Perioperative Glycemic Control Implementation in a Community Hospital

Shaun Sullivan, MD & Janice Whitman, RN MSN CCRN

Perioperative Medical Director & CNS Critical Care, APN

Skagit Valley Hospital

Bellingham Anesthesia Associates
“Public disclosure of the comparative performance of health care providers is one mechanism for improving quality and controlling health care costs”

Before SCOAP
Elective Colorectal Resection, CHARS 2000-2003

17.7 ± 38.2%
After SCOAP
Elective Colorectal Resection CHARS 2006-2009

Percentage of postoperative complications

Hospital sites

9.6±29.4%
Importance of Glucose Control

• Lower infection rates
• Better cardiac performance
• Better neurologic outcomes
• Lower mortality
• Reduced readmissions
• Lower costs
• Improved Patient Satisfaction
Incidence of Inpatient Hyperglycemia

- Hyperglycemia occurred in 38% of hospitalized patients
  - 26% hx of diabetes, 12% had no history of diabetes.
  - 16% mortality rate with no previous hyperglycemia diagnosis.
  - 3% mortality with diabetes history.
  - 1.7% mortality with normoglycemia.
    - $P<.01$
- Longer hospital stays; higher admission rates to intensive care units.
  - Less chance to be discharged to home (required more transitional or nursing home care).
  - Causes: decompensation of DM 1 and 2, Glucocorticoids, vasopressors, stress from illness, injury, infection.

Moghissi, 2009; Umpierrez, 2002
Incidence of severe in-hospital morbidity between patients in whom intraoperative glycemic control was poor (4 consecutive glucose levels > 200 mg/dL) or tight. CV = cardiovascular morbidity; Inf: infectious morbidity; Neuro = neurologic morbidity; Resp = respiratory morbidity. *P<0.05 versus tight control.
Why is Blood Glucose Control so Important in the Perioperative Setting?

Hyperglycemia vs No Hyperglycemia
All Patients

30% of all hyperglycemic patients were not diabetic!

SCOAP data courtesy of Sung (Steve) Kwon
Deep Sternal Wound Infection by Glucose Sextile

P = 0.001

- <150: 0.6%
- 150-175: 0.6%
- 175-200: 1.1%
- 200-225: 1.0%
- 225-250: 2.1%
- >250: 3.7%
Post-Operative Glucose and Mortality for Non-Cardiac Surgical Patients

Frisch, 2010; Adapted from Delllinger, 2011
Portland Diabetic Project Concluded:

- In patients who underwent open heart surgery, hyperglycemia increased the incidence of deep sternal wound infection.
- How much?
  - 2x with BG of 175-225
  - 4x with BG of 225-250
  - 6x with BG >250
Univariate analysis comparing risk of adverse outcome between decreasing incremental mean glucose levels during the initial postoperative period. *$P\leq0.001$ overall between mean glucose levels for each individual outcome. #$P\leq0.001$ between glucose $>200$ mg/dL and glucose $141-170$ mg/dL.. Anesthesiology 2010; 112: 860.

Presented at Washington State Hospital Association Safe Table, April 23, 2014
Graph demonstrating the incidence of perioperative stroke or transient ischemic attack (stroke/TIA), myocardial infarction (MI), or death after CEA as a function of serum glucose level the morning of surgery. The incidence of stroke/TIA, MI, and death were increased (P < 0.05) in patients with preoperative serum glucose greater than 200 mg/dl and greater than 250 mg/dl. Asterisk, P < 0.05. McGirt MJ et al, Neurosurgery 2006
Factors Associated with Surgical Costs

- Reoperation
- In Hospital Mortality
- Infections
- Length of Stay

Presented at Washington State Hospital Association Safe Table on April 23, 2014
1 in 4 Surgery Patients Experiences Hyperglycemia

Demographic > 65 years
1 in 4 will have Diabetes
2 in 4 are Prediabetic

Presented at Washington State Hospital Association Safe Table on April 23, 2014
Pathophysiology of hyperglycemia

- Increased glucose production
- Decreased insulin production
- Insulin resistance
- Receptor defect
IMPLICATIONS OF HYPERGLYCEMIA

- Decreased tissue perfusion
- Impaired metabolism
- Impaired cardiac function
- Decreased wound healing
- Pro-thrombotic state
- Pro-inflammatory state

Braitwaithe, et al. 2008; Adapted from Inzucchi, Magee, & O’ Malley, 2010
‘Stress’ Hyperglycemia—What Happens?

