Beyond the Slide: Exploring the Other Parts of the Inpatient Diabetes Playground

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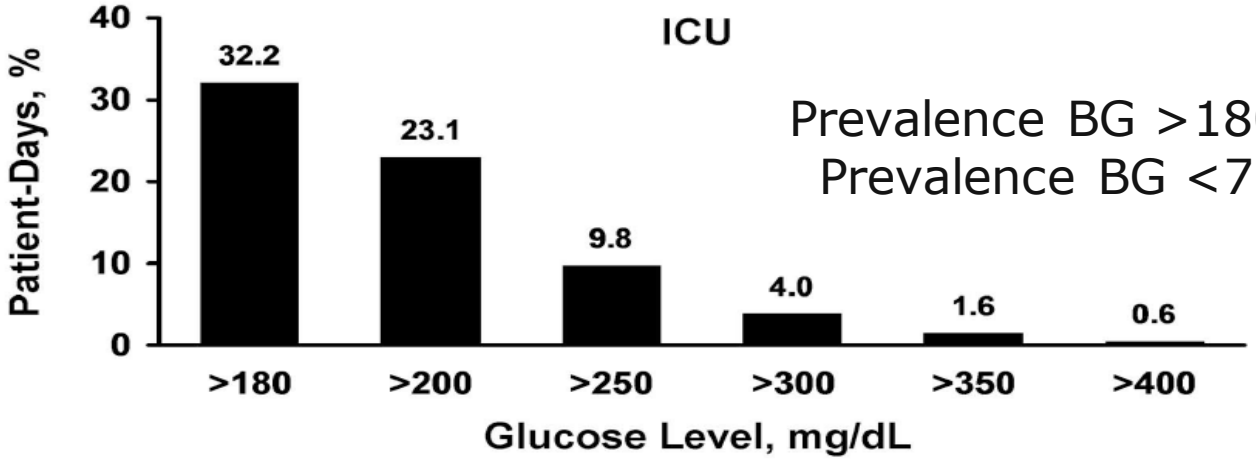
Objectives

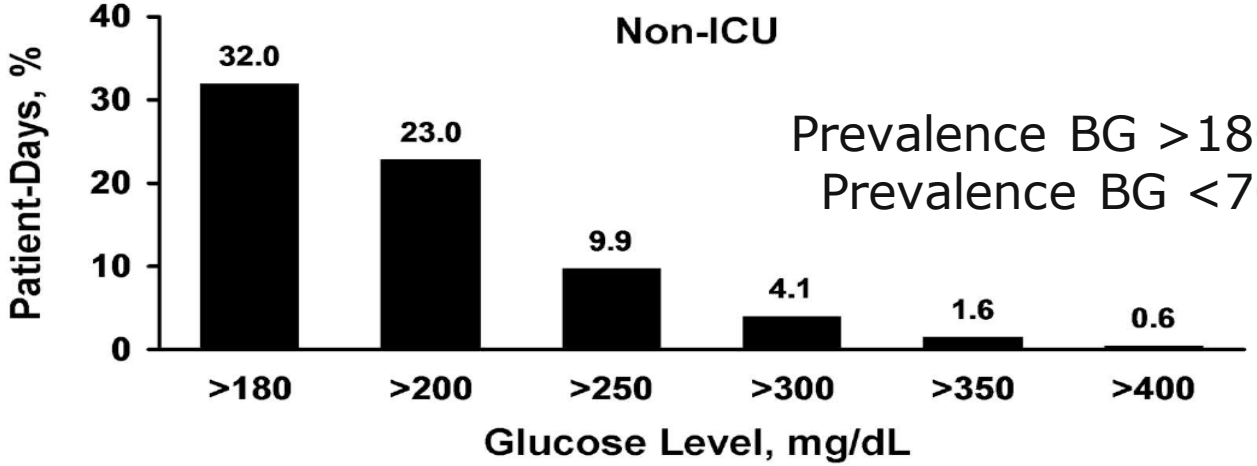
- Define and describe glycemic goals for hospitalized patients.
- Distinguish the various forms of insulin and their pharmacokinetic properties.
- Develop an individualized management plan for hyperglycemia in hospitalized patients, taking into account basal insulin requirements and nutritional intake.
- Interpret the results of frequent blood glucose monitoring and modify insulin dosing as indicated.

Hospital Dysglycemia Prevalence

- Data from >49 million BG readings from nearly 3.5 million patients in U.S. hospitals
- Mean POC BG: 167 mg/dL in ICU patients and 166 mg/dL in non-ICU patients



