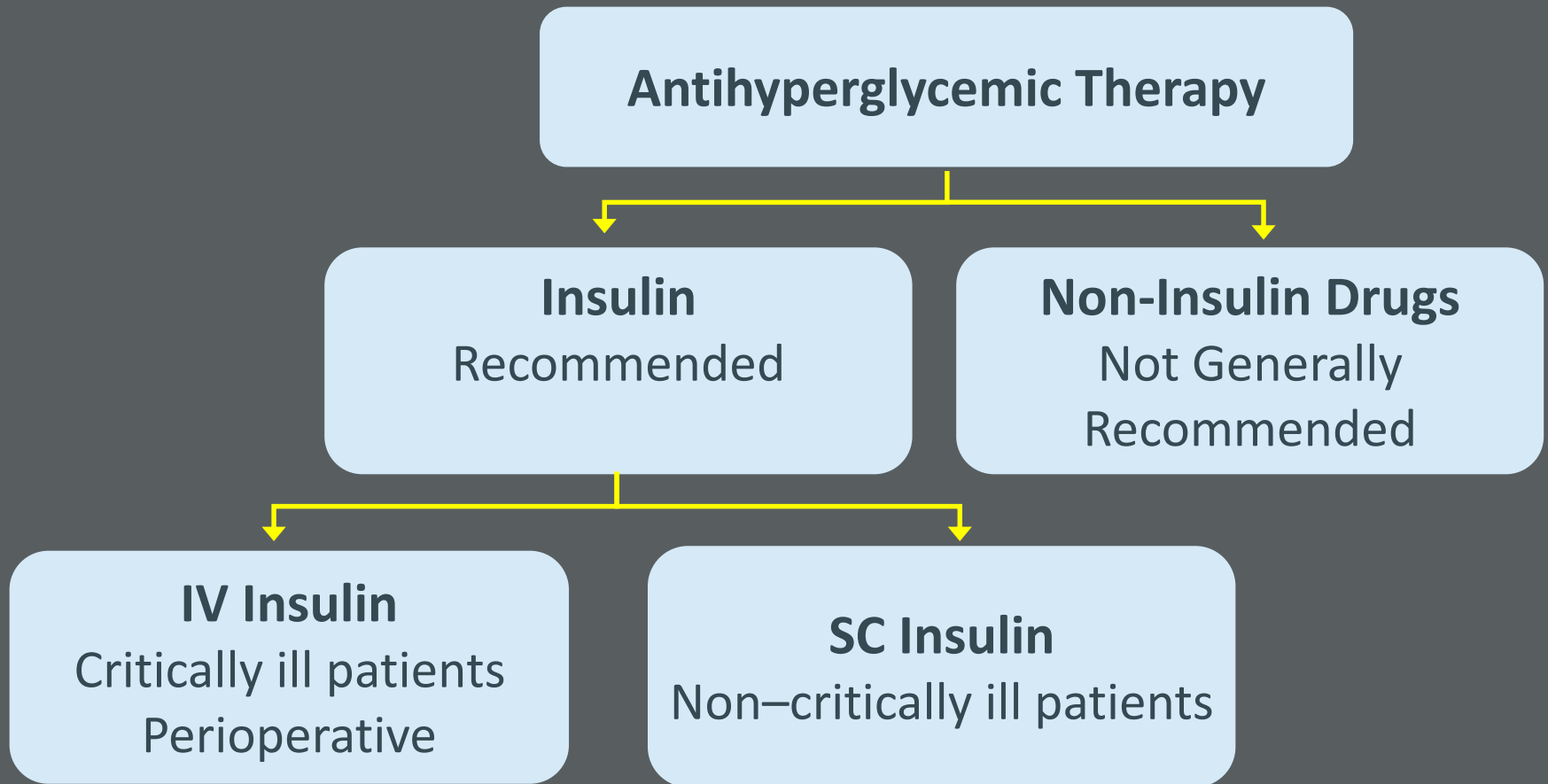Not Generally Recommended

What is the best approach?

Clement S, et al. *Diabetes Care.* 2004;27(2):553-591.
Moghissi ES, et al; AACE/ADA Inpatient Glycemic Control Consensus Panel. *Endocr Pract.* 2009;15(4).
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Recommendations for Managing Inpatient Hyperglycemia

Antihyperglycemic Therapy

Insulin
Recommended

Non-Insulin Drugs
Not Generally Recommended

IV Insulin
Critically ill patients
Perioperative

SC Insulin
Non–critically ill patients

Clement S, et al. *Diabetes Care.* 2004;27(2):553-591.
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Principles of Insulin Management In The Hospital: Do This

- **Use a physiologic basal-bolus regimen**
  - Plus supplemental insulin for correction
  - Avoid sliding scale insulin alone
- **Adjust the regimen daily to optimize control**
  - Use prior day results to adjust
- **Make careful transitions in insulin regimen**
  - Changes in nutrition
  - Insulin drip to SC treatment

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Don't do That: Sliding-Scale Insulin Alone is Not Recommended

BG = 200

BG = 280

BG = 247

BG = 220

Insulin Effect

Concerns:
Reactive approach:
↑ Hyperglycemia

0 2 4 6 8 10 12 14 16 18 20 22 24

Time, h

Adapted from :
DeWitt DE, Dugdale DC. *JAMA*. 2003;289(17):2265-2269.
Skyler JS. In: DeFronzo RA, ed. *Current Therapy of Diabetes Mellitus.* St Louis, MO:
Mosby-Year Book, Inc;1998:36-49.

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Sliding-Scale Insulin Alone Not Recommended
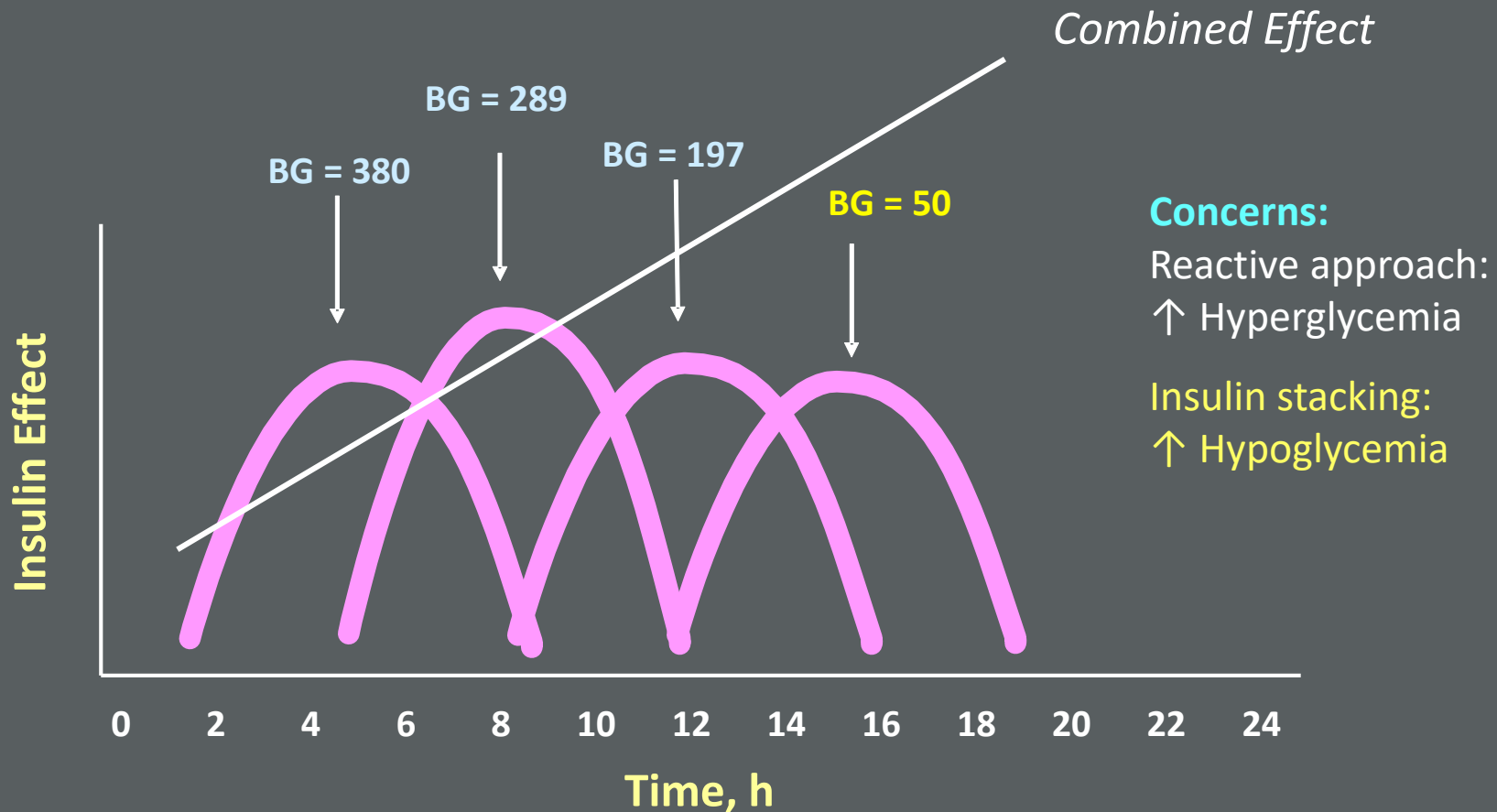
Combined Effect

BG = 380

BG = 289

BG = 197

BG = 50

Insulin Effect

Time, h

0 2 4 6 8 10 12 14 16 18 20 22 24

Concerns:
Reactive approach:
↑ Hyperglycemia

Insulin stacking:
↑ Hypoglycemia

Adapted from :
DeWitt DE, Dugdale DC. *JAMA*. 2003;289(17):2265-2269.
Skyler JS. In: DeFronzo RA, ed. *Current Therapy of Diabetes Mellitus.* St Louis, MO:
Mosby-Year Book, Inc;1998:36-49.

