

Inpatient Glycemic Control: Current Practices

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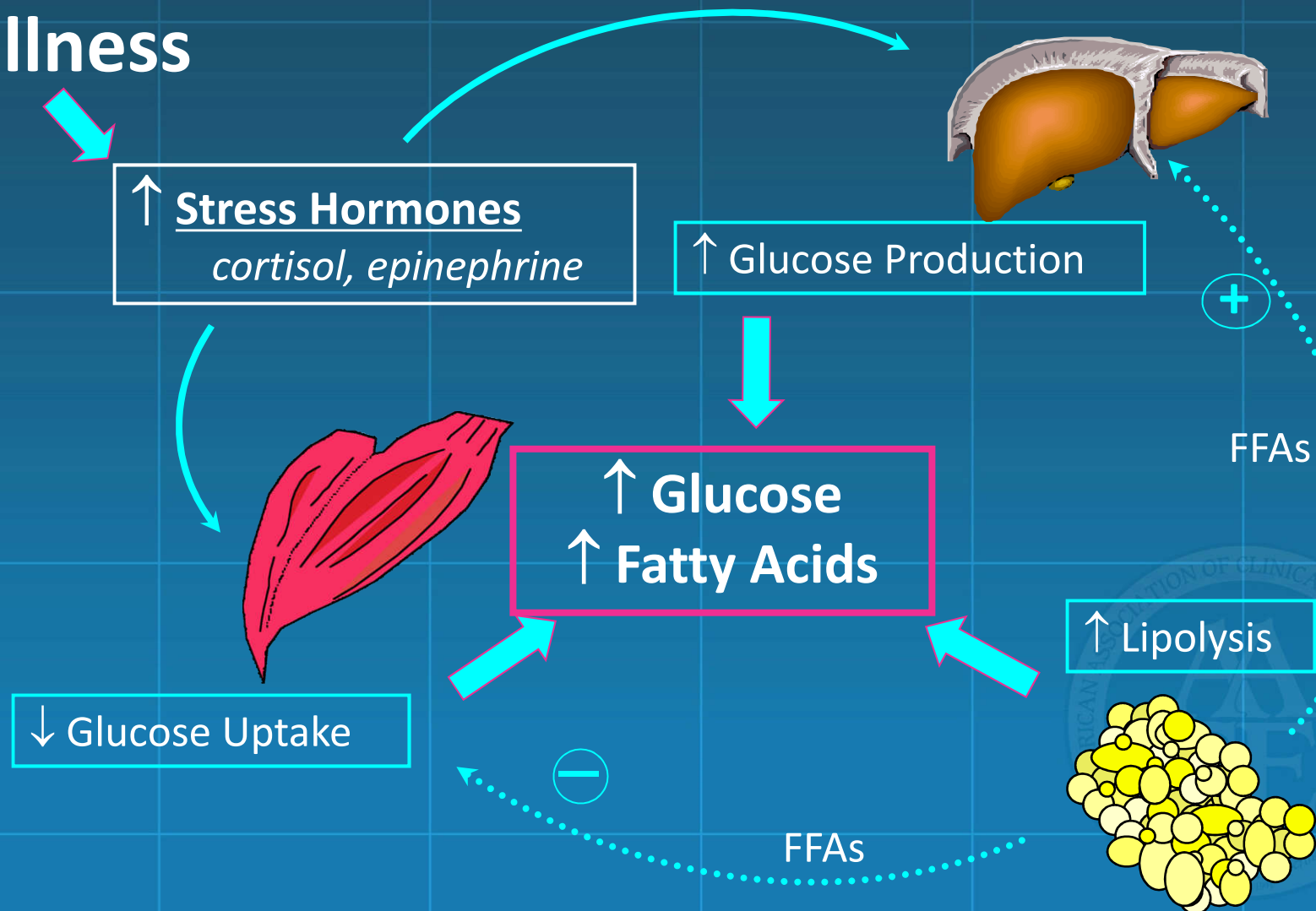
Umpierrez et al, MANAGEMENT OF HYPERGLYCEMIA IN
HOSPITALIZED PATIENTS IN NON CRITICAL SETTING: An
Endocrine Society Guideline. JCEM 97:16-30, 2012