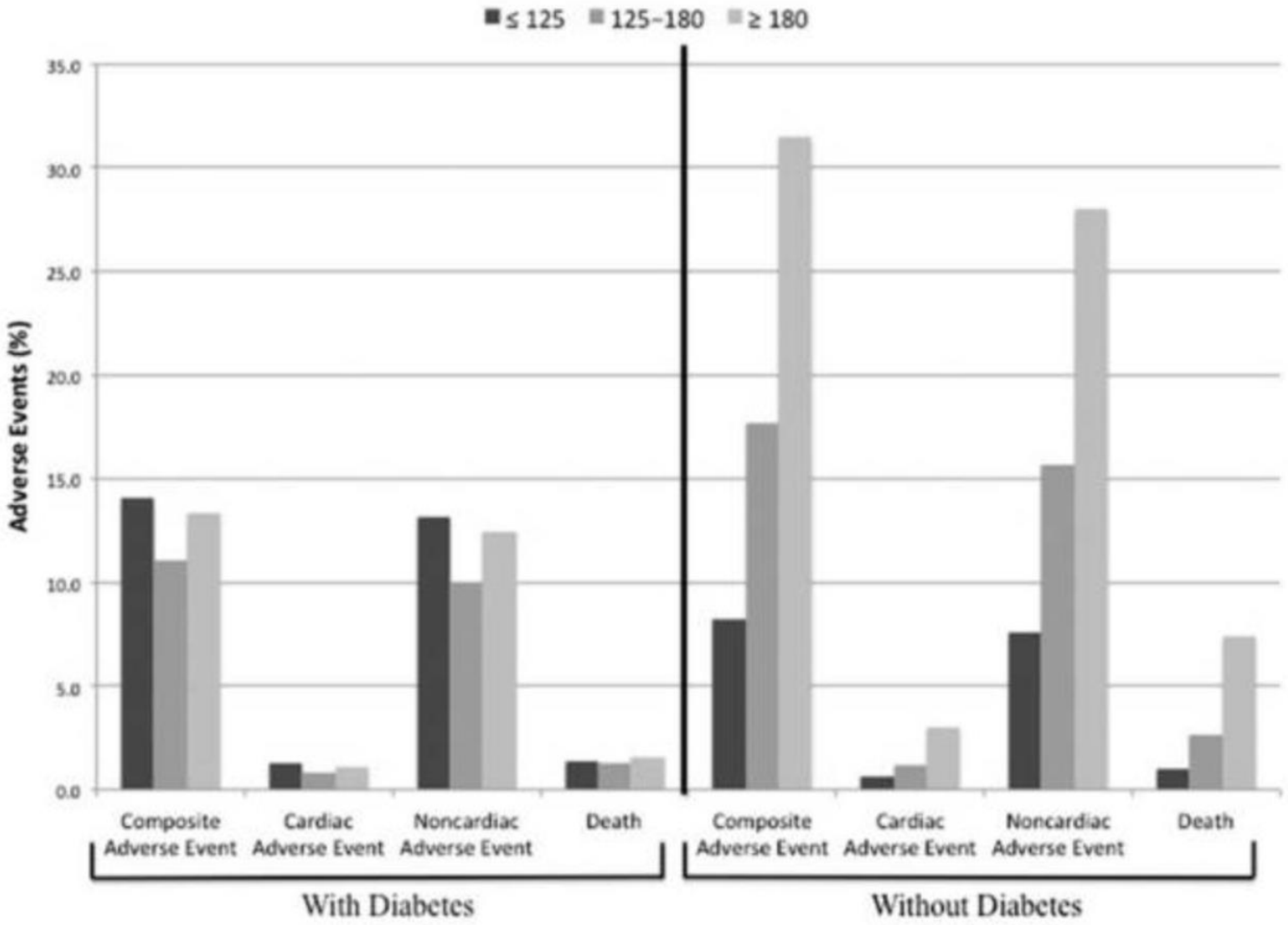
Prevalence BG >180: 32.2%
Prevalence BG <70: 6.3%



Prevalence BG >180: 32.0%
Prevalence BG <70: 5.7%

Swanson et al. Endo Practice 2011;17(6):853.

Hospital Complications from Hyperglycemia



- Cohort study of over 40,000 perioperative patients in Washington state across 53 hospitals
- Evaluated the risk of adverse events including cardiac, non-cardiac (infectious, AKI, unplanned ICU admission, etc.), and death by BG

