Diabetes, Glucose Control, and SSIs
After Median Sternotomy

Latham. ICHE 2001; 22: 607-12
Hyperglycemia and Risk of SSI after Cardiac Operations

No increased risk:
- Elevated HgbA1c
- Preoperative hyperglycemia

Increased risk:
- Diagnosed diabetes
- Undiagnosed diabetes
- Post-op glucose > 200 mg% within 48h

Hyperglycemia and Risk of SSI after Cardiac Operations

- Hyperglycemia - doubled risk of SSI
- Hyperglycemic:  
  48% of diabetics  
  12% of nondiabetics  
  30% of all patients
- 47% of hyperglycemic episodes were in nondiabetics

Deep Sternal SSI and Glucose

Glucose Control and Deep Sternal Wound Infections

Glucose Control and Mortality after CABG in 3554 Diabetics

Early (48h) Postoperative Glucose Levels and SSI after Vascular Surgery

Perioperative Hyperglycemia in Noncardiac Surgical Patients: Does it Increase Postoperative Infections?

Postop inf = pneumonia, SSI, UTI, sepsis within 30 d

Variables = postop gluc, age, race, diabetes, ASA, emergent, op duration, transfusion

Significant: postop gluc > 180 O.R.=2.03
  gluc increase of 40 O.R.=1.9
  ASA & emergent

Mastectomy, Hyperglycemia, and SSI

260 patients, 5 glucose determinations (pre-op, at anesthesia induction, intra-op, in PACU, at 24 hrs)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds Ratio</th>
<th>C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 50</td>
<td>3.7</td>
<td>(1.5-9.2)</td>
</tr>
<tr>
<td>Pre-Op ChemoRads</td>
<td>2.8</td>
<td>(1.4-5.8)</td>
</tr>
<tr>
<td>Any gluc ≥ 150 mg%</td>
<td>2.9</td>
<td>(1.2-6.2)</td>
</tr>
</tbody>
</table>

Villar-Compte. AJIC 2008; 36:192-8
Postop Glucose (within 48h) and SSI

Relative Risk

Glucose

3 - Glucose Control

Proven important for SSI risk:
- Cardiac surgery
- General surgery
- Colorectal surgery
- Vascular surgery
- Breast surgery
- Hepato-pancreatico-biliary surgery
- Orthopedic surgery
- Trauma surgery
Postoperative Glucose and Mortality in Noncardiac Surgery

Hyperglycemia in non-diabetic patients was more dangerous than hyperglycemia in diabetics!

Frisch. Diabetes Care. 2010; 33: 1883-8
### Rabbit 2 Study – Surgery
Basal/Bolus vs Sliding Scale Insulin

<table>
<thead>
<tr>
<th></th>
<th>Basal Bolus</th>
<th>Sliding Scale</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>104</td>
<td>107</td>
<td></td>
</tr>
<tr>
<td>Mean Fasting</td>
<td>155</td>
<td>167</td>
<td>0.04</td>
</tr>
<tr>
<td>Mean Daily</td>
<td>157</td>
<td>176</td>
<td>0.001</td>
</tr>
<tr>
<td>Readings &lt; 140</td>
<td>53%</td>
<td>31%</td>
<td>0.001</td>
</tr>
<tr>
<td>Wound infections</td>
<td>3</td>
<td>11</td>
<td>0.05</td>
</tr>
<tr>
<td>Any complication</td>
<td>9</td>
<td>26</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Umpierrez. Diabetes Care 2011; 34: 256-61
SCOAP Data on Perioperative Glucose Levels and Insulin Use

11,630 patients from 2005-2010 with
  Bariatric operation (5360)
  Colectomy (6273)
Who either
  Experienced hyperglycemia [glucose > 180] (3383)
  Or did not (8247)
During the perioperative period or on
  POD 1 or POD 2

SCOAP data courtesy of Sung (Steve) Kwon
SCOAP Data on Perioperative Glucose Levels and Insulin Use

Diabetic pts 4098 (35%)
  Hyperglycemic 2369 (58%)

Nondiabetic pts 7532 (65%)
  Hyperglycemic 1014 (13%)

30% of all hyperglycemic patients were not diabetic!