Prevalence of Hyperglycemia

- 25% of patients admitted to hospital have DM
- Hyperglycemia present in 32-38% of patients in community hospitals
- DM prevalence in US 30.3 million (9.4%)
- 25.2% of those age 65 or older
- 1.6 million new cases/yr
- 84 million at increased risk (Pre-diabetes)

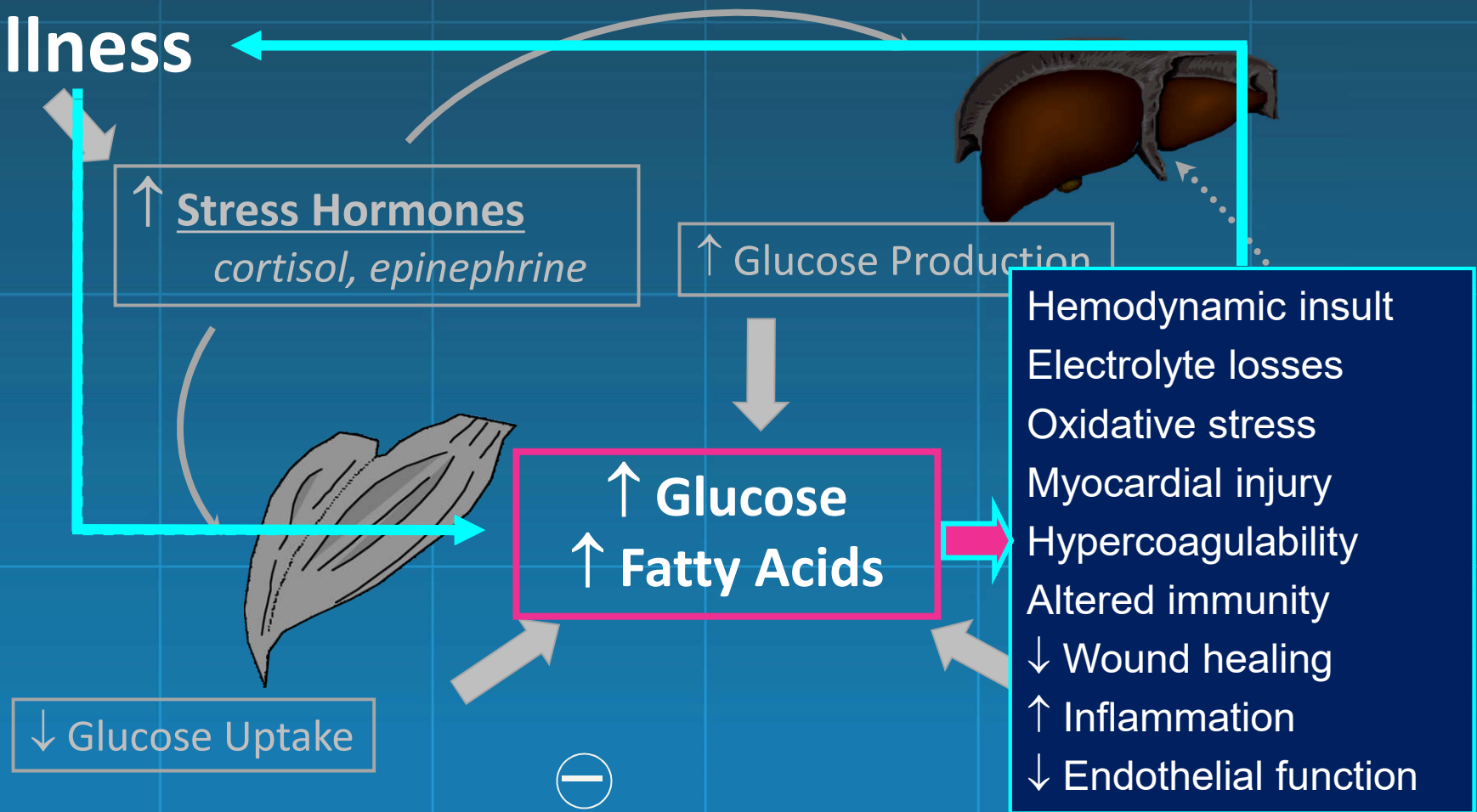
Illness Leads to Stress Hyperglycemia

Illness



Stress Hyperglycemia Exacerbates Illness

Illness



Inpatient Glycemic Management: Definition of Terms

Hospital hyperglycemia	Any BG >140 mg/dL
Stress hyperglycemia	Elevations in blood glucose levels that occur in patients with no prior history of diabetes and A ₁ C levels that are not significantly elevated (<6.5%)
