

**JOSLIN DIABETES CENTER and JOSLIN CLINIC**  
**GUIDELINE for INPATIENT MANAGEMENT OF SURGICAL and ICU PATIENTS with DIABETES**  
**(Pre-, Peri- and Postoperative Care) 12-30-2015**

The Joslin Clinical Guideline for Inpatient Management of Surgical and ICU Patients with Diabetes is designed to assist primary care physicians and specialists individualize the care and set goals for adult, non-pregnant patients with diabetes who are undergoing surgery. This guideline focuses on the unique needs of the patient with diabetes. It is not intended to replace sound medical judgment or clinical decision-making and may need to be adapted for certain patient care situations where more or less stringent interventions are necessary.

The objectives of the Joslin Clinical Guidelines are to support clinical practice and to influence clinical behaviors in order to improve clinical outcomes and assure that patient expectations are reasonable and informed. Guidelines are developed and approved through the Clinical Oversight Committee that reports to the Chief Medical Officer of Joslin Diabetes Center. The Clinical Guidelines are established after careful review of current evidence, medical literature and sound clinical practice. This Guideline will be reviewed periodically and modified as clinical practice evolves and medical evidence suggests.

Joslin's Guidelines are evidence-based. In order to allow the user to evaluate the quality of the evidence used to support each Guideline for care, a modification of the GRADE system has been adopted. The table provided on page 10 describes the categories in which methodological quality and strength of recommendations have been classified. Evidence levels are graded 1A through 2C, as indicated in brackets. Where evidence is not graded, recommendations are made based on the expertise of the Clinical Oversight Committee.

**SURGERY ALGORITHM FOR PATIENTS WITH EXISTING DIABETES**

## **I. PREOPERATIVE MANAGEMENT**

### **General Considerations:**

- ***Aim for early morning surgery:*** Scheduling early morning surgery may decrease the risk of hyperglycemia and hypoglycemia resulting from the disruption in typical medication and food schedules.
- ***Refer to the diabetes educator as soon as feasible.*** All hospitalized diabetes patients need an assessment of their diabetes knowledge in order to help insure their safety after discharge. See Joslin's Guideline: ***Uncontrolled Glucose in the Hospitalized Patient*** for more detail.

### **Morning and Afternoon Prior to Surgery**

- **Management of insulin, oral glucose lowering medications and non-insulin injectable diabetes medication:**
  - Maintain usual meal plan and insulin dose (NPH, glargine, detemir, regular, aspart, glulisine, lispro), insulin via continuous subcutaneous insulin infusion pump (CSII); 70/30, 75/25, 50/50 insulin, or human insulin inhalation [1C] and/or oral glucose-lowering-medications and/or non-insulin injectable diabetes medications (GLP-1 agonists and pramlintide). [1C]

### **Evening Prior to Surgery**

- **Management of insulin:**
  - **Basal insulin:** Consider a 10-20% reduction in the usual dose of long-acting (glargine or detemir) insulin. If NPH insulin is given at bedtime, consider a dose reduction of 50%.
  - **Insulin pump (CSII):** Patients can continue their usual basal rate. The infusion set insertion site should be placed away from the surgical site and can otherwise be placed anywhere on upper outer thighs, upper arms, or abdomen (2 inches away from umbilicus), [1B]

### **Morning of Surgery**

- **Management of insulin:**
  - **Basal insulin:** If fasting after midnight, give 50% of the usual morning dose of intermediate (NPH) insulin. If the patient usually takes a dose of long-acting insulin (glargine or detemir) in the morning, consider a dose reduction of 10-20%.
  - **Bolus Insulin:** Omit morning rapid- or short-acting insulin (including inhaled insulin) [1A], **exception is pump users** who may use corrective insulin per individualized instructions

- **Mixed basal/bolus:** If the patient usually takes morning pre-mixed insulin (70/30, 75/25, 50/50) and is NPO, the optimal regimen would be to give 50% of the NPH component of the usual dose of premixed insulin and no rapid- or short-acting insulin. [1B]
- **Management of Oral Glucose-Lowering Medications and Non-insulin Injectable Diabetes Medications:**
  - **Omit oral antidiabetes medications and non-insulin injectables (GLP1 agonists, and pramlintide) the morning of surgery [1A]**
- **Frequency of Blood Glucose Monitoring:**
  - Check blood glucose level every 2 hours starting before surgery and continue during and after the surgery [1C]