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Inpatient Insulin Management: Tailor to the situation

- Patients that are eating (reliably or unreliably)
- Other nutrition (Tube feeds, TPN)
- Corticosteroids
- Procedures/surgery/NPO

- IV insulin
- Transition from IV to SC insulin

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Inpatient Insulin Management: Tailor to the situation

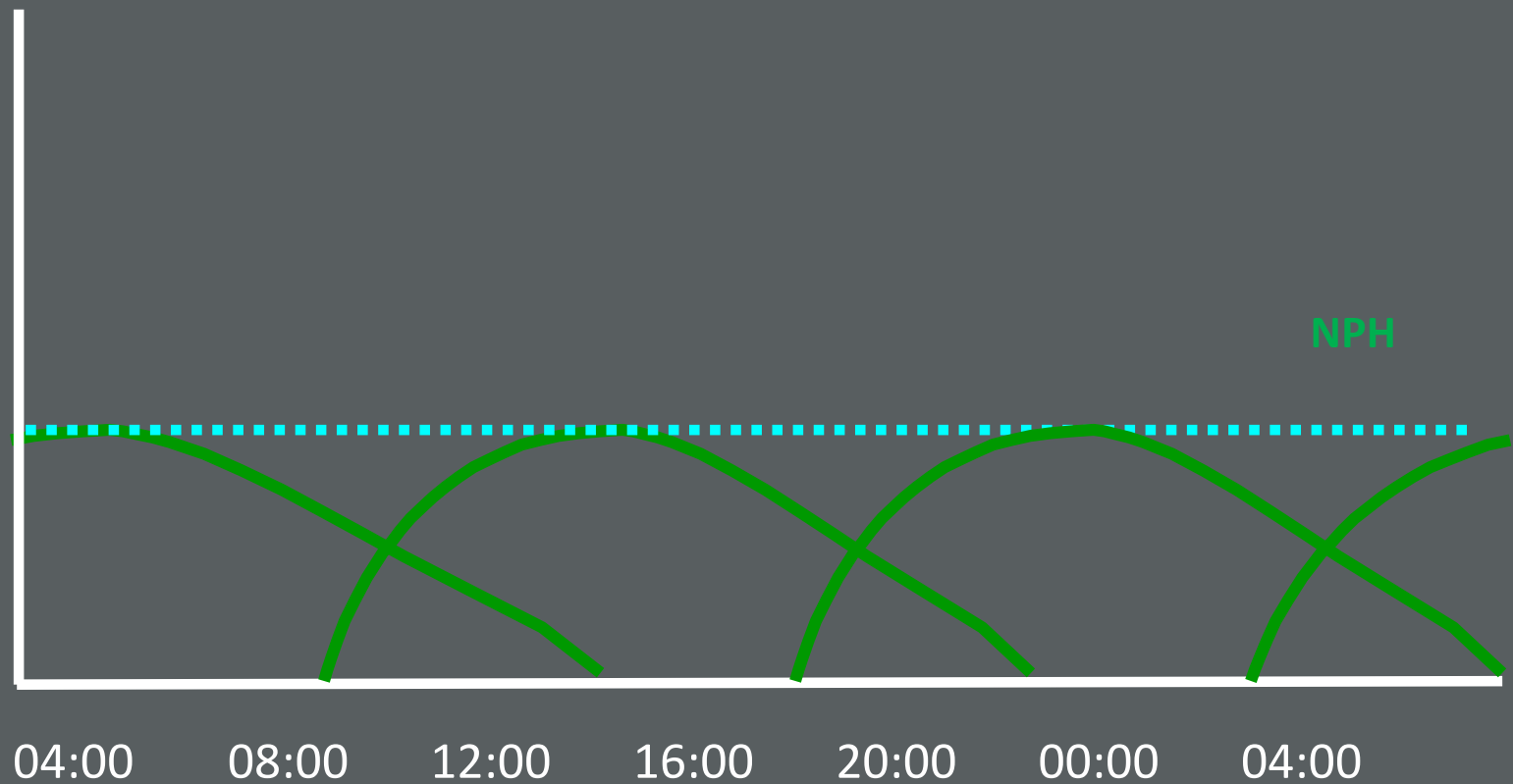- Patients that are eating (reliably or unreliably)

Case 1: Eating Reliably

54 year old man with type 2 diabetes is admitted to vascular surgery with right foot gangrene that will require amputation. You are consulted to assist with glycemic management. He is currently on a diabetic (consistent carbohydrate) diet and eating well.

- Weight: 85 kg
- Home medical regimen: Glipizide 10 mg po bid, Metformin 1000 mg po bid, semaglutide 1 mg SC qwk
- Outpatient glucose control: HbA1c 1 month prior to admission was 7.4%
- Admission glucose is 352 mg/dL

How do you manage his diabetes?

Case 1: Eating Reliably – Do This

- Discontinue oral agents

- Start scheduled insulin:
  - Total daily dose 85 kg x 0.5 units/kg/day = 42.5 units

- Basal: Glargine 21 units daily

- Nutritional: Rapid-acting analog 7 units with meals

- Correction: Rapid-acting analog per scale qac and qhs
  - (Note: Use correction insulin with caution at HS, reduce the daytime correction by up to 50% to avoid nocturnal hypoglycemia)

Inpatient SC Insulin Tips

- If a patient is only on long-acting insulin as an outpatient, it may be covering both basal and mealtime insulin requirements
  - For safety in the hospital, reapportion the insulin to long and short acting components

- Patients on U300 glargine or degludec as basal insulin can convert to U100 glargine at same dose (if well controlled)

- For patients eating unreliably, administer the mealtime insulin after meals in proportion to amount eaten

Inpatient Insulin Management: Tailor to the situation

- Patients that are eating (reliably or unreliably)
- Other nutrition (Tube feeds, TPN)

