Inpatient Glycemic Management

DATE: SEPTEMBER 26, 2019 PRESENTED BY: BETHANY KLOPFENSTEIN, MD

Objectives – to discuss:

- Approach to insulin management in the hospital:
  - Subcutaneous insulin regimens
  - Intravenous insulin infusions

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

Identifying Hyperglycemia in the Hospital

- **Inhospital hyperglycemia 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 > 6.5% can be identified as having diabetes, and HbA1C 5.7%-6.4% is consistent with prediabetes.

AACE/ADA Target Glucose Levels in Hospitalized Patients

- **ICU setting:**

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

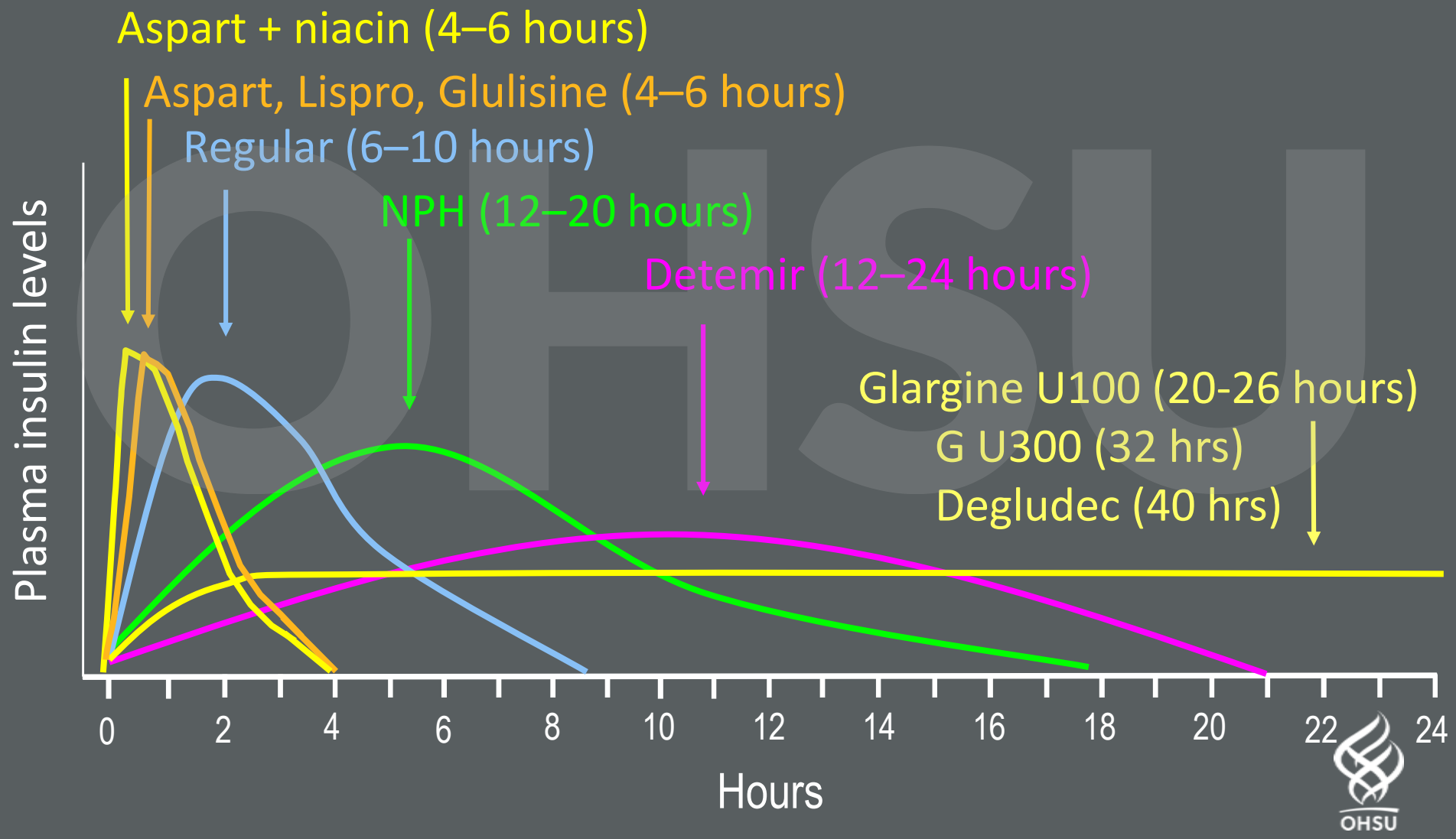
- **Non-ICU setting:**

Pre-Meal	Random
< 140	< 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.

Insulin Time-Action Profiles
Duration



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

Inpatient Insulin Management: Tailor to the situation

- Patients that are eating (reliably or unreliably)

Case 1: Eating Reliably

70 year old man with type 2 diabetes is admitted to vascular surgery with a large necrotic foot ulcer. He is started on IV antibiotics and you are consulted to assist with glycemic management. He is currently on a regular diet and eating well.

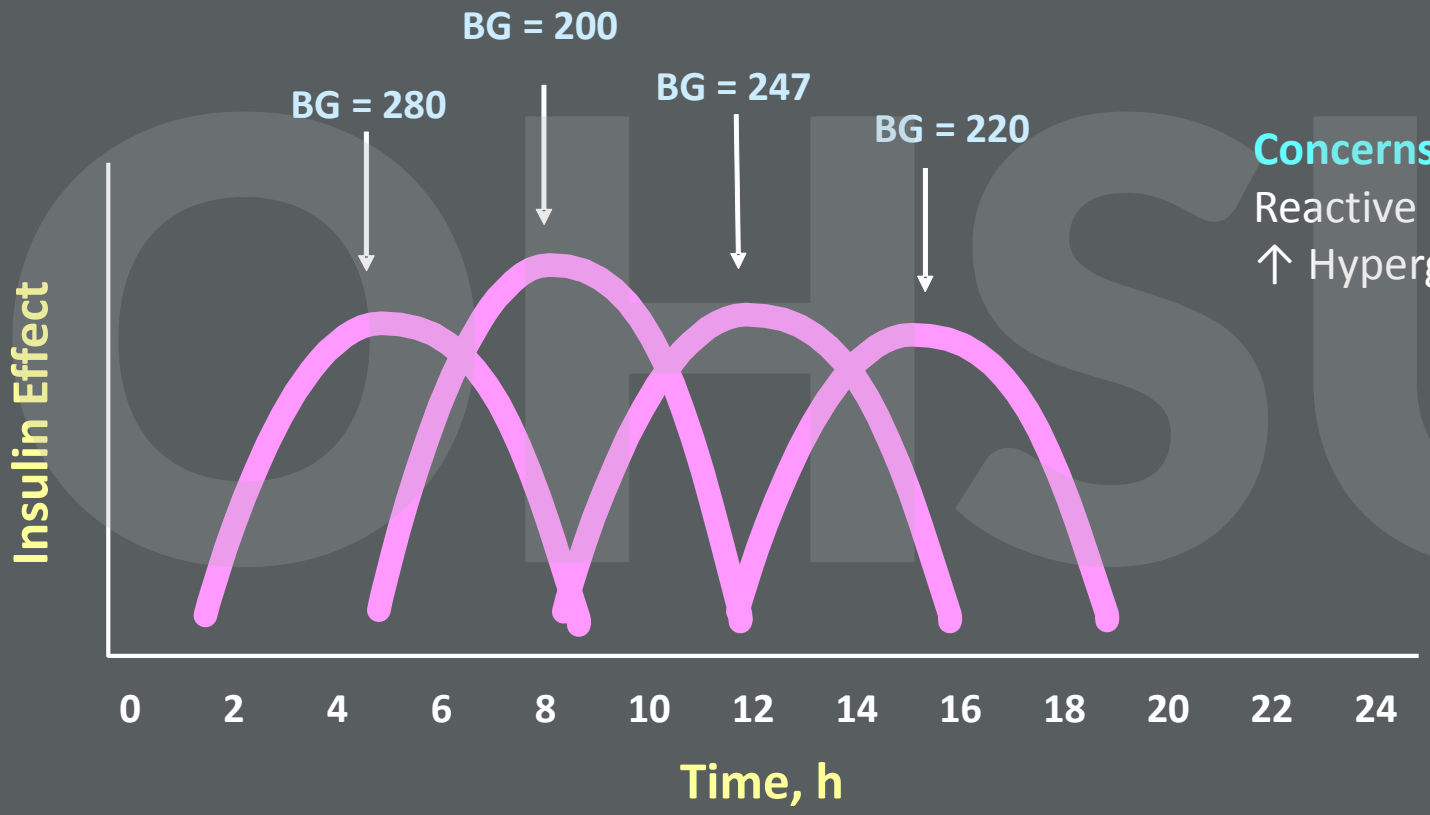
- Weight: 85 kg
- Home medical regimen: Glipizide 5 mg po BID, Metformin 1000 mg po bid, semaglutide 1 mg qwk
- Outpatient glucose control: HbA1c 2 months prior to admission was 7.1%. He does not check CBGs at home.
- Admission glucose is 352 mg/dL

How do you manage his diabetes?

Principles of Insulin Management In The Hospital

- **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

Sliding-Scale Insulin Alone Not Recommended



Concerns:

Reactive approach:

