Management of Special Situations in Inpatient Hyperglycemia: Case Studies in Action

Module B
Learning Objectives

• Assess the impact of special situations on glucose control, eg, an increased risk for either hyperglycemia or hypoglycemia

• Identify potential risks for insulin errors to implement risk reduction strategies that improve patient safety

• Develop treatment strategies to manage special situations affecting glucose control in the inpatient setting
Current Recommendations for Hospitalized Patients: Critically Ill and Noncritically Ill Patients

**ICU**

- BG level 140–180 mg/dL
- IV insulin preferred

**Non-Critical Care Settings**

- Premeal BG level <140 mg/dL
- All BG levels <180 mg/dL

Reassess the regimen if BG level is <100 mg/dL
Modify the regimen if BG level is <70 mg/dL

BG = blood glucose; IV = intravenous.
Causes of Hospital-related Hyperglycemia

- Known diabetes (uncontrolled, undertreated)
- Undiagnosed diabetes
- Stress hyperglycemia (transient physiologic response to the stress of acute illness or injury)
- Iatrogenic (corticosteroids, catecholamines, parenteral and enteral nutrition, reduced exercise)

“New Hyperglycemia”
Hospitalization: Multiple Transitions, Shifting Clinical Situations

Rehabilitation Facility

Primary Care Provider

Skilled Nursing Facility

Perioperative Management

U-500 Insulin

Steroid Therapy

Parenteral Nutrition

Insulin Pump

Enteral Nutrition

Basic Paradigm for Management of Inpatient Hyperglycemia in Patients With Pre-existing Diabetes

Evaluation of patient’s preadmission glycemic control with a quick review of glucose patterns

Discontinuation of non-insulin glucose-lowering medications (in most cases)

Ordering scheduled point-of-care monitoring and scheduled insulin dosing while keeping the patient’s inpatient glucose goals in mind

Outlining clear parameters for the management of hypoglycemia

Evaluation of the daily BG patterns or the daily adjustments of insulin dose and type as needed

Adequate planning for discharge

Special Hospitalized Populations with Altered Insulin Sensitivity as Compared to the General Population

• Decreased insulin sensitivity
  – Infected
  – Acute organ injury (AMI, stroke)
  – Postsurgical
  – Glucocorticoid therapy
  – Pressor therapy (esp. epinephrine)
  – Transplant patients
  – TPN/PPN
  – Enteral (tube) feeding
  – ESRD, pre-dialysis*
  – Severe burns
  – Hyperglycemia (glucotoxicity)

• Increased insulin sensitivity
  – Hypoadrenal
  – Hypopituitary
  – Malnourished
  – ESRD, post-dialysis
  – Post-hyperglycemia correction (reversal of glucotoxicity)

* may still be hypoglycemia prone

Transition From IV to SC insulin
Use of IV Insulin in the Inpatient Setting

- In the intensive care unit
- Patients with DKA
- Patients with HHS
- During/after major surgery

DKA = Diabetic ketoacidosis; HHS = hyperglycemic hyperosmolar state.
Transition From IV Insulin to SC Insulin

- IV insulin should be transitioned to SC basal-bolus insulin therapy
  - When patient begins to eat and BG levels are stable
- Because of short half-life of IV insulin, SC basal insulin should be administered at least 2–3 hours prior to discontinuing the drip
  - If short-acting insulin also administered, IV insulin may be able to be stopped sooner, eg, after 1 hour

SC = subcutaneous.
Rationale for Starting SC Insulin Prior to Discontinuation of IV Insulin

SC insulin prior to d/c of IV insulin keeps BG levels within target range

Failing to give SC insulin prior to d/c of IV insulin leads to rebound hyperglycemia

SC Insulin Administration

“Scheduled”

(Sliding-scale insulin only uses this component)


Basal-bolus Therapy Is Effective for the Maintenance of Glycemic Control

Effective insulin therapy may contain basal, bolus, and supplemental doses to achieve target goals.1

Adapted from Bray.2


Basal-bolus is more effective at glycemic control vs sliding-scale therapy in medical and surgical patients.3,4
**Sliding-scale Insulin**

- **Definition**
  - Use of a mealtime insulin, typically regular insulin, as the sole insulin for managing a patient’s diabetes
  - i.e., no scheduled basal insulin or prandial insulin