**Arrival at Pre-Anesthesia Unit**

- **Glycemic Management:**
  - Check blood glucose every 2 hours before surgery [1C]
  - Start IV insulin for patients undergoing major surgery (e.g., chest or abdominal cavity, vascular bypass, transplant, spinal or brain surgery requiring general anesthesia, total hip or knee replacement, surgery anticipated to be longer than 4 hours)

**II. INTRAOPERATIVE MANAGEMENT**

**General Considerations:**

*This section on intraoperative management contains GENERAL information on intraoperative management. Section VI contains detailed algorithms on intraoperative management. A number of well-validated intraoperative insulin infusion protocols have been shown to work effectively. Section VI contains four sample algorithms, two designed to target BG levels of 100-180mg/dl for the non-critically ill patient, and two others to target BG levels of 140-180 mg/dl for the critically ill patient.*

**Glycemic Management**

- Check blood glucose every 2 hours during surgery [1C]
- Blood glucose level and type of surgery determine the frequency of additional blood glucose checks and treatment as outlined in Table 1 below.
- Insulin pump (CSII) patients can maintain basal rate during surgery [1C] or be changed to IV insulin infusion [1B] or subcutaneous basal insulin injections to maintain blood glucose target. [1B]

**Maintenance of Hydration**

- During surgery the patient should receive maintenance IV fluids without dextrose (e.g. LR or NS or ½ NS rather than D5LR). [2C]
- If an insulin infusion is required, D5W at 40 ml/hr or D10W at 20 ml/hr should be started in a separate IV line to provide adequate substrate. Patients receiving insulin infusion should receive at least 50 grams of glucose/24 hours. [1C]

**Table 1: Type of Surgery**

<b>Major Surgery</b> E.g., chest or abdominal cavity, vascular bypass, transplant, spinal or brain surgery requiring general anesthesia, total hip or knee replacement, surgery anticipated to be >4 hours	<b>Non-Major Surgery</b> e.g., patient able to consume usual meal plan post-operatively			
<b>Start IV Insulin [1A]</b> (See Pre-, Intra- and Postoperative IV Insulin Infusion Algorithm pg. 5-8)	<b>BG &lt;80 mg/dl</b> Consider an IV bolus of at least 100 ml of D10W or 25 – 50 grams of D50 ↓ Check BG in 15-30 min. [1C]	<b>BG 80-100 mg/dl</b> Begin IV of D5W at 40 ml/hour or D10 W at 20 ml/hour ↓ Check BG in 1 hour[1C]	<b>BG 101-180 mg/dl</b> Continue to monitor blood glucose every 2 hours [1C]	<b>BG &gt;180 mg/dl</b> Begin IV insulin (See Pre-, Intra- and Postoperative IV Insulin Infusion Algorithm pgs. 5-8 or subcutaneous insulin algorithm pg. 3 [1C])

### III. IMMEDIATE POSTOPERATIVE MANAGEMENT

#### Glycemic Management

- Check blood glucose when patient returns to post-anesthesia unit [1B]; base frequency of checks on blood glucose levels during surgery [1C]
- Administer insulin according to subcutaneous algorithm (Table 2.) [1B]
  - For glucose level >180 mg/dl, check hourly [1C]; if no improvement in glycemic control, consider insulin dosing according to next higher weight class. [1C] (see chart below)
  - Check glucose every 4-6 hours if using regular insulin (short-acting) [1C]
  - Check glucose every 2-4 hours if using aspart, glulisine, or lispro (rapid-acting) [1C]

**Table 2: Subcutaneous Insulin Algorithm**

	<b>Weight Class I (&lt;175 lbs/80 kg)</b>	<b>Weight Class II (175-220 lbs/81-99 kg)</b>	<b>Weight Class III (&gt;220 lbs/100 kg)</b>
<b><u>BG (mg/dl)</u></b>	<b><u>Insulin Units (subcutaneously)</u></b>	<b><u>Insulin Units (subcutaneously)</u></b>	<b><u>Insulin Units (subcutaneously)</u></b>
≤180	0 units	0 units	0 units
181-200	1 unit	2 units	4 units
201-250	2 units	4 units	6 units
>250	Begin insulin infusion	Begin insulin infusion	Begin insulin infusion

### IV. POSTOPERATIVE MANAGEMENT for NON-CRITICAL, NON-CARDIAC SURGERY PATIENTS

#### Meal Planning:

- Meals should be advanced as tolerated and carbohydrates should be consistent for each meal.