↑ Hyperglycemia

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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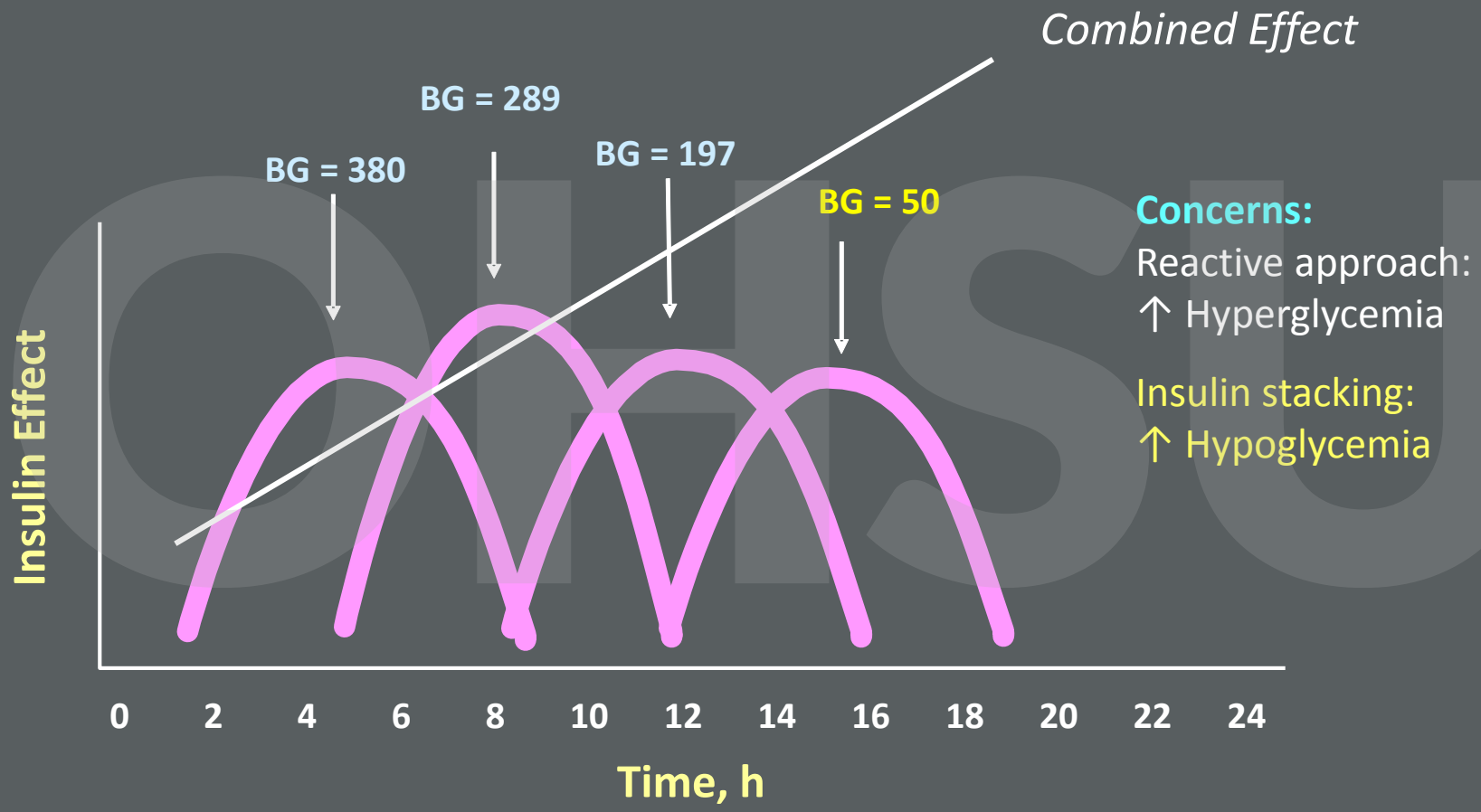

Concerns:

Reactive approach:
↑ Hyperglycemia

Insulin stacking:
↑ Hypoglycemia

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Inpatient Insulin Management: 5 Step Approach

STEP 1: Estimate the Total Daily Insulin Requirement: Basal + Nutritional Insulin = Total Daily Dose (TDD)

- Weight-based estimate:
  - TDD = 0.4-0.5 units/kg (for type 2 diabetes)
  - Adjust TDD down to 0.2-0.3 units/kg for those with hypoglycemia risk factors
    - Elderly, renal failure, liver disease, low body weight, type 1 or no history of diabetes
  - Adjust TDD up to 0.5-0.6 units (or more)/kg for those with hyperglycemia risk factors
    - Obesity, glucocorticoids
- Insulin drip-based estimate (for patients treated with an insulin infusion)
- For patients on insulin prior to admission, consider the patient's preadmission subcutaneous regimen TDD and glycemic control on that regimen

STEP 2: Assess the Patient's Nutritional Situation

- Eating meals predictably
- Eating meals but with unpredictable intake
- Enteral feeding
  - Continuous
  - Part of the day
  - Bolus
- TPN
- Combinations of above
- NPO

STEP 3: Divide the Total Daily Dose (TDD) into Basal and Nutritional Components

- Basal insulin can generally be estimated to be 50% of the TDD
  - Decrease to 40% if receiving AM corticosteroids
- Nutritional insulin can be estimated to be the remaining 50% of the TDD
  - Increase to 60% if receiving AM corticosteroids
  - If eating, divide boluses between meals

STEP 4: Decide Which Components of Insulin the Patient Will Require

- In the majority of cases, basal insulin should be provided
- When a patient is not receiving nutrition, nutritional insulin should not be given, however basal insulin should be continued
- Nutritional insulin needs must be matched to the actual nutritional intake (eating, tube feeds, TPN, etc.)
  - Patients with unpredictable PO intake: Bolus insulin can be given immediately after the meal, in a ratio determined by amount eaten
- Generally, well-designed correction insulin regimens should also be provided in addition to scheduled bolus

STEP 5: Assess Blood Glucose Pattern Daily (at a minimum) and Adjust Insulin Doses

- Adjust basal and bolus doses based on glucose patterns
- If glucoses consistently >180-200, increase TDD by 20%
- If any glucose < 70, decrease TDD by 20%

- Improvement of hyperglycemia and avoidance of hypoglycemia can only be achieved via continuous management of the insulin regimen
- **There is no "autopilot" insulin regimen for a hospitalized patient**

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- Admission glucose is 352 mg/dL

How do you manage his diabetes?

Case 1: One possible Solution

- Change to consistent carbohydrate (diabetic) diet
- Discontinue oral agents
- Total daily dose 85 kg x 0.5 units/kg/day = 42.5 units
- Basal: Glargine 21 units daily
- Nutritional: Rapid-acting analogue 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

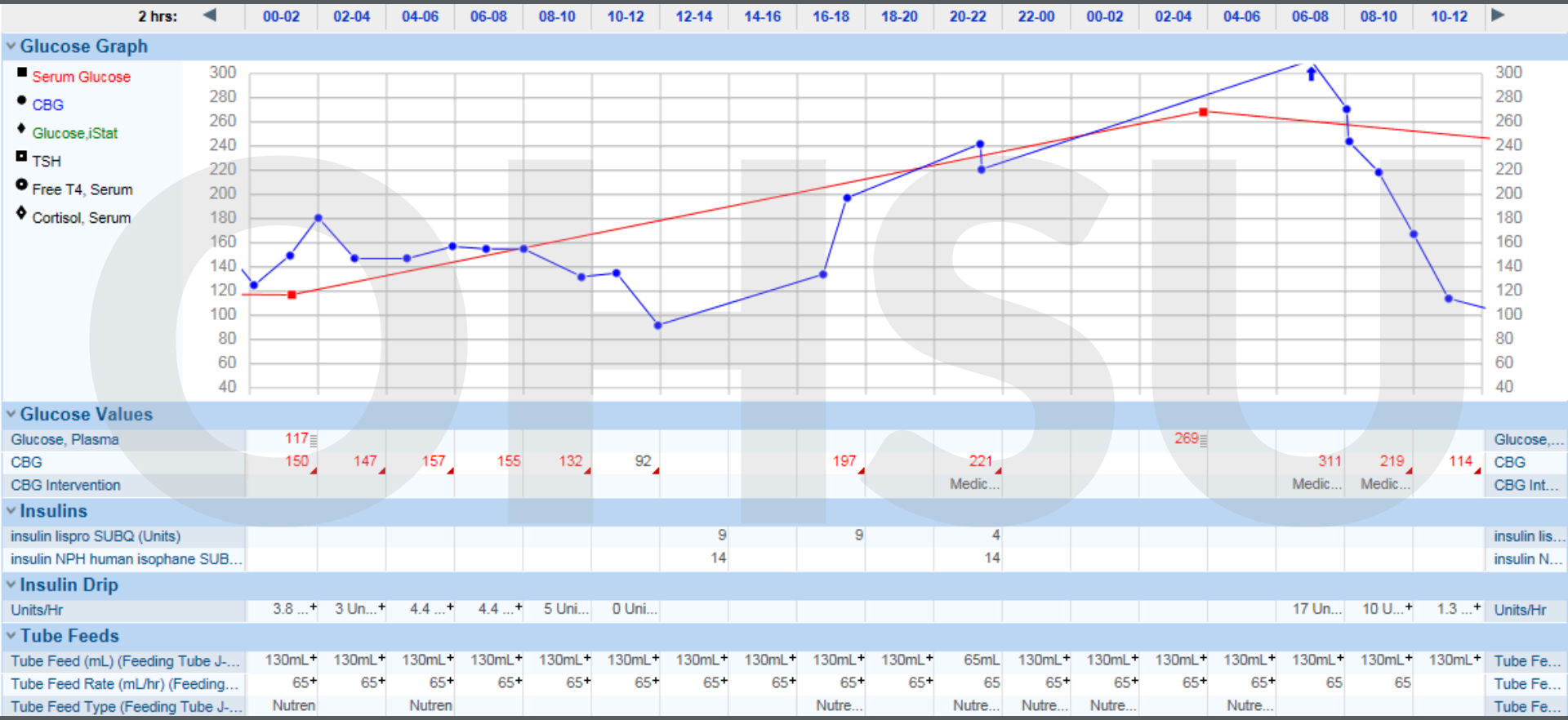
- Patients that are eating (reliably or unreliably)
- Other nutrition (Tube feeds, TPN)

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, glimepiride 2 mg qd, sitagliptin 100mg qd
- Current hospital regimen NPH 14 units bid