• Cytokines/inflammatory mediators contribute to:
  – Inability of immunoglobulin to bind with surface of invading bacteria so decreased bactericidal capacity
  – Impaired platelet function
  – 54% increased blood stream infections
  – 59% increase acute renal failure requiring dialysis and
  – 50% increase in blood transfusions

• Relative hypoinsulinemia contributes to:
  – Decreased insulin sensitivity.
  – Unrestrained free fatty acids and hepatic fatty acids.
  – Increased ketone bodies and metabolic acidosis.
  – Impaired myocardial contractility and larger infarct sizes.
  – Glycosuria induced osmotic diuresis and extracellular K+ shift.

Berghe, 2001; Goldberg & Inzucchi, 2005
Fig. 1. Pathophysiology of hyperglycemia. Anesthesia, metabolic stress, and critical illness lead to metabolic derangements, resulting in hyperglycemia. Hyperglycemia is associated with increased inflammation, susceptibility to infection, and organ dysfunction.
Increasing Glucose, Worse Outcomes

Postoperative Infection

Composite Adverse Events

![Graph showing the relationship between postoperative glucose levels and adverse events.](image)

- Postoperative Infection: 10.30%
- Composite Adverse Events:
  - <130: 6.50%
  - 130-150: 5.90%
  - 150-180: 6.50%
  - 180-250: 10.30%

Presented at Washington State Hospital Association Safe Table on April 23, 2014
Washington State Hospital Survey March 2014

N = 44 Hospitals

Surgical, Infection Prevention and Quality Leaders
27% report a well established preop system

Screening predominantly DM patients and morning of surgery

Glucose targets reported were highly variable; from less than 125 to less than 250; one site reported target A1c <9.

Who is screened for hyperglycemia before surgery?

- All patients 63%
- Patients with DM 20%
- Patients with risk factors for DM 7%
- No guideline for screening 10%
- Unknown 10%

Presented at Washington State Hospital Association Safe Table on April 23, 2014
Intraoperative

Washington Hospitals
Current Practice

- 23% report well established intraoperative monitoring
- Half report monitoring only for patients with diabetes
- Glucose targets, when established, were highly variable

Who is monitored intra-operatively?

- All patients
- Patients with DM
- Patients with risk factors for DM
- No guideline for screening
- Unknown

Presented at Washington State Hospital Association Safe Table on April 23, 2014
Washington Hospitals
Current Practice

- 27% report a well established postoperative system
- 85% monitor patients postoperatively; primarily those with diabetes
- Glucose targets somewhat variable

Patients Monitored Post-Operatively

- 78% All patients
- 12% Patients with DM
- 7% Risk factors for DM
- 3% No coordinated guideline

Presented at Washington State Hospital Association Safe Table on April 23, 2014
Discharge Instructions at Washington Hospitals

- 15% report a well-established system.
- 73% report no postoperative system.
- 82% provide glycemic instructions at discharge mostly DM.
- 10% instructions at discharge mostly DM.

Patients Who Receive Discharge Instructions

- 67% All patients
- 18% No coordinated guideline
- 10% Risk factors for DM
- 5% Unknown

Risk Factors for DM: Present at Washington State Hospital Association Safe Table on April 23, 2014
Best Practices

Preoperative Screening (prior to day of surgery)

- Check A1c in all patients with known diabetes < 90 days of surgery
- Patients with an A1c of > 8.5 may benefit from further evaluation prior to elective surgery
- Consider checking fasting glucose or A1c in all patients at risk for diabetes or pre-diabetes (i.e. BMI ≥ 30, ≥ 45 years old)
Best Practices
Day of Surgery Monitoring

