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; updated 04/22/19

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:

- Consider consultation with a diabetes specialist perioperatively.
- **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**. To help insure patient safety once discharged, all patients, while still in the hospital, need assessment of their diabetes knowledge. See Joslin's guideline***:*** ***Uncontrolled Glucose in the Hospitalized Patient*** for more detail.

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, degludec, regular, aspart, glulisine, lispro), insulin via continuous subcutaneous insulin infusion pump (CSII*);* 70/30, 75/25, 50/50 insulin, or inhaled technoshere insulin -and/or oral glucose-lowering-medications and/or pramlintide [1C],except:
    -Discontinue SGLT2 inhibitors, 7 days before and until 7 days after surgery or until medically stable[1B].
    - Discontinue weeklyGLP-1 receptor agonists, 7 days before surgery, or the daily dose the day before surgery [1C].
    -

Evening Prior to Surgery

- **Management of insulin:**
  - **Basal insulin**: Consider a 10-20% reduction in the usual dose of long-acting (glargine, detemir or degludec) insulin. If NPH or U-500 insulin is given at bed time, 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 ½ of the usual morning dose of intermediate (NPH) insulin. If the patient usually takes a dose of long-acting insulin (glargine, degludec 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 ½ 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 (daily GLP1 agonists, and pramlintide) the morning of surgery[1A] (see caveats for SGLT2 inhibitors and long – acting GLP-1 receptor agonists above).**
- **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

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 >4 hours	**Non-Major Surgery** e.g., patient able to consume usual meal plan post operatively			
Start IV Insulin [1A] (*See Pre, Intra and Post Operative IV Insulin Infusion Algorithm pg. 5-8)*	**BG <80 mg/dl** Consider an IV bolus of at least 100 ml of D10W or 25 – 50 grams of D50 ↓ Check BG in 15-30 min. **[1C]**	**BG 80-100 mg/dl** Begin IV of D5W at 40 ml/hour or D10 W at 20 ml/hour ↓ Check BG in 1 hour**[1C]**	**BG 101-180 mg/dl** Continue to monitor blood glucose every 2 hours **[1C]**	**BG >180 mg/dl** Begin IV insulin (*See Pre, Intra and Post Operative IV Insulin Infusion Algorithm pg. 5-8* **or** subcutaneous insulin algorithm pg 4 [**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]**

Closely monitor for DKA regardless of glycemic status, if previously on SGLT-2 inhibitors.

- 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 Algorithm

	Weight Class I (<175 lbs/80 kg)	**Weight Class II (175-220 lbs/81-99 kg)**	**Weight Class III (>220 lbs/100 kg)**
BG (mg/dl)	**Insulin Units (subcutaneously)**	**Insulin Units (subcutaneously)**	**Insulin Units (subcutaneously)**
≤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
  - Do not start or resume SGLT2 inhibitors until 7 days after and medically stable.

- **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

	Weight Class I (<175 lbs/80 kg)	**Weight Class II (175-220 lbs/81-99 kg)**	**Weight Class III (>220 lbs/100 kg)**
BG (mg/dl)	**Insulin Units (subcutaneously)**	**Insulin Units (subcutaneously)**	**Insulin Units (subcutaneously)**
≤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 ≥ 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 in the critical and cardiac surgery patients

- 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 100-150 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
- Do not start or resume SGLT2 inhibitors less until 7 days after and medically stable [1B].
-

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.

<100	• 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 ≥140mg/dl. Once glucose >140mg/dl, re-initiate drip at 50% of the 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**
101-140	↓ rate by 1unit/hr	↓ rate by 25% or 0.5 units/hr*		↓ rate by 50% or 2 units/hr*			↓ rate by 75% or 2 units/hr*	
141-180	No Change				↓ rate by 50% or 2 units/hr*			
181-200	↑ 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*		
201-250	↑ rate by 25% or 2 units/hr*			↑ rate by 25% or 1 unit/hr*			↑ rate by 1 unit/hr	No Change
251-300	↑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

301-400	↑ rate by 40% or 3 units/hr*
>400	↑ rate by 50% or 4 units/hr*

***Whichever is the greater change**

↓

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

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- 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.