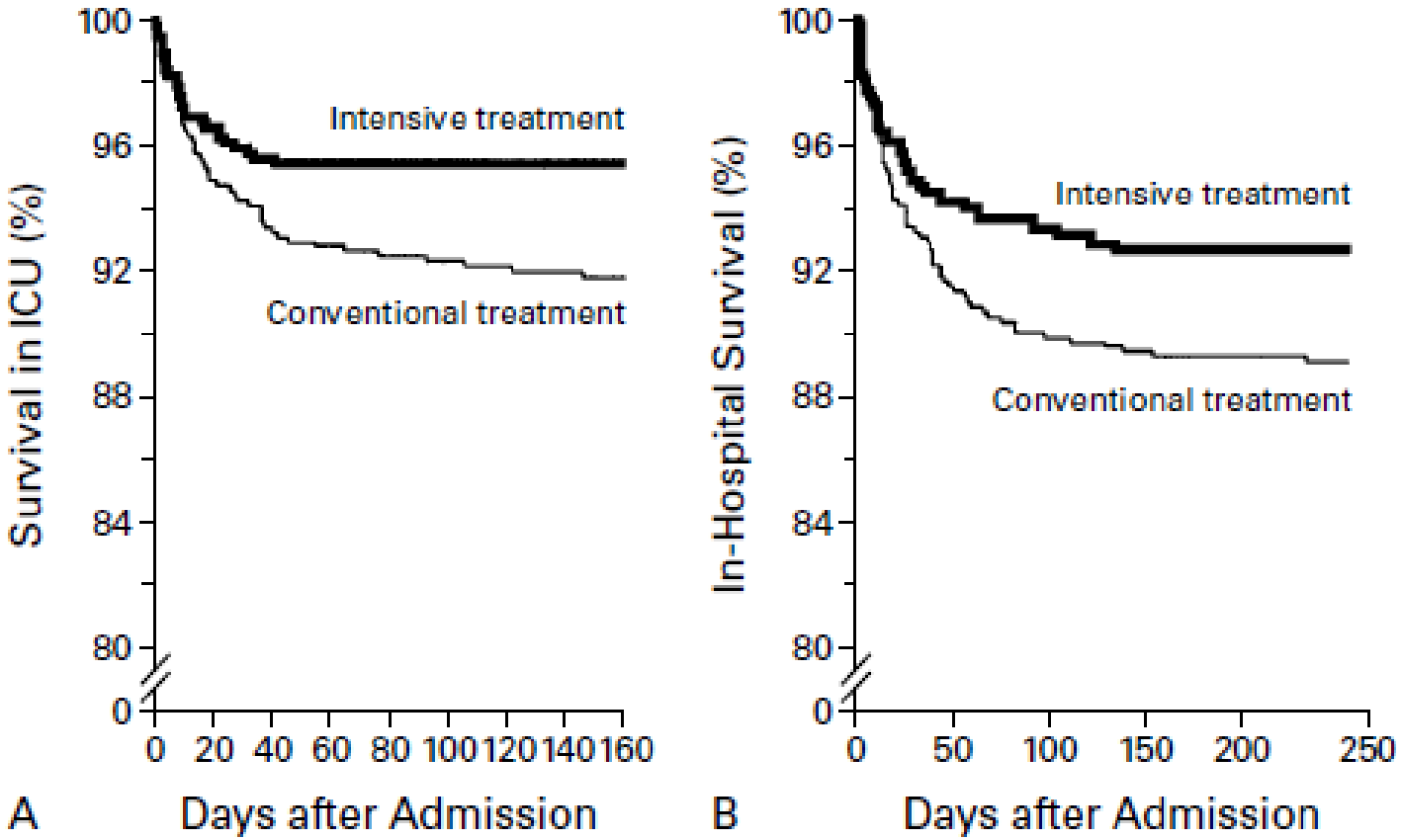
Kotagal, et al. Ann Surg 2015;261(1):97.

Individual Patient Considerations

- Type of diabetes (1 vs. 2 vs. pancreatogenic)
- Diabetes medications/dosages
- Current status
  - Recent or admission A1c
  - Hypoglycemic episodes
  - Compliance
- Co-morbidities that affect glycemic control
  - Renal impairment
  - Steroids
  - Pancreatic dysfunction
  - Weight changes