- Check fasting glucose on all patients with known diabetes on arrival the day of surgery.
- Check fasting glucose in all patients at risk for diabetes or pre-diabetes (i.e. BMI ≥ 30, ≥ 45 years old).
Best Practices
Day of Surgery Protocols

Glucose target:

• On arrival <180mg/dL
• Glucose ≥180mg/dL alone is not a reason to cancel surgery; develop institutional protocol to manage this and any glucose >100
• If acidemia or hyperosmolar in the setting of hyperglycemia, do NOT proceed with surgery unless urgent/emergent
Best Practices
Intraoperative

Monitor glucose after induction and hourly in all patients with diabetes or initial DOS glucose >100mg/dL
Consider rechecking glucose post incision (stress or steroid induced hyperglycemia)
Glucose target: 100-180mg/dL
Rx: Insulin infusion to keep glucose <180mg/dL;
   Do NOT use sliding scale subcutaneous insulin
Develop a clear hypoglycemia protocol for this period
Best Practices
Postoperative – Post Anesthesia Care Unit

Monitoring Glucose on arrival to PACU and hourly in:
All patients with a history of diabetes or BG >140mg/dL on DOS
Consider for any patient at risk for perioperative stress or stress induced hyperglycemia

Rx: Continue insulin infusion if begun intraoperatively
Develop transition protocol from insulin infusion to basal-bolus SQ insulin if infusion will not be continued upon transfer to inpatient unit
Develop a clear hypoglycemia protocol for this period
Best Practices
Discharge

Monitoring
Ensure glucometer for home use
Develop patient specific home monitoring recommendations
Glucose target (consistent with ADA outpatient recommendations)
Premeal 70-130mg/dL; All other glucoses <180mg/dL

Intervention
Ensure patient education
Develop clear and patient friendly discharge instruction sheet
Arrange follow up with primary care provider within 1 week of discharge
Ensure summary of glucose control and goals are communicated to primary care provider and/or other follow-up provider
Diabetes or No Diabetes
In Hospital Mortality

Atlanta Georgia, 2002

- Normoglycemia
- Hyperglycemia DM
- Hyperglycemia NonDM

Washington State, 2013

- Normoglycemia
- Hyperglycemia DM
- Hyperglycemia NonDM

Presented at Washington State Hospital Association Safe Table on April 23, 2014

J Clin Endocrinol Metab. 2002;87:978-982.
Insufficient evidence to suggest delaying surgery for hyperglycemia alone.

Consider optimizing preoperative glucose for patients with A1c >8.5 or frequent glucooses ≥ 180mg/dL.

Glucose <180mg/dL
Targets
Best Practices-Intraoperative

Glucose ≥ 180 mg/dL
Glucose 140-180 mg/dL
Glucose 100-180 mg/dL

Presented at Washington State Hospital Association Safe Table on April 23, 2014
Targets
Best Practices - Postoperative

Glucose ≥ 180 mg/dL
Glucose 140-180 mg/dL
Glucose 100-180 mg/dL

Presented at Washington State Hospital Association Safe Table on April 23, 2014
What is a reasonable blood glucose target?

- 80-110 mg/dl in ICU patients.
  

- 100-180 mg/dl most perioperative patients
Is strict control dangerous?

- Desai SP et al. 2012; “liberal vs strict control”:
  
  Strict control = 90-120 mg/dl
  Liberal control = 120-180 mg/dl

Liberal control not inferior for negative outcomes.

↑ hypoglycemia (< 60 mg/dl) in strict control group, but no difference in severe hypoglycemia (< 40 mg/dl)
NICE-SUGAR trial 2009

- > 6000 pts
- ICU pts assigned to strict control (80-108mg/dl) vs liberal control (< 180 mg/dl)
- Severe hypoglycemia (< 40 mg/dl): 6.8% Strict control group 0.5% Liberal group.

However other outcomes were no different.
What is the best way to deliver insulin?

- SQ vs IV—is your institution using SQ insulin in the OR?
Why is glucose control so hard in the OR?