Case 2: Enteral Feeding



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CBG	150	147	157	155	132	92			197		221					311	219	114	CBG
CBG Intervention											Medic...					Medic...	Medic...		CBG Int...
Insulins																			
insulin lispro SUBQ (Units)							9		9		4								insulin lis...
insulin NPH human isophane SUB...							14				14								insulin N...
Insulin Drip																			
Units/Hr	3.8 ...	3 Un...	4.4 ...	4.4 ...	5 Uni...	0 Uni...										17 Un...	10 U...	1.3 ...	Units/Hr
Tube Feeds																			
Tube Feed (mL) (Feeding Tube J-...	130mL	130mL	130mL	130mL	130mL	130mL	130mL	130mL	130mL	130mL	65mL	130mL	130mL	130mL	130mL	130mL	130mL	130mL	Tube Fe...
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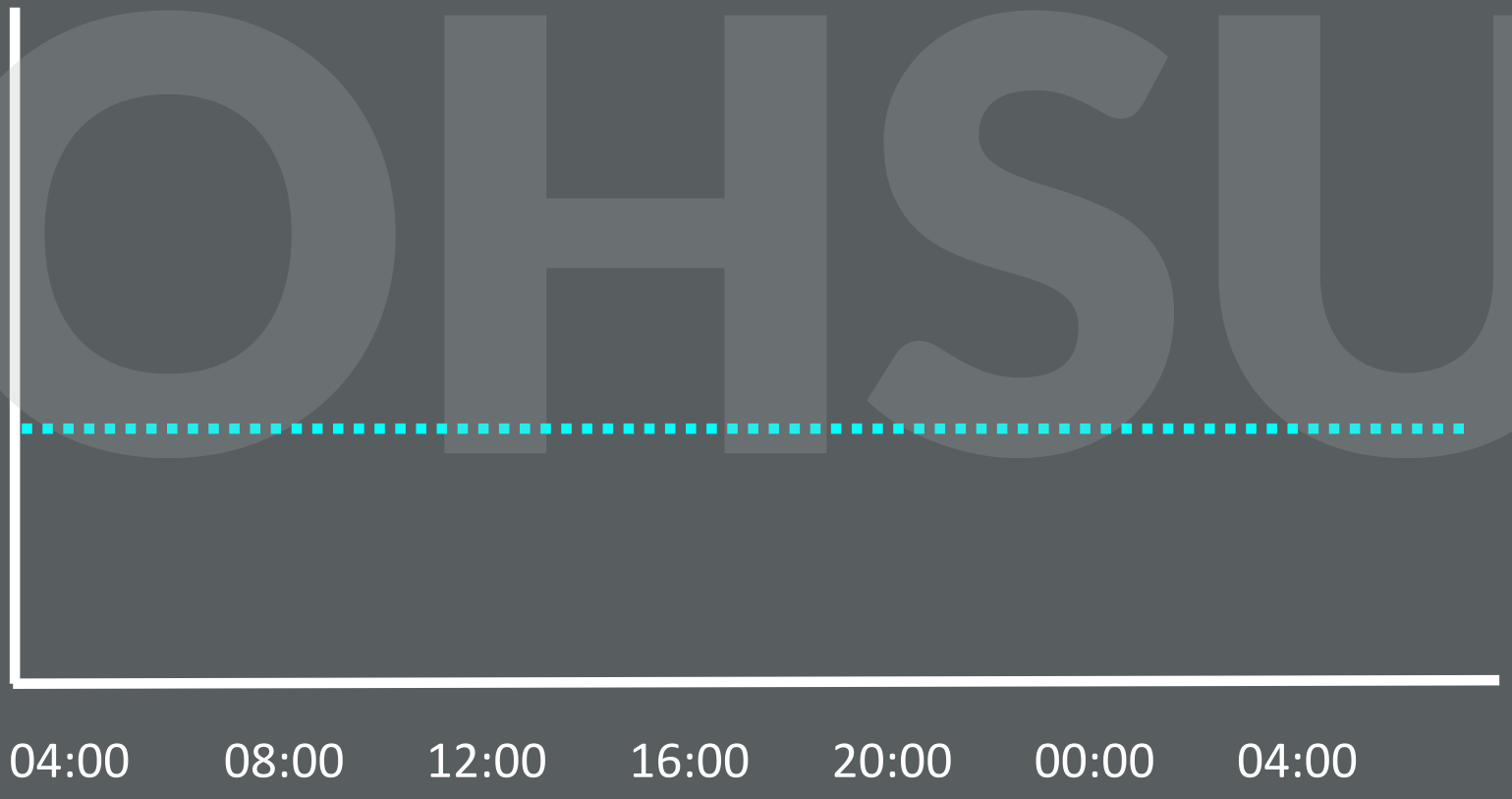
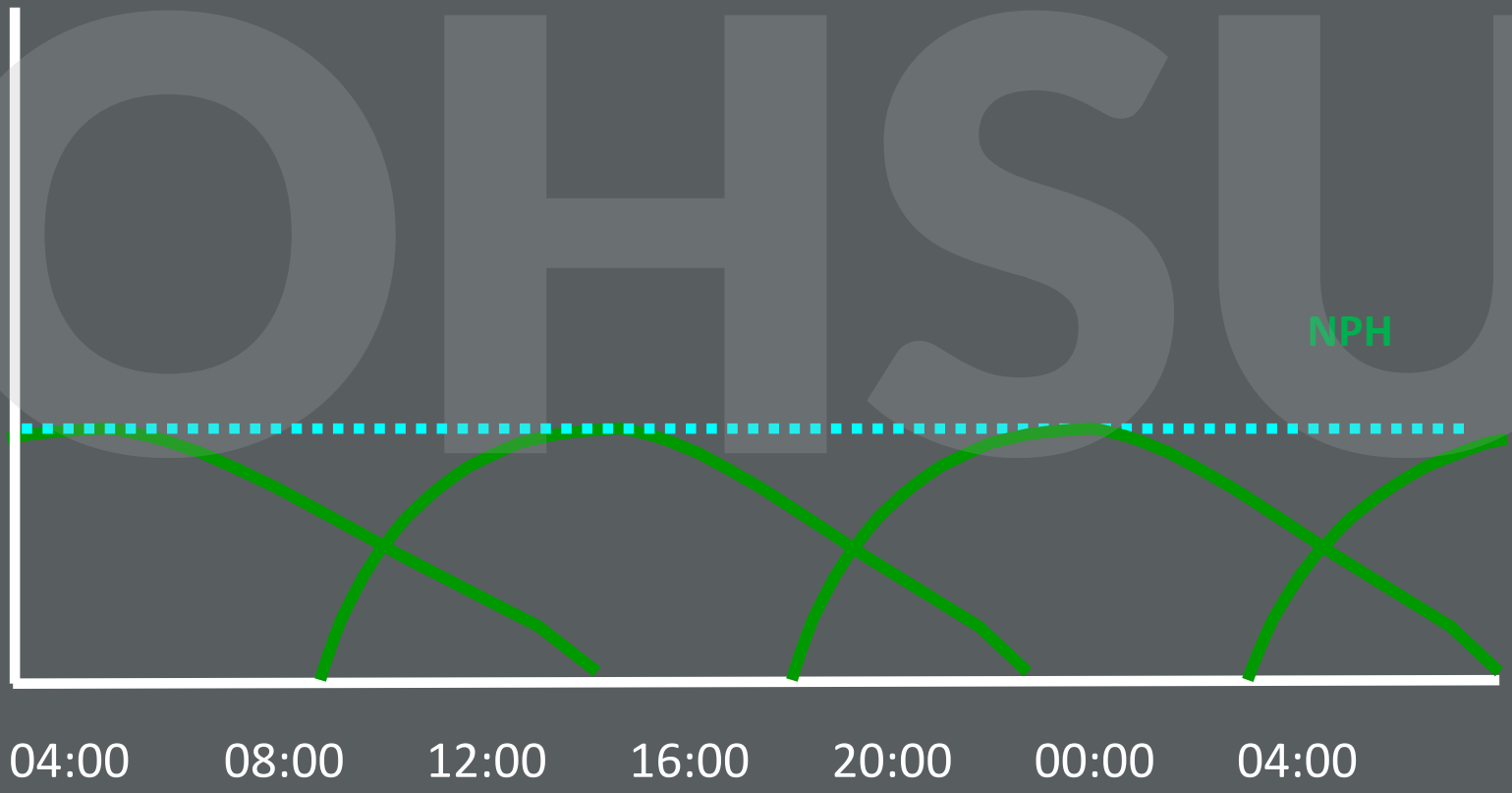
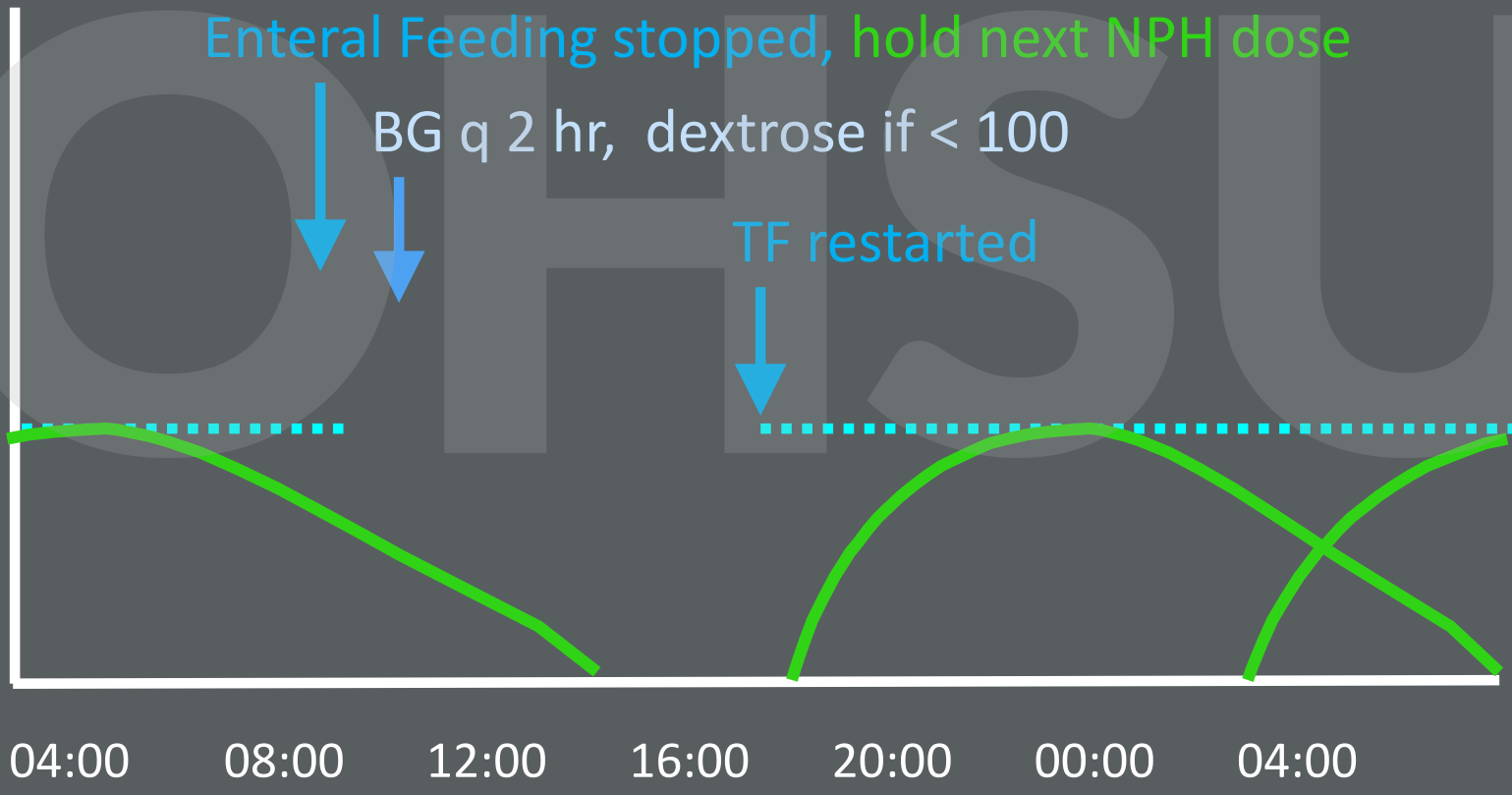
Insulin Requirement During Continuous Enteral Feedings or TPN