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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 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 Critically Ill Intraoperative and ICU Patients (Target BG 140-180 mg/dl)

Type of Patients	Postoperative on clear fluids, continuous enteral or parenteral nutrition
Target Blood Glucose	• 140-180 mg/dl
Frequency of Blood Glucose Monitoring	• Every hour
Diabetes Management Method	• IV regular insulin infusion, 250 units regular insulin into 250 cc normal saline (1 unit/ml)
Manual Calculation of Insulin Infusion Rate	• Starting rate for units / hour = (Current BG – 60) x 0.02 (Where 0.02 is the multiplier) *Example: Current BG is 210 mg/dl (210 - 60) X 0.02 = 3 units/hour (3 ml/hour)*
Manual Adjustment of Insulin Infusion Rate	• Adjust multiplier to keep in desired glucose target range (140 - 180 mg/dl) ▪ If BG 140-180 mg/dl, no change in multiplier ▪ If BG > 180 mg/dl, increase multiplier by 0.01 ▪ If BG 100-139 mg/dl, decrease multiplier by 0.01 *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)* ▪ If BG <100mg/dl, add dextrose. SEE SECTION BELOW ON TREATMENT OF BLOOD GLUCOSE <100MG/DL
Treatment of blood	• Stop insulin infusion

glucose <100 mg/dl	• Administer a bolus of D50, (140 – BG) x 0.4 ml followed by IV infusion of D10W • Check blood glucose in 15 minutes, then every 15-30 minutes until glucose ≥140mg/dl *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* • When blood glucose is back ≥140 mg/dl, restart insulin infusion at 50% previous rate
Transition to Subcutaneous Insulin	• Continue IV insulin infusion for 1 hour after starting subcutaneous short acting insulin and 2 hours after starting subcutaneous long acting insulin

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.

<table>
<tr><td>< 100</td><td colspan="8">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 ≥100 mg/dl and then re-initiate drip at 50% of previous rate</td></tr>
<tr><td rowspan="2">Current BG level (mg/dl)</td><td colspan="8">Previous Blood Glucose (mg/dl)</td></tr>
<tr><td>< 100</td><td>100-140</td><td>141-180</td><td>181-200</td><td>201-250</td><td>251-300</td><td>301-400</td><td>>400</td></tr>
<tr><td>100-180</td><td colspan="3">No change</td><td>↓ rate by 0.5 units/hr</td><td colspan="2">↓ rate by 50% or 2 units/hr*</td><td colspan="2">↓ rate by 75% or 2 units/hr*</td></tr>
<tr><td>181-200</td><td>↑ rate by 1 unit/hr</td><td colspan="2">↑ rate by 0.5 units/hr</td><td colspan="2">No change</td><td colspan="3">↓ rate by 50% or 2 units/hr*</td></tr>
<tr><td>201-250</td><td>↑ rate by 25% or 2 unit/hr*</td><td>↑ rate by 1.0 units/hr</td><td colspan="3">↑ rate by 0.5 unit/hr</td><td>No change</td><td colspan="2">↓ rate by 25% or 2 units/hr*</td></tr>
<tr><td>251-300</td><td colspan="2">↑ rate by 25% or 2 units/hr*</td><td colspan="4">↑ rate by 25% or 1 unit/hr*</td><td>↑ rate by 1 unit/hr</td><td>No Change</td></tr>
<tr><td>301-350</td><td colspan="2">↑rate by 33% or 2.5 units/hr*</td><td>↑ rate by 25% or 1.5 units/hr*</td><td>↑ rate by 25% or 1 unit/hr*</td><td>↑ rate by 1 unit/hr</td><td>↑ rate by 1.5 units/hr</td><td>↑ rate by 25% or 2 units/hr*</td><td>No Change</td></tr>
<tr><td>351-399</td><td colspan="8">↑ rate by 40% or 3 units/hr*</td></tr>
<tr><td>> 400</td><td colspan="8">↑ rate by 50% or 4 units/hr*</td></tr>
</table>