- Lack of knowledge about diabetes/glycemic control
- Lack of education about basic treatment facts
  - Do you flush your insulin tubing or just start insulin running?
  - Do you bolus with regular insulin prior to beginning a drip?
- Historical task prioritization in the OR (Glucose control as important as BP, Temp Control)
- POC glucose testing cumbersome, time consuming
- Lag time between glucose measurement and Rx
Fear of overtreatment—e.g. hypoglycemia

Perioperative Patients are more insulin resistant:
- Stress hormone release (epi, norepi, cortisol, etc)
- Delivery of exogenous catecholamines is common (ephrine, epi, dopamine, etc)
- Underlying conditions (e.g. infection) leading to surgery predispose to insulin resistance
- Anesthetic agents may induce insulin resistance (e.g. sevoflurane, isoflurane induce insulin resistance in pigs)—and yet may have an overall positive effect by lowering stress hormone levels.

Presented at Washington State Hospital Association Safe Table, April 23, 2014
What do we know about glucose management in the OR?

• Do anesthesiologists follow established protocols in testing and treating hyperglycemia in the OR?
• Are established protocols for glucose management in the OR effective?
• Kelly and Nair Studies
Intra-operative Glucose Control Period

- Measure BG at induction and 1h into case.
  - Anesthesia associated with hyperglycemia even in non-diabetic subjects.
- Measure BG every 1h in Type 1 DM patients.
- Method of glycemic control intra-operatively.
  - IV insulin (DM1, critically ill, neurosurgery, TBI).
  - Basal insulin with bolus correction doses.
  - Some hospitals have placed glucometers on every anesthesia cart.

Wisse, 2012
Kelly Study

UWMC 2007 - retrospective chart review of pts at with diabetes undergoing surgery to determine blood glucose levels and compliance of anesthesia providers to treat intraoperative glucose. Both SQ and IV insulin regimens were in use at the time.
Kelly Study

• >250 charts reviewed
• < 25% of anesthesia providers used insulin in OR
  • Few patients hit target range of < 200 mg/dl
• In all patients treated (>200 cases reviewed), only 2 patients reached hypoglycemia
  • Both patients had been treated with SQ insulin.
• Why does this make sense?

Presented at Washington State Hospital Association Safe Table, April 22, 2014.
Nair Study #1

- Used a customized alert system in the AIMS record keeper to nudge anesthesia Providers to check a blood glucose level within ½ hour of start of surgery, & hourly thereafter (15 min grace period allowed)
- Compliance with glucose testing and compliance with a standard IV insulin Protocol were measured before and after institution of the alert system
Compliance with glucose testing improved from 52.6% to 72.1% with the SAM alert system.

Compliance with glucose testing was much higher in cases where SAM was enabled (81%) than when the provider disabled the SAM alert (57.4%).

However, correct insulin dosing only improved from 13.5% to 24.4%—less than ¼ of patients received appropriate treatment.

Target glucose levels did not improve significantly.
Physiologic Insulin Secretion: Basal/Bolus Concept

Nutritional Insulin

Breakfast    Lunch            Supper

Insulin (µU/mL)

Basal Glucose

Glucose (mg/dL)

Nutritional Glucose

The 50/50 Rule

Suppresses Glucose Production Between Meals & Overnight

Adapted from Maynard & Wesorick, Society of Hospital Medicine, 2008
Current Best Practices

- Insulin infusion:
  - If NPO and unstable.
- Basal insulin:
  - Covers the baseline insulin needs.
  - Essential for all type 1 diabetics to prevent ketosis.
  - In most cases should be given even if patient is NPO.
- Nutritional insulin:
  - Covers increases in serum glucose after caloric intake.
- Correctional insulin:
  - Additional to scheduled nutritional dose.

Wisse, 2012
Adapted from Whitman, 2012 WSHA Webcast
STOP
Oral Hypoglycemic Agents
Why Not Sliding Scale?

BG (mg/dL)

Adapted from Whitman, 2012 WSHA Webcast
Pitfalls of Sliding Scale protocols

• Reactive rather than proactive.
• Problems: stacking, hypoglycemia and hyperglycemia more common.
• Nocturnal hypoglycemia and rebound hyperglycemia.
• Greater glucose variability.