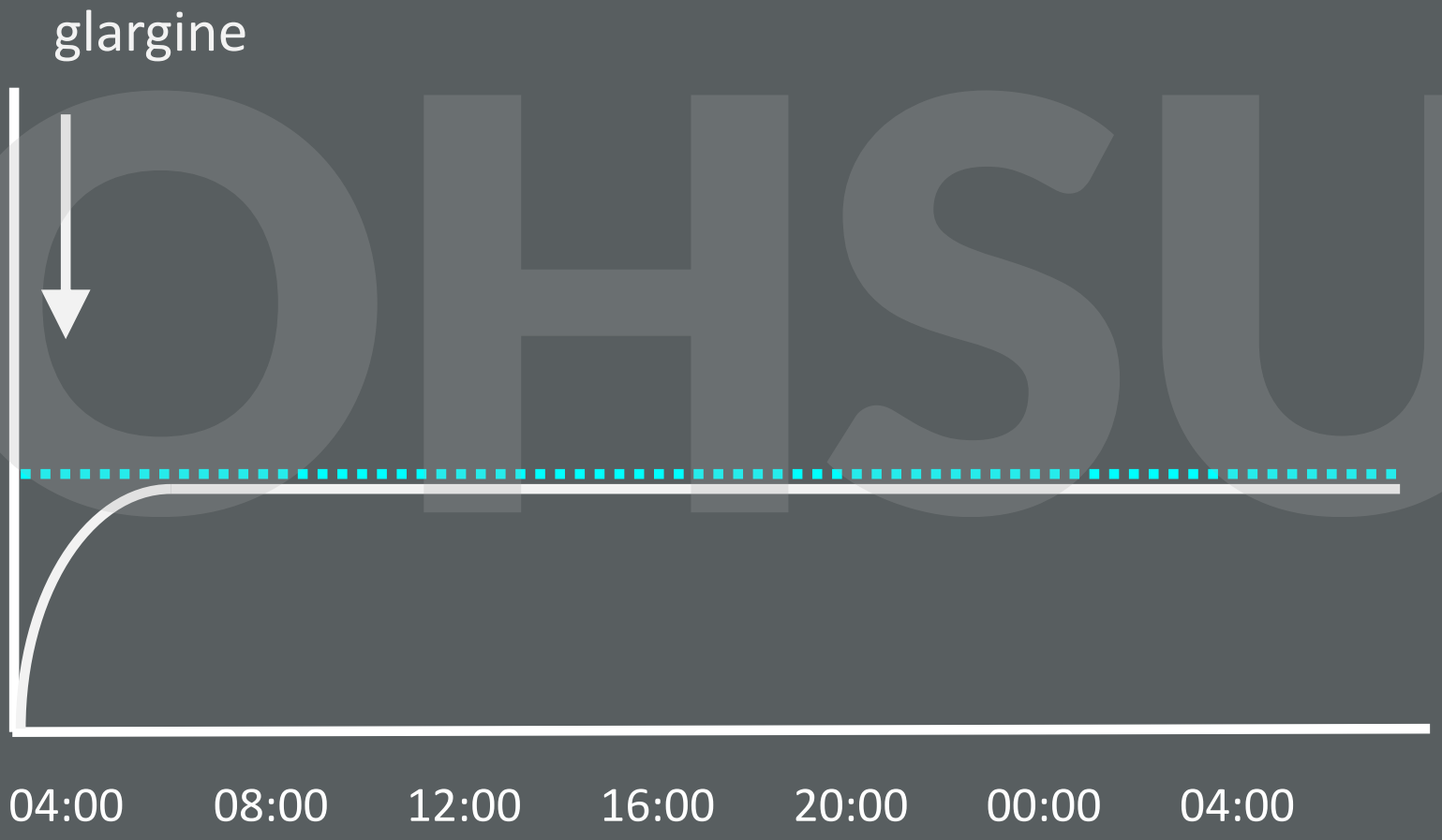
NPH q8 hours During Continuous Enteral Feedings or TPN



NPH q8 hours During Continuous Enteral Feedings (or TPN)



Glargine During Continuous Enteral Feedings (or TPN)



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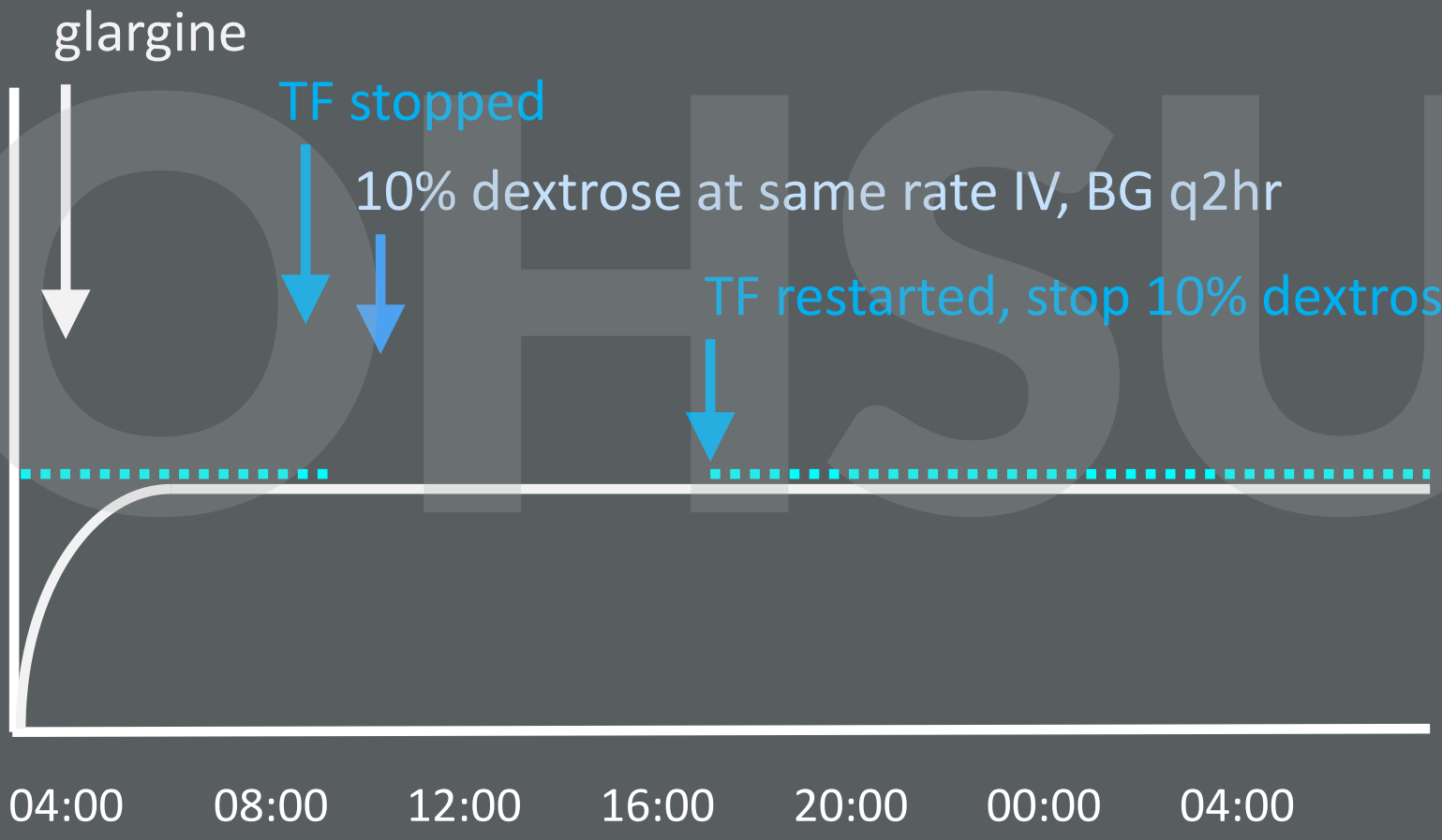
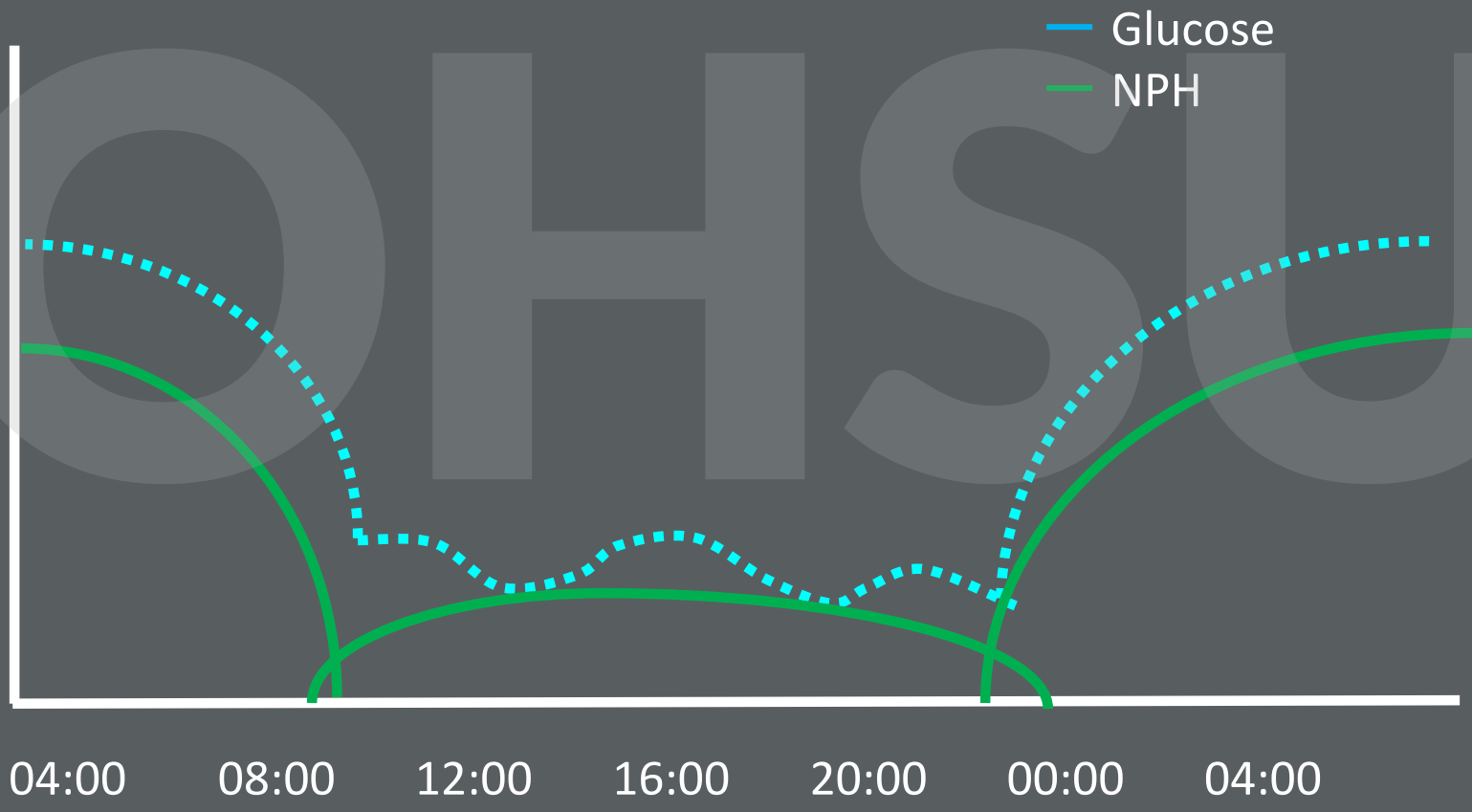
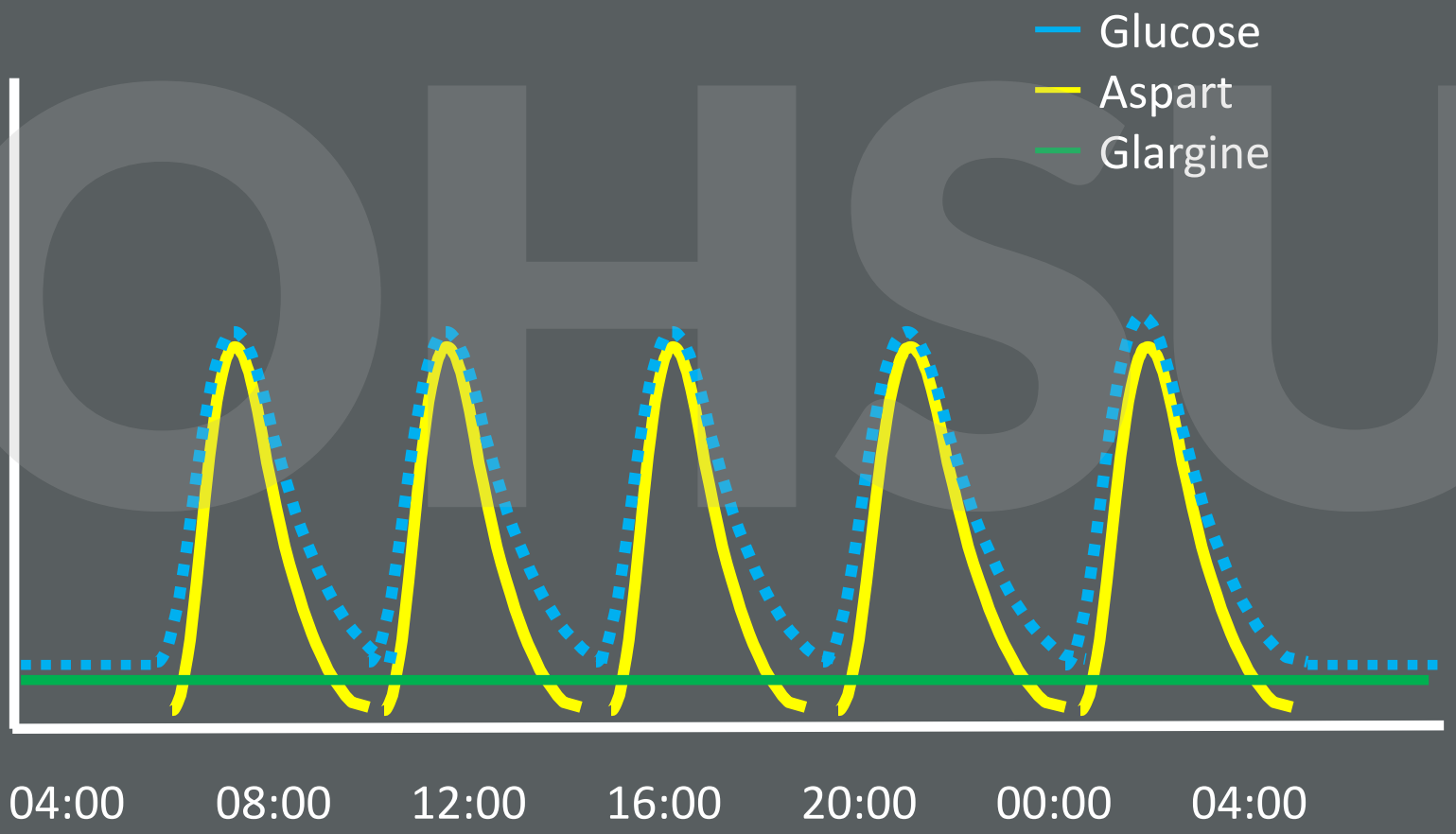