- **Potential problems**
  - Poor control of hyperglycemia (does not address basal insulin needs); also does not address premeal needs
  - Insulin “stacking”
  - Hypoglycemia

- **Not preferred method of SC insulin delivery**

Converting From IV to SC Insulin

• Endocrine Society guidelines conservatively recommend the following:
  – Establishing the 24-hour insulin requirement by averaging the IV insulin dose required over the previous 6–8 hours
  – Using a fraction of that (ie, 75%–80%) as the total daily dose (TDD) of SC insulin
    • Giving half of that as basal and dividing the other half among rapid-acting insulin before meals
• Clinical trial support using 80% of the TDD to achieve 80–140 mg/dL

Case Study Example: Moving to Step-down Unit

- Patient is stable, will be moved out of the CCU and will begin scheduled meals
- The average dose of IV insulin was 1.5 units/hour over the past 8 hours
- TDD: ~40 units
  - 80% of 40 = 32 units
- Basal insulin = 50% of TDD = ~16 units (glargine/detemir) or 8 units NPH bid
- Nutritional = 50% of TDD = ~5 units per meal (x 3 meals) (lispro/glulisine/aspart; = 15 units)

Doses are then titrated against actual glucose levels.
Mean Glucose and In-hospital Mortality in Patients With AMI: Hypoglycemia and Hyperglycemia Both Associated with Increased Mortality, Especially in Patients with No Diabetes

Tight Glycemic Control in Critically Ill Adults: Risk of Severe Hypoglycemia

A Meta-analysis of 26 Randomized Controlled Trials (13,567 patients)

Severe Hypoglycemia (≤40 mg/dL)

Overall Severe Hypoglycemia RR 5.99 (4.47–8.03)

Study
Van den Berghe et al.8
Henderson et al.31
Bland et al.25
Van den Berghe et al.9
Mitchell et al.35
Azevedo et al.22
De La Rosa et al.12
Devos et al.13
Oksanen et al.36
Brunkhorst et al.11
Iapichino et al.32
Arabi et al.10
Mackenzie et al.33
NICE-SUGAR18

Overall

Risk Ratio (95% CI)
0.1 1 10

Favors IIT
Favors conventional control

CI = confidence interval.
MANAGING HYPOGLYCEMIA IN THE HOSPITAL
Hypoglycemia was a predictor of higher mortality in patients not treated with insulin, but not in patients treated with insulin.

Hypoglycemia and Risk of Death in Critically Ill Patients: NICE-SUGAR Study

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Deaths no.</th>
<th>Population no.</th>
<th>Median Time From Hypoglycemia to Death (IQR days)</th>
<th>Hazard Ratio (95% CI)</th>
<th>P Value</th>
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<tr>
<td>No hypoglycemia</td>
<td>726</td>
<td>3089</td>
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<td>Moderate hypoglycemia</td>
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<td>Insulin</td>
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<td>2066</td>
<td>9 (3–23)</td>
<td>1.22 (1.03–1.44)</td>
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<tr>
<td>No insulin</td>
<td>136</td>
<td>378</td>
<td>5 (1–22)</td>
<td>1.64 (1.34–2.01)</td>
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<tr>
<td>Severe hypoglycemia</td>
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<td>0.003</td>
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<tr>
<td>Insulin</td>
<td>57</td>
<td>186</td>
<td>10 (4–15)</td>
<td>1.68 (1.23–2.29)</td>
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<tr>
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<td>22</td>
<td>37</td>
<td>1 (0–9)</td>
<td>3.84 (2.37–6.23)</td>
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</tr>
</tbody>
</table>

Deleterious Impact of Hypoglycemia

- Sympathoadrenal response
- Cardiac dysrythmias
- Neuroglycopenia
  - Altered sensorium and vision
  - Falls
  - Aspiration
- ? Pro-inflammatory state
- ? Procoagulant state
- ? Endothelial dysfunction

The Hidden Costs of Inpatient Hypoglycemia

- Prolonged length of stay
- Malpractice suits
- CMS and “never events”

CMS = Centers for Medicare and Medicaid Services
CMS and “Never Events”

