Glycemic Control
Insulin In The Hospital Setting

Glycemic Control

- The Evidence For Insulin’s Benefit
- The Mechanism of Insulin’s Benefit
- The Achievement of Insulin’s Benefit
- A Few Cases…

Glycemic Control In The Hospital
Major Prospective Studies

- DIGAMI  Post MI
  BMJ, 1997
  ~28% Decreased All Cause Mortality

- Leuven 1  SICU
  NEJM, 2001
  ~34% Decreased In Hospital Mortality + Reduced Morbidity

- Leuven 2  MICU
  NEJM, 2006
  ~16% Decrease In Hospital Mortality* + Reduced Morbidity

* MICU Stay > 3 Days
Glycemic Control In The Hospital
Major Prospective Studies

- Portland Post CABG
  J Thoracic CV Surg 2003
  ~45% Decrease Mortality

- Lazar Post CABG
  Circulation, 2004
  Major Morbidity Reduction

- Krinsley ICU
  Mayo Clin Proc, 2004
  ~29% Decrease Mortality

Characteristics Of Negative Trials

- Lack Of Glycemic Separation
  - Underpowered

Insulin In The Hospital Setting

The days of casual glycemic control for critically ill patients should be over!
So, Reducing Glucose Is Good!!

But how low should we go...

Glycemic Control In The Hospital
Major Prospective Studies

- DIGAMI Post MI
  BMJ, 1997
  ~28% Decreased All Cause Mortality

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* MICU Stay > 3 Days

AACE Position Statement 12/16/03: Hospital Glycemic Goals

Intensive Care Units: 110 mg/dL

Non-Critical Care Units:
  Pre-Prandial 110 mg/dL
  Max. Glucose 180 mg/dL
NICE-SUGAR
Normoglycemia in Intensive Care Evaluation-
Survival Using Glucose Algorithm Regulation

The NEW ENGLAND JOURNAL OF MEDICINE
Published in 1999
Vol. 341, Iss. 19

Intensive versus Conventional Glucose Control
in Critically Ill Patients
The NICE-SUGAR Study Investigators

6104 Patients From ICUs of 42
Hospitals in Australia, New Zealand,
and North America

Conventional
- Insulin Given For Glucose > 180 mg/dl
  and Stopped For Glucose < 144 mg/dl

Intensive
- Glucose Target: 81 – 108 mg/dl

Primary Outcome
Death from Any Cause Within
90 Days After Randomization

90% Power To Detect Absolute Mortality
Difference of 3.8% Assuming Baseline
Mortality of 30%
The NICE-SUGAR Study Investigators. NEJM 360: 1283-1297, 2009

144 ± 23 mg/dl
115 ± 18 mg/dl

OR 1.14 (CI, 1.02, 1.28)
P = 0.02

The NICE-SUGAR Study Investigators. NEJM 367: 1108-1118, 2012

Hypoglycemia and Risk of Death in Critically Ill Patients
The NICE-SUGAR Study Investigators®
**NICE-SUGAR**

*Normoglycemia in Intensive Care Evaluation-Survival Using Glucose Algorithm Regulation*

<table>
<thead>
<tr>
<th>Hypoglycemia</th>
<th>HR For Mortality</th>
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<tbody>
<tr>
<td>None</td>
<td>1.00 (Reference)</td>
</tr>
<tr>
<td>Moderate (41-70 mg/dl)</td>
<td>1.41 (1.21, 1.62, ( p &lt; 0.001 ))</td>
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<tr>
<td>Severe (≤ 40 mg/dl)</td>
<td>2.10 (1.59, 2.77, ( p &lt; 0.001 ))</td>
</tr>
<tr>
<td>Hypoglycemia: no insulin</td>
<td>3.84 (2.37, 6.23, ( p &lt; 0.001 ))</td>
</tr>
</tbody>
</table>


---

**Insulin In The Hospital Setting**

The days of casual glycemic control for critically ill patients should be over!