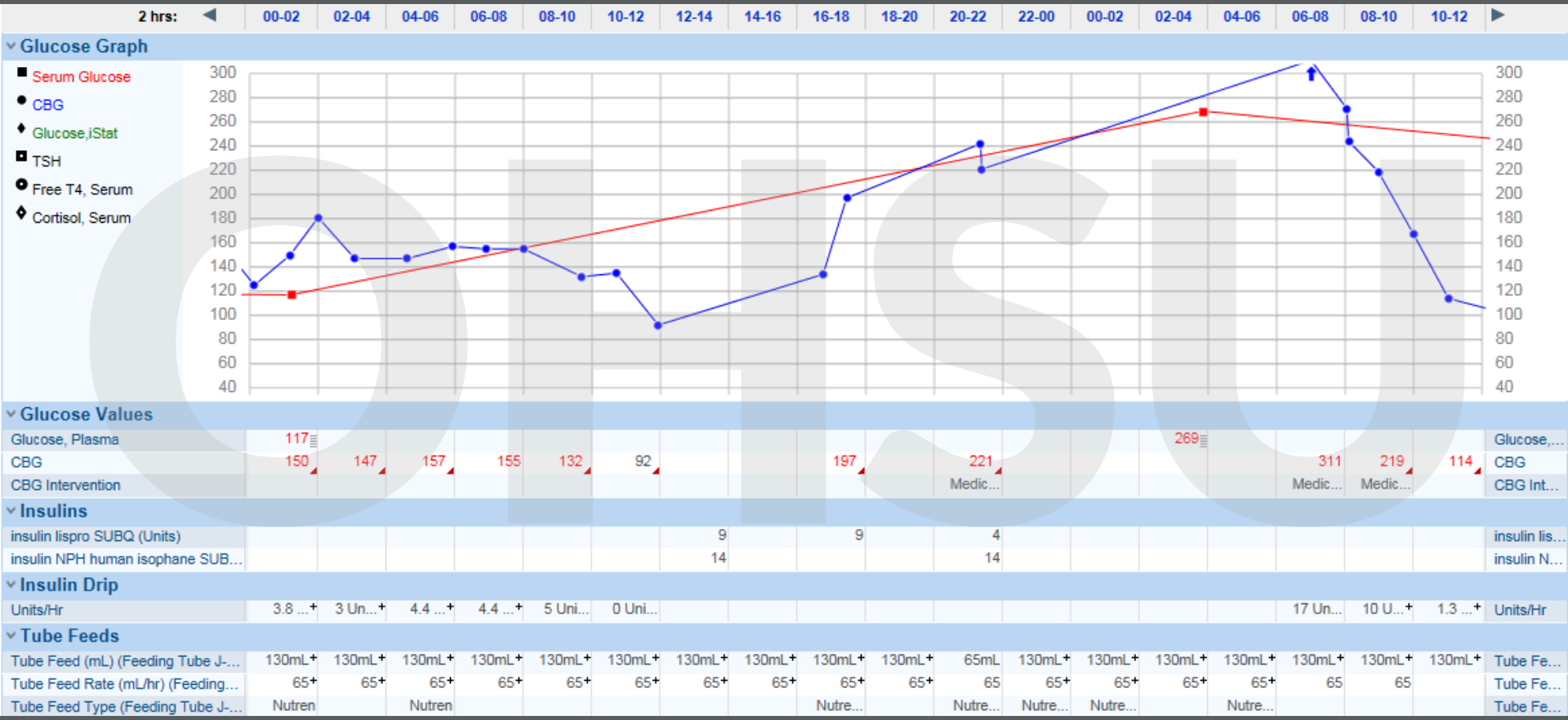
Overnight Enteral Feedings with Daytime Grazing



Bolus Enteral Feedings



Case 2: Enteral Feeding



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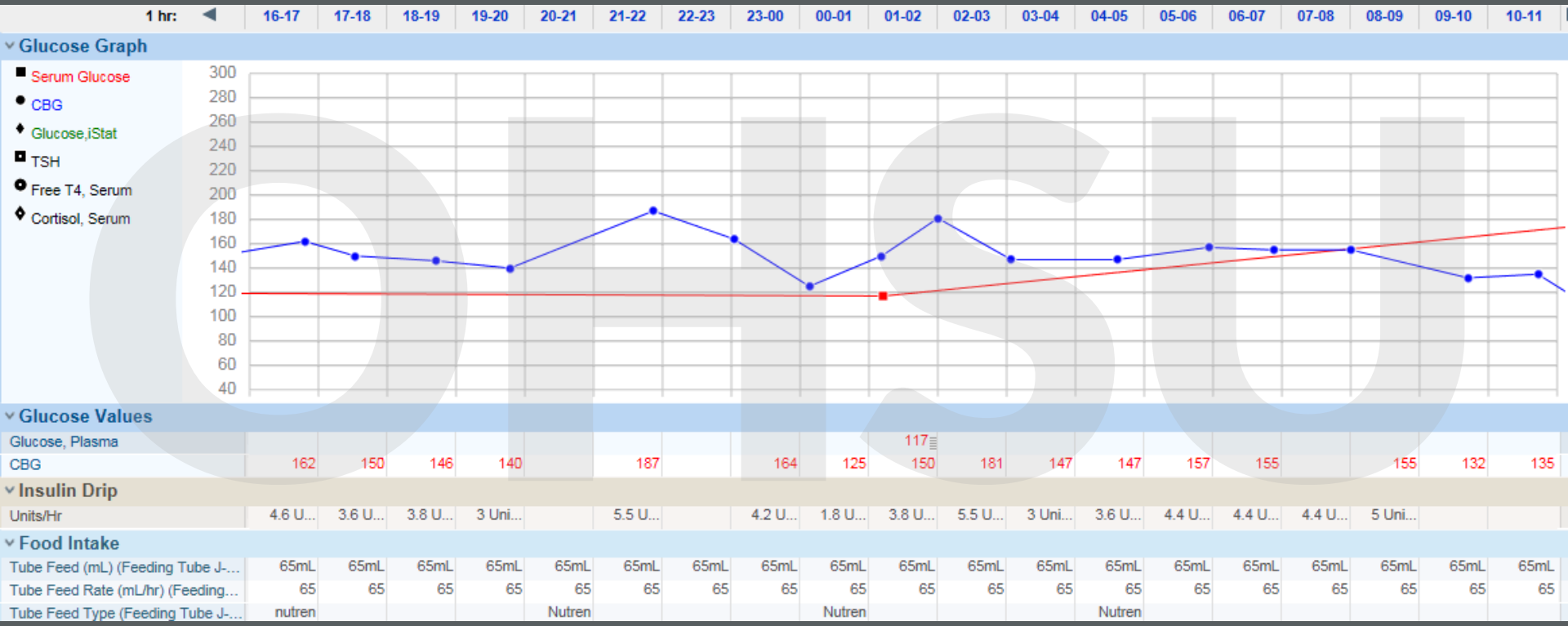
Case 2: Enteral Feeding

How do you manage this patient?