- In 2008, the Centers for Medicare and Medicaid Services (CMS) implemented a provision that denies Medicare payment for hospital-acquired conditions (HACs).
- This provision brings attention to the quality of patient care and the financial impact associated with "never events" occurring during a patient's hospitalization.
- Examples include:
  - Stages III and IV pressure ulcers
  - Catheter-associated urinary tract infection
  - Vascular catheter-associated infection
  - Falls resulting in fractures, dislocations, and/or intracranial injuries
  - Manifestations of poor glycemic control
    - Complications associated with hypoglycemia (death/disability)

Causes of Treatment-related Hypoglycemia

Incidence percentage of proximate causes of hypoglycemia

- Excess insulin: 60%
- Inadequate monitoring: 45%
- Diet change: 20%
- Administration error: 15%
- Hyperkalemia treatment: 10%
- Physician computer entry error: 5%

Scenarios Prompting Increased Monitoring and Possible Decreases in Insulin Dose

- Patient is switched to NPO status
- Reduction in food intake
- Discontinuation of enteral feeding or TPN
- Discontinuation or reduction in IV dextrose
- Timing of premeal insulin if meal disrupted due to medical procedures or patient transport
- Reduction in corticosteroid administration

NPO = nothing by mouth.
Special Situations

Hypoglycemia

<70 mg/dL  <40 mg/dL (severe)

- Can take PO  Give 15 g carb (4 oz. orange juice)
- NPO  Give 12.5 g carb IV (1/2 amp D50)
- MS changes  Give 25 g carb IV (1 amp D50)

Rule of thumb: 25 g carb will ↑ BG 25–50 mg/dL

- Document in chart
- Assess reason for hypoglycemia (food, insulin dose, sepsis, renal failure, hepatic failure)
- Re-evaluated regimen; usually decrease insulin
Patients Receiving Enteral or Parenteral Nutrition
Case Study: Total Parenteral Nutrition

• 55-year-old obese male is admitted with enterocutaneous fistula, no prior history of diabetes
• On admission, his BG level = 200 mg/dL
• A1C level: 7.5% (previously unrecognized DM)
• Patient is not eating, and it is anticipated that he will not be able to eat for 1 week
• TPN is started

DM = diabetes mellitus.
Prevalence of Hyperglycemia in Patients Receiving Specialized Nutritional Support

- Prevalence of hyperglycemia in patients receiving enteral nutrition is up to 30%
- May be >50% in patients receiving parental nutrition

Hyperglycemia During TPN: Marker of Poor Outcomes and Mortality in the Hospital

# Adverse Outcomes Significantly Associated With Hyperglycemia in Patients Receiving TPN

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>BG Level (mg/dL)</th>
<th>Odds Ratio P &lt;0.05</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Death</td>
</tr>
<tr>
<td>Cheung et al.</td>
<td>111</td>
<td>&lt;125 vs &gt;164</td>
<td>10.9</td>
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<tr>
<td>Lin et al.</td>
<td>457</td>
<td>&lt;114 vs 137–180</td>
<td>2.3</td>
</tr>
<tr>
<td>Pasquel et al.</td>
<td>276</td>
<td>≤120 vs &gt;180</td>
<td>2.8</td>
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<tr>
<td>Sarkisian et al.</td>
<td>100</td>
<td>≤180 vs &gt;180</td>
<td>7.22</td>
</tr>
<tr>
<td>Olveira et al.</td>
<td>605</td>
<td>&gt;180 vs &lt;140</td>
<td>5.6</td>
</tr>
</tbody>
</table>

*Data reported for pneumonia only.*

What is the insulin treatment you would recommend for a DM patient on TPN?

1. IV insulin, separate from TPN
2. Insulin added to TPN
3. Basal-bolus insulin
Approach to the Management of Hyperglycemia in Patients Receiving Enteral or Parenteral Nutrition

- **Enteral Nutrition (EN) or Parenteral Nutrition (PN) is initiated**

- **Start (no diabetes) or continue (known diabetes)**
  - POC BG monitoring q4–6h

- **BG >180 mg/dL x1 or BG = 140–180 mg/dL x2**

- **Patient on EN**
  - Use diabetes-specific formula. Start insulin therapy: basal insulin 0.15–0.25 U/kg (NPH q8h, glargine qd, detemir qd, bid). Supplemental short-acting insulin q4–6h

- **Patient on PN**
  - Consider limiting load in TPN to 150–200 g/dL/day. Start insulin therapy.
  - Mix regular insulin with PN or use supplemental short-acting insulin q4–6h.