---

**AACE Position Statement 12/16/03: Hospital Glycemic Goals**

- **Intensive Care Units:** 110 mg/dL
- **Non-Critical Care Units:**
  - Pre-Prandial: 110 mg/dL
  - Max. Glucose: 180 mg/dL
ADA/AACE Consensus Statement on Inpatient Glycemic Control 2009

- **Critically Sick Patients**
  - Threshold to Start Insulin Therapy No Greater Than 180 mg%
  - On Therapy Goal Is 140-180 mg%

- **Non Critically Sick Patients**
  - Pre-Meal < 140 mg%
  - Random < 180 mg%

Moghissi, E et al Endocrine Practice May/June, 2009
*Reaffirmed by the Endocrine Society, 2012*

---

**Take Home Points**

- There is considerable evidence that good glycemic control is beneficial to critically ill patients.
- Hypoglycemia must be avoided.

---

**Glycemic Control**

- The Evidence For Insulin’s Benefit
  - The Mechanism of Insulin’s Benefit
  - The Achievement of Insulin’s Benefit
  - A Few Cases…
Beneficial Effects Of Insulin In The Critical Care Setting

- Hyperglycemia Is Bad
- Since Insulin Reduces Glucose, It Is Good…
- But Beyond Glucose…

Insulin In The Critical Care Setting

- Vasodilates
- Acts As Metabolic Modulator
- Enhances Cell Survival
- Restrains Platelets
- Promotes Fibrinolysis
- Enhances Granulocyte Function
- Is A Potent Anti-Inflammatory Agent

Take Home Points

- There is considerable evidence that good glycemic control is beneficial to critically ill patients.
- Hypoglycemia must be avoided.
- Beneficial effects may be mediated in part by properties of the insulin molecule itself.
### Glycemic Control

- The Evidence For Insulin's Benefit
- The Mechanism of Insulin’s Benefit
- The Achievement of Insulin’s Benefit
- A Few Cases…

### IV Insulin Infusion Protocols

<table>
<thead>
<tr>
<th>Algorithm 1</th>
<th>Algorithm 2</th>
<th>Algorithm 3</th>
<th>Algorithm 4</th>
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<tbody>
<tr>
<td>BG Units/hr</td>
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<td>2</td>
<td>4</td>
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### IV Insulin Protocol Based On Insulin Sensitivity
**IV Insulin Protocol Based On Insulin Sensitivity**

**Algorithm 1**

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**Algorithm 2**

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**Algorithm 4**

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**Algorithm 5**

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**Algorithm 6**

<table>
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- **Insulin Drip Algorithm**
  - **Algorithm 1**
    - **Algorithm**: 1.0, 1.5, 2.0, 3.0, 4.0
  - **Algorithm 2**
    - **Algorithm**: 1.0, 1.5, 2.0, 3.0, 4.0
  - **Algorithm 3**
    - **Algorithm**: 1.0, 1.5, 2.0, 3.0, 4.0
  - **Algorithm 4**
    - **Algorithm**: 1.0, 1.5, 2.0, 3.0, 4.0
  - **Algorithm 5**
    - **Algorithm**: 1.0, 1.5, 2.0, 3.0, 4.0
  - **Algorithm 6**
    - **Algorithm**: 1.0, 1.5, 2.0, 3.0, 4.0

---

**Suppose The Patient Starts With BG = 254 mg/dl**

**But After One Hour The Glucose Remains About The Same**
Computer-based Insulin Infusion Protocols

Glucommander
Practical Alternative to IV Insulin Protocols

Recommended IV Fluids To Prevent Hypoglycemia, Hypokalemia & Ketosis:

- Glucose: 5-10 gms/hour
- Potassium: 20 meq/L
- The Primary Service Should Choose the Type and the Rate of the Fluid Depending on the Underlying Disease
Take Home Points

- Intensive care patients, not eating or not eating very much, should be treated with continuous intravenous insulin.

Life After The Drip....