- Calculate insulin requirement from insulin infusion when TF at goal rate

Case 2: Enteral Feeding



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Food Intake																			
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Tube Feed Type (Feeding Tube J-...	nutren				Nutren				Nutren				Nutren						

- Total insulin received over 24 hours = 130 units

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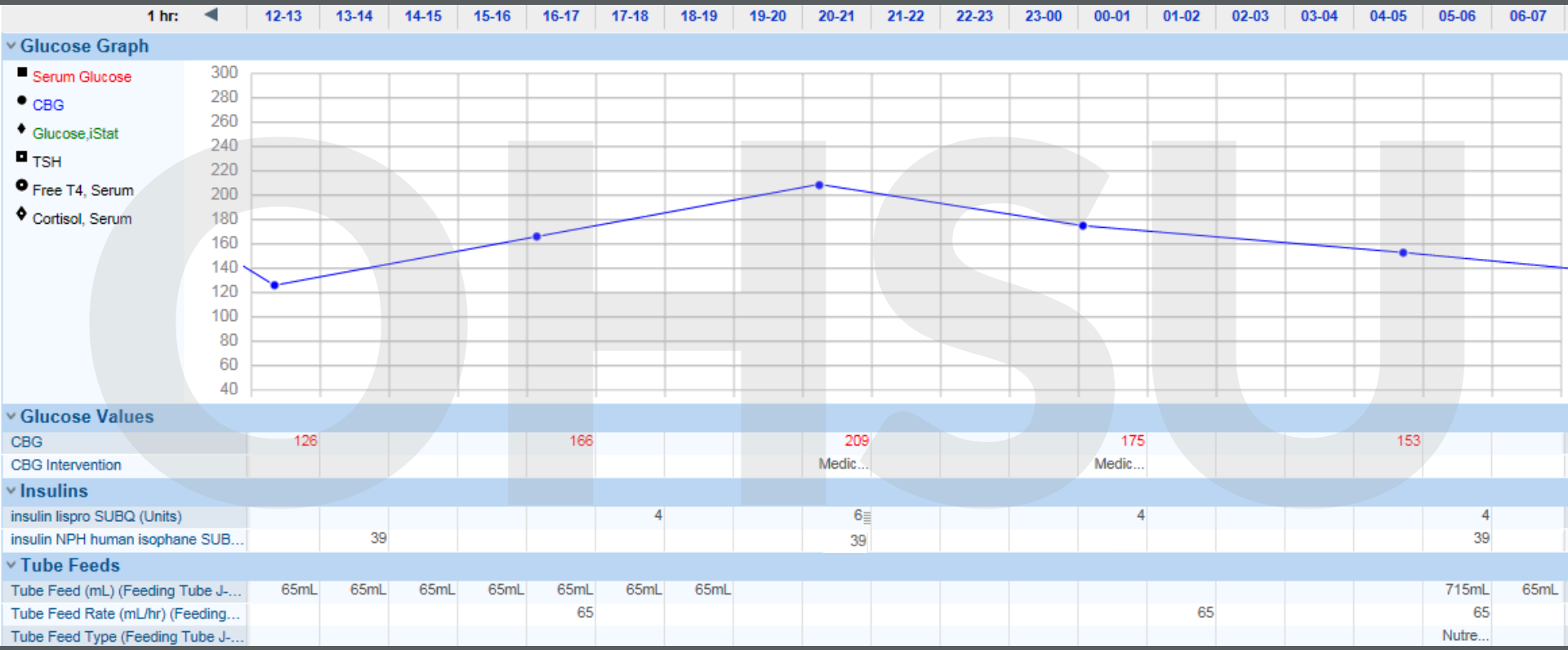
Case 2: Enteral Feeding

How do you manage this patient?

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

Case 2: Enteral Feeding



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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

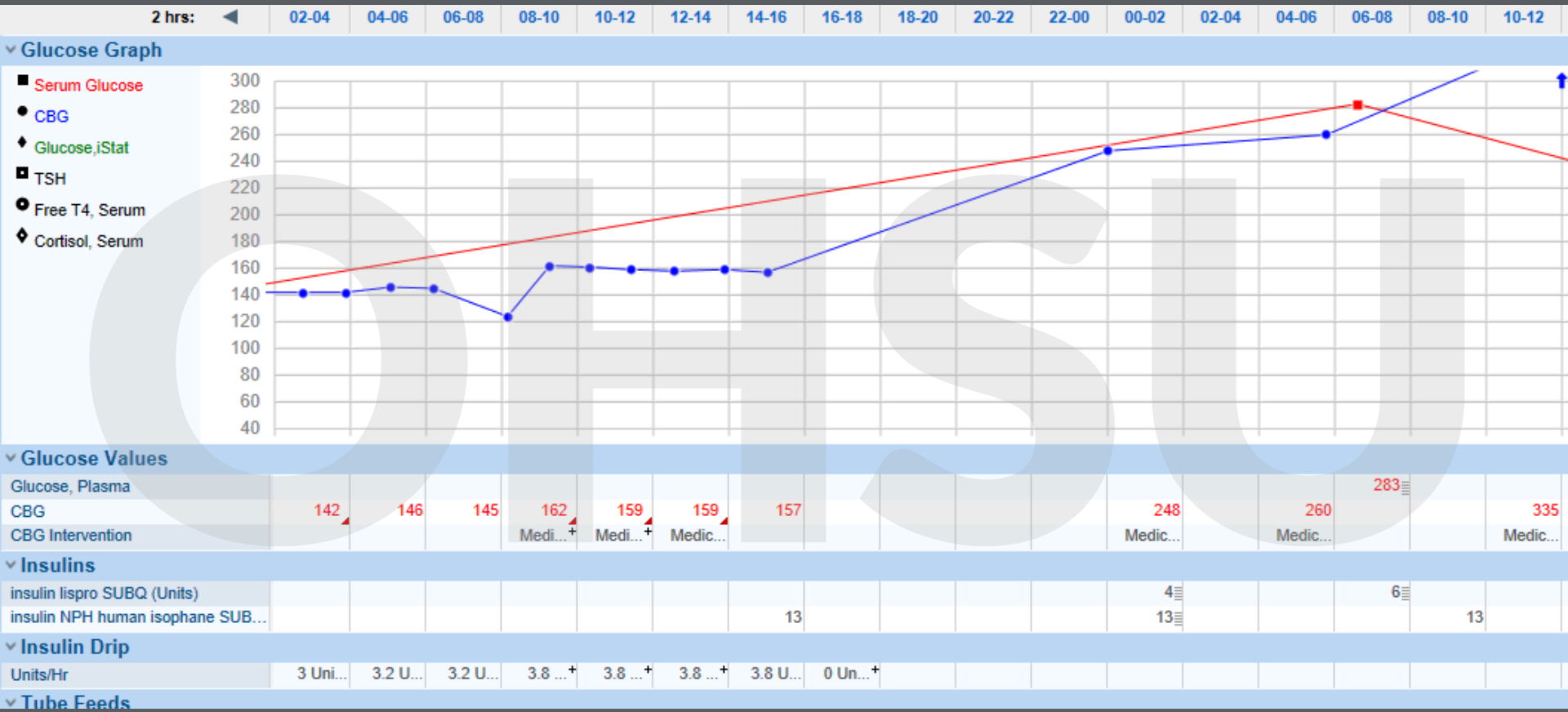
- Or, could estimate insulin requirement using carb ratio of 1 unit:10 grams of carbohydrate in TPN, and put this amount in the TPN bag

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

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



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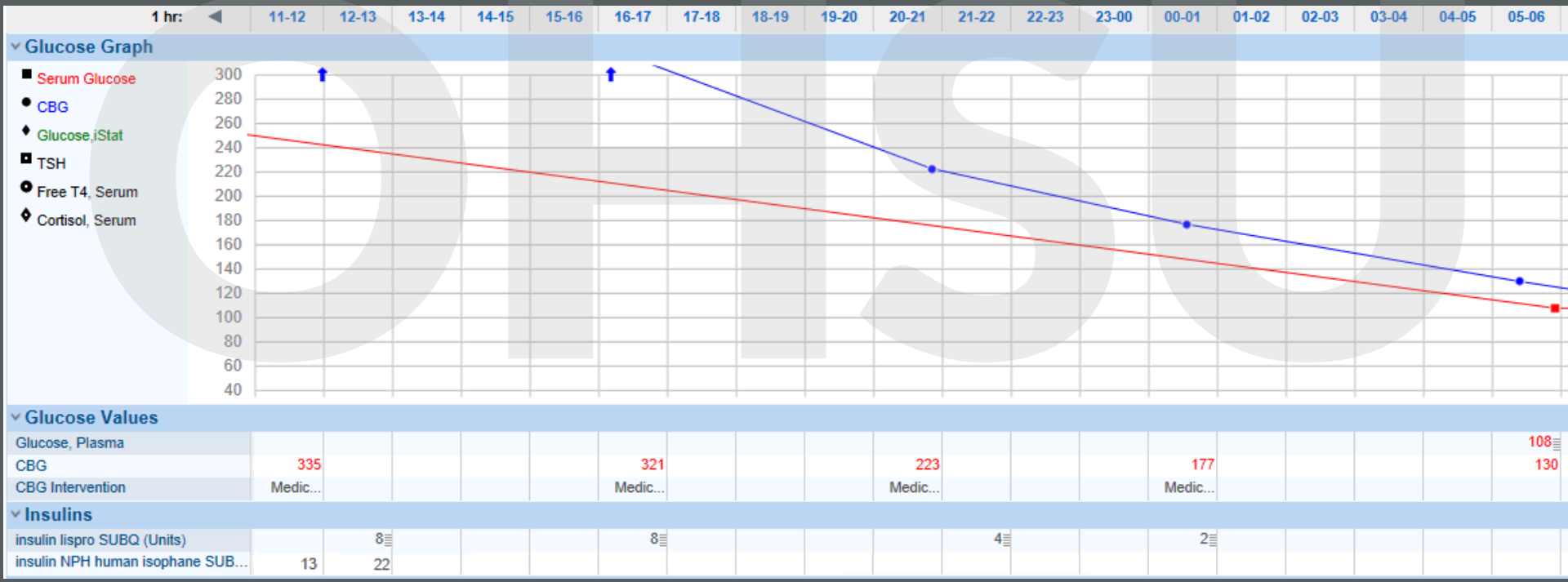
Case 3: TPN