#### Blood Glucose Goals:

- Fasting and premeal blood glucose: 100-140 mg/dl
- Random or bedtime blood glucose: ≤180 mg/dl

#### Glycemic Management

- Oral agents and non-insulin injectables:
  - Consider starting basal-bolus therapy as outlined below under **Insulin Calculation**.
  - If IV contrast is used, hold the metformin dose on the day of contrast study. **Restart metformin 48hrs after IV contrast if repeat eGFR is ≥45mL/min.**
  - It is safe to resume oral antidiabetes medications and non-insulin injectables (GLP1 agonists, and pramlintide) if the patient meets the following criteria [1B]:
    - Eating >50% of diet **and**
    - Expected discharge within 24-48 hours **and**
    - No plans for contrast studies **and**
    - No acute kidney failure
- **Insulin Calculation:**
  - **If insulin naïve, use the following:**
    - **Basal Insulin:** 0.2 units x weight (kg) in the form of glargine (once daily at bedtime), or detemir (used in type 1 diabetes detemir is given as 50% of dose in the morning and 50% in the evening; used in type 2 diabetes, detemir is given as one injection at bedtime only), or NPH (used in type 1 and 2 diabetes, NPH dosing is given as 2/3 of the total dose at breakfast and 1/3 of the total dose at bedtime.)
    - **Bolus (meal-time) Insulin:** 0.2 units x weight (kg) divided equally among three meals in the form of lispro, aspart, or glulisine. Hold bolus dose if patient is NPO
    - **Corrective Insulin:** see Table 3, Corrective Insulin Table

**Table 3: Corrective Insulin Table**

	<b>Weight Class I (&lt;175 lbs/80 kg)</b>	<b>Weight Class II (175-220 lbs/81-99 kg)</b>	<b>Weight Class III (&gt;220 lbs/100 kg)</b>
<b><u>BG (mg/dl)</u></b>	<b><u>Insulin Units (subcutaneously)</u></b>	<b><u>Insulin Units (subcutaneously)</u></b>	<b><u>Insulin Units (subcutaneously)</u></b>
<180	0 units	0 units	0 units
181-200	1 unit	2 units	4 units
201-250	2 units	4 units	6 units
251-300	4 units	6 units	8 units
301-350	6 units	8 units	10 units
351-400	8 units	10 units	12 units
>400	call provider	call provider	call provider

- **If total daily dose at home is  $\geq 0.4$  units/kg**
  - **Basal Insulin:** Give 80% of home basal dose of intermediate (NPH) or long-acting (glargine or detemir) insulin
  - **Bolus Insulin:** Initially resume 50% of home rapid- or short-acting insulin **[1B.]**
  - **Mixed Basal/Bolus:** Resume pre-mixed insulin (70/30, 75/25, 50/50) at 80% of home dose. **[1B]**
  - **Corrective Insulin:** See Table 3 above
- **For Insulin pump patients:**
  - **If not cognitively impaired,** insulin pump (CSII) patients can continue their usual basal rate, continue carb counting for prandial insulin administration, and continue the use of blood glucose correction dosing using their pump
  - **If the patient is cognitively incapacitated** the patient needs to be transitioned off the pump to basal-bolus insulin under the guidance of an endocrinologist **[1B]**
  - **Resuming insulin pump:** If a basal insulin (glargine, detemir or NPH) is temporarily used, the insulin pump should only be resumed after the effect of the basal insulin has dissipated in order to avoid stacking or overlapping insulin action (Dissipation of insulin action occurs 12-24 hours after the last basal insulin injection, depending on the type of insulin used)