A₁C value >6.5%	Suggestive of prior history of diabetes
Hypoglycemia	Any BG <70 mg/dL
Severe hypoglycemia	Any BG <40 mg/dL

Considerations with Non-insulin therapies in the hospital

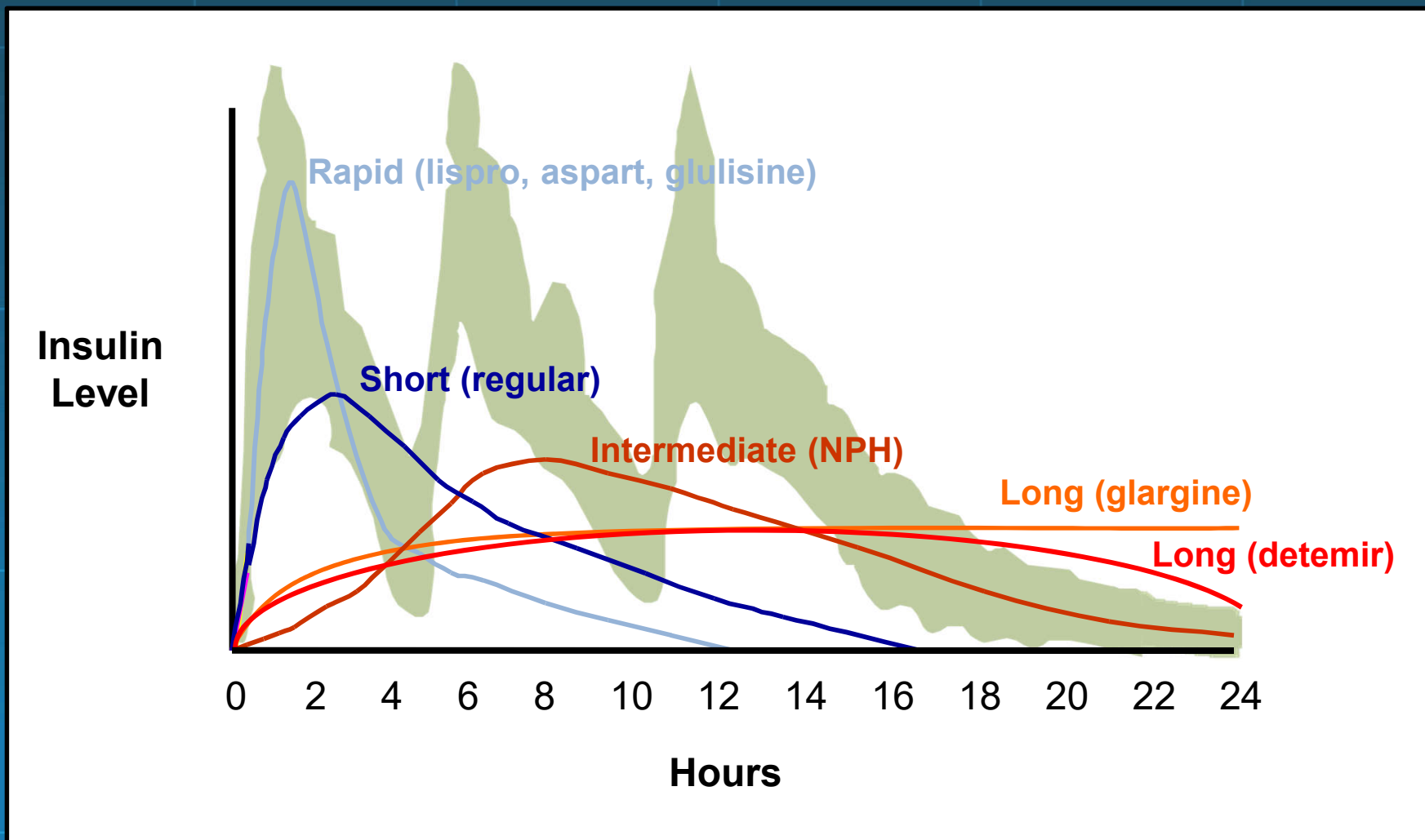
- Sulfonylureas are a major cause of prolonged hypoglycemia
- Metformin is contraindicated in patients with decrease renal function, use of iodinated contrast dye, and any state associated with poor tissue perfusion (CHF, sepsis)
- Thiazolidinediones associated with edema and CHF
- GLP1 agonists can cause nausea and exert a greater effect on postprandial glucose
- SGLT-2 inhibitors increased risk DKA, UTI
- DPP4's have role in hospital