- **Titrate daily insulin therapy per glycemic. Request notifications if nutrition support regimen is changed. Initiate appropriate discharge planning.**

EN = enteral nutrition; PN = parenteral nutrition; POC = point of care.
General Recommendations: Hyperglycemia Associated With Parenteral Nutrition (PN)

For patients receiving PN, regular insulin administered as part of the PN formulation can be both safe and effective.

- A BG level >120 mg/dL before PN predicts the need for insulin

SC correction-dose insulin is often used, in addition to insulin that is mixed with the IV nutrition.

- When starting PN, the initial use of a separate insulin infusion can help in estimating the TDD of insulin that will be required
- Separate IV insulin infusions may be needed to treat marked hyperglycemia during PN

Case Study: Insulin Needs and Enteral Nutrition

• 70-year-old woman admitted with a stroke
  – She has a prior history of T2DM, controlled on oral agents
  – BG level on admission = 150 mg/dL, A1C level = 7%
  – Currently she is unable to swallow
  – Continuous EN is started on hospital day 2

T2DM = type 2 diabetes mellitus.
Case Study:
Insulin Needs and Enteral Nutrition

What insulin treatment would you recommend for a DM patient on enteral tube feedings? (BG >200 mg/dL)

1. Sliding scale only with rapid-acting insulin
2. IV insulin, variable-rate infusion
3. NPH and regular insulin every 8 hours
4. Glargine qd or detimir qd/bid
5. Supplemental short-acting insulin every 4–6 hours
Glycemic Management of the Patient Receiving Enteral Nutrition (EN)

**Continuous EN**
- Basal insulin: 40%–50% of TDD as long- or intermediate-acting insulin given once or twice a day
- Short-acting insulin: 50%–60% of TDD given q6h

**Cycled EN**
- Intermediate-acting insulin given together with a rapid- or short-acting insulin with start of TF
- Rapid- or short-acting insulin administered q4–6h for duration of EN administration
- Correctional insulin given for BG level above goal range

**Bolus EN**
- Rapid- or short-acting insulin given prior to each bolus

Limited Clinical Trial Data Comparing Insulin Therapy During Enteral Nutrition (EN)

- **One** prospective RCT has evaluated different insulin regimens in hospitalized patients receiving EN support.
- 50 patients with and without history of DM with BG levels >140 mg/dL randomized to sliding scale with regular insulin (SSRI) alone vs with long-acting insulin glargine once daily.
- **Results**
  - “No difference” in glucose control but 48% of SSRI group required rescue with NPH due to persistent hyperglycemia.

RCT = randomized controlled trial.
Cautions With Insulin and Enteral Feedings

• Unexpected interruptions in enteral feeding occur frequently!
  – Administration of long-acting insulin independent of enteral feeding may increase the risk of hypoglycemia
  • Consider ordering D10 infusion (to provide calories) to be administered if tube feeding is discontinued or interrupted to prevent hypoglycemia
  – Some data suggest that the use of “biphasic” analogs (premixed 70/30, 70/25) may be less likely to cause hypoglycemia because of their shorter durations of action

Preventing Hypoglycemia in Patients Receiving Enteral and Parenteral Nutrition

If tube feeding is interrupted:

- Start IV 10% dextrose infusion 50 mL/hour
- Consider reducing next dose of long- or intermediate-acting insulin, and
- Increase frequency of bedside glucose monitoring

If parenteral nutrition is interrupted:

- Consider reducing next dose of long- or intermediate-acting insulin (if used)

Reduce dose of scheduled insulin if:

- Renal insufficiency
- Discontinuation or reduction in steroids
- Discontinuation of vasopressors
- Decrease in carbohydrate intake

An insulin protocol for management of hyperglycemia in patients receiving TPN was superior to ad hoc management

- Initiation of insulin at rate of 1 unit:20 g of dextrose with further up-titration to ratio of 1 unit:15 g if BG >140 mg/dL was effective in nondiabetic patients in ICU (or average total daily insulin dose of 0.3 ± 0.2 u/kg)