Insulin Requirement During Continuous Enteral Feedings or TPN
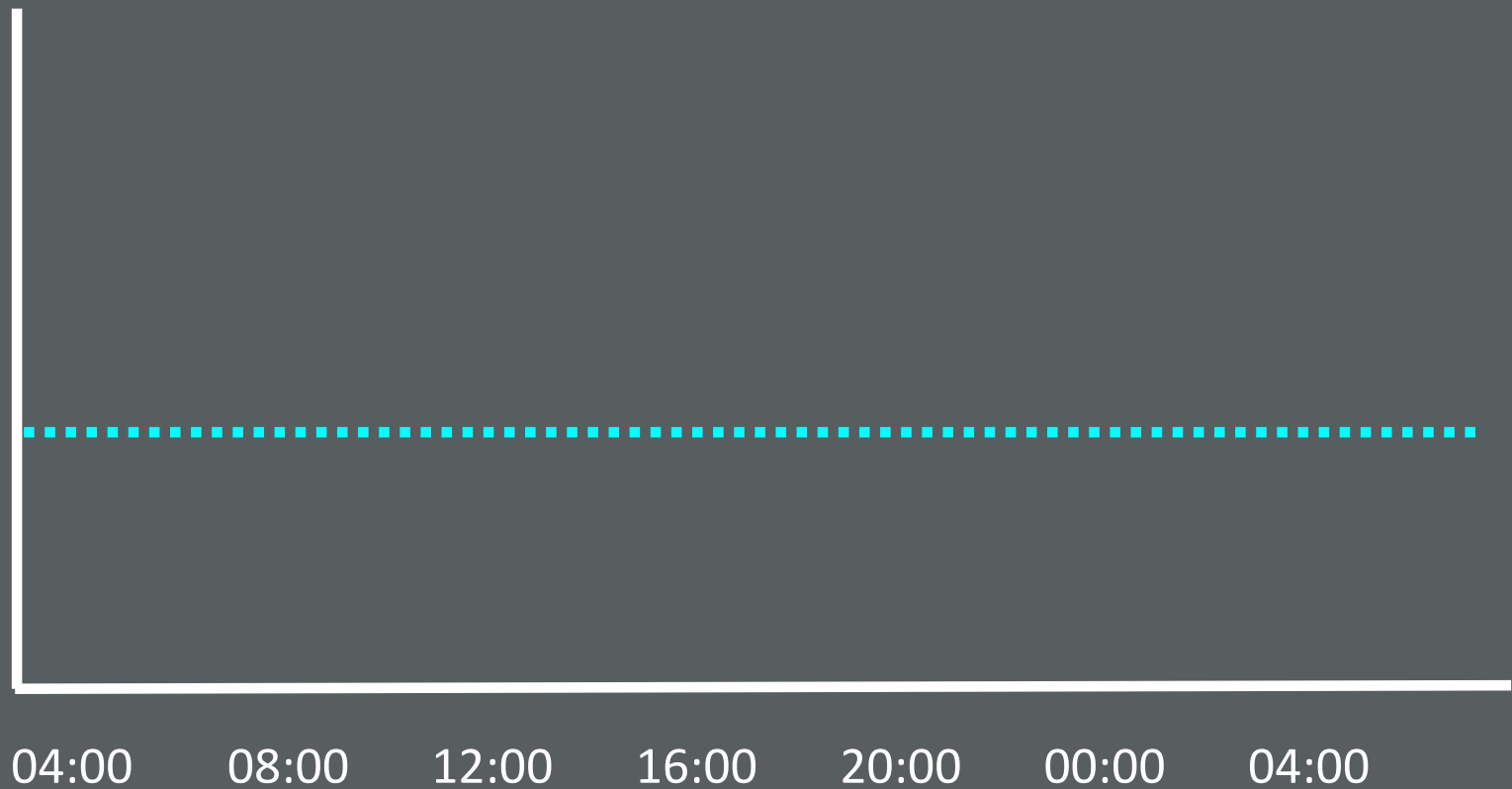
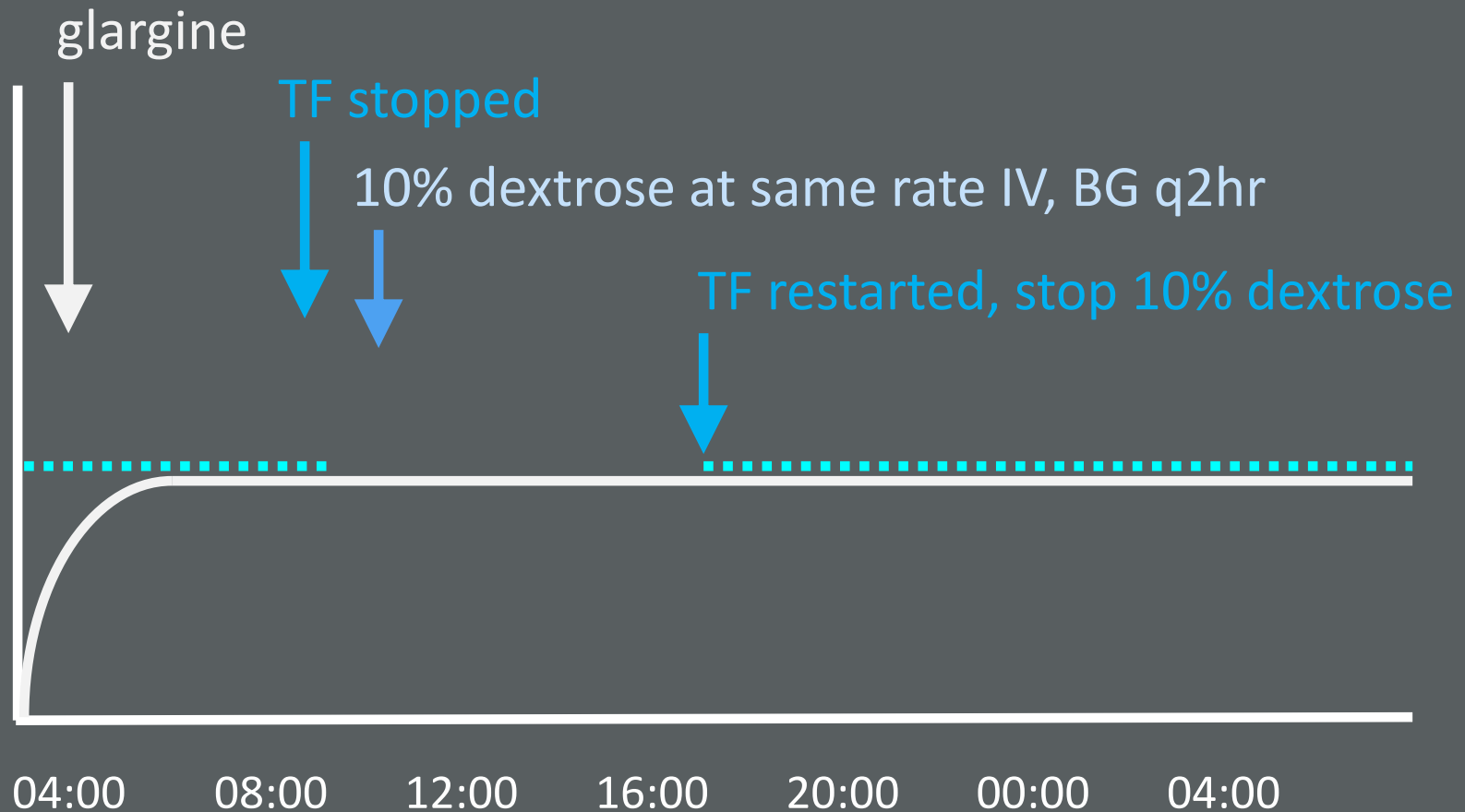# NPH q8 hours During Continuous Enteral Feedings or TPN