## **V. POSTOPERATIVE MANAGEMENT for CRITICAL and CARDIAC SURGERY PATIENTS**

### **Goal blood glucose**

- Blood glucose should remain below 180 mg/dl
  - A target range of 110-140 mg/dl is advocated by ADA/AACE and a target range of 100-50 mg/dl is advocated by the Critical Care Society for cardiothoracic and surgical trauma cases
  - Avoidance of blood glucose <110 mg/dl is advocated by (ADA/AACE) and <100 mg/dl is advocated by the Critical Care Society, especially in neurosurgery patients
- Note that significant vasopressive therapy may result in vasoconstriction and poor perfusion making subcutaneous blood glucose monitoring unreliable

### **Initiate IV insulin if:**

- BG >150 mg/dl twice postoperatively for cardiothoracic surgery **[1C]**
- BG >180 mg/dl twice in intensive care units in non-cardiothoracic cases **[1C]**
- BG >150 mg/dl twice in intensive care units for trauma and neurosurgery for intraparenchymal hemorrhage or aneurismal subarachnoid hemorrhage or traumatic brain injury **[2C]**

## VI. ALTERNATIVE ALGORITHMS for INTRAOPERATIVE and POSTOPERATIVE MANAGEMENT

### General Considerations:

This section contains detailed algorithms on intraoperative management. A number of well-validated intraoperative insulin infusion protocols have been shown to work effectively. This section contains four sample algorithms, two designed to target BG levels of 100-180mg/dl for the non-critically ill patient, the other two to target BG levels of 140-180 mg/dl for the critically ill patient.

Listed below are two alternative Insulin Infusion Algorithms that can be used for Critically Ill Intraoperative and ICU Patients:

### Insulin Infusion Algorithm #1 for Critically Ill Intraoperative and ICU Patients (Target BG 140-180 mg/dl)

Insulin dose adjustments using this algorithm do not replace sound medical judgment.

<b>&lt;100</b>	<ul style="list-style-type: none"> <li>Hold drip and give an IV bolus of 25-50 grams of 50% glucose followed by IV infusion of D10W. Check BG in 15 minutes, then every 15-30 minutes until glucose <math>\geq</math>140mg/dl. Once glucose &gt;140mg/dl, re-initiate drip at 50% of the previous rate.</li> </ul>							
<b>Current BG level (mg/dl)</b>	<b>Previous Blood Glucose (mg/dl)</b>							
	<b>&lt;100</b>	<b>100-140</b>	<b>141-180</b>	<b>181-200</b>	<b>201-250</b>	<b>251-300</b>	<b>301-400</b>	<b>&gt;400</b>
<b>101-140</b>	↓ rate by 1 unit/hr	↓ rate by 25% or 0.5 units/hr*		↓ rate by 50% or 2 units/hr*		↓ rate by 75% or 2 units/hr*		
<b>141-180</b>	No Change			↓ rate by 50% or 2 units/hr*				
<b>181-200</b>	↑ rate by 1 unit/hr	↑ rate by 0.5 units/hr		↑ rate by 25% or 1 unit/hr*	No Change	↓ rate by 25% or 2 units/hr*		
<b>201-250</b>	↑ rate by 25% or 2 units/hr*		↑ rate by 25% or 1 unit/hr*			↑ rate by 1 unit/hr	No Change	
<b>251-300</b>	↑ rate by 33% or 2.5 units/hr*		↑ rate by 25% or 1.5 units/hr*	↑ rate by 25% or 1 unit/hr*	↑ rate by 1 unit/hr	↑ rate by 1.5 units/hr	↑ rate by 25% or 2 units/hr*	No Change
<b>301-400</b>	↑ rate by 40% or 3 units/hr*							
<b>&gt;400</b>	↑ rate by 50% or 4 units/hr*							

\*Whichever is the greater change

↓  
This algorithm assumes hourly blood glucose checks during insulin dose titration.

- If BG in desirable range (140-180 mg/dl) for 4 hours, decrease frequency of BG checks to every 2 hours while BG stays in target.
- If experiencing unexplained hypoglycemia or hyperglycemia, investigate and correct causative factors.
- If there is any significant change in glycemic source (i.e., parenteral, enteral or oral intake), expect to make insulin adjustment.