Transition From IV to SQ Insulin In The Adult Patient

Basal - Bolus
Currently Available Basal Insulins

- Neutral Protamine Hagedorn (1946)
- Insulin Glargine (2001)
- Insulin Detemir (2006)

_NPH/Reg Vs. Glargine Insulin After Cardiovascular Surgery_

Transition to SQ: An Approach

*To Transition A Patient From An IV Insulin Infusion To SQ Insulin*
Multiply Last Drip Dose By 20, And Give This Amount As Glargine
Turn The IV Drip Off 2 Hours Later
Example: Last Drip Dose Is 1.0 Unit/Hour; Give 1.0 x 20 = 20 Units Of Glargine SQ; Discontinue Drip Two Hours Later

This Is Basal Insulin

Basal - Bolus

Transition From IV to SQ Insulin In The Adult Patient

- Basal Insulin
- Bolus Insulin
- Prandial Insulin
- Correction Factor Insulin
Currently Available Bolus Insulins

- Regular (1921)
- Insulin Lispro (1996)
- Insulin Aspart (2000)
- Insulin Glulisine (2006)

Insulin Profiles

First, The Prandial Dose...
When Patient Is Able To Eat,

✓ Add Rapid Acting Insulin For Mealtime Coverage

✓ Rule Of Thumb
  50% Basal
  50% Prandial, Divided Over 3 Meals

Example: Patient Is On 20 Units Glargine Daily; Give 7 Units With Each Meal Of Lispro (Humalog) Or Aspart (Novolog) Or Glulisine (Apidra)

This Is Prandial Insulin

Basal-Bolus Insulin Therapy: Glargine at HS and Mealtime Insulin Lispro, Aspart, Or Glulisine

Insulin Effect

- 20 units

B L S HS B
### Transition From IV to SQ Insulin In The Adult Patient

- Basal Insulin
- Bolus Insulin

### Correction Factor Insulin

<table>
<thead>
<tr>
<th>Low Dose</th>
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<th>High Dose</th>
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### What About Patients Admitted With Hyperglycemia On The Floor?


Basal Bolus Versus SSI
Randomized Study Of Basal-Bolus Insulin Therapy In The Inpatient Management Of Patients With Type 2 Diabetes
The RABBIT 2 Trial

- 130 Type 2 Diabetic Patients Admitted to General Medicine Services
- Managed By Internal Medicine Residents Who Received A Copy Of Assigned Treatment Protocol
- Basal-Bolus Regime With Glargine And Glulisine Compared To SSI

Umpierrez, G. et al Diabetes Care 30: 2181-2186, 2007
Basal Bolus Versus SSI
Randomized Study Of Basal-Bolus Insulin Therapy In The
Inpatient Management Of Patients With Type 2 Diabetes
The RABBIT 2 Trial

- Glucose Difference Between Groups 27 mg\% (p < 0.01)

<table>
<thead>
<tr>
<th>Percentage of Patients at Target ( &lt; 140 mg/dL)</th>
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<tr>
<td>Basal - Bolus</td>
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<tr>
<td>66%</td>
</tr>
</tbody>
</table>

- No Difference In Hypoglycemia (<0.5%)

Umpierrez, G. et al Diabetes Care 30: 2181-2186, 2007

Basal Bolus Versus SSI
Randomized Study Of Basal-Bolus Insulin Therapy In The
Inpatient Management Of Patients With Type 2 Diabetes
The RABBIT 2 Trial

- 211 Type 2 Diabetic Surgical Patients on
  Surgical Wards, NOT ICU
- Age 58 ± 11 Years
- Admission Glucose 190 ± 92 mg/dl
- HbA1c 7.7 ± 2.2 %
- Basal-Bolus Regime With Glargine And Glulisine Compared To SSI

Umpierrez, G. et al Diabetes Care 34: 256-261, 2011
Basal Bolus Versus SSI
The RABBIT 2 Surgery Study

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<td>157 ± 32</td>
<td>&lt; 0.001</td>
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<tr>
<td>Hypoglycemia</td>
<td>4.7%*</td>
<td>23%</td>
<td>&lt; 0.001</td>
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* % of patients, but no difference in severe hypoglycemia (< 40 mg/dl)