***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)

Type of Patients	Postoperative on clear fluids, continuous enteral or parenteral nutrition
Target Blood Glucose	• **100-180** mg/dl
Frequency of Blood Glucose Monitoring	• Every hour
Diabetes Management Method	• IV regular insulin infusion, 250 units regular insulin into 250 cc NS (1 unit/ml)
Manual Calculation of Insulin Infusion Rate	• Starting rate in units / hour = **(Current BG – 60) x 0.02** (Where 0.02 is the multiplier) *Example: Current BG is 210 mg/dl (210 - 60) X 0.02 = 3 units/hour (3 ml/hour)*
Manual Adjustment of Insulin Infusion Rate	• Adjust multiplier to keep in desired glucose target range (100 to 180 mg/dl) ▪ If BG 100 - 180 mg/dl, no change in multiplier ▪ If BG > 180 mg/dl, increase multiplier by 0.01 ▪ If BG 80-99 mg/dl, decrease multiplier by 0.01 *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)* • If BG <80mg/dl, add dextrose. SEE SECTION BELOW ON TREATMENT OF BLOOD GLUCOSE <100MG/DL
Treatment of blood	• Stop insulin infusion

glucose <80 mg/dl	• Administer a bolus of D50, (100 – BG) x 0.4 ml followed by IV infusion of D10W • Check blood glucose in 15 minutes, then every 15-30 minutes until ≥100mg/dl *Example: Current BG is 55 mg/dl* *Give a bolus of (100 - 55) X 0.4 = 18 ml, followed by D10W infusion until blood glucose is 100-180 mg/dl* • When blood glucose is back ≥100 mg/dl, restart insulin infusion at half previous rate
Transition to Subcutaneous Insulin	• Continue IV insulin infusion for 1 hour after starting short acting subcutaneous insulin and 2 hours after starting long acting subcutaneous insulin

VII. MANAGEMENT OF HYPOGLYCEMIA IN THE PERIOPERATIVE SETTING

Management of Hypoglycemia in the Perioperative Setting	
Management Method	• Oral or IV glucose or subcutaneous glucagon
Frequency of Testing	• Every 15-30 minutes
Oral Glucose	• If patient is conscious and on oral feedings, give 15-20 grams of carbohydrates such as: o 4 glucose tablets o 1 tube glucose gel o 4 oz (1/2 cup) of juice or regular soda o 3-4 teaspoons of sugar
IV Glucose	• If patient has an IV line and is unconscious or conscious, and not able to take anything by mouth: o ICU patients on insulin infusion: ▪ Stop insulin infusion ▪ Give a bolus of D50, (140 – BG) x 0.4 ml followed by IV infusion of D10W ▪ After reaching the target blood glucose, resume insulin infusion at 1/2 previous rate o Patients on subcutaneous insulin and NPO ▪ Give a bolus of D50, (100 – BG) x 0.4 ml followed by IV infusion of D10W ▪ After reaching the target blood glucose, resume insulin regimen after appropriate insulin adjustment if needed
Subcutaneous glucagon injection	• If patient without IV access, is unconscious or unable to take anything by mouth ▪ Give 1cc of glucagon 1mg/ml intramuscular or subcutaneously

Approved by Clinical Oversight Committee 11/20/2015, revised on 04/21/19
The Working Group for this guideline was led by Osama Hamdy, MD and included Natasha Khazai, MD.

Joslin Clinical Oversight Committee	
Om Ganda, MD - Chairperson	Medha Munshi, MD
Richard Beaser, MD	Sethu Reddy, MD
Elizabeth Blair, MS, ANP-BC, CDE	Jo- Anne Rizzotto, MEd, RD, CDE
Cathy Carver, ANP-BC, CDE	Sylvia Rosas, MD
Jerry Cavallerano, OD, PhD	Susan Sjostrom, JD
William Hsu, MD	William Sullivan, MD
Lori Laffel, MD, MPH	Howard Wolpert, MD
Melinda Maryniuk, MEd, RD, CDE	John Zrebiec, LICSW
Joanna Mitri, MD, MS	Robert Gabbay, MD *(ex officio)*
Samar Hafida, MD	

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

Grading System Used in the Guidelines

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.

[1]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

Grade of Recommendation	Clarity of risk/benefit	Quality of supporting evidence
1A Strong recommendation High quality of evidence	Benefits clearly outweigh risk and vice versa.	Consistent evidence from well performed randomized, controlled trails or overwhelming evidence of some other form. Further research is unlikely to change our confidence in the estimate of benefit and risk.
1B 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.
1C 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 trails with serious flaws. Any estimate of effect is uncertain.
2A 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.
2B Weak recommendation Moderate quality of evidence	Benefits closely balanced with risks and burdens; some uncertainly 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.
2C 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 trails with serious flaws. Any estimate of effect is uncertain.