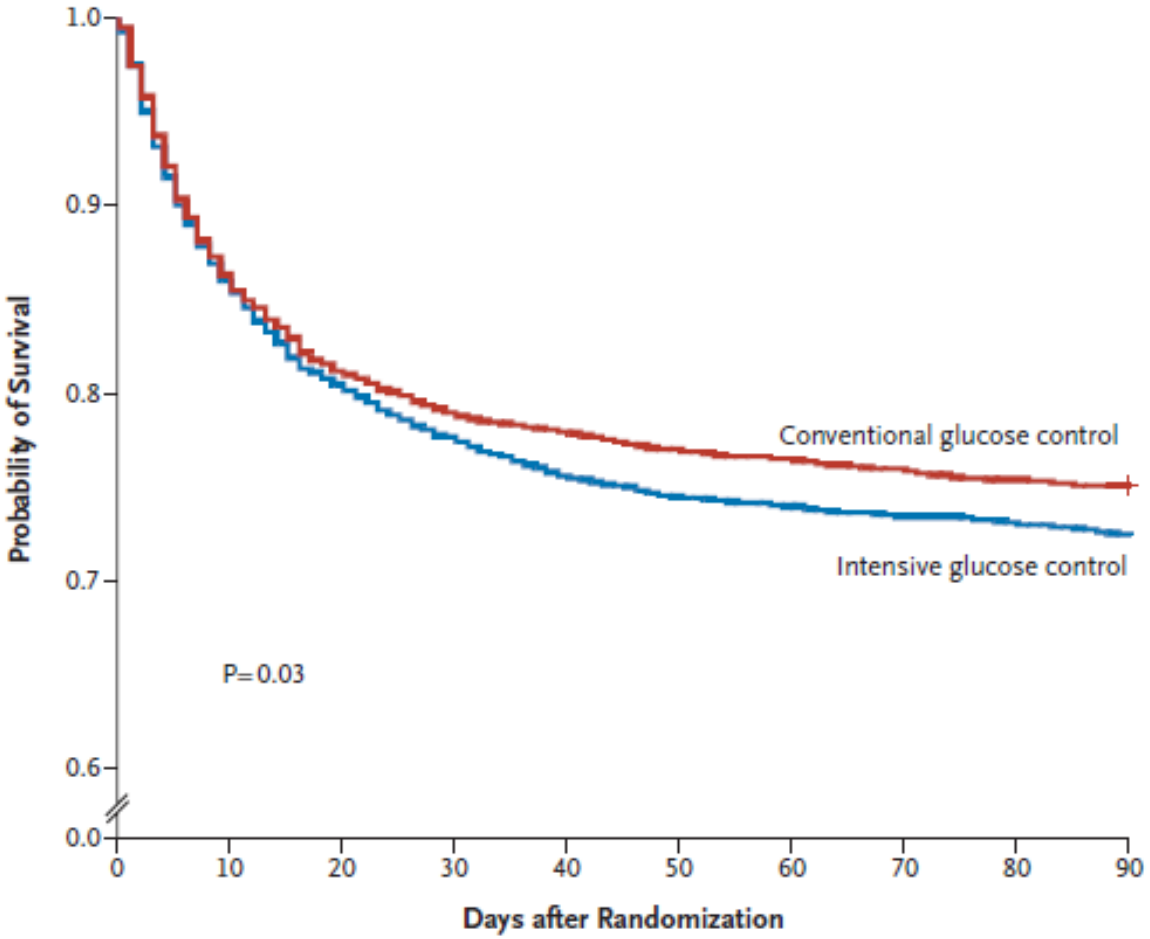
Target Glucose Levels

- Van den Berghe, et al. performed RCT of 1548 patients in the ICU
- Compared intensive (BG 80-100 mg/dL) vs. conventional insulin therapy (BG 180-200 mg/dL)
- Intensive insulin reduced mortality by nearly half, also reduced bloodstream infections, AKI, transfusion, critical-illness polyneuropathy



Van den Berghe, et al. NEJM 2001;345(19):1359.

Target Glucose Levels



- NICE-SUGAR: RCT of 6104 patients in the ICU
- Compared intensive (BG 81-108 mg/dL) vs. conventional control therapy (BG <180 mg/dL)
- Intensive control increased mortality by 14%, severe hypoglycemia more than 14-fold

NICE-SUGAR Investigators. NEJM 2009;360(13):1283.

Monitoring and Target Glucose – American Diabetes Association

- POC BG monitoring:
  - **With oral nutrition - before each meal and at bedtime**, consider adding a 2 am check in those at high risk for hypoglycemia
  - **NPO** - every 4-6 hours
  - **Insulin gtt** – every 30 min to 2 hours
- Targets extrapolated to non-critically ill patients
- **Insulin** should be initiated for persistent BG ≥180 mg/dL
- **Target 140-180 mg/dL** in most
- 110-140 mg/dL may be reasonable in some patients (e.g., critically ill postsurgical patients) if achieved without hypoglycemia

ElSayed, et al. Diab Care 2023;S1:S267.