SCOAP data courtesy of Sung (Steve) Kwon
Composite Infection
Hyperglycemia vs No Hyperglycemia
All Patients

SCOAP data courtesy of Sung (Steve) Kwon
Composite Infection
Hyperglycemia vs No Hyperglycemia
Diabetic Patients

SCOAP data courtesy of Sung (Steve) Kwon
Composite Infection
Hyperglycemia vs No Hyperglycemia
Nondiabetic Patients

SCOAP data courtesy of Sung (Steve) Kwon
Composite Infection in Hyperglycemic Patients With and Without Use of Insulin

SCOAP data courtesy of Sung (Steve) Kwon
Operative Reintervention in Hyperglycemic Patients With and Without Use of Insulin

SCOAP data courtesy of Sung (Steve) Kwon
Mortality in Hyperglycemic Patients With and Without Use of Insulin

SCOAP data courtesy of Sung (Steve) Kwon
Glucose Control

Proven important for SSI risk:
- Cardiac surgery
- General surgery
- Colorectal surgery
- Vascular surgery
- Breast surgery
- Hepato-pancreatico-biliary surgery
- Orthopedic surgery
- Trauma surgery
Glucose Levels & SSI

- The exact “best” level of glucose control in the perioperative period is not known.
- High glucose levels unequivocally increase the risk of SSI and other perioperative infections.
- Tight glucose control in the perioperative period is tricky.
- Hypoglycemia increases the risk of morbidity and mortality.
- Some examples of successful glucose control programs follow.
GLUCOSE CONTROL ALGORITHMS

The Rabbit 2 basal bolus protocol is online at

The Society of Hospital Medicine Glycemic Control Resource room contains links to multiple insulin infusion protocols at
http://www.hospitalmedicine.org/ResourceRoomRedesign/html/12Clinical_Tools/04_Insulin_OrdersIV.cfm
## Rabbit 2 Protocols

### 1. Basal Bolus Regimen with Insulin Glargine and Glulisine

#### 1.A. Insulin Orders

- Discontinue oral antidiabetic drugs (sulfonylureas, repaglinide, nateglinide, metformin, pioglitazone, rosiglitazone, sitagliptin) and non-insulin injected antidiabetic medication (pramlintide, exenatide) on admission.

- Starting insulin total daily dose (TDD): 0.5 units per kg of body weight.
  - Reduce insulin TDD to 0.3 units per kg of body weight in patients ≥ 70 years of age and/or with a serum creatinine ≥ 2.0 mg/dL.

- Give half of total daily dose as insulin glargine and half as insulin glulisine.

- Give insulin glargine once daily, at the same time of the day.

- Give insulin glulisine in three equally divided doses before each meal. Hold insulin glulisine if patient not able to eat.
### Rabbit 2 Protocols

#### 1.B. Supplemental insulin

- Give supplemental insulin glulisine following the “sliding scale” protocol (1E) for blood glucose > 140 mg/dl.

- If a patient is able and expected to eat all, give supplemental glulisine insulin before each meal and at bedtime following the “usual” column.

- If a patient is not able to eat, give supplemental glulisine insulin every 6 hours (6-12-6-12) following the “sensitive” column.
## Rabbit 2 Protocols

### 1.C. Insulin adjustment

- If the fasting and predinner BG is between 100 - 140 mg/dl in the absence of hypoglycemia the previous day: no change
- If the fasting and predinner BG is between 140 - 180 mg/dl in the absence of hypoglycemia the previous day: increase insulin TDD by 10% every day
- If the fasting and predinner BG is >180 mg/dl in the absence of hypoglycemia the previous day: increase insulin TDD dose by 20% every day
- If the fasting and predinner BG is between 70 - 99 mg/dl in the absence of hypoglycemia: decrease insulin TDD dose by 10% every day
- If a patient develops hypoglycemia (BG <70 mg/dL), the insulin TDD should be decreased by 20%.