References:

Reviews and consensus statements:

1. American Diabetes Association. Standards of Medical care in diabetes – 2019. *Diabetes Care* 2012 42 Suppl 1:S 90-102.
2. Furnary AP, Cheek DB, Holmes SC, Howell WL, Kelly SP. Achieving tight glycemic control in the operating room: lessons learned from 12 years in the trenches of a paradigm shift in anesthetic care. *Semin Thorac Cardiovasc Surg*. 2006;18:339-345.
3. Griesdale DE, de Souza RJ, van Dam RM. Intensive insulin therapy and mortality among critically ill patients: a meta-analysis including NICE-SUGAR study data. *CMAJ* 2009; 180:821-827.
4. Jacobi J, Bircher N, Krinsley J, Agus M, Braithwaite SS, Deutschman C, Freire AX, Geehan D, Kohl B, Nasraway SA, Rigby M, Sands K, Schallom L, Taylor B, Umpierrez G, Mazuski J, Schunemann H. Guidelines for the use of an insulin infusion for the management of hyperglycemia in critically ill patients. *Crit Care Med*. 2012 40(12):3251-76.
5. Lipshutz, ACM, Gropper, MA *Perioperative Glycemic Control. An Evidence-based Review Anesthesiology 2009; 110: 408-421*3.NICE- SUGAR study Investigators, Finfer S, Chittock DR, Su SY, Blair D, Foster D, Dhingra V et al. Intensive versus conventional glucose control in critically ill patients. *N Engl J Med* 2009; 360(13):1283-1297.
6. Moghissi ES, Korytkowski MT, DiNardo M, Einhorn D, Hellman R, Hirsch IB et al. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. *Diabetes Care* 2009; 32(6):1119-1131.
7. Qaseem A, Humphrey LL, Chou R, Snow V, Shekelle P. Use of intensive insulin therapy for the management of glycemic control in hospitalized patients: a clinical practice guideline from the American College of Physicians. *Ann Intern Med*. 2011;154:260-267.
8. Umpierrez GE, Hellman, R, Korytowski, MT et al Management of Hyperglycemia in Hospitalized Patients in Non-Critical Care Setting: An Endocrine Society Clinical Practice Guideline. *J Clin Endocrinol Metab* 2012; 97: 16-38.
9. Davidson PC, Steed RD, Bode BW, Hebblewhite HR, Prevosti L, Cheekati V. Use of a Computerized Intravenous Insulin Algorithm within a Nurse-Directed Protocol for Patients Undergoing Cardiovascular Surgery. *Journal of diabetes science and technology*. 2008;2(3):369-375.
10. Danne T, Garg S, Peters AL, et al. International Consensus on Risk Management of Diabetic Ketoacidosis in Patients with Type 1 Diabetes Treated with Sodium-Glucose Cotransporter (SGLT) Inhibitors. Diabetes Care 2019:dc182316.

Other studies and reviews:

1. Brunkhorst FM, Engel C, Bloos F, Meier-Hellmann A, Ragaller M, Weiler N et al. Intensive insulin therapy and pentastarch resuscitation in severe sepsis. *N Engl J Med* 2008; 358(2):125-139.
2. Bolk J, van der Ploeg T, Cornel JH, Arnold AE, Sepers J, Umans VA. Impaired glucose metabolism predicts mortality after a myocardial infarction. *Int J Cardiol* 79:207-214, 2001.
3. Browning LA, Dumo P. Sliding-scale insulin: An antiquated approach to glycemic control in hospitalized patients. *Am J Health Syst Pharm* 61:1611-1614, 2004.
4. Butler PC, Elashoff M, Elashoff R, Gale EA. A critical analysis of the clinical use of incretin-based therapies: Are the GLP-1 therapies safe? *Diabetes Care* 2013 Jul;36(7):2118-25.
5. Capes SE, Hunt D, Malmberg K, Gerstein HC. Stress hyperglycemia and increased risk of death after myocardial infarction in patients with and without diabetes: a systematic overview. *Lancet* 355:773-778, 2000.
6. Carr JM, Sellke FW, Fey M, Doyle MJ, Krempin JA, de la Torre R, Liddicoat JR. Implementing tight glucose control after coronary artery bypass surgery. *Ann Thorac Surg* 80:902-909, 2005.
7. Clement S, Braithwaite SS, Magee MF, Ahmann A, Smith EP, Schafer RG, Hirsh IB. Management of diabetes and hyperglycemia in hospitals. *Diabetes Care* 27:553-591, 2004.
8. Davidson PC, Steed RD, Bode BW. Glucommander, a computer-directed intravenous insulin system, shown to be safe, simple, and effective in 120,618 h of operation. *Diabetes Care*. 2005;28(10):2418–2423.
9. Furnary AP, Wu Y, Bookin SO. Effect of hyperglycemia and continuous intravenous insulin infusion on outcomes of cardiac surgical procedures: The Portland Diabetic Project. *Endocr Pract* 10 (suppl 2): 21-33, 2004.
10. Furnary AP, Gao G, Grunkemeier GL,Wu Y, Zerr KJ, Bookin SO, Floten HS, Starr A: Continuous insulin infusion reduces mortality in patients with diabetes undergoing coronary artery bypass grafting. *J Thorac Cardiovasc Surg* 125:1007–1021, 2003