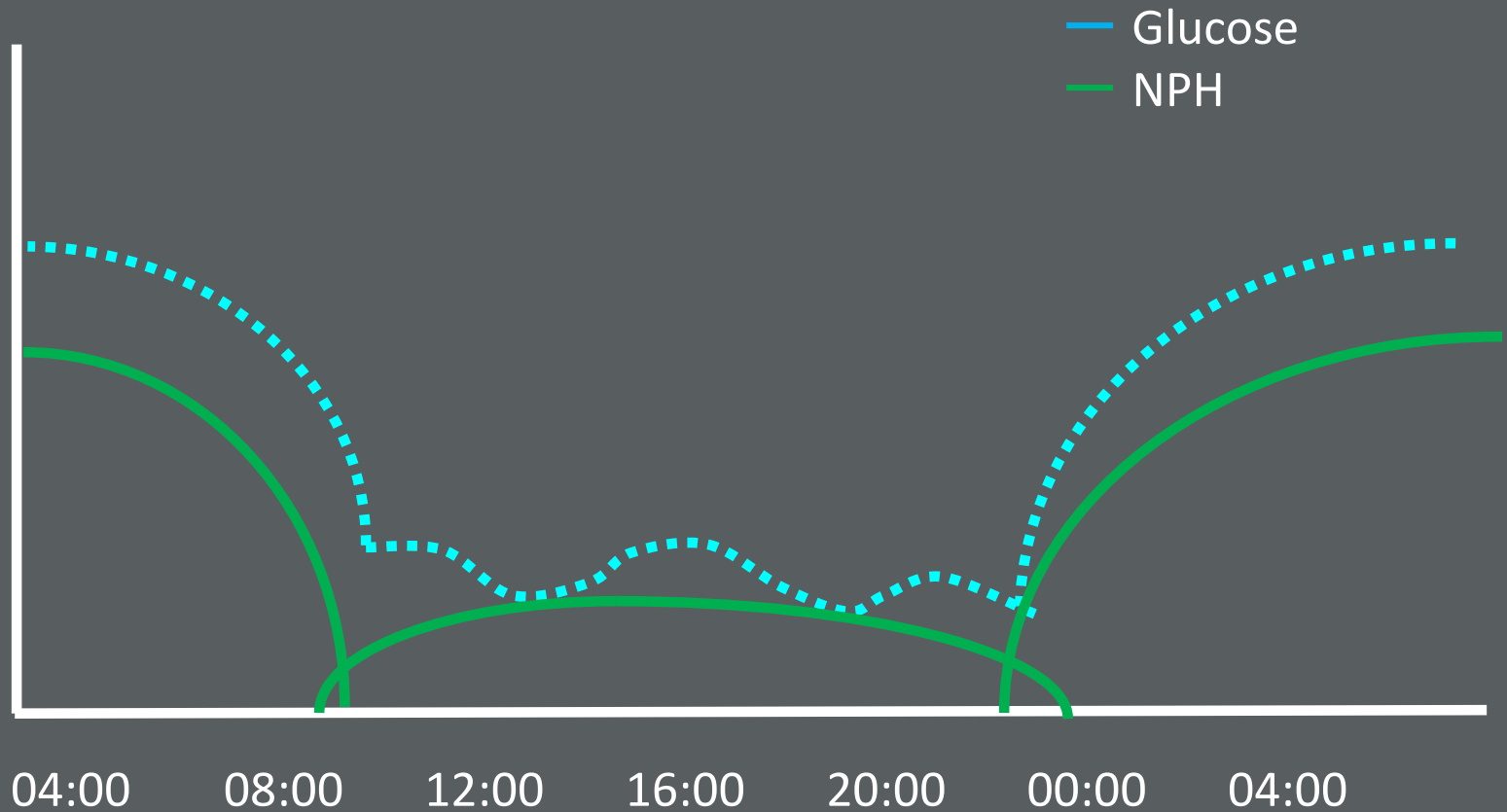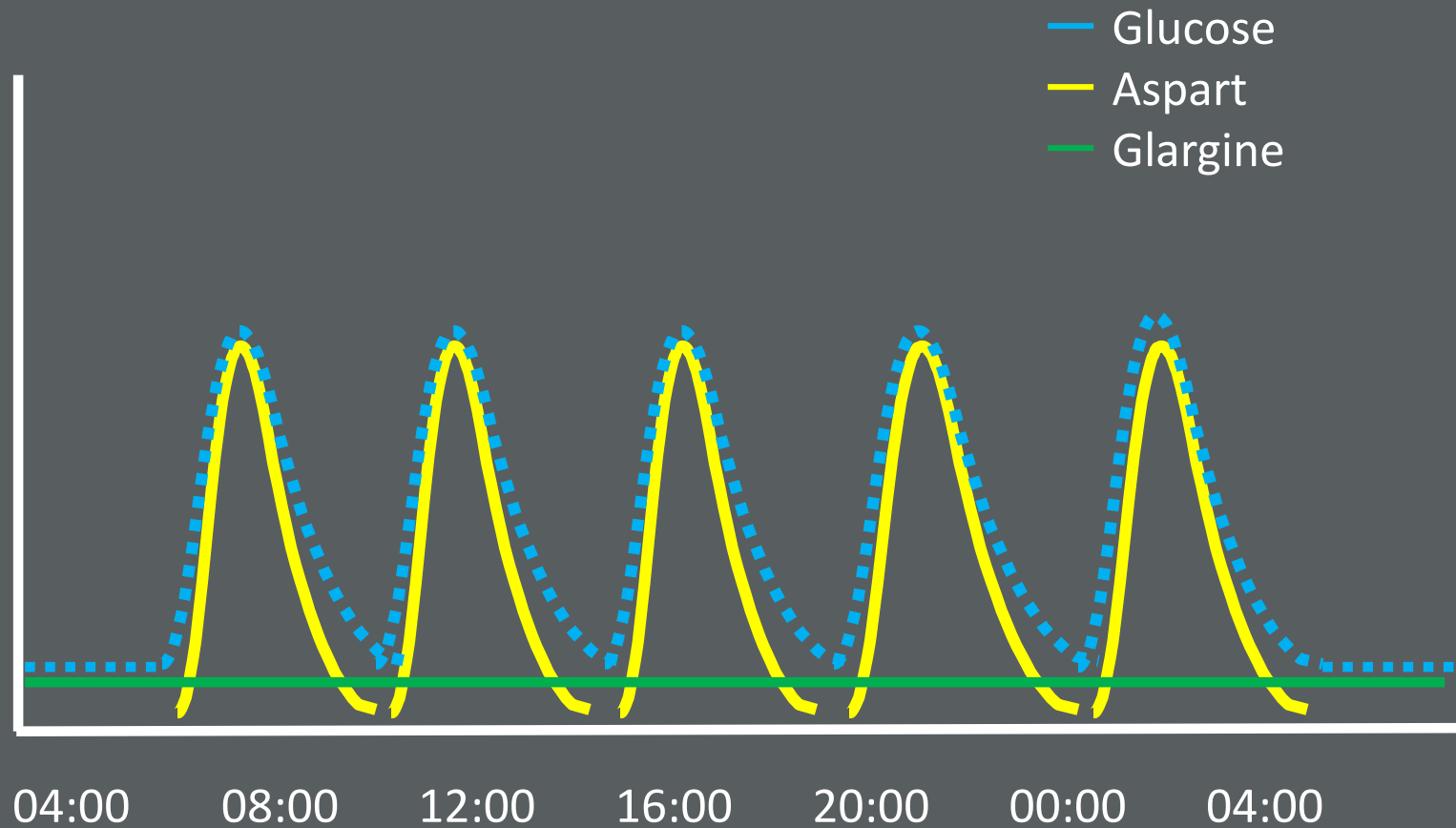# NPH q8 hours During Continuous Enteral Feedings (or TPN)