<table>
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<tr>
<td>Composite AE</td>
<td>24.3%</td>
<td>8.6%</td>
<td>= 0.003</td>
</tr>
</tbody>
</table>

* % of patients, but no difference in severe hypoglycemia (< 40 mg/dl)

Table 2—Composite hospital complications and outcomes composite hospital complications

<table>
<thead>
<tr>
<th></th>
<th>SSI</th>
<th>Basal Bolus</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound infections</td>
<td>14</td>
<td>11</td>
<td>0.000</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>3</td>
<td>3</td>
<td>0.242</td>
</tr>
<tr>
<td>Acute respiratory failure</td>
<td>0</td>
<td>3</td>
<td>0.217</td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>15</td>
<td>11</td>
<td>0.136</td>
</tr>
<tr>
<td>Anemia</td>
<td>2</td>
<td>1</td>
<td>0.006</td>
</tr>
<tr>
<td>Number of patients with complications</td>
<td>35</td>
<td>26</td>
<td>0.003</td>
</tr>
<tr>
<td>Mortality</td>
<td>2</td>
<td>5</td>
<td>0.56</td>
</tr>
<tr>
<td>Postoperative ICU admission (%)</td>
<td>16</td>
<td>16</td>
<td>0.56</td>
</tr>
<tr>
<td>Length of stay (days)</td>
<td>2.5 ± 1.90</td>
<td>3.19 ± 3.14</td>
<td>1.23 ± 0.60</td>
</tr>
<tr>
<td>Hospital</td>
<td>0.0 ± 0.09</td>
<td>0.3 ± 5.8</td>
<td>7.21 ± 11.30</td>
</tr>
</tbody>
</table>

Umpierrez, G. et al Diabetes Care 34: 256-261, 2011
**Starting Basal-Bolus From Scratch**

Calculate Starting Total Daily Dose (TDD)

- Previous Total Daily Insulin Units Used or
- 0.4 units/kg (Type 1 DM)
- 0.6 units/kg (New Onset Or Lean Type 2)
- 0.8 units/kg (Type 2 DM)

*This Is Very Conservative and Actual Needs May Turn Out to Be Substantially More*

---

**Median Inpatient glucose levels**

<table>
<thead>
<tr>
<th>Glucose (mg/dL)</th>
<th>Median</th>
<th>UCL</th>
<th>LCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>135</td>
<td>157.00</td>
<td>166.82</td>
<td>147.18</td>
</tr>
<tr>
<td>140</td>
<td>153.22</td>
<td>166.82</td>
<td>147.18</td>
</tr>
<tr>
<td>145</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>155</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>160</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>165</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>170</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Definition:** Median inpatient glucose levels in patients with diabetes. Glucose readings below 40mg/dL and above 400mg/dL were excluded. **Data Source:** Clarity database, FORCE database.

**Analysis:** The median inpatient glucose value, which was previously stable with a median of 157mg/dL, has decreased, and continues to decrease, with the implementation of inpatient insulin protocols.

---

**Take Home Points**

- Intensive care patients, not eating or not eating very much, should be treated with continuous intravenous insulin.
- When patients begin to eat, either in ICU or on wards, they should be transitioned to a basal bolus insulin regime.
A Word About Oral Agents....

Therapy of Type 2 Diabetes Mellitus: Hospital Use of Oral Agents

<table>
<thead>
<tr>
<th>Secretagogues</th>
<th>Illness Decreases Endogenous Insulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>α Glucosidase Inhibitors</td>
<td>Not for Acute Illness With Variable Intake</td>
</tr>
<tr>
<td>Metformin</td>
<td>Hold for Acute Illness With Renal, Cardiac, or Liver Function Unstable, or Surgery, or Radiocontrast</td>
</tr>
<tr>
<td>Glitazone(s)</td>
<td>Can Give or Not</td>
</tr>
</tbody>
</table>

Take Home Points

- In selective, non critically ill patients, oral glycemic agents can be considered.
Have A Discharge Plan

Can A Patient Go Back To Oral Agents At Discharge?