Subcutaneous Insulin Options

Basal insulin	Controls blood glucose in the fasting state •Detemir , glargine , NPH, Degludec
Nutritional (prandial) insulin	Blunts the rise in blood glucose following nutritional intake (meals, IV dextrose, enteral/parenteral nutrition) •Rapid-acting: aspart (NovoLog), glulisine (Apidra), lispro (Humalog) •Short-acting: regular (Humulin, Novolin)
Correction insulin	Corrects hyperglycemia due to mismatch of nutritional intake and/or stress hyperglycemia and scheduled insulin administration

Pharmacokinetics of Insulin Products



Adapted from Hirsch I. *N Engl J Med.* 2005;352:174–183.
AACE Inpatient Glycemic Control Resource Center

Initial Insulin Total Daily Dose

0.4 Units/kg if BG 140-200

0.5 Units/kg if BG 201-400

0.2-0.3 Units/kg if age ≥ 70 or
GFR < 60

Divided 50% basal 50% prandial.

Optional: 0.1 Units/kg TID with meals

Case 1

- 72 YO female presents with pneumonia , BG 275, A1c 9.2% on metformin, Victoza , creatinine 1.6; wt: 80 kg eating some
- Start insulin therapy: 0.3 or 0.5 units/kg TDD?

Consistent Carbohydrate Diet

Diets Available	Servings of CHO/meal	Total (g) CHO each meal	Total (g) CHO HS Snack	Total (g)/svgs CHO per day
Diabetic Diet 45 grams CHO/meal (1200-1500 Calories)	3 servings	45 grams of Carbohydrate	15 - 30 g of Carbohydrate	150 – 165 grams Or 10 - 11 servings
Diabetic Diet 60 grams CHO/meal (1600 – 2000 Calories)	4 servings	60 grams of Carbohydrate	15 – 30g of Carbohydrate	195 - 210 grams Or 13 -14 servings
Diabetic Diet 75 grams CHO/meal (>2000 Calories)	5 servings	75 grams of Carbohydrate	15 – 30g of Carbohydrate	240 – 255 grams Or 16 – 17 servings
Diabetic Diet 6 small meals	2-3 servings	30 – 45 grams of Carbohydrate	Will receive 30-45g at each of 6 meals	180 – 270 grams Or 12 – 18 servings
Gestational Diabetic Diet**	2-3 servings at breakfast 3-4lunch/dinner	30-45grams 45-60 grams	15-30g (2- 3 snacks)	225 - 240 grams Or 15 – 16 servings
Diabetic Clear Liquid or Diabetic Full Liquid Diet	4 servings	60 grams	15-30 grams	195 – 210 grams Or 13– 14 servings

Randomized Study of Basal-Bolus Insulin Therapy in the Inpatient Management of Patients With Type 2 Diabetes (RABBIT 2 Trial)