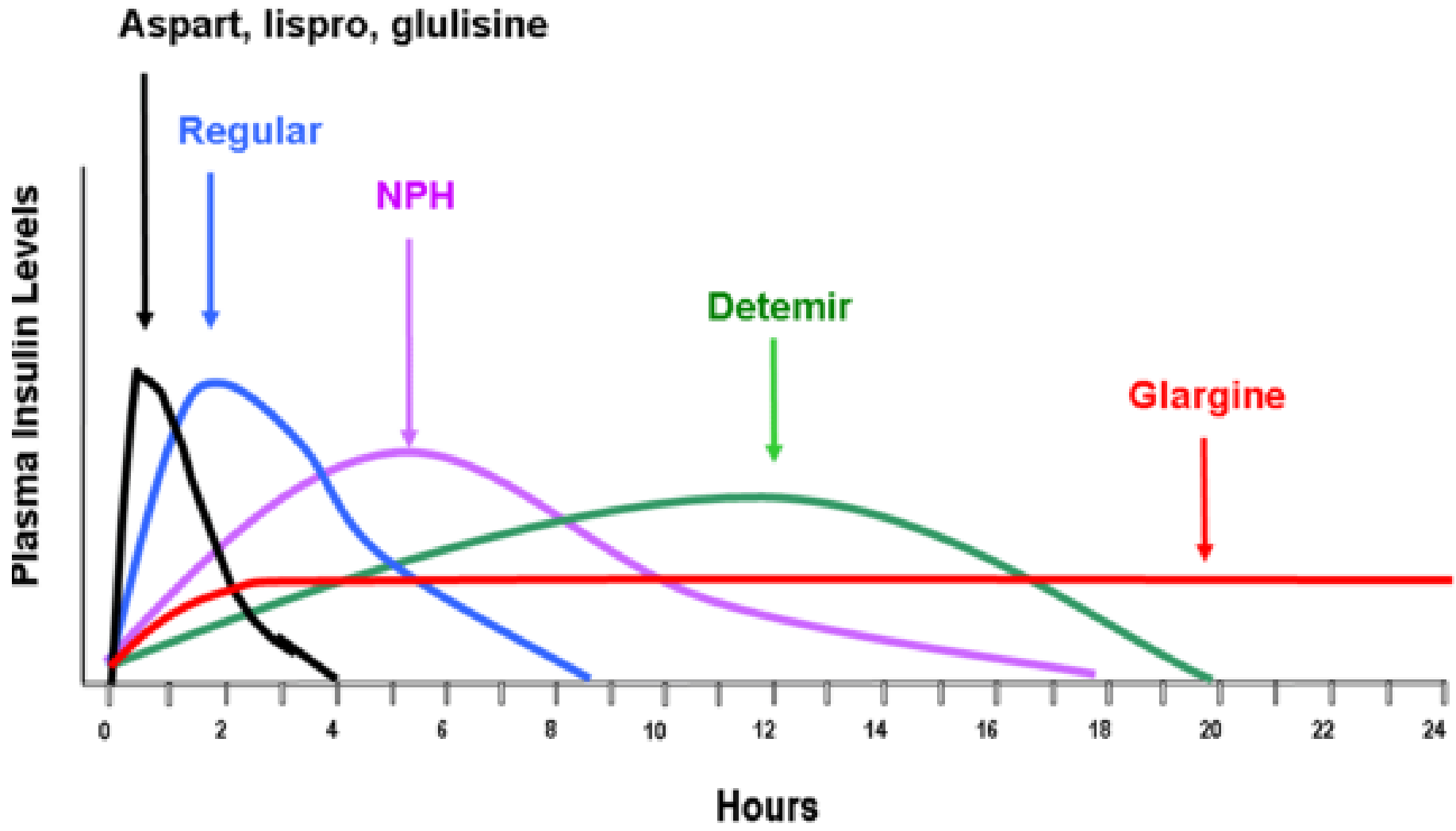
Monitoring Considerations

- HbA1c
  - % of RBCs with glucose moieties attached
  - Any condition affecting the RBC affects the HbA1c (e.g. acute blood loss, transfusion, etc.)
  - Venous glucose and fingerstick values supercede the A1c
  - Generally, A1c of 6.0% corresponds to BG of 125 with each additional 1% A1c equating to ~29 mg/dL of BG
- POC BG
  - Slightly higher than plasma and whole blood glucose
  - Glucose on the fingers or decreased blood flow to the fingers can affect values

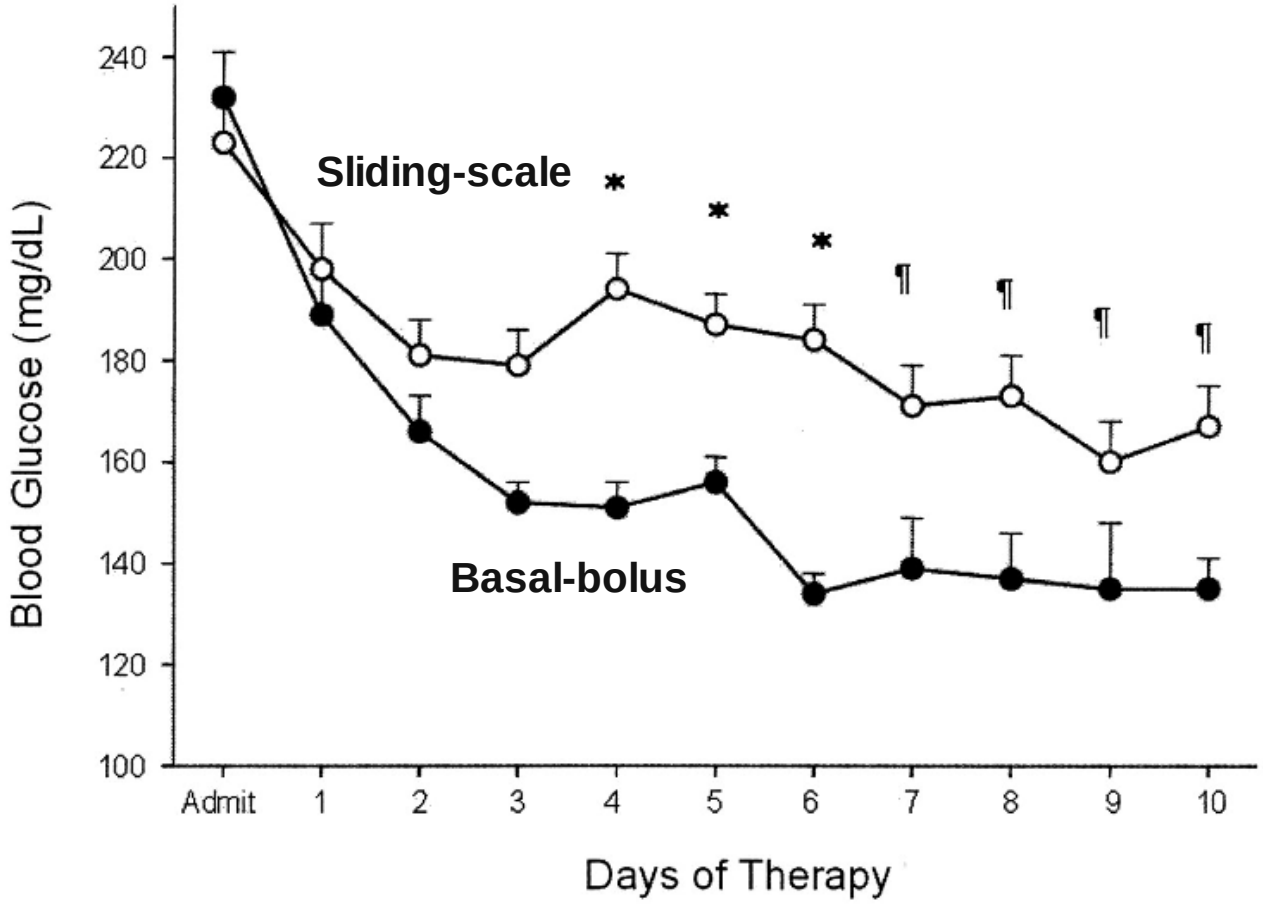
Types of Insulin

Insulin	Onset	Peak	Duration
Long-acting (basal): glargine (Lantus, Semglee, Basaglar, Toujeo), degludec (Tresiba), detemir (Levemir)	**2-3 hrs**	**Flat**	**16-42 hrs**
Intermediate-acting: NPH (Novolin-H, Humulin-H)	1-3 hrs	4-8 hrs	12-14 hrs
Short-acting: Regular (Novolin-R, Humulin-R)	30-60 min	2-3 hrs	6-8 hrs
Rapid-acting: lispro (Humalog, Admelog), aspart (Novolog), glulisine (Apidra)	**5-10 min**	**1-2 hrs**	**4-6 hrs**
Ultra-rapid-acting: lispro (Lyumjev), aspart (Fiasp)	2-3 min	1-2 hrs	3-4 hrs
Mixed insulin: usually Novolin 70/30, Humulin 70/30	30 min	2-12 hrs	<24 hrs
Concentrated insulin: U500 regular	30-45 min	2-4 hrs	8-24 hrs