Enteral Feeding stopped, hold next NPH dose

BG q 2 hr, dextrose if < 100

TF restarted

04:00   08:00   12:00   16:00   20:00   00:00   04:00

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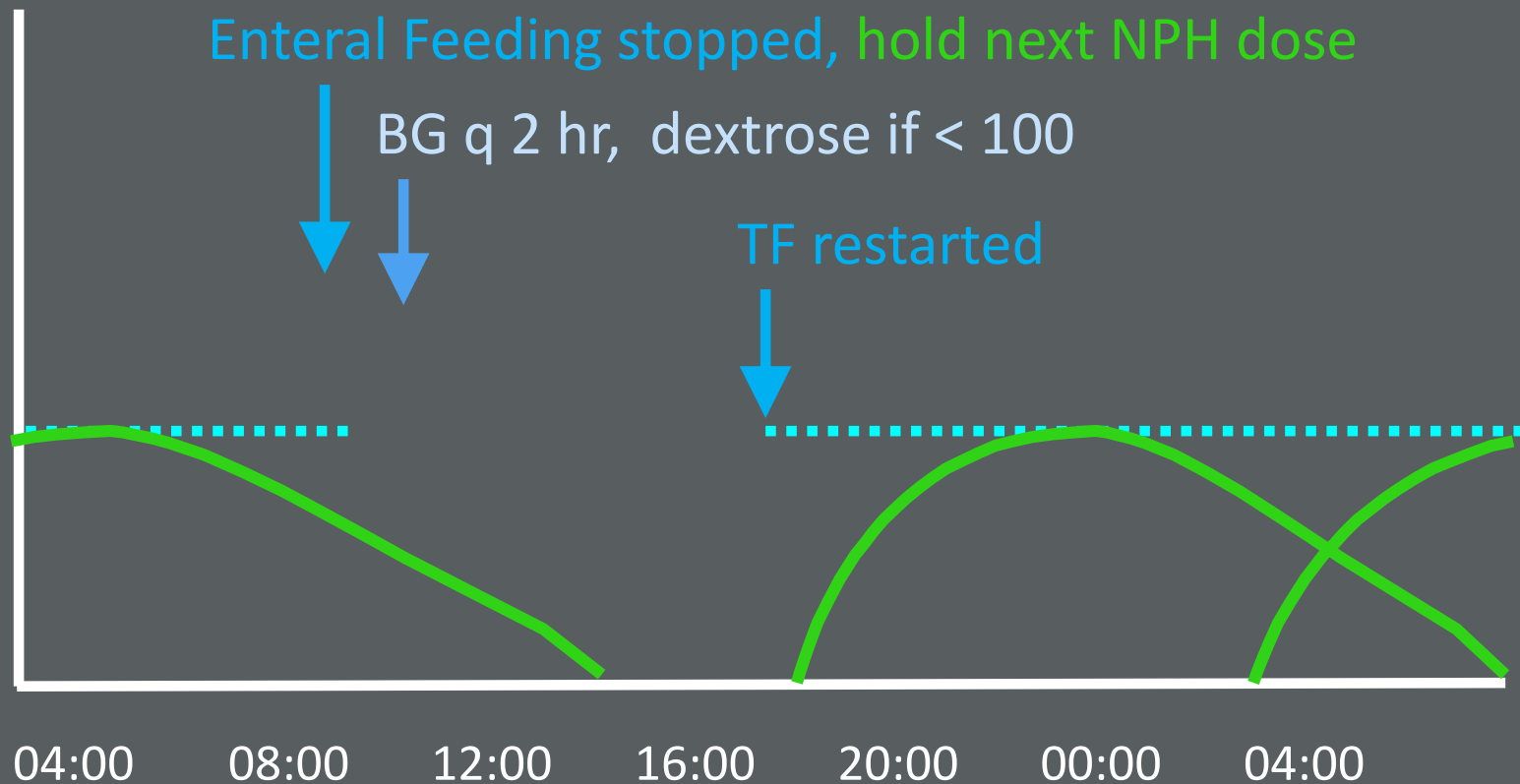
Glargine During Continuous Enteral Feedings (or TPN)
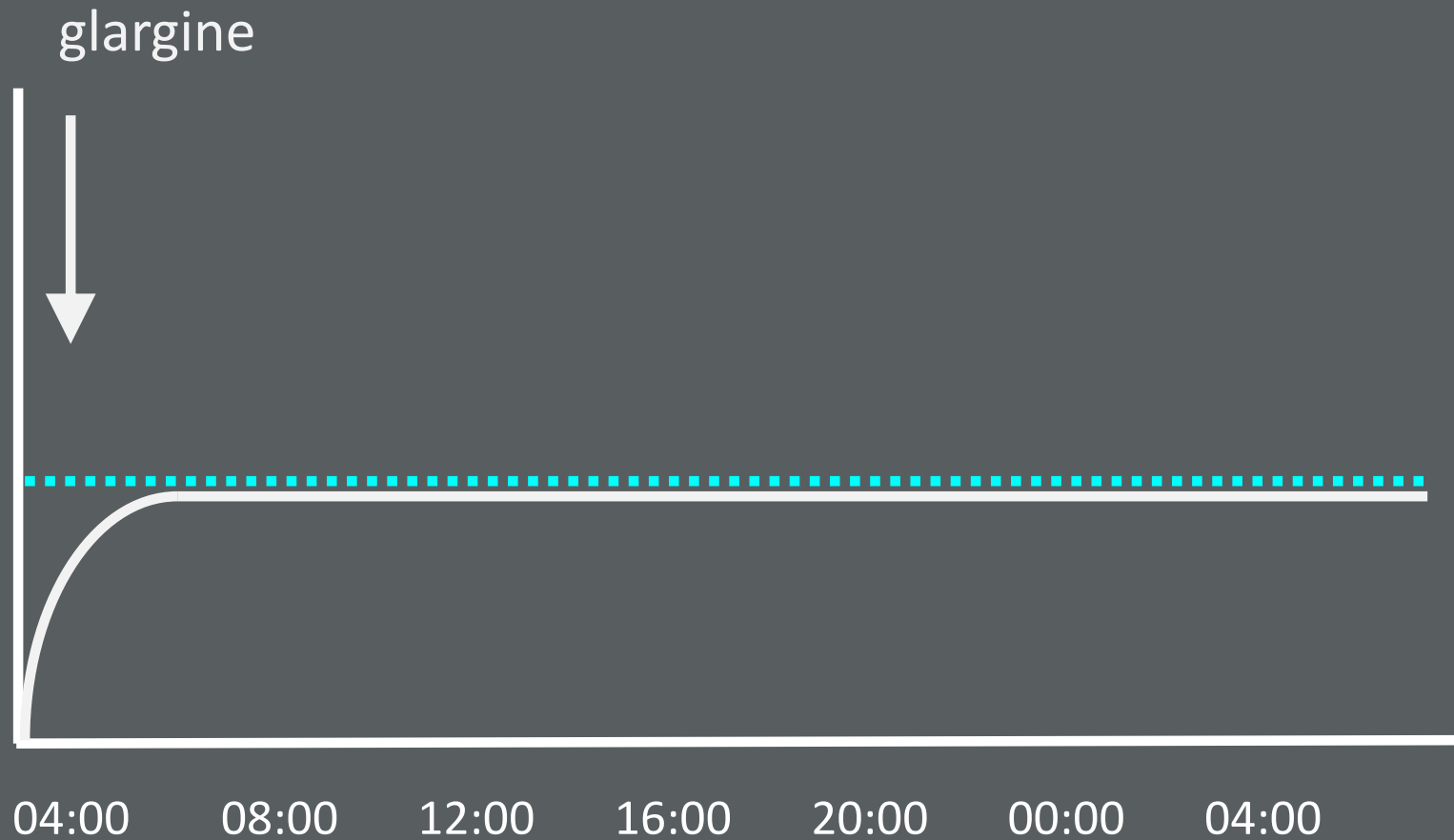
Glargine During Continuous Enteral Feedings (or TPN)

# Overnight Enteral Feedings with Daytime Grazing

Bolus Enteral Feedings

Case 2: Enteral Feeding

An 83 yo M with esophageal adenocarcinoma and Type 2 diabetes undergoes esophagectomy. Postoperatively he receives continuous tube feeds and the surgical team places him on an insulin infusion while the tube feeds are gradually increased to goal rate of 65 cc/hr. His glucose levels are stable on the insulin infusion, however they attempt to transition him to SQ insulin and he becomes hyperglycemic. You are consulted to assist with glycemic management.

- Weight: 81 kg (BMI 27)
- HbA1c 5.9% 1 month before surgery
- Home regimen: glargine 16 units bid, sitagliptin 100mg qd
- Current hospital regimen NPH 14 units bid
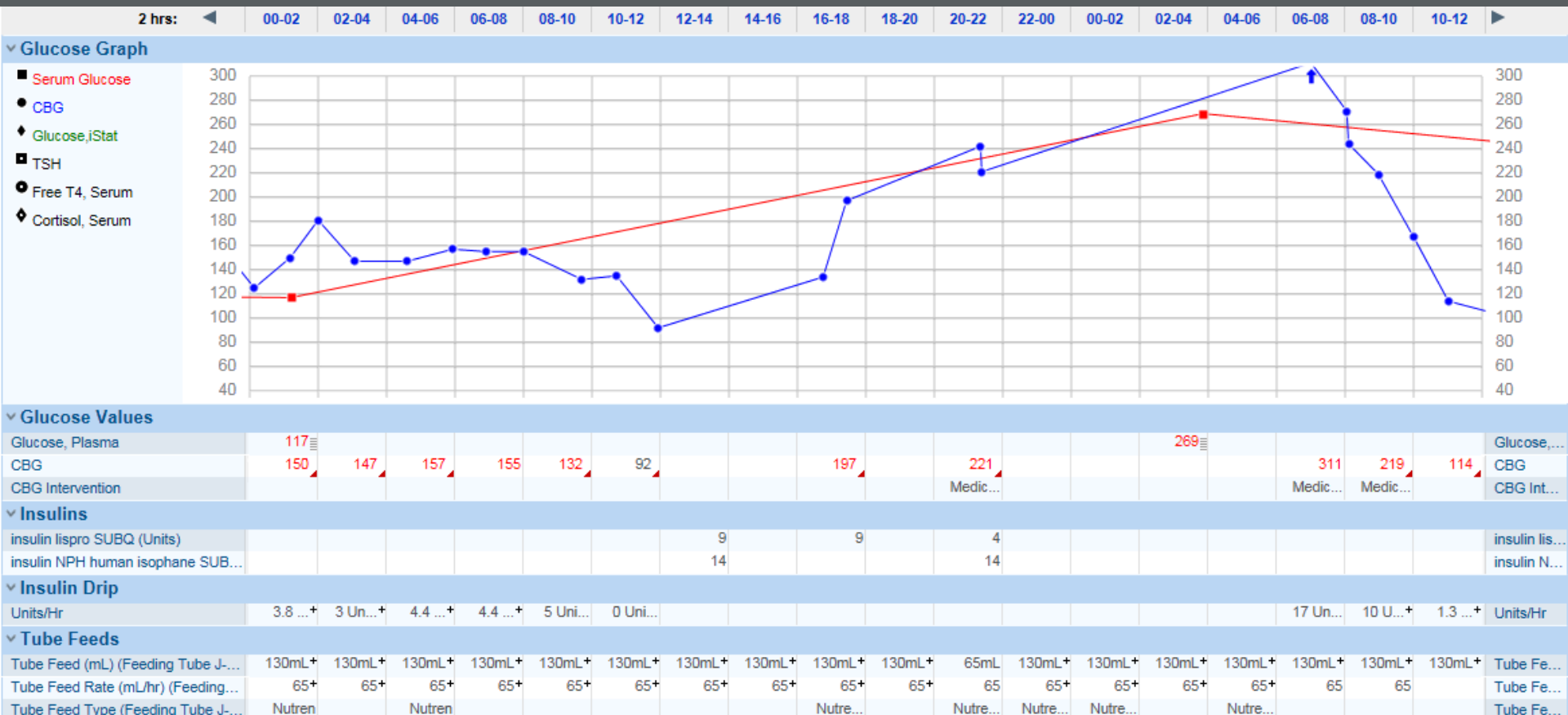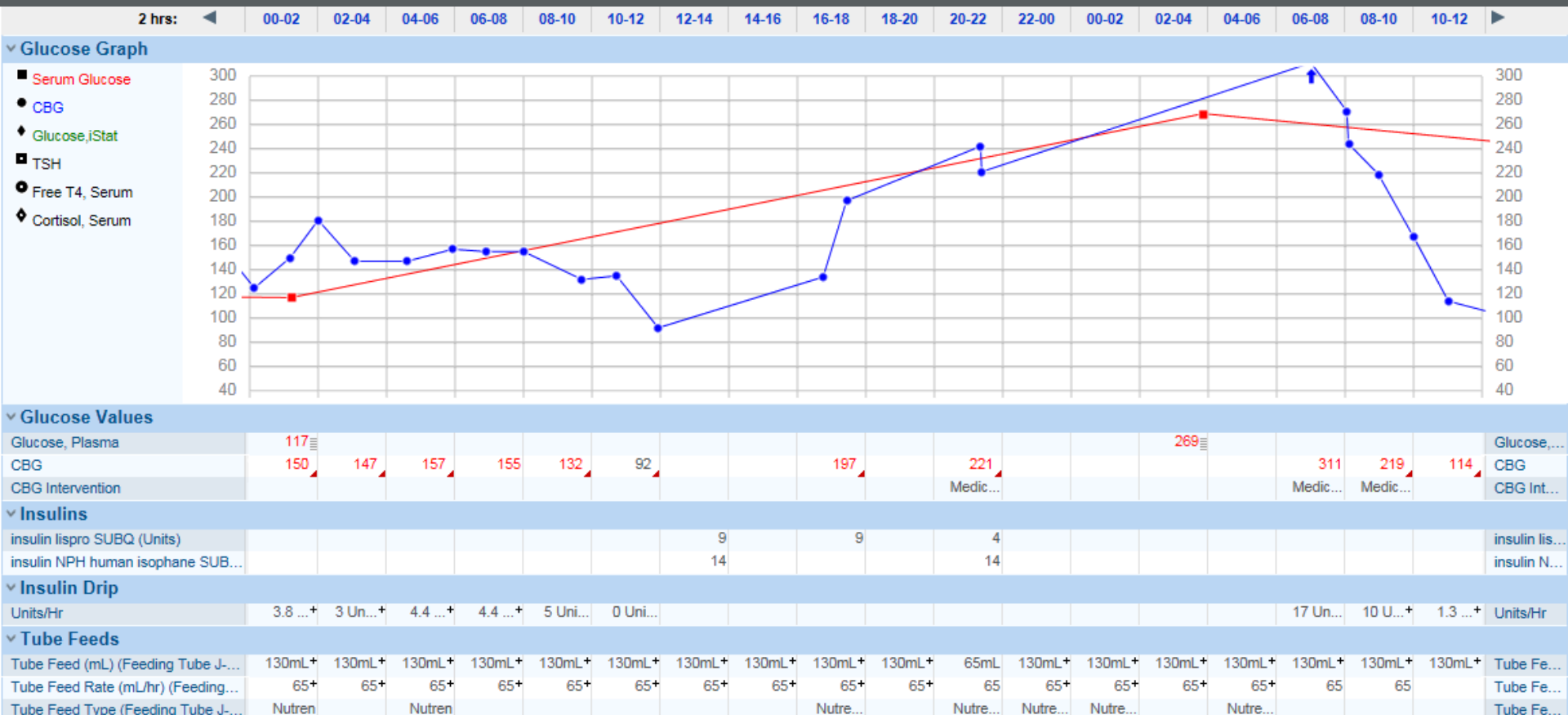
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Case 2: Enteral Feeding