- If Pre-Admission Control Acceptable, YES!!!
- Admission HbA1C Helpful
- If Pre-Admission Control Not Acceptable, Medication Adjustment Needed

Glycemic Control

- The Evidence For Insulin’s Benefit
- The Mechanism of Insulin’s Benefit
- The Achievement of Insulin’s Benefit
- A Few Cases…
Floor Patient

- 65 y/o male with DM2, hyperlipidemia, HTN, and DJD
- Admitted to General Medicine with chest pain
- Metformin 1000mg BID and glipizide 5mg BID; HbA1c 6.4% 2 weeks ago
- Glucose on floor arrival 275 mg/dl
- Admit orders
  - Serial troponins
  - Possible adenosine myoview

What should be started to control glucose?

a) Metformin only  
b) Glipizide only  
c) Metformin and glipizide  
d) Glargine and log  
e) Insulin and metformin  
f) Insulin and glipizide

Floor Patient

- 65 y/o male (75kg)
- DM2, hyperlipidemia, HTN, and DJD
- Metformin 1000mg BID and glipizide 5mg BID
- HbA1c 6.4%
- Glucose 275 mg/dl
- Admit orders
  - Serial troponins
  - Possible adenosine myoview
- Start glargine and log

What would be the insulin doses?

1) 75 kg patient  
2) 75 x 0.8 = 60 units insulin total  
3) 60 / 2 = 30 units  
4) 30 units basal (glargine)  
5) 30 units prandial (log) -- 10 units after each meal  
6) Medium dose correction factor
**Floor Patient**
- 65 y/o male (75kg)
- DM2, hyperlipidemia, HTN, and DJD
- Metformin 1000mg BID and glipizide 5mg BID
- HbA1c 6.4%
- Glucose 275 mg/dl

**Admit orders**
- Serial troponins
- Possible adenosine myoview

**Log**
Patient NPO after midnight for adenosine myoview

**How should insulin orders be changed once he is NPO?**
- a) Stop all of the insulin
- b) Hold the prandial log only, continue glargine and correction scale
- c) Hold the glargine only, continue log and correction scale

**Floor Patient**
- 65 y/o male (75kg)
- DM2, hyperlipidemia, HTN, and DJD
- Metformin 1000mg BID and glipizide 5mg BID
- HbA1c 6.4%
- Glucose 275 mg/dl

**Reversible defect on myoview led to stent**

**With which diabetes medication(s) should the patient be sent home?**
- a) Glargine and log
- b) Metformin 1000mg BID and glipizide 5mg BID
- c) Insulin pump

---

**ICU Patient**
- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the MICU with sepsis
- Metformin 1000mg BID, glipizide 10mg BID q day
- HbA1c 8% 3 months ago
- Glucose on MICU arrival 230 mg/dl

**What therapy should be started for glucose control?**
- a. Continue metformin and glipizide
- b. Start glargine and log
- c. Start an insulin drip
ICU Patient
- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the MICU with sepsis
- Glucose on MICU arrival 230 mg/dl
- Insulin drip started

What diabetes lab should be ordered?
- a) Urine microalbumin
- b) Hemoglobin A1c
- c) Nothing

ICU Patient
- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the MICU with sepsis
- Glucose on MICU arrival 230 mg/dl
- Insulin drip started
- Clear liquids started

How should new diet be covered?
- a) Adjust the insulin drip
- b) Continue the drip, start SC log with carbohydrate counting
- c) Continue the drip, restart glipizide

ICU Patient
- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the MICU with sepsis
- Glucose on MICU arrival 230 mg/dl
- Insulin drip started
- Clear liquids started
- Transferring to Gen Med

What about insulin orders?
- a) Continue the insulin drip
- b) Stop the drip, start sliding scale log
- c) Stop drip, start glargine/log
ICU Patient

- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the MICU with sepsis
- Glucose on MICU arrival 230 mg/dl
- Insulin drip started
- Clear liquids started
- Transferring to Gen Med

What are the insulin doses, assuming last drip dose was 1.5 units/hour?