#### Common reasons to discontinue insulin infusion:

- Patient tolerating at least 50% of normal oral intake or enteral feedings
- Clinically appropriate to transfer patient to a unit that does not do insulin infusions
- Patient on stable regimen of TPN with most of the insulin already in the TPN solution

**One-two hours before discontinuing the insulin infusion, initiate alternative glycemic management:**

- For patients with type 1 diabetes or those with type 2 diabetes previously controlled on insulin:
  - **If NPO**, initiate basal subcutaneous insulin (glargine, detemir or NPH) at 80% of the insulin administered over the previous 24 hours by insulin infusion. Stop insulin infusion 2 hours after injecting long-acting insulin.
  - **If the patient is taking more than 50% of usual oral or enteral intake**, give 50% of insulin dose as basal insulin based on the previous 24 hours of insulin infused or 0.2 units/kg and initiate pre-meal bolus and correction dose to maintain BG in target. If subcutaneous short acting insulin is given, stop the insulin infusion 1 hour after subcutaneous injection.
  - **Another alternative is to resume pre-hospital insulin regimen.**
  - **Insulin pump patients** can resume pump use based on hospital policy.
- For patients with type 2 diabetes previously treated with oral antidiabetes agents, non-insulin injectables, and/or inhaled insulin:
  - **If patient had good diabetes control prior to hospitalization**, a return to prior treatment plan may be considered based on postoperative clinical status
  - **If pre-hospital control was inadequate**, plan for discharge on subcutaneous insulin.

**Insulin Infusion Algorithm #2  
for Critically Ill Intraoperative and ICU Patients  
(Target BG 140-180 mg/dl)**

<b>Type of Patients</b>	Postoperative on clear fluids, continuous enteral or parenteral nutrition
<b>Target Blood Glucose</b>	<ul style="list-style-type: none"> <li>• 140-180 mg/dl</li> </ul>
<b>Frequency of Blood Glucose Monitoring</b>	<ul style="list-style-type: none"> <li>• Every hour</li> </ul>
<b>Diabetes Management Method</b>	<ul style="list-style-type: none"> <li>• IV regular insulin infusion, 250 units regular insulin into 250 cc normal saline (1 unit/ml)</li> </ul>
<b>Manual Calculation of Insulin Infusion Rate</b>	<ul style="list-style-type: none"> <li>• Starting rate for units / hour = (Current BG – 60) x 0.02 (Where 0.02 is the multiplier) <i>Example: Current BG is 210 mg/dl (210 - 60) X 0.02 = 3 units/hour (3 ml/hour)</i></li> </ul>
<b>Manual Adjustment of Insulin Infusion Rate</b>	<ul style="list-style-type: none"> <li>• Adjust multiplier to keep in desired glucose target range (140 - 180 mg/dl)               <ul style="list-style-type: none"> <li>▪ If BG 140-180 mg/dl, no change in multiplier</li> <li>▪ If BG &gt; 180 mg/dl, increase multiplier by 0.01</li> <li>▪ If BG 100-139 mg/dl, decrease multiplier by 0.01</li> </ul> </li> <li><i>Example: Current BG is 220 mg/dl, last multiplier 0.02 units/hr and last rate 2 units/hr (220 - 60) X 0.03 = 4.8 units/hour (4.8 ml/hour)</i> <ul style="list-style-type: none"> <li>▪ If BG &lt;100mg/dl, add dextrose. SEE SECTION BELOW ON TREATMENT OF BLOOD GLUCOSE &lt;100MG/DL</li> </ul> </li> </ul>
<b>Treatment of blood glucose &lt;100 mg/dl</b>	<ul style="list-style-type: none"> <li>• Stop insulin infusion</li> <li>• Administer a bolus of D50, (140 – BG) x 0.4 ml followed by IV infusion of D10W</li> <li>• Check blood glucose in 15 minutes, then every 15-30 minutes until glucose ≥140mg/dl <i>Example: Current BG is 55 mg/dl Give a bolus of (140 - 55) X 0.4 = 34 ml, followed by D10W infusion until blood glucose is 140-180 mg/dl</i></li> <li>• When blood glucose is back ≥140 mg/dl, restart insulin infusion at 50% previous rate</li> </ul>
<b>Transition to Subcutaneous Insulin</b>	<ul style="list-style-type: none"> <li>• Continue IV insulin infusion for 1 hour after starting subcutaneous short acting insulin and 2 hours after starting subcutaneous long acting insulin</li> </ul>

Listed below are two alternative Insulin Infusion Algorithms that can be used for Non-Critically Ill Patients:

**Insulin Infusion Algorithm #1  
for Non-Critically Ill Patients  
(Target BG 100-180 mg/dl)**

Insulin dose adjustments using this algorithm do not replace sound medical judgment. Some evidence suggests a higher incidence of hypoglycemia using these lower glucose targets. There is disagreement among experts about the degree of glycemic control needed to decrease morbidity and mortality while avoiding severe hypoglycemia.