Pre-Operative Period

- ALL patients with a blood glucose of 180mg/dl and greater.
- Regardless of diabetes diagnosis or not.
- NOT to be used on OB patients, 23 hour admits or those admitted with DKA or HHS (hyperglycemic crises)

Review the protocol
Perioperative Glycemic Control Algorithm
Skagit Valley Hospital

General Goals of perioperative glycemic control:
1. BG 80-180
2. Prevention of ketoacidosis, marked hypoglycemia or hyperglycemia
3. Maintenance of fluid and electrolyte balance

Preoperative Evaluation:
1. Determination of type of diabetes: - Undiagnosed Diabetes, Type 2 diet controlled, Type 2 - oral hypoglycemics, Insulin using Type 1 or 2, Stress induced
2. Assess glycemic control: HbA1C, frequency of monitoring, average BG, range of BG levels
3. Detailed history of diabetes therapy, including type of medication, dosing, and timing.
4. Other pharmacologic therapy, including type of medication, dosing, and specific timing.
5. Consider length of surgery, minor or major, how long NPO, bowel prep, time of day - first case or later in day, and duration of the procedure.
6. Regional/neuraxial block may reduce cortisol/BG
7. Medications may increase BG - i.e. Decadron

Monitoring all Diabetics: Check Preop BG and q HR

Type 2 diet controlled
BG > 130

Type 2 diabetes treated with oral hypoglycemic agents:
Morning of surgery:
hold their oral hypoglycemic and noninsulin injectable drugs.
HbA1C < 6.5 may not need insulin for short surgical procedures.
HbA1C > 7.5 or long or major surgical procedures, generally require SQ or IV insulin

Type 1 or Insulin using type 2 diabetic patients:
Patients able to eat after surgery:
Patients may delay taking their usual morning insulin until after the surgery and before eating.
Patients not likely to eat after surgery:
Basal Insulin Needs:
Omit any short-acting insulin on the morning of surgery.
Pt to take ½ of their usual total morning insulin dose (both long, short and intermediate insulin) as intermediate (NPH) or long-acting (Lantus) insulin
Insulin Pump Pt: Preferable to start a non DKA IV-insulin infusion protocol at the same rate as the basal rate for the patient’s insulin pump, and turn off the patients insulin pump. Or use Pt pump at basal rate.

Sliding Scale Insulin
(used short acting: glulisine, lispro, aspart, not regular)

<table>
<thead>
<tr>
<th>(mg/dL)</th>
<th>Usual</th>
<th>Insulin sensitive</th>
<th>Insulin resistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>150-200</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>201-250</td>
<td>4</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>251-300</td>
<td>6</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>301-350</td>
<td>8</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>351-400</td>
<td>10</td>
<td>5</td>
<td>20</td>
</tr>
</tbody>
</table>

Insulin types:
Short acting Insulins: Glulisine (Apidra), Lispro (Humalog), Aspart (Novolog), Regular, etc.
Intermediate Insulins: NPH, etc.
Long-acting Insulins: Lantus (Glargine), Leemir (Detemir)

BG <150 on multiple tests
BG < 180 on a single test, and not quickly corrected with SC insulin,
Long/complex cases
Prolonged NPO post op

Transition IV to SQ insulin orders

IV Insulin Infusion Pump Orders
Start D5½ NS @ 100 cc per hour.
Transition Algorithm

- Transition any time of day.
- Give basal insulin 2hrs before stopping IV gtt
- TDD of SC basal insulin = IV units insulin used last 4 hrs x 5.
- Also give nutritional insulin if timing with a meal.

**Transition Algorithm**

**Blood Glucose (BG) Goals:**
- Pre-meal Goal: 90-150mg/dL or
- Goal Postprandial BG: 
- Goal HgbA1C
- Goal for BG @ 3 am

**Blood Glucose (BG) Monitoring Frequency:**
- Before meals & at bed time
- 2 hours after meals
- 2-3AM

- If transitioning from IV insulin see Transition Protocols

**Basal Insulin:**

<table>
<thead>
<tr>
<th>Meal</th>
<th>Nutritional</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Breakfast</td>
<td>Glulisine (Apidra)</td>
<td></td>
</tr>
<tr>
<td>Post-Lunch</td>
<td>Glulisine (Apidra)</td>
<td></td>
</tr>
<tr>
<td>Post-Dinner</td>
<td>Glulisine (Apidra)</td>
<td></td>
</tr>
<tr>
<td>Bedtime</td>
<td>Glulisine (Apidra)</td>
<td></td>
</tr>
</tbody>
</table>