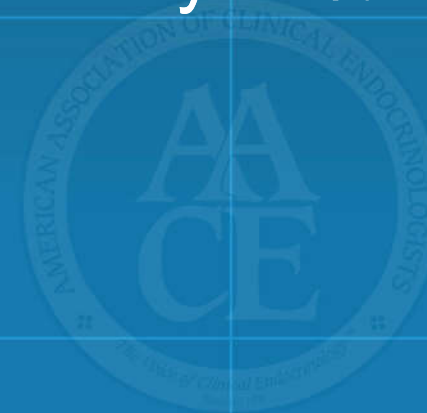
- 130 nonsurgical insulin-naive patients age 18-80 with known type 2 diabetes admitted to noncritical care unit
- Randomly assigned to sliding scale insulin (SSI) or a basal-bolus regimen with glargine and glulisine
 - 0.4 units per kg/day for BG 140-200
 - 0.5 units per kg /day for BG > 200
 - 50% given as glargine and 50% as glulisine
- Oral antidiabetic drugs discontinued
- 2 hypoglycemic events (BG < 60 mg/dl) in each group

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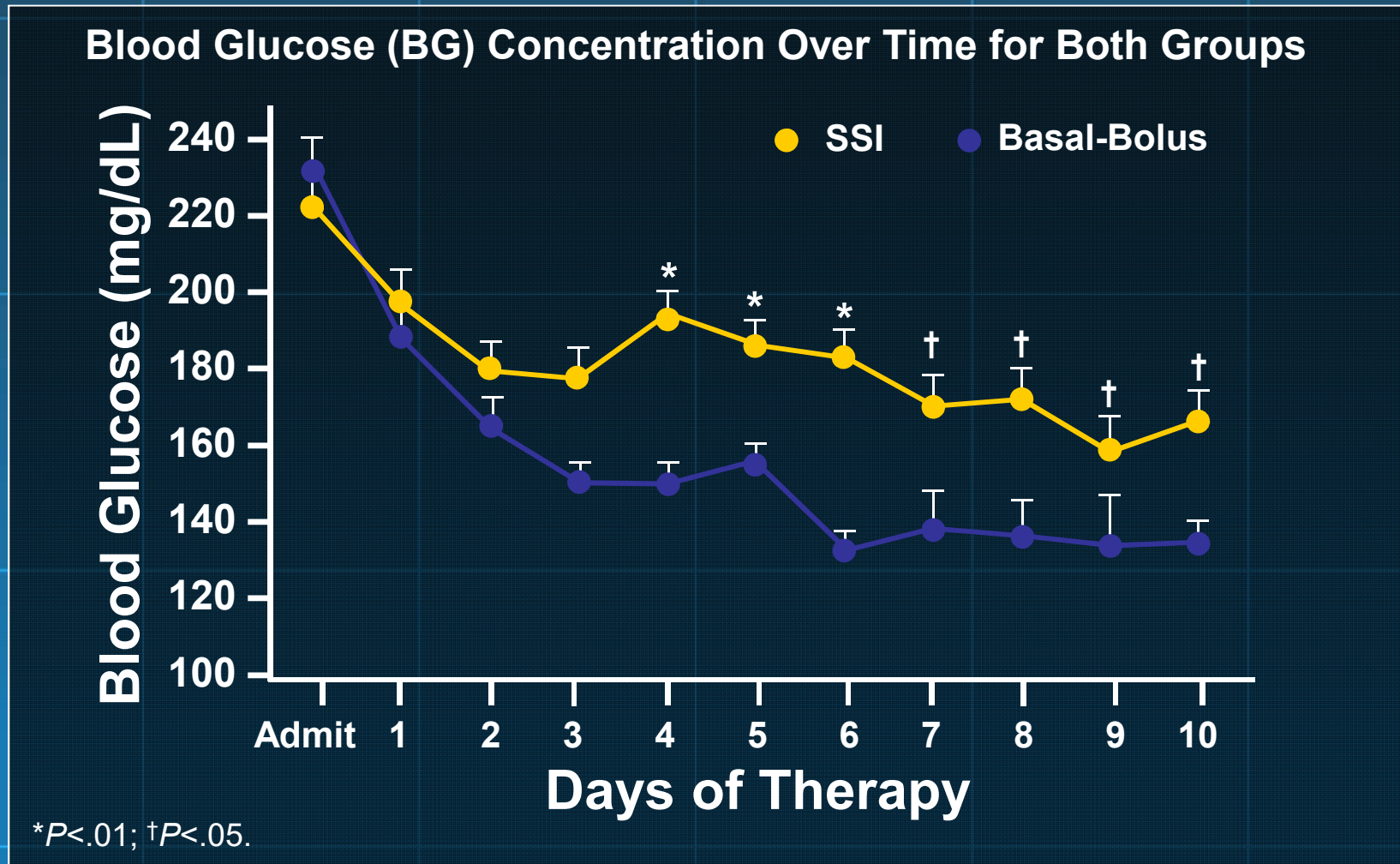
Adjusting scheduled insulin regimen