< 100	Hold drip and administer an IV bolus of 25-50grams of 50% glucose followed by IV infusion of D10W and check BG in 15 min then every 15-30 minutes until $\geq 100$ mg/dl and then re-initiate drip at 50% of previous rate							
Current BG level (mg/dl)	Previous Blood Glucose (mg/dl)							
	< 100	100-140	141-180	181-200	201-250	251-300	301-400	>400
100-180	No change			↓ rate by 0.5 units/hr	↓ rate by 50% or 2 units/hr*	↓ rate by 75% or 2 units/hr*		
181-200	↑ rate by 1 unit/hr	↑ rate by 0.5 units/hr		No change		↓ rate by 50% or 2 units/hr*		
201-250	↑ rate by 25% or 2 unit/hr*	↑ rate by 1.0 units/hr	↑ rate by 0.5 unit/hr			No change	↓ rate by 25% or 2 units/hr*	
251-300	↑ rate by 25% or 2 units/hr*		↑ rate by 25% or 1 unit/hr*				↑ rate by 1 unit/hr	No Change
301-350	↑ rate by 33% or 2.5 units/hr*		↑ rate by 25% or 1.5 units/hr*	↑ rate by 25% or 1 unit/hr*	↑ rate by 1 unit/hr	↑ rate by 1.5 units/hr	↑ rate by 25% or 2 units/hr*	No Change
351-399	↑ rate by 40% or 3 units/hr*							
> 400	↑ rate by 50% or 4 units/hr*							

\*Whichever is the greater change

This algorithm assumes hourly BG checks during insulin dose titration.

- If BG 100-180 mg/dl for 2-3 hours, decrease frequency of BG checks to every 2 hours while BG stays in target.
- If experiencing unexplained hypoglycemia or hyperglycemia, investigate and correct causative factors.
- If there is any significant change in glycemic source (i.e., parenteral, enteral or oral intake), expect to make insulin adjustment.

**Common reasons to discontinue insulin infusion:**

- Patient tolerating at least 50% of normal oral intake or enteral feedings
- Clinically appropriate to transfer patient to a unit that does not do insulin infusions
- Patient on stable regimen of TPN with most of insulin already in TPN solution

**One-two hours before discontinuing insulin infusion, initiate alternative glycemic management:**

- **For patients with type 1 diabetes or those with type 2 diabetes previously controlled on insulin:**
  - **If NPO:** initiate basal subcutaneous insulin (glargine, detemir or NPH) at 80% of the insulin administered over the previous 24 hours by insulin infusion. Stop insulin infusion 2 hours after injecting long-acting insulin.

- **If the patient is taking more than 50% of usual oral or enteral intake**, administer 50% of insulin dose as basal based on previous 24 hours of insulin infused or 0.2 units/kg and initiate pre-meal bolus and correction dose to maintain BG in target. If subcutaneous short acting insulin is given, stop insulin infusion 1 hour after injection.
- **Another alternative is to resume pre-hospital insulin regimen.**
- **Insulin pump patients** can resume pump use based on hospital policy.
- **For patients with type 2 diabetes previously treated with oral antidiabetes agents, non-insulin injectables, and/or inhaled insulin:**
  - **If patient had target diabetes control previous to hospitalization**, a return to prior treatment plan may be considered based on postoperative clinical status
  - **If pre-hospital control was inadequate**, plan for discharge on subcutaneous insulin.