**Correction Algorithm for Hyperglycemia:**
To be administered IN ADDITION TO the scheduled insulin dose to correct pre-meal BG.
- Administer correctional insulin immediately post meal
- Give full dose if 50-100% of meal eaten
- Give half dose if less than 50% of meal eaten
- If BG check is every 6 hours for NPO patient, use the pre-meal Algorithm Insulin doses
- Correction insulin type will be the same type as nutritional insulin

MANDATORY BG CHECK AT 3AM IF BEDTIME CORRECTIONAL INSULIN GIVEN. IF 3AM BG > 150mg/d USE BEDTIME BG DOSING

**Hypoglycemia Protocol for blood glucose less than 70mg/dL:**
A. If pt can take PO, give 15 grams of fast-acting carbohydrate (120mL apple/orange juice, 240mL nonfat milk)
B. If pt cannot take PO, give 25mL of D50 as IV push
C. Check finger-stick glucose every 15-20 minutes until BG above 100mg/dL

**Attention Physician:**
All must be checked to initiate order

**HgbA1C**

**Blood Glucose (BG) Goals:**
- Pre-meal Goal: 90-150mg/dL
- Goal Postprandial BG: 
- Goal for BG @ 3 am

**Blood Glucose (BG) Monitoring Frequency:**
- 2 hours after meals
- 2-3AM

**Transition Algorithm**

<table>
<thead>
<tr>
<th>Blood Glucose (BG)</th>
<th>Additional Insulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>150-199</td>
<td>1 unit</td>
</tr>
<tr>
<td>200-249</td>
<td>2 units</td>
</tr>
<tr>
<td>250-299</td>
<td>3 units</td>
</tr>
<tr>
<td>300-349</td>
<td>4 units</td>
</tr>
<tr>
<td>greater than 349</td>
<td>5 units</td>
</tr>
<tr>
<td>Bedtime / 3am BG</td>
<td>Additional Insulin</td>
</tr>
<tr>
<td>150-199</td>
<td>None</td>
</tr>
<tr>
<td>200-249</td>
<td>1 unit</td>
</tr>
<tr>
<td>250-299</td>
<td>2 units</td>
</tr>
<tr>
<td>300-349</td>
<td>3 units</td>
</tr>
<tr>
<td>4 units greater than 349</td>
<td></td>
</tr>
</tbody>
</table>

**LOW DOSE ALGORITHM**

<table>
<thead>
<tr>
<th>Blood Glucose (BG)</th>
<th>Additional Insulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>150-199</td>
<td>1 unit</td>
</tr>
<tr>
<td>200-249</td>
<td>3 units</td>
</tr>
<tr>
<td>250-299</td>
<td>5 units</td>
</tr>
<tr>
<td>300-349</td>
<td>8 units</td>
</tr>
<tr>
<td>greater than 349</td>
<td>10 units</td>
</tr>
<tr>
<td>Bedtime / 3am BG</td>
<td>Additional Insulin</td>
</tr>
<tr>
<td>150-199</td>
<td>None</td>
</tr>
<tr>
<td>200-249</td>
<td>2 units</td>
</tr>
<tr>
<td>250-299</td>
<td>3 units</td>
</tr>
<tr>
<td>300-349</td>
<td>5 units</td>
</tr>
<tr>
<td>4 units greater than 349</td>
<td></td>
</tr>
</tbody>
</table>