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

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

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Case 3: TPN

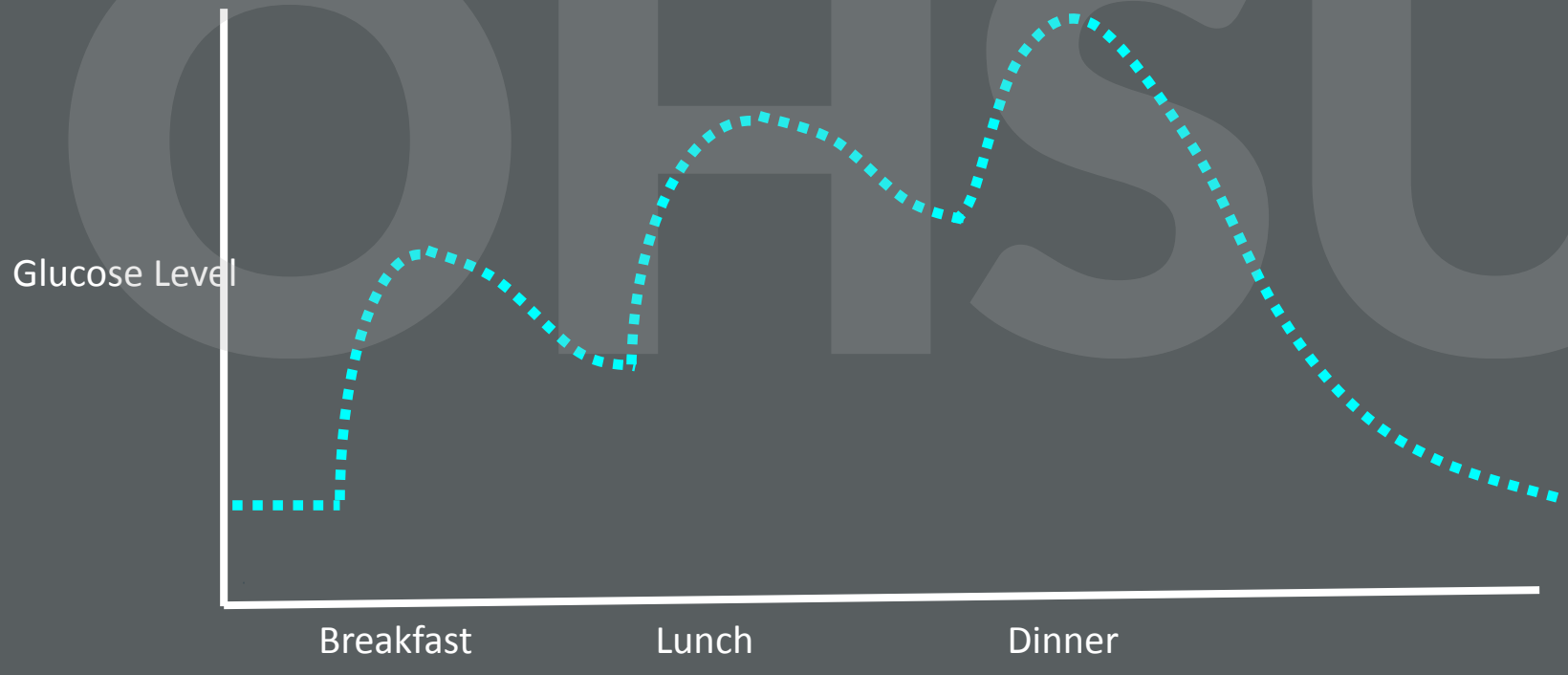
- Five days later the dietician recommends increasing her caloric intake. The dextrose is increased from 165 grams to 205 grams per 24 hours. What change do you make?

- 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

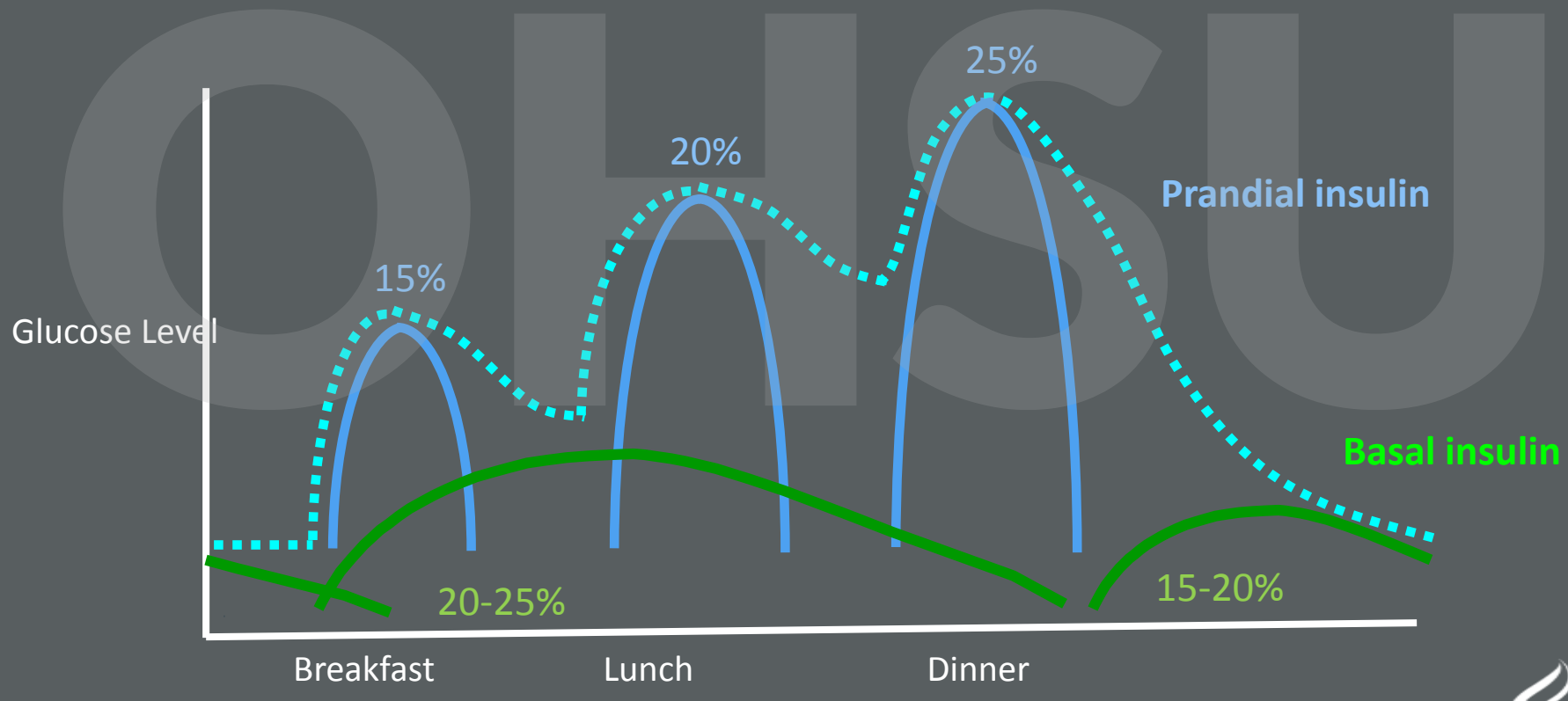
Inpatient Insulin Management: Tailor to the situation

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

Typical Blood Glucose Pattern With Morning Steroid Therapy



Inpatient Therapy of Patients on AM Corticosteroids



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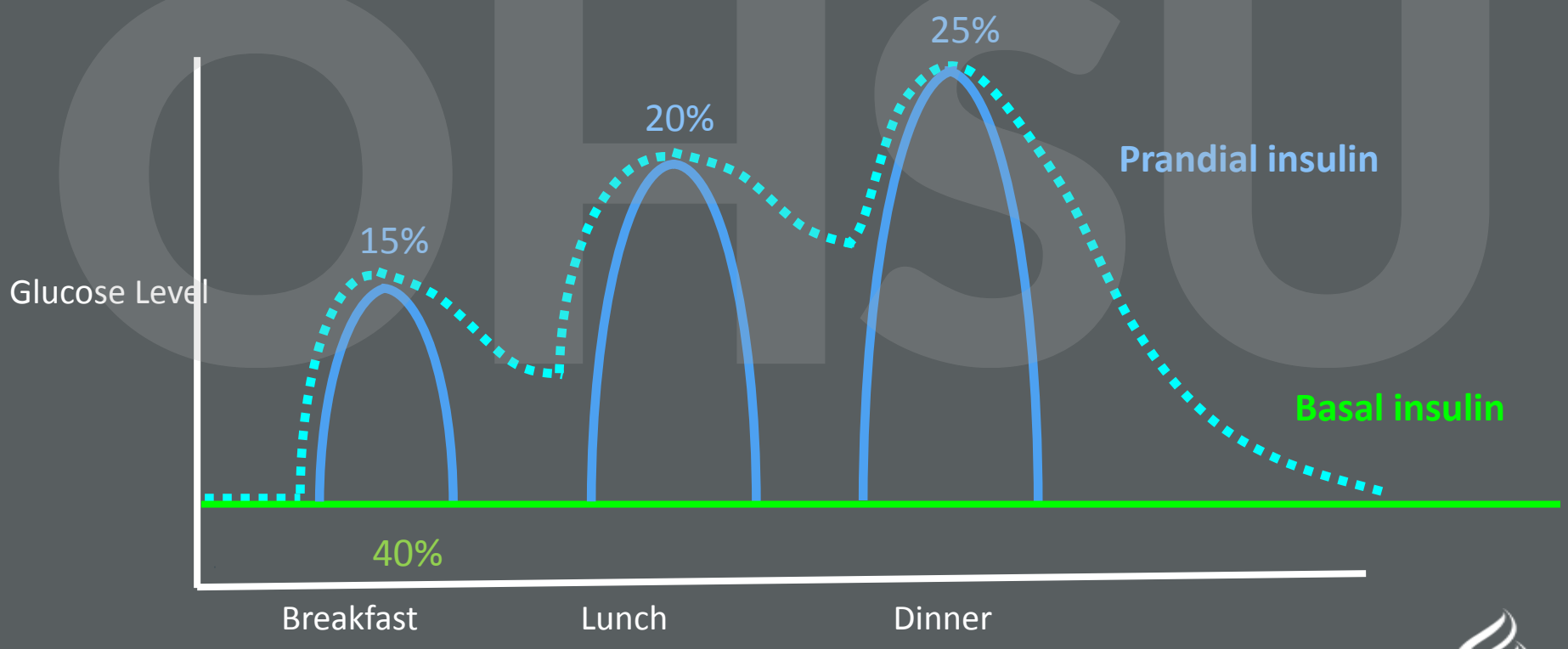