- Glargine (1.5 units x 20 = 30 units)
- Log (30 units / 3 = 10 units)
- 10 units after each meal
- Medium dose correction factor

ICU Patient

- 65 y/o female with DM2, HTN, & hyperlipidemia
- Admitted to the MICU with sepsis
- Glucose on MICU arrival 230 mg/dl
- Insulin drip started
- Clear liquids started
- Transferring to Gen Med

What happens to the insulin drip?

- Discontinue the insulin drip 2 hours after glargine injected

Former ICU, Now Floor, Patient

- 65 y/o female with DM2 and sepsis
- Glargine 30 units daily and log 10 units TID
- Medium dose correction factor
- Daily insulin dose adjustments
  - Take the previous day’s correction factor insulin dose
  - Add to today’s insulin dose
ADA/AACE Consensus Statement on Inpatient Glycemic Control 2009

- Critically Sick Patients
  - Threshold to Start Insulin Therapy No Greater Than 180 mg%
  - On Therapy Goal Is 140-180 mg%

- Non Critically Sick Patients*
  - Pre-Meal < 140 mg%
  - Random < 180 mg%

*Reaffirmed by the Endocrine Society, 2012

Correction Factor Dose, Added To Prandial Dose

**Low Dose**
- Premeal BG
- Medium Dose
- High Dose

<table>
<thead>
<tr>
<th>Premeal BG</th>
<th>Additional Insulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>120-170</td>
<td>1 unit</td>
</tr>
<tr>
<td>171-220</td>
<td>2 units</td>
</tr>
<tr>
<td>221-270</td>
<td>3 units</td>
</tr>
<tr>
<td>271-320</td>
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<td>&gt;320</td>
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</tr>
<tr>
<td>271-320</td>
<td>9 units</td>
</tr>
<tr>
<td>&gt;320</td>
<td>11 units</td>
</tr>
</tbody>
</table>

Former ICU, Now Floor, Patient

- 65 y/o female with DM2 and sepsis
- Glargine 30 units daily and log 10 units TID
- Medium dose correction factor
- Yesterday’s Glucose values:
  - Fasting 175 mg/dl 3 units
  - Pre-lunch 190 mg/dl 3 units
  - Pre-dinner 225 mg/dl 5 units
  - HS 190 mg/dl
- 11 units of correction factor (CF) aspart given
How would you adjust today's insulin dose?

Since all readings are above target, you could add ~½ of CF to glargine and the remainder divided equally with each meal.

65 y/o female with DM2 and sepsis
- Glargine 30 units daily and log 10 units TID
- Medium dose correction factor

Yesterday's Glucose values:
- Fasting 120 mg/dl 1 unit
- Pre-lunch 150 mg/dl 1 unit
- Pre-dinner 150 mg/dl 1 unit
- HS 180 mg/dl

3 units of correction factor (CF) aspart given
Former ICU, Now Floor, Patient

How would you adjust today's insulin dose?

Fasting glucose is at target, but the rest of the day is above target. So, you could add the 1/3 of the entire CF with each meal.

Former ICU, Now Floor, Patient

- 65 y/o female with DM2 and sepsis
- Glargine 35 units daily and log 12 units TID
- Medium dose correction factor

Former ICU, Now Floor, Patient

- 65 y/o female with DM2 and sepsis
- Glargine 35 units daily and log 13 units TID
- Medium dose correction factor
- Yesterday's Glucose values:
  - Fasting  115 mg/dl
  - Pre-lunch  118 mg/dl
  - Pre-dinner  119 mg/dl
  - HS  170 mg/dl
- No correction factor (CF) aspart given
**Former ICU, Now Floor, Patient**

- Patient going home!!
- On Glargine and aspart
- HbA1c 9%

How should her diabetes medication(s) be adjusted?
- a) Discontinue insulin and restart oral medications
- b) Reintroduce metformin to insulin
- c) Continue insulin only

---

**Special Situations**

- Patients Receiving Corticosteroids
- Patients Receiving Tube Feeds
- Patients With Renal Failure

---

**Patient on Glucocorticoids**

**Glucocorticoid Effects on Glucose Metabolism**

- Increased hepatic gluconeogenesis increases fasting glucose
- Inhibition of glucose uptake especially in adipose tissue increases post-prandial glucose
- Predominant effect is post-prandial, so glucose rises during the day
Take Home Points

- In selective, non critically ill patients, oral glycemic agents can be considered.
- In glucocorticoid treated patients, consider giving more than 50% as bolus.
- Consider NPH instead of glargine in patients on shorter acting glucocorticoids.