**Insulin Infusion Algorithm #2  
for Non-Critically Ill Patients  
(Target BG 100-180 mg/dl)**

<b>Type of Patients</b>	Postoperative on clear fluids, continuous enteral or parenteral nutrition
<b>Target Blood Glucose</b>	<ul style="list-style-type: none"> <li>● <b>100-180 mg/dl</b></li> </ul>
<b>Frequency of Blood Glucose Monitoring</b>	<ul style="list-style-type: none"> <li>● Every hour</li> </ul>
<b>Diabetes Management Method</b>	<ul style="list-style-type: none"> <li>● IV regular insulin infusion, 250 units regular insulin into 250 cc NS (1 unit/ml)</li> </ul>
<b>Manual Calculation of Insulin Infusion Rate</b>	<ul style="list-style-type: none"> <li>● Starting rate in units / hour = <b>(Current BG – 60) x 0.02</b> (Where 0.02 is the multiplier) <i>Example: Current BG is 210 mg/dl (210 - 60) X 0.02 = 3 units/hour (3 ml/hour)</i></li> </ul>
<b>Manual Adjustment of Insulin Infusion Rate</b>	<ul style="list-style-type: none"> <li>● Adjust multiplier to keep in desired glucose target range (100 to 180 mg/dl) <ul style="list-style-type: none"> <li>▪ If BG 100 - 180 mg/dl, no change in multiplier</li> <li>▪ If BG &gt; 180 mg/dl, increase multiplier by 0.01</li> <li>▪ If BG 80-99 mg/dl, decrease multiplier by 0.01</li> </ul> </li> <li><i>Example: Current BG is 200 mg/dl, last multiplier 0.02 units/hr and last rate 2 units/hr (200 - 60) X 0.03 = 4.2 units/hour (4.2 ml/hour)</i></li> <li>● If BG &lt;80mg/dl, add dextrose. SEE SECTION BELOW ON TREATMENT OF BLOOD GLUCOSE &lt;100MG/DL</li> </ul>
<b>Treatment of blood glucose &lt;80 mg/dl</b>	<ul style="list-style-type: none"> <li>● Stop insulin infusion</li> <li>● Administer a bolus of D50, (100 – BG) x 0.4 ml followed by IV infusion of D10W</li> <li>● Check blood glucose in 15 minutes, then every 15-30 minutes until ≥100mg/dl</li> <li><i>Example: Current BG is 55 mg/dl</i> <i>Give a bolus of (100 - 55) X 0.4 = 18 ml, followed by D10W infusion until blood glucose is 100-180 mg/dl</i></li> <li>● When blood glucose is back ≥100 mg/dl, restart insulin infusion at half previous rate</li> </ul>
<b>Transition to Subcutaneous Insulin</b>	<ul style="list-style-type: none"> <li>● Continue IV insulin infusion for 1 hour after starting short acting subcutaneous insulin and 2 hours after starting long acting subcutaneous insulin</li> </ul>



## VII. MANAGEMENT of HYPOGLYCEMIA in the PERIOPERATIVE SETTING

Management of Hypoglycemia in the Perioperative Setting	
<b>Management Method</b>	<ul style="list-style-type: none"> <li>Oral or IV glucose or subcutaneous glucagon</li> </ul>
<b>Frequency of Testing</b>	<ul style="list-style-type: none"> <li>Every 15-30 minutes</li> </ul>
<b>Oral Glucose</b>	<ul style="list-style-type: none"> <li>If patient is conscious and on oral feedings, give 15-20 grams of carbohydrates such as:               <ul style="list-style-type: none"> <li>4 glucose tablets</li> <li>1 tube glucose gel</li> <li>4 oz (1/2 cup) of juice or regular soda</li> <li>3-4 teaspoons of sugar</li> </ul> </li> </ul>
<b>IV Glucose</b>	<ul style="list-style-type: none"> <li>If patient has an IV line and is unconscious or conscious, and not able to take anything by mouth:               <ul style="list-style-type: none"> <li><u>ICU patients on insulin infusion:</u> <ul style="list-style-type: none"> <li>Stop insulin infusion</li> <li>Give a bolus of D50, <math>(140 - BG) \times 0.4</math> ml followed by IV infusion of D10W</li> <li>After reaching the target blood glucose, resume insulin infusion at 1/2 previous rate</li> </ul> </li> <li><u>Patients on subcutaneous insulin and NPO</u> <ul style="list-style-type: none"> <li>Give a bolus of D50, <math>(100 - BG) \times 0.4</math> ml followed by IV infusion of D10W</li> <li>After reaching the target blood glucose, resume insulin regimen after appropriate insulin adjustment if needed</li> </ul> </li> </ul> </li> </ul>
<b>Subcutaneous glucagon injection</b>	<ul style="list-style-type: none"> <li>If patient without IV access, is unconscious or unable to take anything by mouth               <ul style="list-style-type: none"> <li>Give 1cc of glucagon 1mg/ml intramuscular or subcutaneously</li> </ul> </li> </ul>