### Managing Hypoglycemia (BG <70 mg/dL) in Patients Receiving Enteral or Parenteral Nutrition

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Administer IV dextrose 50% 25–50 mL</strong></td>
<td>If repeat BG is &lt;70 mg/dL in 15 minutes, repeat dextrose IV push and start IV 10% dextrose infusion 50 mL/hour</td>
</tr>
<tr>
<td></td>
<td>If repeat BG is ≥70 mg/dL in 15 minutes, measure BG in 1 hour and repeat treatment until BG is &gt;100 mg/dL</td>
</tr>
<tr>
<td><strong>Administer intramuscular 1 mg glucagon if there is no IV access</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Reduce or hold next dose of long- or intermediate-acting insulin</strong></td>
<td>(if used)</td>
</tr>
</tbody>
</table>

Perioperative Glucose Control
Examples of Perioperative Hyperglycemia and Poor Outcomes

Independent of diabetes status, increases the risk of perioperative morbidity and mortality.¹

Preoperative BG >200 mg/dL is associated with deep sternal wound infections among patients undergoing CABG.²

Preadmission hyperglycemia independent risk factor for inpatient symptomatic pulmonary embolism after major orthopedic surgery.³

Hyperglycemia before carotid endarterectomy is associated with increased perioperative stroke, transient ischemic attack, myocardial infarction, and death.⁴

CABG = coronary artery bypass grafting.
Importance of Perioperative Glycemic Control in General Surgery

- Study evaluated relationship of perioperative hyperglycemia (>180 mg/dL) and insulin administration on mortality, preoperative interventions, and infections for patients undergoing elective colorectal and bariatric surgery at 47 participating hospitals between 4th quarter of 2005 and 4th quarter of 2010
- If preoperative hyperglycemia was corrected with insulin, outcomes were better
  - NO significant increase in
    - infections
    - preoperative interventions
    - or death
  - Worst outcomes: BG >180 mg/dL
  - Best outcomes: BG <130 mg/dL

Glycemic Control (<180 mg/dL) in Patients With Diabetes During Cardiac Surgery

- Reduces mortality
- Reduces morbidity
- Lowers the incidence of wound infections
- Reduces hospital LOS
- Enhances long-term survival

IV Insulin Infusions: A Treatment Consideration During Surgery for Patients With T1DM

In the critically ill, glycemic control is best achieved with continuous insulin infusions rather than intermittent SC insulin injections or intermittent IV insulin boluses.

All patients with diabetes undergoing cardiac surgical procedures should receive an insulin infusion postoperatively for at least 24 hours to keep BG <180 mg/dL.

In patients with T1DM and labile T2DM patients on insulin, it is advisable to begin insulin infusion preoperatively or intraoperatively to facilitate better postoperative control.

Preoperative Management and Assessment for Patients With Diabetes

- Obtain A1C level prior to surgery in patients with DM or those at risk for postoperative hyperglycemia to characterize level of glycemic control.

- Initiate scheduled insulin therapy, using a combination of long- and short-acting SC insulin, to achieve glycemic control for in-hospital patients awaiting surgery.

- Consider insulin infusion protocol in selected T1DM patients or T2DM patients with labile control.

- Hold nutritional insulin after dinner the evening prior to surgery; consider modest 10%–20% reduction in evening long-acting insulin.

Oral Agents

• All oral hypoglycemic agents and non-insulin diabetes medications should be held starting the night before surgery
  – Especially those that stimulate insulin secretion, such as sulfonylureas and meglitinides, because of their potential for producing hypoglycemia during fasting prior to surgery
  – Potential for decreased renal function and metformin considerations
• ...but stopping antidiabetic therapy too early may compromise glucose control perioperatively
Early Postoperative Period

If an IV insulin infusion is initiated in the preoperative period, it should be continued throughout the intraoperative and early postoperative period according to institutional protocols to maintain serum glucose levels ≤180 mg/dL.