Case 2: Enteral Feeding – Do This

How do you manage this patient?

- Calculate insulin requirement from insulin infusion when tube feed at goal rate

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Case 2: Enteral Feeding

Case 2: Enteral Feeding – Do This

How do you manage this patient?

- Calculate insulin requirement from insulin infusion when tube feed at goal rate (130 units in 24 hours)
- Consider decreasing the TDD 0-20% depending on glucose control on the infusion
  - 130 x 0.9 = 117 units
- Administer as NPH q8hrs
  - 117 / 3 = 39 units NPH q8hrs

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Case 2: Enteral Feeding

Case 2: Enteral Feeding, continued

His clinical status starts to improve, and the surgical team decides to change him to bolus tube feeds, five times per day (same total volume of tube feed).

Glucoses have been stable on NPH 39 units q8 hours, ranging between 120-180.

What is the best option?
- A. No change to his insulin regimen
- B. Discontinue scheduled insulin, place on sliding scale
- C. Discontinue scheduled insulin, place on home diabetes medications and sliding scale
- D. Change his insulin to a rapid acting analog 23 units with each tube feed bolus, plus a correction insulin scale

- Total daily insulin on continuous TF: 39 x 3 = 117 units
- 117 units/5 boluses per day = 23 units/bolus

TPN

- Parenteral nutrition often causes hyperglycemia and often requires insulin treatment, even in patients who would not require insulin otherwise

- If patient is significantly hyperglycemic, consider IV insulin for first 1-2 days to gauge the insulin requirements
- Then place 80-100% of the insulin requirement in the TPN and use a supplemental insulin scale

- Or, could estimate insulin requirement using carb ratio of 1 unit:10 grams of carbohydrate in TPN, and put this amount in the TPN bag

- Redistribution strategy
    – add 75% of yesterdays correction therapy to today's bag

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Case 3: TPN

- 75 yo F with Type 2 Diabetes is admitted for chronic mesenteric ischemia and undergoes a right iliac to SMA bypass.

- She is on TPN, and her glucose levels are stable on an insulin infusion.

- Her primary team attempts to transition off the infusion to SQ insulin. However, she develops hyperglycemia so you are consulted to assist with management.

Case 3: TPN

Case 3: TPN – Do This

How do you manage this patient?

- Calculate insulin requirement from insulin infusion (88 units/24 hours)
- Put 80% of this in the next TPN bag
  - 88 units x 0.8 = 70 units
- However it is currently 11am, and the next bag is not due to hang until 9pm
  - Give an injection of NPH to make up the difference in requirement

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Case 3: TPN

- Calculated insulin requirement of 70 units for 24 hours is equivalent to NPH 35 units q12.
- Patient had received 13 units NPH. Give additional 22 units NPH.

NPH 13 units   Give NPH 22 units for total 35 units to last until next TPN bag
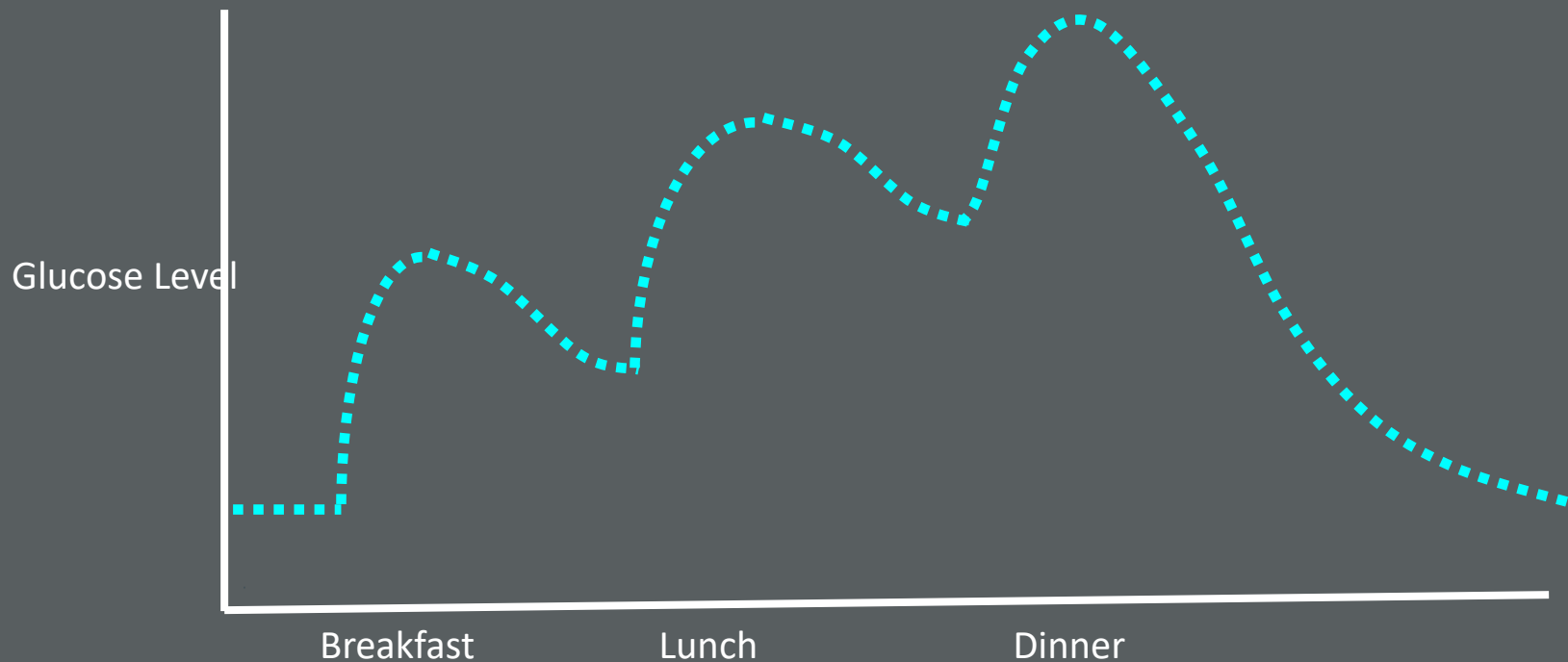
Case 3: TPN

- Five days later the dietitian recommends increasing her caloric intake. The dextrose is increased from 165 grams to 205 grams per 24 hours. What change do you make?