11. Gandhi GY, Nuttall GA, Abel MD, Mullany CJ, Schaff HV, Williams BA, Schrader LM, Rizza RA, McMahon MM. Intraoperative hyperglycemia and perioperative outcomes in cardiac surgery patients. *Mayo Clin Proc* 80:862-866, 2005.
12. Gandhi GY, Nuttall GA, Abel MD, Mullany CJ, Schaff HV, O'Brien PC, Johnson MG, Williams AR, Cutshall SM, Mundy LM, Rizza RA, McMahon MM. Intensive intraoperative insulin therapy versus conventional glucose management during cardiac surgery: a randomized trial. *Ann Intern Med*. 2007 Feb 20;146(4):233-43.
13. Goldberg PA, Siegel MD, Sherwin RS, Halickman JI, Lee M, Bailey VA, Lee SL, Dziura JD, Inzucchi SE. Implementation of a safe and effective insulin infusion protocol in a medical intensive care unit. *Diabetes Care* 27:461-467, 2004
14. Hamdy, O Management of surgical patients with diabetes. In Joslin's Diabetes Handbook. 3rd edition Beaser, RS (Ed); Joslin Diabetes Center 2014, pp 637-658
15. Inzucchi SE, Siegel MD. Glucose control in the ICU--how tight is too tight? *N Engl J Med* 2009; 360(13):1346-1349.
16. Hirsch I. Inpatient diabetes: Review of data from the cardiac care unit. *Endocr Pract* 12:27-34, 2006.
17. Hirsch IB, McGill JB: Role of insulin in management of surgical patients with diabetes mellitus. *Diabetes Care* 13:980–991, 1990
18. Hemmerling TM, Schmid MC, Schmidt J, et al. Comparison of a continuous glucose-insulin-potassium infusion versus intermittent bolus application of insulin on perioperative glucose control and hormone status in insulin-treated type 2 diabetics. *J Clin Anesth.* 2001;13:293-300.
19. Inzucchi SE. Management of hyperglycemia in the hospital setting. *N Engl J Med* 355:1903-11, 2006.
20. Krinsley JS. Effect of an intensive glucose management protocol on the mortality of critically ill adult patients. *Mayo Clin Proc*. 2004 Aug;79(8):992-1000
21. Lazar HL, Chipkin SR, Fitzgerald CA, Bao Y, Cabral H, Apstein CS.Tight glycemic control in diabetic coronary artery bypass graft patients improves perioperative outcomes and decreases recurrent ischemic events. *Circulation*. 2004 Mar 30;109(12):1497-502.
22. Malhotra A. Intensive insulin in intensive care. *N Engl J Med* 354:516-518, 2006.
23. McAlister FA, Man J, Bistritz L, et al. Diabetes and coronary artery bypass surgery: an examination of perioperative glycemic control and outcomes. *Diabetes Care.* 2003;26:1518-1524.
24. Najarian J, Swavely D, Wilson E, Merkle L, Wasser T, Hesener Quinn A, Urffer S, Young M. Improving outcomes for diabetic patients undergoing vascular surgery. *Diabetes Spectr* 18:23-60, 2005.
25. Pittas AG, Siegel RD, Lau J. Insulin therapy and in-hospital mortality in critically ill patients: Systematic review and meta-analysis of randomized controlled trials. *J Parenter Enteral Nutr* 30:164-172, 2006.
26. Pomposelli JJ, Baxter JK 3rd, Babineau TJ, Pomfret EA, Driscoll DF, Forse RA, Bistrian BR: Early postoperative glucose control predicts nosocomial infection rate in diabetic patients. *JPEN J Parenter Enteral Nutr* 22:77– 81, 1998
27. Rosenblatt SI, Duklatz T, Jahn R, Ramsdell C, Sakharova A, Henry M, Arndt-Mutz M, Miller V, Rogers K, Balasubramanian M: Insulin Glargine Dosing before next-day surgery: Comparing three strategies. *J Clin Anesth* 2012 Dec:24(8):610-17
28. Schmeltz LR, DeSantis AJ, Thiyagarajan V, Schmidt K, O'Shea-Mahler E, Johnson D, Henske J, McCarthy PM, Gleason TG, McGee EC, Molitch ME Reduction of surgical mortality and morbidity in diabetic patients undergoing cardiac surgery with a combined intravenous and subcutaneous insulin glucose management strategy. *Diabetes Care.* 2007 Apr;30(4):823-8. Epub 2007 Jan 17.
29. Schricker, Thomas, Lattermann, Ralph, Wykes, Linda, Carli, Franco Effect of IV Dextrose Administration on Glucose Metabolism during Surgery *JPEN: Journal of Parenteral and Enteral Nutrition*, May/Jun 2004
30. Swift CS, Boucher JL. Nutrition therapy for the hospitalized patient with diabetes. *Endocr Pract* 12:61-67, 2006.
31. Umpierrez GE, Isaacs SD, Bazargan N, You X, Thaler LM, Kitabchi AE: Hyperglycemia: an independent marker of in hospital mortality in patients with undiagnosed diabetes. *J Clin Endocrinol Metab* 87:978 –982, 2002
32. Umpierrez GE, Smiley D, Hermayer K, Khan A, Olson DE, Newton C, Jacobs S, Rizzo M, Peng L, Reyes D, Pinzon I, Fereira ME, Hunt V, Gore A, Toyoshima MT, Fonseca VA. Randomized study comparing Basal-bolus with a basal plus correction insulin regimen for the hospital management of medical and surgical patients with type 2 diabetes: basal plus trial. *Diabetes Care* 2013. 36(8):2169-74
33. Umpierrez GE, Smiley D, Jacobs S, Peng L, Temponi A, Mulligan P, Umpierrez D, Newton C, Olson D, Rizzo M. Randomized study of basal-bolus insulin therapy in the inpatient management of patients with type 2 diabetes undergoing general surgery (RABBIT 2 surgery). *Diabetes Care* 2011 34(2):256-61

34. Umpierrez GE, Korytkowski M. Is incretin-based therapiy ready for the care of hospitalized patients with type 2 diabetes?: Insulin therapy has proven itself and is considered the mainstay of treatment. *Diabetes Care* 2013 36(7):2112-7
35. Van den Berghe G, Wilmer A, Hermans G, Meersseman W, Wouters PJ, Milants I, Van Wijngaerden E, Bobbaers H, Bouillon R. Intensive insulin therapy in the medical ICU. *N Engl J Med* 354: 449-461, 2006.
36. Van den Berghe G, et al. Intensive insulin therapy in critically ill patients. *N Engl J Med* 345:1359-1367, 2001.
37. Vanhorebeek I, Langouche L, Van den Berghe G. Intensive insulin therapy in the intensive care unit: Update on clinical impact and mechanisms of action. *Endocr Pract* 12:14-21, 2006.
38. Wiener RS, Wiener DC, Larson RJ. Benefits and risks of tight glucose control in critically ill adults: a meta-analysis. *JAMA* 2008; 300(8):933-944.