Glucocorticoid-induced Diabetes
Steroid Case Study

- 65-year-old patient with T2DM is admitted for severe COPD exacerbation.
  - His outpatient medications include insulin glargine 32 units SC at bedtime and insulin aspart 9 units SC before meals.
  - He is started on prednisone 60 mg orally every morning as part of his treatment regimen.
  - What do you expect the impact will be on his BG level,
  - How might you adjust his Inpatient regimen?

COPD = chronic obstructive pulmonary disease.
Steroid Case Study: Which of the following is most likely to occur?

1. All insulin requirements are likely to increase; therefore, his insulin glargine and insulin aspart doses should be increased by approximately 30%

2. His fasting BG level is likely to increase significantly; will need to increase his insulin glargine dose by approximately 30%

3. His postprandial gluoses are likely to increase significantly; will need to increase his premeal insulin aspart by approximately 30%
Glucocorticoids and Glycemic Control

Administration of glucocorticoids

- Glucose elevation is predominantly postprandial with relative lack of fasting hyperglycemia
- Treatment often requires large doses of rapid-acting insulin before meals (usually before lunch and dinner)
- Significant increase in basal insulin should be avoided as overnight hypoglycemia may be induced

Prandial vs Fasting Glycemia

Plasma Glucose Concentration (mg/dL)

High Incidence of Steroid-induced Hyperglycemia in the Hospital

80 non-diabetic patients treated with high-dose steroids
At least one BG level

Mean BG levels

Frequency of Hyperglycemia in Patients Receiving High-dose Corticosteroids

High dose defined as a dose equivalent of at least 40 mg/day of prednisone.

General Recommendations: Hyperglycemia Associated With Steroids

• Initiate SC basal-bolus insulin therapy is recommended
  – Starting insulin dose and timing of administration individualized depending on severity of hyperglycemia and duration/dosage of steroid therapy
  – Suggested starting dosage of 0.3–0.5 U/kg • day

• For patients receiving high-dose glucocorticoids and in those with severe hyperglycemia that is difficult to control, the use of continuous insulin infusion may be appropriate

Basal-bolus Therapy with Emphasis on Nutritional Insulin

- Medium-dose glucocorticoids (40–60 mg/day) tend to cause minimal increase in FPG and marked elevation in PPG.

<table>
<thead>
<tr>
<th>“Scheduled”</th>
<th>Nutritional*</th>
<th>Supplemental/Correction*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal</td>
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<tr>
<td>- Insulin drip</td>
<td></td>
<td>Emphasis on regular or rapid-acting insulin analog</td>
</tr>
<tr>
<td>- NPH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Long-acting insulin analog (glargine, detemir)</td>
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</tr>
</tbody>
</table>

*Rapid analog preferred.
FPG = fasting plasma glucose; PPG = postprandial glucose.
Hyperglycemia and Glucocorticoid Therapy: Summary

- Institute glucose monitoring for at least 48 hours in all patients
- Prescribe insulin therapy as needed according to results of bedside BG monitoring

*During initiation and taper of steroid therapy, proactive adjustment of insulin therapy can help avoid uncontrolled hyperglycemia and hypoglycemia.*

Concentrated Forms of Insulin: The Example of U-500
U-500 Case Study

• 58-year-old male complaining of right toe pain and foot infection admitted to rule osteomyelitis
  – Height = 5’11”; weight = 257 lb; BMI = 36 kg/m²
  – A1C level = 10.9%
  – Patient states that he is on insulin human injection U-500 (concentrated) insulin 30 units before breakfast and dinner at home
  – Started on vancomycin 1g IV q12h
Essential Prescribing Information

- Insulin human injection U-500 contains 500 units of insulin in each milliliter (5 times more concentrated than traditional insulin human injection U-100).
- Extreme caution must be observed in the measurement of dosage because inadvertent overdose may result in serious adverse reaction or life-threatening hypoglycemia.
- To reduce the risk of dosing errors, the actual dose in units, corresponding unit marking on U-100 insulin syringe or mL markings on volumetric (TB or allergy) syringe with accompanying conversion chart.
When a U-500 Insulin Patient Is Admitted to the Hospital, Several Safety Issues Arise

- U-500 insulin syringes do not exist, so patients use regular U-100 insulin syringes to draw up their insulin at home.

- As the corresponding units on a regular insulin syringe are not comparable, there is misrepresentation of actual dose given. Dosed in tenths of milliliters.