Types of Insulin



Differences in Glucose Levels with Basal-Bolus vs. Sliding Scale Insulin



- Multicenter RCT of 130 non-surgical, insulin-naïve patients with known diabetes and BG >140 mg/dL
- Treated with sliding scale regular insulin 4 times daily vs. glargine once daily and glulisine 3 times daily with meals with target <140 mg/dL (0.4-0.5 units/kg/day)
- Mean fasting and mean glucose was higher in the SSI group, with an overall difference of 27 mg/dL

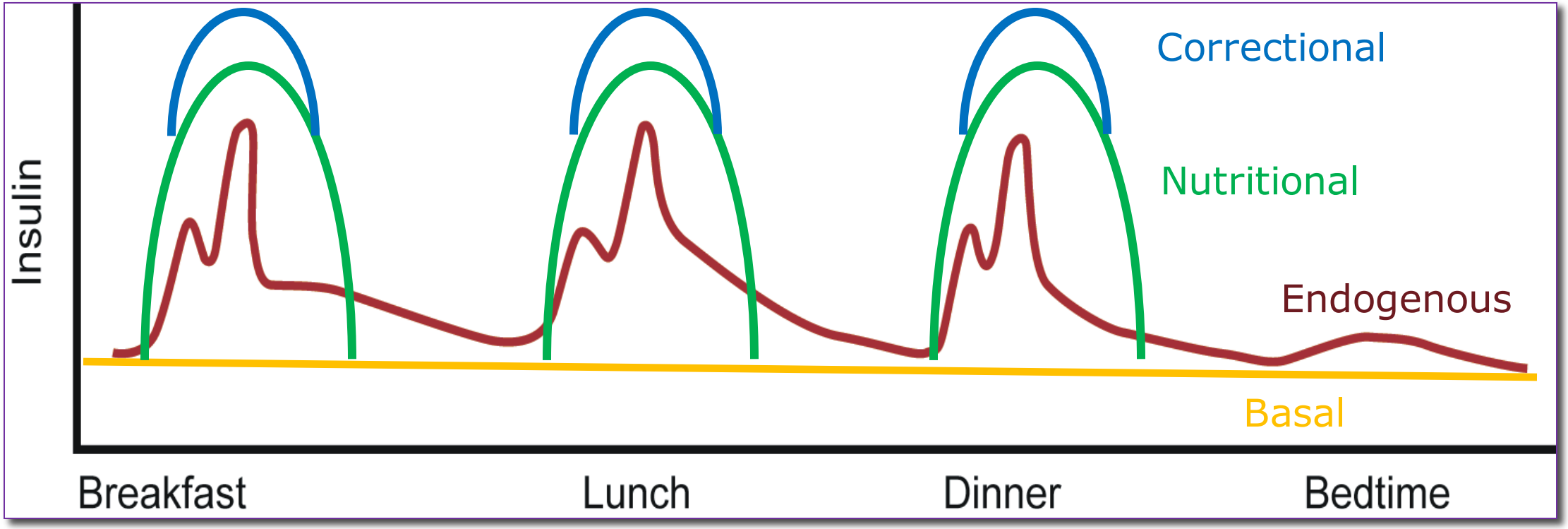
Umpierrez, et al. Diab Care 2007;30(9):2181.

Components of Insulin Regimen

- Basal:
  - Covers **fasting hyperglycemia**
  - Long-acting insulin
  - Usually 40-50% of TDD
- Bolus:
  - Covers **nutrition** (oral, tube feed, etc.)
  - Rapid-acting insulin
  - Usually 50-60% of TDD
- Correctional (sliding scale):
  - Covers **acute hyperglycemia**
  - Rapid-acting insulin
  - Can be given **in addition to bolus** to reduce hyperglycemia at the time of a meal

ElSayed, et al. Diab Care 2023;S1:S267.

Components of Insulin Regimen



Slide courtesy of Janet McGill

Dosing Decisions

- Weight-based dosing: Total daily dose (TDD) = patient's weight (kg) * multiplier based on clinical presentation
- Compare weight-based dosing to 80% of your patient's home dose and (usually) use the **lower**
- Divide TDD into 50% basal and 50% bolus split TID with meals

Insulin Sensitive TDD = 0.3 units/kg/day
Insulin naive
T1DM
BMI less than 30
Pancreatectomy
AKI/CKD/ESRD/ESLD
Malnourished/elderly
Insulin Resistant TDD = 0.5 units/kg/day
Insulin experienced T2DM
BMI greater or equal to 30
Steroids