- Increase the insulin proportionally to the amount of dextrose
  - 165g/70 units = carb/insulin ratio of 2.36 (1 unit of insulin for 2.36g dextrose)
  - Insulin in next bag should be increased to: 205g/(2.36 g/unit) = 87 units
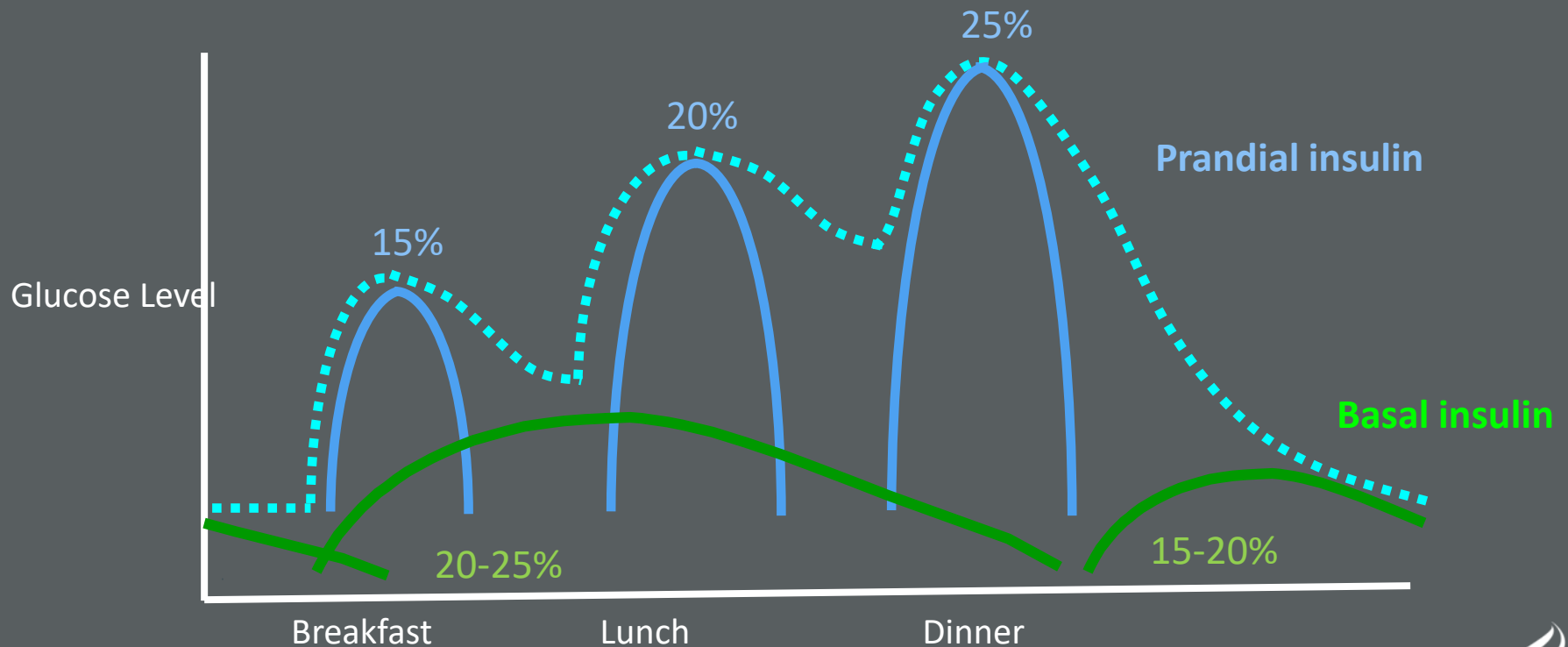
Inpatient Insulin Management: Tailor to the situation

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- Corticosteroids

Typical Blood Glucose Pattern With Morning Steroid Therapy

Glucose Level

Breakfast   Lunch   Dinner

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Inpatient Therapy of Patients on AM Corticosteroids