- Pharmacy should interview the patient on admission to verify correct dose by having the patient demonstrate drawing up actual home dose.

U-500 Case Study

- When Pharmacy interviews the patient, he demonstrates that he draws the insulin to the 30 mark on the U-100 syringe. What is the actual dose the patient is receiving at home?
  1. 30 units of R U-500 insulin before meals
  2. 150 units of R U-500 insulin before meals
  3. 6 units of R U-500 insulin before meals
Comparison of U-100 mL Syringe With Insulin Human Recombinant U-100 and Insulin Human Recombinant U-500 Dose

Although both are drawn to the 5-unit mark, the syringe with U-500 contains 25 units, whereas the syringe with U-100 contains 5 units of insulin.
Safety Measures Required to Reduce the Risk of Dosing Errors

- Standardized CPOE, with alerts to Pharmacist and Diabetes Educator
- Pharmacy home dose verification of R U-500 insulin on admission
- Patient’s R U-500 sent home or stored in Pharmacy
- Pharmacy dispenses prefilled volumetric syringe to the unit
- U-500 insulin dose and volume documented in the “MAR”
Continuous Subcutaneous Insulin Infusions (CSII), Also Known as Insulin Pump Therapy, in the Hospital Setting
Insulin Pumps

• Electronic devices that deliver insulin through a subcutaneously inserted catheter: basal rate (variable) + bolus delivery for meals
• Used predominantly in T1DM
• Pump patients are fastidious about their BG control and reluctant to yield control to the inpatient medical team
• Hospital personnel tend to be unfamiliar with pumps
• Hospitals do not stock pump supplies
• Need policies to allow pump patients to manage their own diabetes during hospitalizations (many ethical/medicolegal considerations!)
Insulin Pumps
Physiological Insulin Delivery From an Insulin Pump

Mealtime boluses:
- 8 U at 0.8 U/h from 0 to 2 hours
- 5 U at 0.7 U/h from 2 to 6 hours
- 10 U at 1.1 U/h from 6 to 12 hours
- 2 U at 0.9 U/h from 12 to 14 hours
- 1.1 U/h from 14 to 24 hours

Basal rates:
- 0.6 U/h from 24 to 36 hours
- 0.6 U/h from 36 to 48 hours

Insulin Level
Inpatient CSII Protocol

- Patients who have been well controlled with CSII at home can self-manage their pumps during hospitalization
  - Patients should confirm in writing their willingness and ability to use insulin pumps
- Nurses should verify and document all administered basal rates and bolus doses
  - If pump is interrupted for >1 hour, another source of insulin (either IV or SC) MUST be given 30 minutes prior to discontinuation
    - eg, Insulin pumps must be discontinued for an MRI

Patient Attestation

I confirm that I have been fully trained on the use of my insulin pump prior to this hospitalization and that
I am capable and willing to manage it independently during my hospital stay.
If at any time I feel that I am unable to manage the pump, I will alert my medical team.

_________             ________
Patient Witness

CSII = continuous SC insulin infusion; MRI = magnetic resonance imaging.
Transitioning Insulin Pump Therapy From the Outpatient to the Inpatient Setting: A Review of 6 Years' Experience With 253 Cases

- Data show that adherence to core process measures improved over time
  - 100% of cases had an endocrinology consultation
  - 100% had insulin pump order set completed
  - 94% had documentation of signed agreement specifying patient responsibilities for continued use of pump technology while hospitalized
  - 64% had documentation of insulin pump flow sheet

- Clinical outcomes
  - Episodes of severe hyperglycemia (>300 mg/dL) and hypoglycemia (<40 mg/dL) were significantly less common among pump users
  - No pump site infections, mechanical pump failures, or episodes of diabetic ketoacidosis were observed among patients remaining on therapy

Resources

American Association of Clinical Endocrinologists Inpatient Glycemic Resource Center
   http://www.aace.com/resources/igcrc/
Institute for Safe Medication Practices
   http://www.ismp.org/default.asp
American Society of Hospital Pharmacists: Safe Use of Insulin in Hospitals
   http://www.ashop.org/s_ashp/docs/files_Safe_Use_of_Insulin.pdf
Society for Hospital Medicine Resource Center
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