Intake Considerations

- Carbohydrates
  - Some savvy patients (and insulin pumps!) calculate bolus dosing based on carbohydrate consumed
  - Carbohydrate ratio, amount of carbs covered for each until of insulin, is ~500/TDD
  - **Average carbohydrate consistent meal is 60 gm carb** and a typical snack is ~15 gm carb
- Tube feeds
  - **Should be treated like "meals"** regardless of whether bolus or continuous
  - Bolus feeds can be dosed with scheduled short-acting insulin with correction at the start of each feed, just like meals
  - Continuous feeds should be dosed with short-acting insulin with correction q4 hours as longer acting insulin can cause hypoglycemia if TFs are stopped
- TPN
  - **IV regular insulin typically mixed into the TPN bag** with a set carbohydrate ratio

Correctional Insulin (sliding scale)

- Correctional insulin is based on sensitivity = the number of mg/dL 1 unit of insulin will decrease BG
- Sensitivity ~1500-1700/TDD (or 3 times the carbohydrate ratio)
- **Should be included in basal/bolus regimen** (if eating) or basal regimen (if not eating)
- Not recommended alone as it is reactive rather than proactive
- **Inappropriate alone** in type 1 diabetes
- Scales at Barnes-Jewish Hospital:

Sensitive	**Resistant**
150-199: 1 unit	150-199: 2 units
200-249: 2 units	200-249: 4 units
250-299: 3 units	250-299: 6 units
300-349: 4 units	300-349: 8 units
>/= 350: 5 units	>/= 350: 10 units

Approach by Nutritional Situation

Nutritional situation	Basal Insulin (typically once daily)	Nutritional Insulin (rapid-acting)	Correctional Insulin (rapid-acting)
NPO (or sugar-free clear liquids)	50% of TDD (do NOT hold basal, especially in T1DM patients)	None	Every 4 hours
Oral meals	50% of TDD	50% of TDD, divided equally before each meal	4 times daily before meals and at bedtime (lower bedtime scale)
Bolus tube feeds	40-50% of TDD	50-60% of TDD, divided equally before each bolus feed	Usually 5-6 times per day, with each bolus feed
Continuous tube feeds	40% (conservative) of TDD	60% of TDD, divided equally every 4 hours	Every 4 hours with each nutritional dose
Parenteral nutrition	40-50% of TDD	In TPN as **regular** insulin (generally 1 unit /10 gm carb is safe starting point)	Every 4 hours

Hypoglycemia

- Defined as <70 mg/dL, <54 mg/dL = clinically significant, <40 mg/dL = severe
- Treat with:
  - **10-15 gm carb if eating** (4 glucose tables, 1 tube glucose gel, 4 oz juice)
  - D10W 250 ml over 10 min or D50W 25 ml over 2 min if NPO or unresponsive
  - Glucagon 1 mg IM if no IV access, follow with PO or IV as above
- **Recheck BG in 15 min** and repeat until BG >100-110 mg/dL
- Once BG >100 mg/dL, **recheck in 1 hour**
- Do not overtreat or hold future insulin – adjust insulin doses

ElSayed, et al. Diab Care 2023;S1:S267.

Insulin Dosing Adjustments

- Assess and adjust **daily**
  - If BG >100–140mg/dL fasting OR >180mg/dL random, increase 10-20%
  - If BG <100mg/dL, decrease 10-20%
- Increase basal if:
  - Fasting BG >140mg/dL AND BG drops less than 50mg/dL from bedtime to fasting
- Increase nutritional if:
  - BG are elevated pre-lunch, pre-dinner, and/or bedtime, particularly if rising throughout the day
- Beware of stacking – rapid-acting SQ should not be given more frequently than every 4 hours

Insulin Dosing Adjustments

- High correctional needs should prompt adjustment to scheduled insulin
- Alternative calculation for adjustment:
  - Calculate half of previous 24 hour correctional insulin requirements
  - Add half to basal
  - Add half to divided bolus insulin doses
  - (Or some variation of above depending on patterns of hyperglycemia)

Transitioning from IV Insulin

- Surgical stress peaks immediately post op and then generally improves over the next 2-3 days
- Dosing approach:
  - For pre-existing diabetics, take 80% of the prior 24-hour insulin needs and use that as a guide to dose the next 24 hours
  - Repeat the 20% reduction for up to 3 days or until dosing is in line with weight-based or home dosing
  - For stress hyperglycemia or non-diabetic patients, use 60% reduction factor
- Be cognizant of the effects of pressors, especially epinephrine, on insulin needs
- When transitioning, use the drip requirements over 24 hours or the last 6 hours if most stable to estimate dosing, then dose SQ basal **2 hours prior** to discontinuing drip