Special Situations

- Patients Receiving Corticosteroids
- Patients Receiving Tube Feeds
- Patients With Renal Failure

The Impact of Tube Feed on In-Patient Hyperglycemia

Continuous And Persistent Carbohydrate Absorption
→ Continuous And Persistent Hyperglycemia

The Basal/Bolus Rule Is Different.....
The Impact of Tube Feeding on In-Patient Hyperglycemia

Tube Feed
Glucose
No Tube Feed

Breakfast Lunch Dinner

Tube Feeding And In-Patient Hyperglycemia

Insulin
Glucose

Continuous Tube Feed

Basal Insulin = Total Daily Dose

Patients on Continuous Tube Feed

- Check Blood Glucose Every 6 Hours
- Give Correction Factor Rapid Acting Insulin Based On Algorithms
Patients on Continuous Tube Feed

- Decrease Total Dose
  - 10% if Glucose Level < 120 mg/dl
  - 20% Glucose Level < 80 mg/dl

- Increase Total Dose
  - By Adding The Total Dose Of Correction Factor Insulin The Previous Day

BEWARE of HYPOGLYCEMIA

- High Risk Of Hypoglycemia If Tube Feed Temporarily Stopped

  - **Immediately Initiate IV Fluids To Provide The Amount Of Glucose That Was In The Tube Feeding**

Tube Feed at Bedtime

- **Glucose**
  - Breakfast
  - Lunch
  - Dinner
  - NPH Insulin
Patient on Continuous Tube Feeding
- 71 year old male with type 2 diabetes recovering from massive CVA leaving him unable to swallow
- His outpatient glycemic regime consisted of oral agents only, no insulin
- He is receiving continuous tube feeding
- He weighs 180 lbs (82 kg)

How would you begin to develop his insulin regime?

Starting Basal-Bolus From Scratch

Calculate Starting Total Daily Dose (TDD)
- Previous Total Daily Insulin Units Used or
- 0.4 units/kg (Type 1 DM)
- 0.6 units/kg (New Onset Or Lean Type 2)
- 0.8 units/kg (Type 2 DM)
Patient on Continuous Tube Feeding

- Weight based total daily dose of insulin would be 1.0 units/kg X 82 kg = 82 units
- So, give 82 units glargine as basal
- There is no bolus
- There is, however, correction factor; high dose correction factor

---

### Correction Factor Dose, Added To Prandial Dose

<table>
<thead>
<tr>
<th>Low Dose</th>
<th>Medium Dose</th>
<th>High Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Insulin Dose</td>
<td>Total Insulin Dose</td>
<td>Total Insulin Dose</td>
</tr>
<tr>
<td>&lt;40 units/day</td>
<td>40-80 units/day</td>
<td>&gt;80 units/day</td>
</tr>
<tr>
<td>Premeal BG</td>
<td>Additional Insulin</td>
<td>Premeal BG</td>
</tr>
<tr>
<td>120-170</td>
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<tr>
<td>271-320</td>
<td>4 units</td>
<td>271-320</td>
</tr>
<tr>
<td>&gt;320</td>
<td>5 units</td>
<td>&gt;320</td>
</tr>
</tbody>
</table>

---

Patient on Continuous Tube Feeding

- Patient on 82 units glargine

**Yesterday’s Sugars** | **CF Aspart**
---|---
6 AM | 210 mg/dl | 5 units
Noon | 280 mg/dl | 9 units
6 PM | 290 mg/dl | 9 units
Midnight | 310 mg/dl | 9 units

32 units correction factor aspart

How would you adjust today’s insulin dose?
Patient on Continuous Tube Feeding

- Patient on **114** units glargine (may split)