If fasting and premeal BG >140 mg/dl, dose of glargine increased by 20%

For BG <70 mg/dl, glargine reduced by 20%

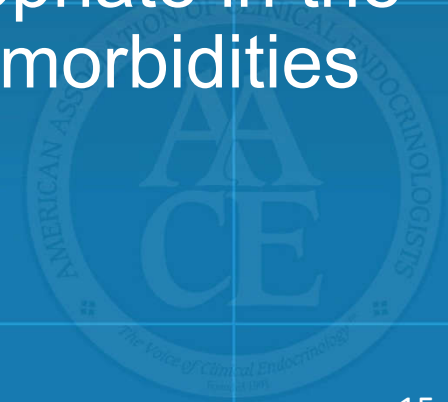


Randomized Study of Basal-Bolus Insulin Therapy in the Inpatient Management of Patients With Type 2 Diabetes (RABBIT 2 Trial)



Glycemic Targets in Noncritical Care Setting

- Maintain fasting and preprandial BG <140 mg/dL
- Modify therapy when BG <100 mg/dL to avoid risk of hypoglycemia
- Maintain random BG <180 mg/dL
- More stringent targets may be appropriate in some stable patients
- Less stringent targets may be appropriate in the terminally ill or those with severe comorbidities



Northern Greenville Co. Roadside Stand



Pre-op Insulin: when NPO for procedure

- Oral Agents: transition to Lantus .25 U/kg
- Basal insulin + Oral Agents: May reduce basal insulin by 30%, withhold oral agents
- Premixed Insulin: Give 50% of AM dose as NPH
- Basal Bolus Insulin: Continue basal
- Prolonged procedure (CABG) begin IV infusion

The NPO Patient

- When the patient is NPO for prolonged period, consider infusing D₅ or D₁₀W to provide a margin of safety against hypoglycemia
- D₅ at 100 ml per hour provides 500 calories per day, and can prevent protein breakdown

AACE/ADA Recommended Target Glucose Levels in ICU Patients

- ICU setting:
 - Starting threshold no higher than 180 mg/dL
 - Once IV insulin is started, the glucose level should be maintained between 140 and 180 mg/dL
 - Lower glucose targets (110-140 mg/dL) may be appropriate in selected patients
 - Targets <110 mg/dL or >180 mg/dL are not recommended

Not recommended <110	Acceptable 110-140	Recommended 140-180	Not recommended >180
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Indications for Intravenous Insulin Therapy

- Diabetic ketoacidosis
- Nonketotic hyperosmolar state
- Critical care illness (surgical, medical)
- Postcardiac surgery
- Myocardial infarction or cardiogenic shock
- NPO status in type 1 diabetes
- Labor and delivery
- Glucose exacerbated by high-dose glucocorticoid therapy
- Perioperative period
- After organ transplant
- Total parenteral nutrition therapy

American College of Endocrinology Task Force on Inpatient Diabetes and Metabolic Control.
Endocr Pract. 2004;10:77-82.