Inpatient Insulin Summary

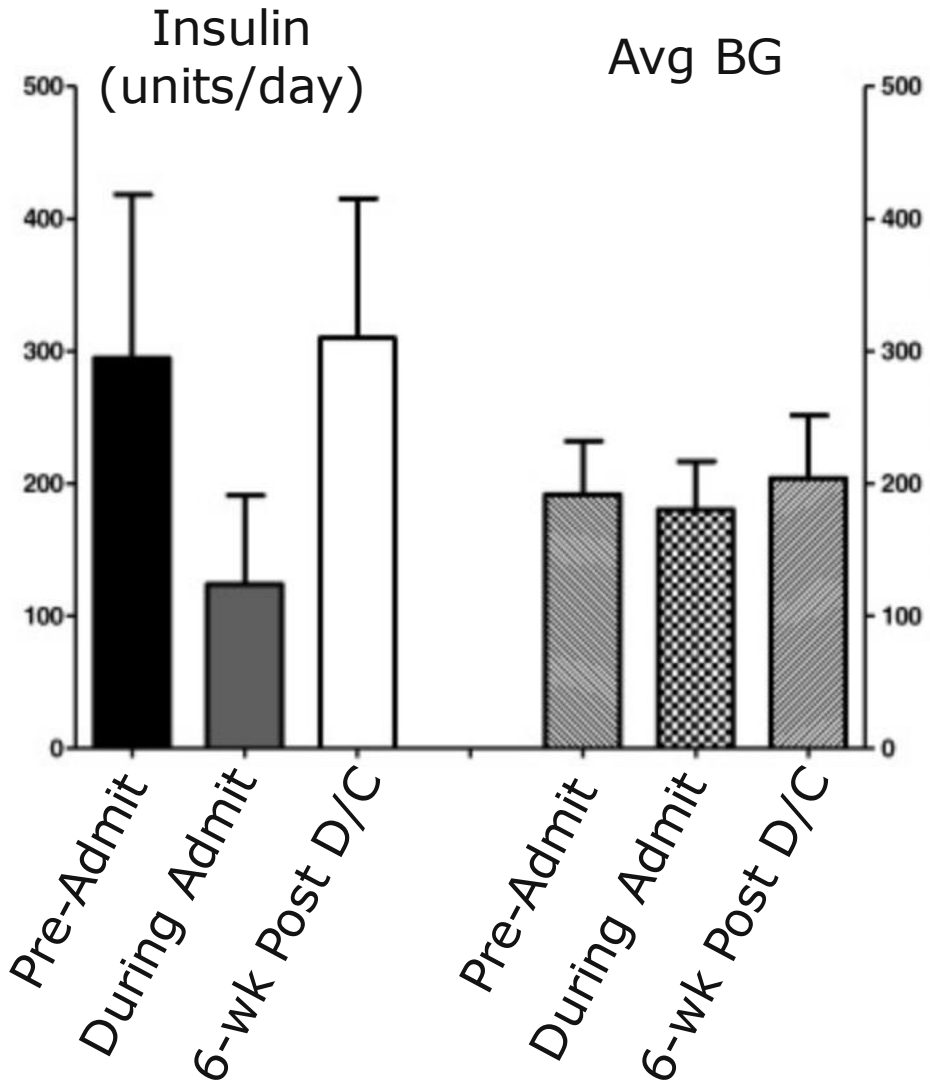
- Should be initiated for persistent BG ≥180 mg/dL
- **Target 140-180 mg/dL** in most patients, though 110-140 mg/dL may be reasonable in some patients if achieved without hypoglycemia
- Check POC BG **before each meal and at bedtime** in patients with oral nutrition, consider adding a 2 am check in those at high risk for hypoglycemia
- To choose insulin dosing, calculate **80% of home regimen and weight-based dosing** -> choose based on clinical judgment and safety (usually the lower value)
- Assess and adjust **daily**
- High correctional needs should prompt adjustment to scheduled insulin
- Overlap SQ insulin by 2 hours before discontinuing drip

Less Common Insulins

- Split mixed insulins (e.g. 70/30)
  - Intermediate-acting insulin mixed with short- or rapid-acting insulin
  - Allows for twice daily dosing but doesn't accommodate meals or adjustments in food timing well
  - **Not appropriate in the hospital**
  - Convert to basal bolus by:
    - Adding up TDD at home
    - Reduce by 20% for safety
    - Split into 50% basal, 50% bolus split TID with meals

Less Common Insulins

- U-500
  - **5X concentrated at 500 units/mL** Generally used when patients exceed ~200 units/day or 100 units/injection
  - Acts more like a depot insulin, dosed 2-4 times per day
  - Can often decrease dose by 50% and use U-100 inpatient
  - Retrospective study of 20 VA patients on U-500 as outpatients showed significantly lower insulin needs during hospitalization



Kedia, et al. J of Diab and its Comp 2017;31:874.

Glucocorticoid Use

- Glucocorticoids usually cause post-prandial hyperglycemia more than fasting
- Goal is to match the hyperglycemia
- Estimated insulin needs for glucocorticoid:
  - Convert to prednisone equivalent (pred 20 = methylpred 16 = dex 3 mg)
  - If insulin naïve or pred <40, start at 10 units
  - If insulin resistant or pred ≥40, start at [pred equivalent (mg) – 20] x weight (kg) ÷ 200 units (max initial dose 20 units if insulin naïve, 40 units if not)
- Use NPH for coverage of once or twice daily intermediate glucocorticoid (pred, methylpred), dosed with steroid
- For multiple daily dosing or dex, may need to increase basal, bolus, and correctional
- Adjust frequently based on glycemic levels

ElSayed, et al. Diab Care 2023;S1:S267.

Diabetes Tech

- Continuous glucose monitors
  - Subcutaneous catheter that **measures interstitial glucose on a continuous basis**
  - Sometimes integrated with insulin pumps to allow for automated insulin adjustment to prevent hypo- and hyperglycemia
  - Allowed in the hospital, but not approved for insulin dosing because some substances and procedures interfere
- Insulin pumps
  - Deliver **short-acting insulin on a continuous basis** that comprises basal, bolus, and correctional insulin delivery based on settings from their physician
  - Allowed in the hospital but not FDA-approved for ”auto mode”

Questions?