Inpatient Therapy of Patients on AM Corticosteroids

Inpatient Insulin Management: Tailor to the situation

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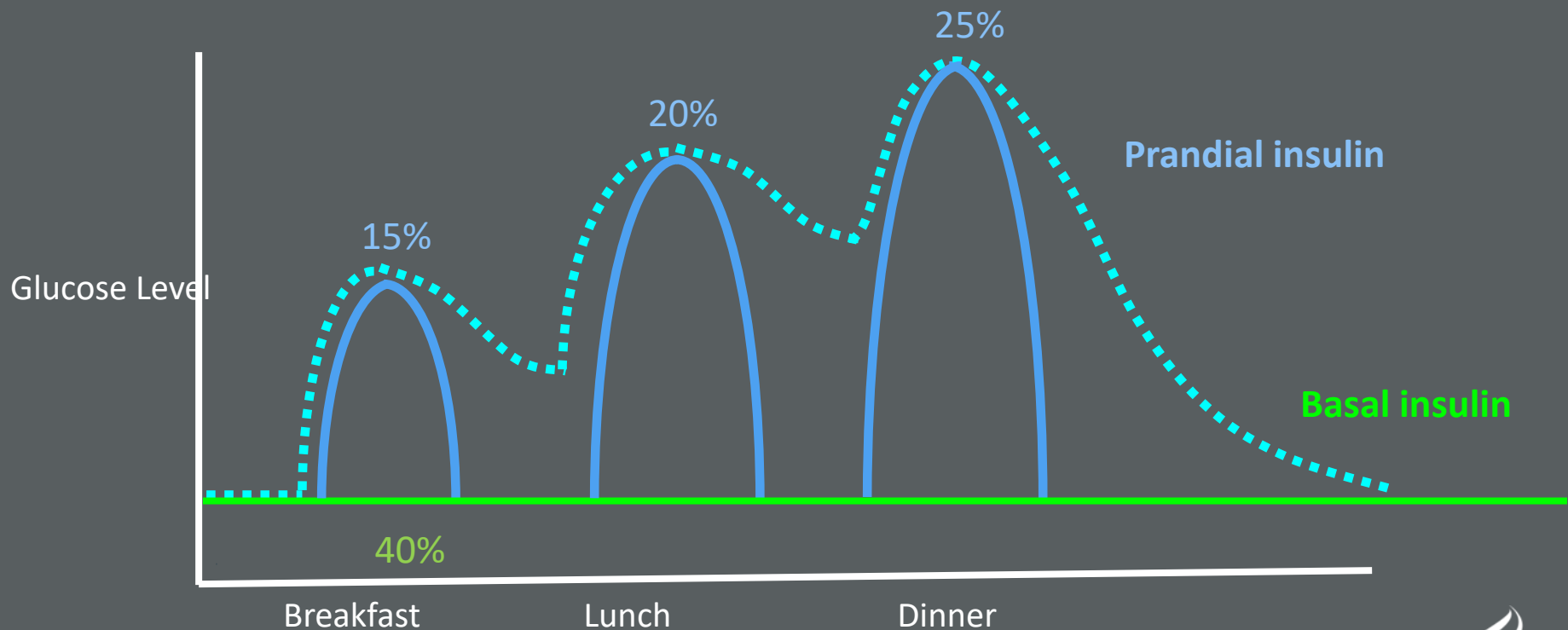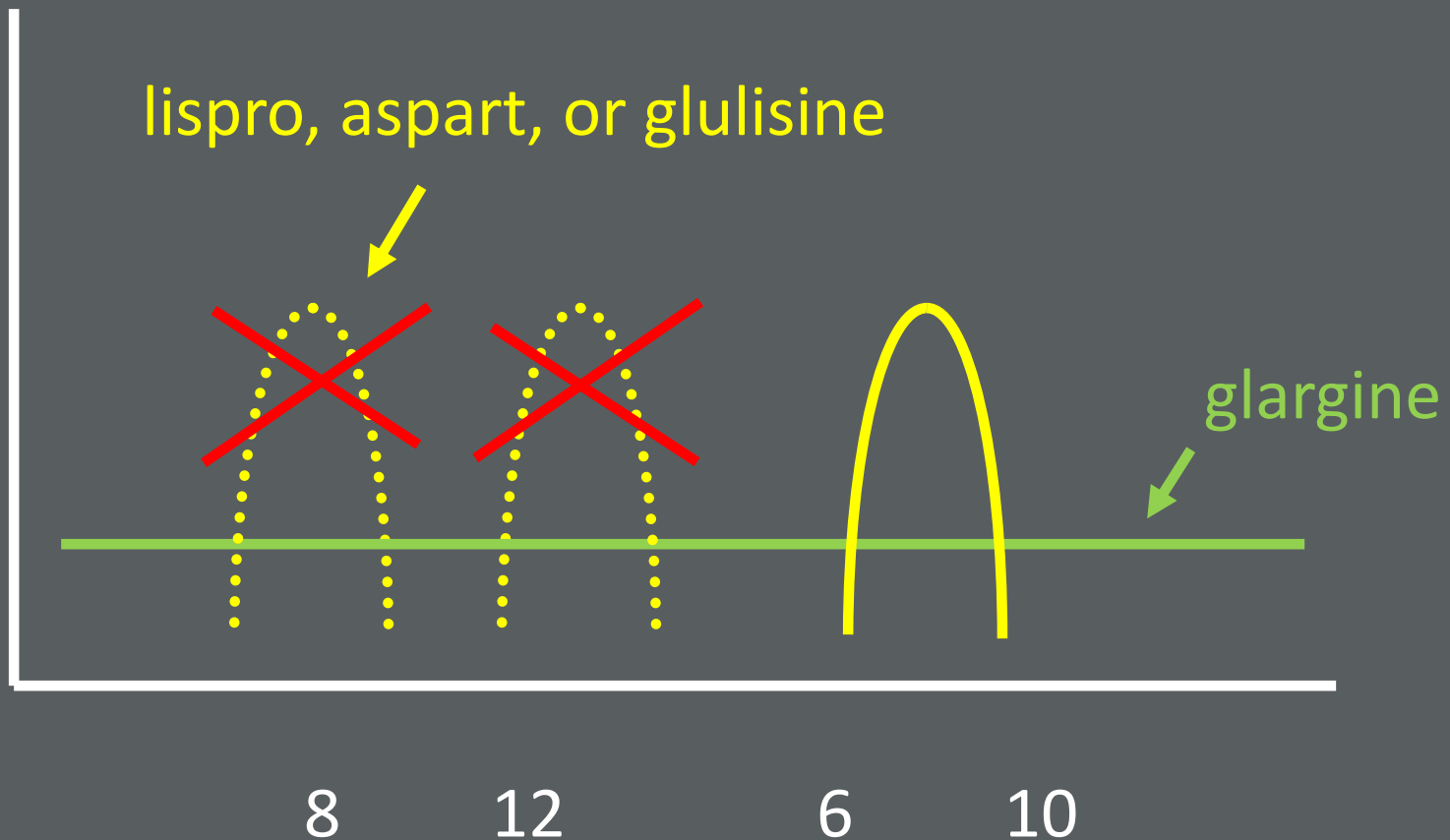- Other nutrition (Tube feeds, TPN)
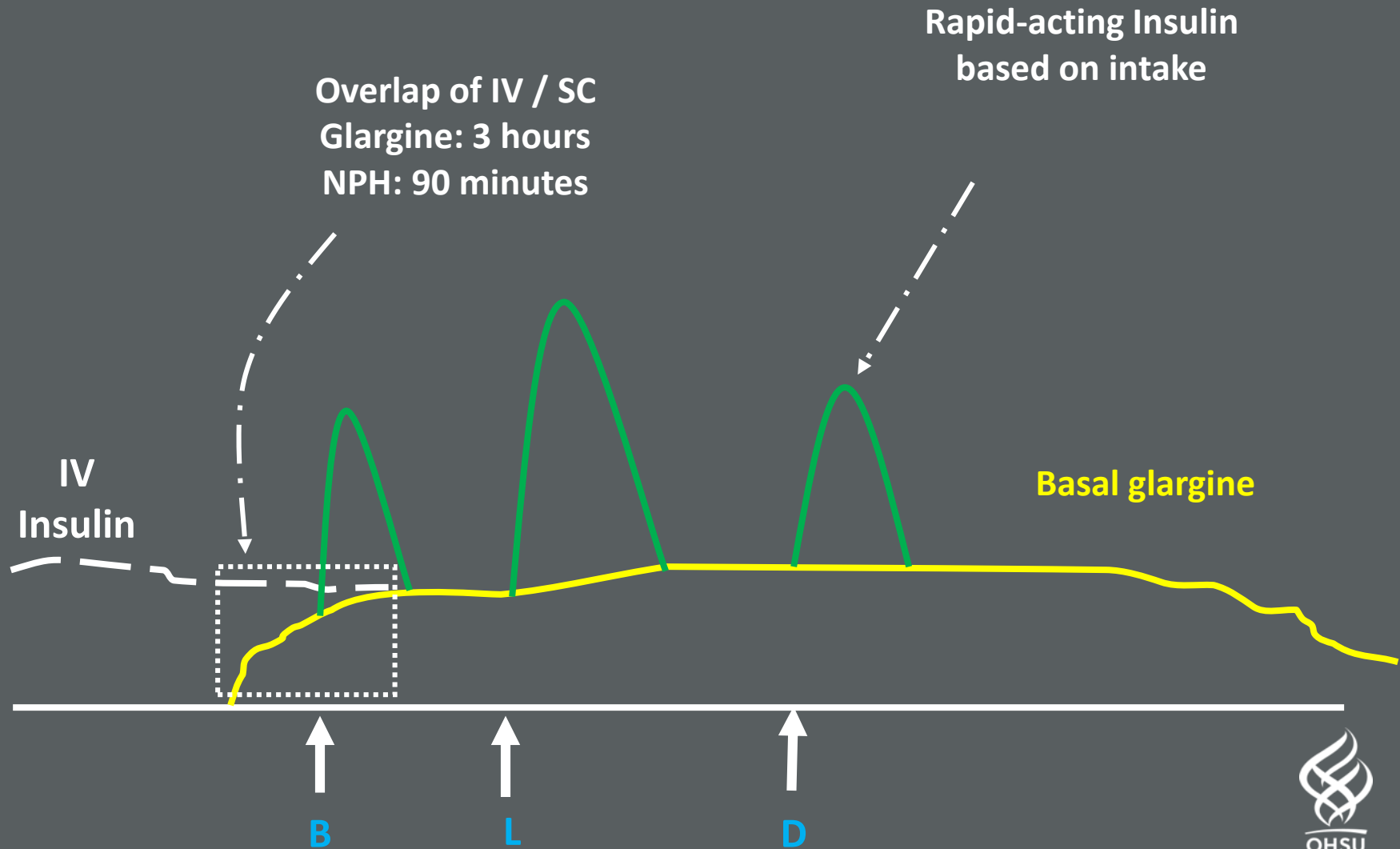- Corticosteroids
- Procedures/surgery/NPO

Inpatient Insulin Management

- Patients that are eating (reliably or unreliably)
- Other nutrition (Tube feeds, TPN)
- Corticosteroids
- Procedures/surgery/NPO

- IV insulin
- Transition from IV to SC insulin

Intravenous Insulin

- Many different protocols published
- There are several decision support software systems available that can help guide insulin infusion dosing

- Therapy of choice in the ICU
- Best (most stable) results in patients who are NPO
- in patients that are eating, if using a traditional insulin infusion protocol:
  - Use IV insulin as basal insulin
  - Add SC mealtime insulin
- Infusion software systems manage meals with IV or SQ boluses

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Basics of SC Insulin After IV

Overlap of IV / SC
Glargine: 3 hours
NPH: 90 minutes

Rapid-acting Insulin
based on intake

IV
Insulin

Basal glargine

B   L   D

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Converting From IV Insulin Infusion to SC In The Hospital Without Rapid Medical Improvement

- Calculate the insulin requirement
  - Total Daily Dose = amount received IV + SC
    - Or
  - Basal: Insulin delivered overnight for 4-6 hours (stability)
    - Extrapolate to get 24 hour basal requirement
- Multiply by **80%** to get a safe SC dose /24 hours
- Apportion into appropriate basal and nutritional components
- Adjust according to overnight glucose control

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Converting From IV Insulin Infusion to SC In The Hospital **With** Rapidly Changing Medical Status

- When this applies:
  - After surgery as the patient rapidly improves each day
  - Acute medical illness where effective therapy can cause rapidly changing insulin sensitivity
  - Particularly in those without diabetes
- Use **60%** of recent IV basal insulin for calculation (rather than 80%)
- From that point, other calculations remain the same

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Summary – Do This

- Hyperglycemia in the hospital is best managed via physiologic insulin therapy (basal/nutritional), with additional supplemental insulin used if needed

- Choice of regimen needs to be individualized and account for source of nutrition, changing medical status, and factors increasing risk of hypoglycemia and hyperglycemia

- Insulin regimen should be adjusted daily depending on prior day's results

Summary – Don't do That

- Using sliding scale alone is reactive and doesn't prevent hyperglycemia

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Thank you!