AACE Inpatient Glycemic Control Resource Center

Glytec Enterprise

- Drip rate = (BG-60) X multiplier (.02)
- BG >180 increase multiplier (25%)
- BG <140 decrease multiplier (25%)
- Meal profile
- Sign on: SMS#, Password 1



Case 2

- 48 YO male DM2 previously on 2 oral agents
A1c 8.5%, weight 70 kg
- Post Bypass surgery 48 hours on insulin drip
1.8-2.2 units/hr BG 95-138
- Beginning to take PO

Considerations for Transition From IV to SC Insulin

- Which patients on IV insulin will need a transition to scheduled SC insulin?
 - Type 1 DM
 - Type 2 DM on insulin prior to admission
 - Type 2 DM (or new hyperglycemia) requiring ≥ 2 units/hour of insulin
 - Start SQ insulin 1-2 hours prior to D/C insulin infusion



Recommendations for Converting IV to SC Insulin: Basal or MDI

- Establish 24 hr insulin requirement from average over last 4-8 h if stable
- Give 60-80% amount as basal for surgical patients, as basal bolus 50/50% for medical
- AC boluses:
 - 50% of TDD given 1/3 before each meal
 - Weight Based: 0.1 U of insulin/kg body weight TID AC
- Monitor ac, hs, and 2 AM, or Q4-6 hr if NPO
- Correction for all BG >150 mg/dL



Case 2 cont

- Patient on 1.8-2.2 U/hr, 70 Kg
- Transition to SQ Glargine 38 units daily
- D/C insulin drip 2 hours after SQ injection
- 7 units Humalog TID AC
- Correction 2/50 over 150 AC, HS, 0200

Case 3

- 49 YO female T1DM for 16 years, no complications. Good control on insulin pump basal 15.8 units, TDD 26 units, carb ratio 15.
- Pre-operative assessment: advised to turn her pump off before surgery.

Insulin Pump Therapy

- Electronic devices that deliver insulin through a SC catheter
 - Basal rate (variable) + bolus delivery for meals
- Used predominately in type 1 diabetes
- “Pumpers” tend to be fastidious about their glycemic control
 - Often reluctant to yield control of their diabetes to the inpatient medical team
- Hospital personnel typically unfamiliar with insulin pumps
 - Hospitals do not stock infusion sets, reservoirs, etc, for insulin pumps

Insulin Pump Policy:

Main Elements

- Patient qualifications for self-management (normal mental status, able to control device, etc)
- Pump in proper functioning order and supplies stocked by patient/family
- Signed patient contract/agreement
- Order set entry
- Documentation of doses delivered (pump flow sheet)
- Ongoing communication between patient and RN
- Policies regarding procedures, surgeries, CTs, MRIs, etc

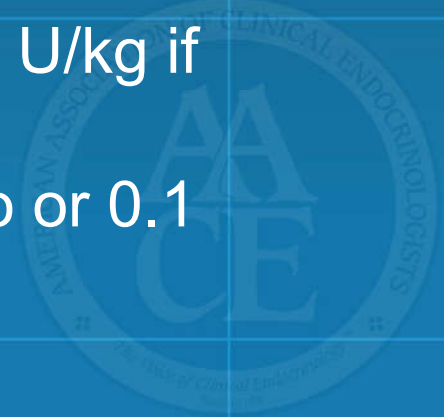
Inpatient Pump Protocol

An insulin pump should NEVER be discontinued without initiation of either SQ or IV insulin.

If the pump is discontinued , insulin (either IV or subcutaneous) MUST be given 30 minutes prior to discontinuation

Off pump: Basal insulin: daily Lantus same as total daily basal on pump or 50% of TDD or 0.3 U/kg if unknown

Meal Insulin: carb count and use carb ratio or 0.1 U/kg TID AC



Case 3 cont

- Post op lethargic, can not work pump
- Place on basal glargine 16 units QD
- Meal insulin 1 unit per 15 gm CHO or 4 units TID AC for 60 gm CHO diabetic diet
- Correction scale #2 AC, HS , 0200
- Back on pump when able to operate it - 20-24 hours after glargine injection

Enteral Nutrition and Hyperglycemia

- Delivery of calorie-dense nutrients
- Increased risk of hyperglycemia
- Basal insulin should be ideal treatment strategy, but...
 - Concerns about potential hypoglycemia after abrupt discontinuation (eg, gastric residuals, tube pulled, etc)
- Combined basal-bolus strategies may be optimal



Glycemic Management of the Patient Receiving Enteral Nutrition

Continuous enteral nutrition (EN)

Basal: 40-50% of TDD as long or intermediate acting insulin given once twice a day

Rapid acting 50-60% of TDD given q4-6hr

Bolus enteral nutrition

Rapid acting insulin given prior to each bolus – QID, continue basal?