Approved by Clinical Oversight Committee 11/20/2015

The Working Group for this guideline was led by Osama Hamdy, MD and included Natasha Khazai, MD.

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Glossary		
<b>AACE:</b> American Association of Clinical Endocrinologists	<b>D50: 50% dextrose</b>	<b>LR:</b> lactated ringers
<b>ADA:</b> American Diabetes Association	<b>DM:</b> diabetes mellitus	<b>mg/dl:</b> milligram per deciliter
<b>BG:</b> blood glucose	<b>GLP-1:</b> Glucagon-like peptide-1	<b>ml:</b> milliliter
<b>cc:</b> cubic centimeter	<b>hr:</b> hour	<b>ml/hr:</b> milliliter per hour
<b>CSII:</b> continuous subcutaneous insulin infusion	<b>ICU:</b> intensive care unit	<b>ml/min:</b> milliliter per minute
<b>D5LR:</b> lactated ringers in 5% dextrose	<b>IV:</b> Intravenous	<b>NPO:</b> nothing by mouth
<b>D5W:</b> dextrose in 5% water	<b>kg:</b> kilogram	<b>NS:</b> normal saline
<b>D10W:</b> dextrose in 10% water	<b>LE:</b> lower extremity	<b>TPN:</b> total parenteral nutrition

## Grading System Used in the Guideline

Evidence graded less than “A” is acceptable to support clinical recommendations. It is also assumed that for many important clinical recommendations, it would be unlikely that level A evidence be obtained because appropriate studies may never be performed.

<sup>1</sup>Guyatt G et al. Grading strength of recommendations and quality of evidence in clinical guidelines: Report from an American College of Physicians Task Force. *Chest* 129:174-181, 2006

<b>Grade of Recommendation</b>	<b>Clarity of risk/benefit</b>	<b>Quality of supporting evidence</b>
<b>1A</b> Strong recommendation High quality of evidence	Benefits clearly outweigh risk and vice versa.	Consistent evidence from well performed randomized, controlled trials or overwhelming evidence of some other form. Further research is unlikely to change our confidence in the estimate of benefit and risk.
<b>1B</b> Strong recommendation Moderate quality of evidence	Benefits clearly outweigh risk and burdens, or vice versa.	Evidence from randomized, controlled trials with important limitations (inconsistent results, methodological flaws, indirect or imprecise), or very strong evidence of some other research design. Further research is likely to have an impact on our confidence in the estimate of the benefit and risk and may change the estimate.
<b>1C</b> Strong recommendation Low quality of evidence	Benefits outweigh risk and burdens, or vice versa.	Evidence from observational studies, unsystematic clinical experience, or from randomized controlled trials with serious flaws. Any estimate of effect is uncertain.
<b>2A</b> Weak recommendation High quality of evidence	Benefits closely balanced with risks and burdens.	Consistent evidence from well performed randomized controlled trials or overwhelming evidence of some other form. Further research is unlikely to change our confidence in the estimate of benefit and risk.
<b>2B</b> Weak recommendation Moderate quality of evidence	Benefits closely balanced with risks and burdens; some uncertainty in the estimates of benefits, risks and burdens.	Evidence from randomized controlled trials with important limitations (inconsistent results, methodological flaws, indirect or imprecise), or very strong evidence of some other research design. Further research is likely to have an impact on our confidence in the estimate of benefit and risk and may change the estimate.
<b>2C</b> Weak recommendation Low quality of evidence	Uncertainty in the estimates of benefits, risks and burdens; benefits may be closely balanced with risks and burdens.	Evidence from observational studies, unsystematic clinical experience, or from randomized controlled trials with serious flaws. Any estimate of effect is uncertain.

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