### 1.D. Blood glucose monitoring

Blood glucose will be measured before each meal and at bedtime (or every 6 hours if a patient is not eating) using a glucose meter.
### 1.E. Supplemental Insulin Scale

<table>
<thead>
<tr>
<th>Blood Glucose (mg/dL)</th>
<th>Insulin Sensitive</th>
<th>Usual</th>
<th>Insulin Resistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>141-180</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>181-220</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>221-260</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>261-300</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>301-350</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>351-400</td>
<td>12</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>&gt; 400</td>
<td>14</td>
<td>16</td>
<td>18</td>
</tr>
</tbody>
</table>

**Check appropriate column below and cross out other columns**

The numbers in each column indicate the number of units of glulisine or regular insulin per dose. Supplemental” dose is to be added to the scheduled dose of glulisine or regular insulin.
I.V. Insulin Infusion Protocol

CONSULT ENDOCRINE SERVICE FOR:
- Acute Care patients on insulin infusion receiving oral nutrition or intermittent tube feeding

GOAL Blood Glucose (BG) RANGE:

ACUTE CARE OR ICU: 100-180 mg/dL initiate when ordered
ICU ONLY: 100-140 mg/dL initiate when BG>140 x 2
- Discontinue all previous insulin orders.
- Insulin Infusion: 100 units insulin/100 mL NS given IV infusion, at:
  - Algorithm 1: Start here for most patients.
  - Algorithm 2: Start here if S/P CABG surgery, solid organ transplant, receiving glucocorticoids, or patient receiving >80 units/day of insulin as an outpatient.
- NO PATIENT STARTS AT ALGORITHM 3 OR 4.

See back of form for the Algorithms and decision tree
When transitioning to SubQ: Use www.uwmedres.org/resources for dosing assistance: Give specified basal SubQ insulin dose, and then stop insulin infusion in 2 hours.

Fluid/Nutrition Orders:
Recommendations for patients that are not eating:

- **DM Type 1** (10 grams glucose/hour) **DM Type 2** (5 grams glucose/hr)
  - D51/2 normal saline with_______ mEq/L Potassium chloride IV at ______________mL/hr
  - D5LR with_______ mEq/L Potassium chloride IV at ______________mL/hr
  - TPN or Enteral Feeds (see separate orders)
  - Other ____________________________ at __________mL/hr
Patient Monitoring:

- Check BG every 1 hour until it is within goal range for 4 hours. Then decrease BG checks to every 2 hours. ALWAYS resume hourly checks if BG exits goal range.
- Hourly monitoring may be indicated for critically ill patients or patients having medical or surgical procedures even if they have stable BG.

Notify the Provider:

- For any BG increase >100 mg/dL from a stable baseline
- For 2 consecutive BG decreases of >100 mg/dL
- For any hypoglycemia which results in loss of consciousness OR does not resolve within 20 min of implementing the hypoglycemia protocol below

Treatment of Hypoglycemia (BG <70 mg/dL) or symptoms of hypoglycemia

- Turn off insulin infusion for any BG below goal AND
- Give 25 mL (1/2 amp) of 50% dextrose IV if BG 50-69 mg/dL OR
- Give 50 mL (1 amp) of 50% dextrose IV if BG < 50 mg/dL.
- Recheck BG every 20 minutes until BG ≥100 mg/dL
  - IF BG is <70 mg/dL repeat 25 mL (1/2 amp) 50% dextrose
  - WHEN BG is ≥100 mg/dL, restart the insulin infusion at a lower dose by using one algorithm LEFT from previous algorithm (see “Evaluating Trends & Using Algorithms” section).
**BG monitoring**: Check BG every 1 hour until it is within goal range for 4 hours. Then decrease BG checks to every 2 hours. ALWAYS resume hourly checks if BG exits goal range and when there is a change in algorithm. Check BG in 20-30 minutes as noted below. Hourly monitoring may be indicated for critically ill patients or patients having medical or surgical procedures even if they have stable BG.
I.V. Insulin Infusion Protocol

Insulin Infusion Algorithm Decision Tree

Blood Glucose in Goal Range?