<table>
<thead>
<tr>
<th>Time</th>
<th>Sugar (mg/dl)</th>
<th>CF Aspart</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 AM</td>
<td>180</td>
<td>5</td>
</tr>
<tr>
<td>Noon</td>
<td>250</td>
<td>7</td>
</tr>
<tr>
<td>6 PM</td>
<td>270</td>
<td>7</td>
</tr>
<tr>
<td>Midnight</td>
<td>280</td>
<td>9</td>
</tr>
</tbody>
</table>
- **28 units correction factor aspart**

How would you adjust today’s insulin dose?

Patient on Continuous Tube Feeding

- Patient on **142** units glargine (may split)

<table>
<thead>
<tr>
<th>Time</th>
<th>Sugar (mg/dl)</th>
<th>CF Aspart</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 AM</td>
<td>135</td>
<td>3</td>
</tr>
<tr>
<td>Noon</td>
<td>155</td>
<td>3</td>
</tr>
<tr>
<td>6 PM</td>
<td>160</td>
<td>3</td>
</tr>
<tr>
<td>Midnight</td>
<td>170</td>
<td>3</td>
</tr>
</tbody>
</table>
- **12 units correction factor aspart**

How would you adjust today’s insulin dose?

Patient on Continuous Tube Feeding

- Patient on **154** units glargine (may split)

<table>
<thead>
<tr>
<th>Time</th>
<th>Sugar (mg/dl)</th>
<th>CF Aspart</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 AM</td>
<td>110</td>
<td>0</td>
</tr>
<tr>
<td>Noon</td>
<td>115</td>
<td>0</td>
</tr>
<tr>
<td>6 PM</td>
<td>119</td>
<td>0</td>
</tr>
<tr>
<td>Midnight</td>
<td>119</td>
<td>0</td>
</tr>
</tbody>
</table>
- **0 units correction factor aspart**

How would you adjust today’s insulin dose?
Take Home Points

- In tube fed patients, give basal and correction factor. There is no bolus per se.

Special Situations

- Patients Receiving Corticosteroids
- Patients Receiving Tube Feeds
- Patients With Renal Failure

The Impact Of Renal Failure On In-Patient Hyperglycemia

- Decreased Insulin Clearance
- Decreased Gluconeogenesis
- Both increase the risk of hypoglycemia
Reduce Dose For Renal Insufficiency

<table>
<thead>
<tr>
<th>GFR cc/min</th>
<th>Total Insulin Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;30</td>
<td>No Change</td>
</tr>
<tr>
<td>15-29</td>
<td>Reduce to 70%</td>
</tr>
<tr>
<td>&lt;15 or Dialysis</td>
<td>Reduce to 50%</td>
</tr>
</tbody>
</table>

Take Home Points

- In tube fed patients, give basal and correction factor. There is no bolus per se.
- Remember to consider e GFR in those with impaired kidney function.

Special Situations

- Patients Receiving Corticosteroids
- Patients Receiving Tube Feeds
- Patients With Renal Failure
Take Home Points

- There is considerable evidence that good glycemic control is beneficial to critically ill patients.
- Hypoglycemia must be avoided.
- Beneficial effects may be mediated in part by properties of the insulin molecule itself.

Take Home Points

- Intensive care patients, not eating or not eating very much, should be treated with continuous intravenous insulin.
- When patients begin to eat, either in ICU or on wards, they should be transitioned to a basal bolus insulin regime.

Take Home Points

- In selective, non critically ill patients, oral glycemic agents can be considered.
- In glucocorticoid treated patients, consider giving more than 50% as bolus.
- Consider NPH instead of glargine in patients on shorter acting glucocorticoids.
Take Home Points

- In tube fed patients, give basal and correction factor. There is no bolus per se.
- Remember to consider eGFR in those with impaired kidney function.

Glycemic Control

- The Evidence For Insulin’s Benefit
- The Mechanism of Insulin’s Benefit
- The Achievement of Insulin’s Benefit
- A Few Cases…