Inpatient Insulin Management: Tailor to the situation

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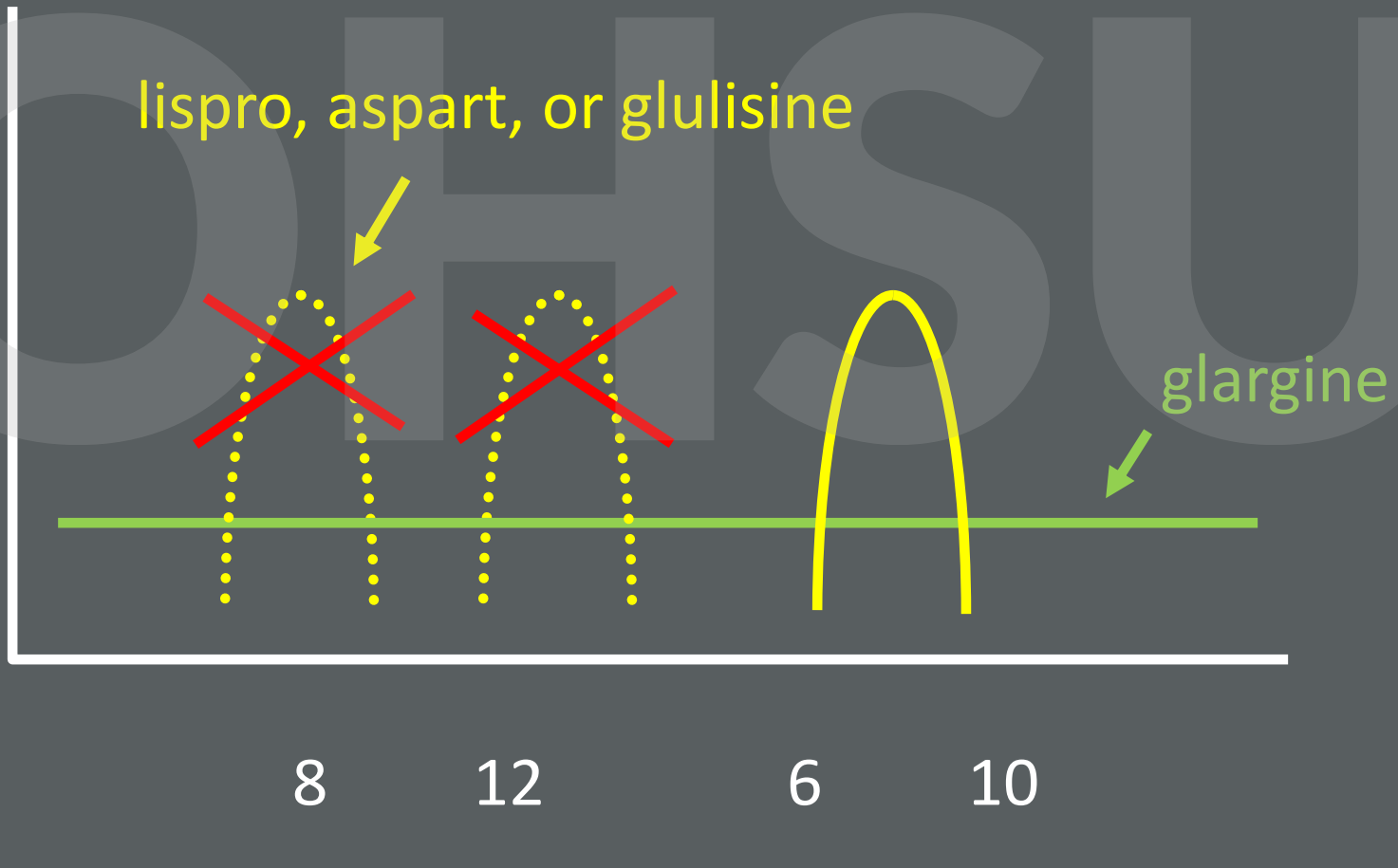
- Procedures/surgery/NPO

For procedures or brief NPO status, hold the prandial insulin but maintain basal insulin



Inpatient Insulin Management

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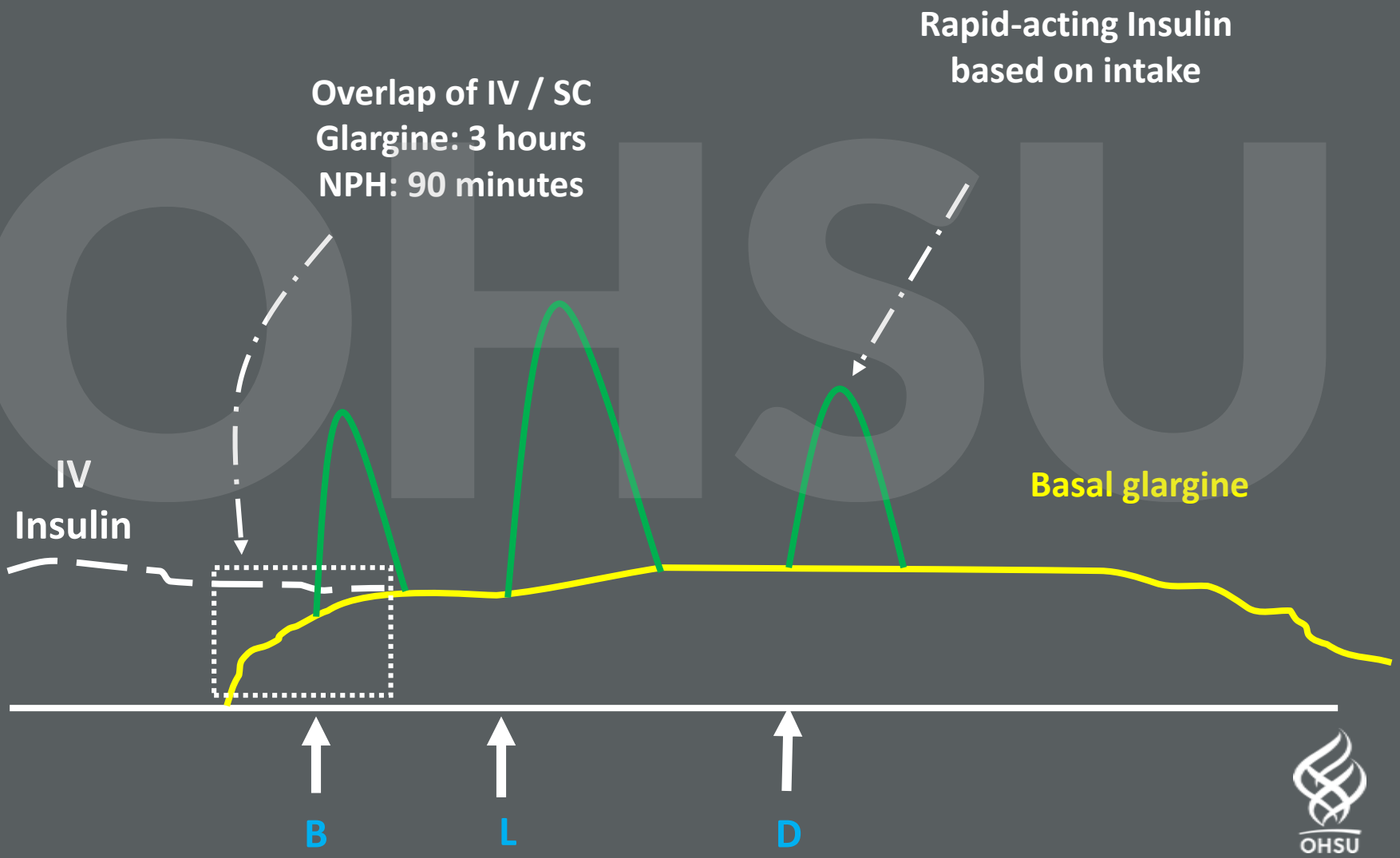
- IV insulin
- Transition from IV to SC insulin

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

Basics of SC Insulin After IV



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

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

Transition to Outpatient Care

Case 4: Discharge Regimen

65 yo M with type 2 diabetes admitted with multiple fractures after a MVA. His glucoses were in the 300's on admission, and during his hospitalization you have treated him with a basal/bolus regimen of glargine and novolog and achieved glucoses within target range. He will be discharged tomorrow.

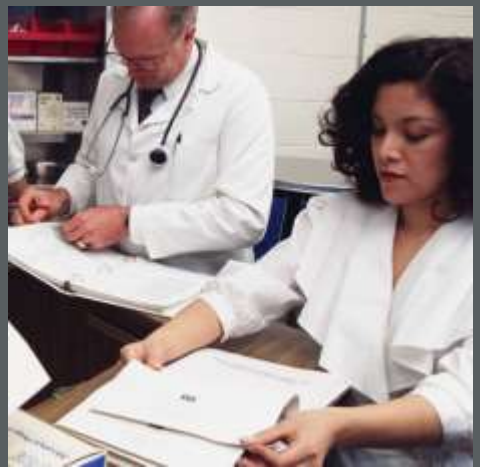
- Wt 90 kg
- Current medications: glargine 28U qhs, aspart 9U TID with meals
- Outpatient medications: metformin 1000mg bid and dulaglutide 1.5 mg per week (both held)
- Pertinent labs: Cr 1.6 on admission, now 0.9
- HbA1c 9.2% on admission.

What do you send him home on?

A. Resume previous medications
B. Resume metformin and dulaglutide, add glargine once daily
C. Send home on current inpatient insulin regimen of glargine and aspart

Hospital Discharge Transition

- Stabilize blood glucose prior to discharge
- Obtain A_{1c} for discharge planning if result not available for the previous 2-3 months
- Provide inpatient education (survival skills)
- Refer patient for outpatient education
- Prepare for outpatient follow-up with PCP



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AACE Discharge Recommendations For Patients with Type 2 Diabetes on Orals

HbA1c level	Recommended Actions
<7%	Return to previous therapy
7-8%	Increase dose of previous oral agents, or Add a third agent, or Add bedtime basal insulin
>8%	If already on 2 oral agents, add once daily basal insulin
10%	Consider discharging on basal-bolus regimen, continuing doses as started in the hospital

Summary

- 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

Thank you!