Yes
Was decrease more than 30 mg/dL OR previous BG below goal range?

No

Above Goal Range

BG decreased > 75

BG decreased 50-75

BG increased by any amt. or decreased <50

Below Goal Range and Hypoglycemia

TURN OFF insulin infusion

- For BG 70-99 No dextrose
- For BG 50-69 Give 25mL (½ amp) 50% dextrose
- For BG < 50 Give 50mL (1 amp) 50% dextrose

Recheck BG in 20-30 min.

When BG has increased to goal range, move LEFT one algorithm. Adjust rate to match BG range

If TPN/ Enteral nutrition is stopped or significantly reduced, decrease insulin infusion rate by moving LEFT one algorithm. Then, use algorithm table & instructions to determine subsequent rate changes AND check BG every 1 hour x 4 hours.

Once within goal range for 4 hrs, check BG q2hr. Do NOT adjust rate unless BG < 110 or > 180

Adjust rate hourly to match BG range in current algorithm until BG is in goal range X 4 hrs

Move LEFT one algorithm and adjust rate to match BG range

Recheck BG in 20-30 minutes if BG decreased > 100 mg/dL

Move LEFT one algorithm and adjust rate to match BG range in current algorithm

Move RIGHT one algorithm and adjust rate to match BG range

Move LEFT one algorithm and adjust rate to match BG range
I.V. Insulin Infusion Protocol

<table>
<thead>
<tr>
<th>Algorithm 1</th>
<th>Algorithm 2</th>
<th>Algorithm 3</th>
<th>Algorithm 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG</td>
<td>Unit/hr</td>
<td>BG</td>
<td>Units/hr</td>
</tr>
<tr>
<td>100-120</td>
<td>0.5</td>
<td>100-120</td>
<td>1</td>
</tr>
<tr>
<td>121-140</td>
<td>0.8</td>
<td>121-140</td>
<td>1.5</td>
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<tr>
<td>141-160</td>
<td>1.2</td>
<td>141-160</td>
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<tr>
<td>161-180</td>
<td>1.5</td>
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<td>2.5</td>
</tr>
<tr>
<td>181-210</td>
<td>2</td>
<td>181-210</td>
<td>3</td>
</tr>
<tr>
<td>211-240</td>
<td>2.5</td>
<td>211-240</td>
<td>4</td>
</tr>
<tr>
<td>241-270</td>
<td>3</td>
<td>241-270</td>
<td>5</td>
</tr>
<tr>
<td>271-300</td>
<td>3.5</td>
<td>271-300</td>
<td>6</td>
</tr>
<tr>
<td>301-330</td>
<td>4</td>
<td>301-330</td>
<td>6.5</td>
</tr>
<tr>
<td>331-360</td>
<td>4.5</td>
<td>331-360</td>
<td>7.5</td>
</tr>
<tr>
<td>&gt;360</td>
<td>5</td>
<td>&gt;360</td>
<td>8.5</td>
</tr>
</tbody>
</table>

<70 = Hypoglycemia See front of form for treatment
70-99: Off x 20-30 minutes & recheck BG

If NOT achieving glycemic control with Algo 4 X 3 consecutive hours Consider High Dose Infusion Protocol


Glucose-SSI Refs - 2


Glucose-SSI Refs - 4


Glucose-SSI Refs - 7


Glucose-SSI Refs - 8


Slide Set and References by Request

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