**MEDIUM DOSE ALGORITHM**

<table>
<thead>
<tr>
<th>Blood Glucose (BG)</th>
<th>Additional Insulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>150-199</td>
<td>1 unit</td>
</tr>
<tr>
<td>200-249</td>
<td>3 units</td>
</tr>
<tr>
<td>250-299</td>
<td>5 units</td>
</tr>
<tr>
<td>300-349</td>
<td>7 units</td>
</tr>
<tr>
<td>greater than 349</td>
<td>9 units</td>
</tr>
<tr>
<td>Bedtime / 3am BG</td>
<td>Additional Insulin</td>
</tr>
<tr>
<td>150-199</td>
<td>None</td>
</tr>
<tr>
<td>200-249</td>
<td>2 units</td>
</tr>
<tr>
<td>250-299</td>
<td>3 units</td>
</tr>
<tr>
<td>300-349</td>
<td>5 units</td>
</tr>
<tr>
<td>4 units greater than 349</td>
<td></td>
</tr>
</tbody>
</table>

**INDIVIDUALIZED ALGORITHM**

<table>
<thead>
<tr>
<th>Blood Glucose (BG)</th>
<th>Additional Insulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>150-199</td>
<td>1 unit</td>
</tr>
<tr>
<td>200-249</td>
<td>3 units</td>
</tr>
<tr>
<td>250-299</td>
<td>5 units</td>
</tr>
<tr>
<td>300-349</td>
<td>7 units</td>
</tr>
<tr>
<td>greater than 349</td>
<td>9 units</td>
</tr>
<tr>
<td>Bedtime / 3am BG</td>
<td>Additional Insulin</td>
</tr>
<tr>
<td>150-199</td>
<td>None</td>
</tr>
<tr>
<td>200-249</td>
<td>2 units</td>
</tr>
<tr>
<td>250-299</td>
<td>3 units</td>
</tr>
<tr>
<td>300-349</td>
<td>5 units</td>
</tr>
<tr>
<td>4 units greater than 349</td>
<td></td>
</tr>
</tbody>
</table>

Hypoglycemia Protocol for blood glucose less than 70mg/dL
A. If pt can take PO, give 15 grams of fast-acting carbohydrate (120mL apple/orange juice, 240mL nonfat milk)
B. If pt cannot take PO, give 25mL of D50 as IV push
C. Check finger-stick glucose every 15-20 minutes until BG above 100mg/dL

Date: ____________________________  Time: ____________________________  Provider Signature: ____________________________
Post-Operative Period

- Initiate for BG >140mg/dL x2 or >180mg/dL x 1
- Goal range 110-180 mg/dL
- Standard infusions are regular insulin 100units/100 mLs in a dedicated line
## Signs and Symptoms of Hypoglycemia

| · Sweating | · Anxiety | · Confusion |
| · Hunger   | · Dizziness | · Tachycardia |
| · Irritability | · Shakiness | · Trembling |
| · Pallor   | · Headache | · Weakness |

Hypoglycemia can occur without symptoms, so it is important to check blood glucose levels regularly.

Adapted from Whitman, 2012 WSHA Webcast
Treating Hypoglycemia: 3 Steps

Give 15g of glucose or another fast-acting carbohydrate

- 4oz (1/2 cup) fruit juice
- 8 oz (1 cup) milk
- 1 Tbsp honey
- IV Dextrose

Wait 15 mins

Recheck BG – give another 15g if necessary

* Assess for cause

Goal to restore BG above 100
Avoid overtreatment (excessive amount of glucose), which may result in significant hyperglycemia over next 4-6 hrs.

Adapted from Whitman, 2012 WSHA Webcast
Key to Success

- Engage and educate clinicians on importance of managing glucose in both diabetic and non-diabetic patients having surgery.
- Start with one type of surgery such as colorectal and then spread to other surgeries.
- Ensure glucose is in good control prior to arrival for surgery. (Strong for Surgery)
- Implement policies, procedures, and order sets to identify and treat blood glucose levels greater than 180 mg/dl in the perioperative period.
- Monitor surgical site infection data and blood glucose data to evaluate compliance with these practices. Discuss in forums from board to unit based meetings.
Summary

- Hyperglycemia and diabetes are common perioperatively, each independently associated with worse outcomes
- Treatment with insulin improves outcomes
- Preoperatively optimize if time allows
- Intraoperatively minimize hyperglycemia
- Postoperatively maintain euglycemia (100-180mg/dL)
- At discharge, re-evaluate the best home regimen, provide targeted education