Nocturnal enteral nutrition

Intermediate acting insulin given together with a rapid or short acting insulin with start of TF – role for premixed insulin? (similar situation with PD Cycler)

Parenteral Nutrition

- Continuous IV delivery of high concentrations of dextrose (10-25 gm/100 mL)
- No incretin stimulation of insulin secretion
- Hyperglycemia extremely common
- Basal insulin should be ideal treatment strategy, but...
 - Concerns about potential hypoglycemia after abrupt discontinuation (eg, technical issues with line)

TPN Glucose Management/Case 4

- 56YO T₁DM: basal bolus insulin, TDD: 45U
- Initiate with Dextrose 10%, 70 gm amino acids, 65 cc/hr = 156 gm glucose
- NOT ON INSULIN: add 15 units Reg insulin (.1 units/gm glucose)
- TYPE 1 & 2 ON INSULIN: continue basal 22 units; SQ, nutritional 1/3 TDD: 15 units Reg insulin in TPN
- Correction scale #2: Rapid acting Q 4hr

Steroid Therapy and Glycemic Control Patients With and Without Diabetes

- 40% Patients without prior diabetes and 75% of those with diabetes – hyperglycemia: BG > 200
- No DM or DM controlled with oral agents:
 - Begin BG monitoring with low-dose correction insulin scale administered prior to meals
- DM previously treated with insulin:
 - Increase total daily dose by 20% to 40% with start of high-dose steroid therapy
 - Increase correction insulin by 1 step (low to moderate dose)

**Adjust insulin as needed to maintain glycemic control
(with caution during steroid tapers)**

Can U500 Regular Insulin Be Used in the Hospital?

General Guidelines

Inpatient use of U500 insulin is reserved for patients who use this concentrated form of regular insulin as outpatients and who demonstrate a similar degree of insulin resistance in hospital .

To avoid dosing errors, potential for hypoglycemia:

- Order written as volume to be given using a TB syringe
- All doses prepared in pharmacy

Example:

U-500 Reg insulin 0.2 cc = 100 units Subcutaneously 8am,
5 pm.

Hypoglycemia Is Associated With Cardiovascular Complications

- Tachycardia and high blood pressure
- Myocardial ischemia
 - Silent ischemia, angina, infarction
- Cardiac arrhythmias
 - Transiently prolonged corrected QT interval
 - Increased QT dispersion
- Sudden death



Hypoglycemia Protocol: BG < 70

PATIENT	TREATMENT
Conscious and NOT NPO, able to swallow	15 gm Glucose PO
Conscious and NPO, unable to swallow or Unconscious	Dextrose 50% (25 grams) IV IF NO IV then Glucagon 1 mg IM

Recheck BG Q 15 min until > 80, if BG < 40 continuously observe until > 60
Call Physician for BG < 40 or BG < 70 x 2

Increased Risk for Hypoglycemia

- Changes in carbohydrate intake (NPO, enteral or parenteral nutrition interrupted)
- Changes in medications (steroids, vasopressors, tapered or stopped)
- Failure to make insulin adjustments based on daily BG pattern
- Poor coordination of BG testing , meals, insulin administration
- Use of long acting sulfonylurea in elderly or those with kidney, liver insufficiency

Summary

- Hyperglycemia and DM common in hospital
- Insulin therapy the preferred method for achieving and maintaining glycemic control in the hospital, usually basal bolus; starting dose 0.3-0.5 U/kg; 50% as basal, 50% divided TID AC
- Pre meal BG levels of 100-140, maximal glucose 180 mg/dl are suggested for non-critically ill patients; 140-180 in ICU
- Correction insulin alone may be appropriate for periods of < 24 to 48 hours in patients without diabetes or prior insulin therapy with initiation of therapies high risk for hyperglycemia (TPN, EN, Steroids)
- Basal bolus often needed for enteral nutrition, regular insulin in TPN is effective.
- Hypoglycemia in the hospital has significant CV risk