Managing Diabetes in CCU

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Hyperglycemia: A Common Comorbidity in Medical-Surgical Patients in the Community Hospital Setting

- Normoglycemia
- Known Diabetes
- New Hyperglycemia

n = 2,020

* Hyperglycemia: Fasting BG ≥ 126 mg/dL
or Random BG ≥ 200 mg/dL X 2

Umpierrez G et al, J Clin Endocrinol Metab 87:978, 2002
Proved link in CCU.

Diabetes control

(one circle)

CCU outcomes

Mechanism
Hyperglycemia -------- CVS
Diabetic patients tend to present with more complexity

WHY?
Smaller vessels
Higher rate of calcified lesions
More multi-vessel disease
In-stent restenosis
Higher incidence of AHA/ACC class “C” lesions
More hypertensive patients
More hyperlipidemia
More CKD
Mechanism
Hypoglycemia ---------- CVS

Hypoglycemia and Mortality
in the Medical ICU.

N=1826 ICU patients.
Managing Diabetes in CCU

Oral Antidiabetic in CCU

Why not recommended?

- Variable *nutritional* strategies
- Need *many days* to reach target
- Enhanced drugs *side effects*
  - Metformin / acidosis
  - TZDs / hypervolemia - CHF
  - SUAs / hypoglycemia(old or RI.)

*(Basic role no oral till original condition stabilizes)*
**sliding-scale alone**

**Bad**

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***fluctuating blood glucose values***
Questionable or doubtful and not recommended, particularly when not used in combination with basal insulin.

Figure 2. Mean blood glucose levels.

- **558 medication errors** involved insulins (24%) attributed to sliding-scale insulin.
- **The types of medication errors** reported included:
  - Dose omission (17%)
  - wrong **drug** administered (11%)
  - **Over**dose administered (8%)
  - **Extra** dose administered (7%)
  - **Drug** list incorrect (6%)
  - **Under**dose administered (3%)

( **Lack of communication and training** were believed to be the two factors that contributed to errors most frequently).
(Conventional - Twice premixed insulins)

(Not recommended)

*** 50-70% don't attain target A1c
*** Erratic blood glucose values
    (2 hypo + 2 hyper)
*** Requires fixed life style

(Basal / bolus ) +/- (correction)

(one of Best)
How to calculate the TDD for Insulin-Naive Patients?

<table>
<thead>
<tr>
<th>TDD estimation</th>
<th>Patient Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3 units/kg body weight</td>
<td>Underweight&lt;br&gt;Old age&lt;br&gt;Haemodialysis</td>
</tr>
<tr>
<td>0.4 units/kg body weight</td>
<td>Normal weight</td>
</tr>
<tr>
<td>0.5 units/kg body weight</td>
<td>Overweight</td>
</tr>
<tr>
<td>≥ 0.6 units/kg body weight</td>
<td>Obese&lt;br&gt;Insulin resistant&lt;br&gt;Glucocorticoids</td>
</tr>
</tbody>
</table>

TDD: Total daily dose
Basal/bolus insulin dose calculation for a patient weighting 80 kg with a BMI 28 kg/m² and normal renal function

Step 1
**TDD calculation:**
\[ \text{TDD} = 0.5 \text{ u/kg} \times 80 \text{ kg} = 40 \text{ Units} \]

Step 2
**Basal Insulin Dose Calculation:**
Basal insulin dose = 50% of TDD
\[ = 50\% \times 40 \]
\[ = 20 \text{ units} \]

Step 3
**Bolus insulin dose calculation:**
Bolus insulin dose/meal = (50% of TDD)/3
\[ = (50\% \times 40)/3 \]
\[ = 6.6 \approx 6 \text{ units} \]

**N.B.** If the patient or nurse estimates that the patient is only eating 50% of the food on the tray, a reduced dose of 3 units should be ordered instead of the full dose of 6 units.

Step 4
**Correctional scale estimation:**
Based on TDD of 40 unit, for this patient the low correctional scale should be ordered.

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** Intravenous Insulin Infusion **

**Yale-New Haven Hospital**

**ICU Insulin Infusion Protocol (IIP) for Adults**

The following IP is intended for use in hypoglycemic adult patients in the ICU, adapted from our earlier protocols, in keeping with the latest glucose guidelines from national organizations. It should NOT be used in diabetic ketoacidosis (DKA) or hyperosmolar hyperglycemic state (HHS), as these patients may require higher initial insulin doses, IV fluids at some point, and important adjunctive therapies for their metabolic derangements/status. (See DKA Guidelines in YNHCH Clinical Practice Manual (CPM) for further instructions.) In any patient with BG >180 mg/dL, the initial orders should also be carefully reviewed with the MD, since a higher initial insulin dose and additional monitoring/therapy may be required. If the patient’s response to the insulin infusion is at any time unusual or unexpected or if any situation arises that is not adequately addressed by this protocol, the MD must be contacted for assessment and further S&D.

**Getting Started**

1. **PATIENT SELECTION:** Begin IIP in any ICU patient with more than 2 BGS >180 mg/dL who is not expected to rapidly normalize their glycemic status. Patients who are eating (see #9 below); transferring out of ICU imminently (<24 hrs); or pre-terminal or being considered for CMO status are generally not appropriate candidates for this IIP.

2. **TARGET BLOOD GLUCOSE (BG) RANGE:** 120-160 mg/dL

3. **ORDERS:** MD order required for use in the ICU.

4. **INSULIN INFUSION SOLUTION:** Obtain from pharmacy (1 unit Regular Human Insulin / 1 cc 0.9% NaCl).

5. **PRIMING:** Before connecting, flush 20 cc infusion through all tubing.

6. **ADMINISTRATION:** Via infusion pump in 0.5 units/hr increments.

7. **BOLUS & INITIAL INFUSION RATE:** Divide initial BG level by 100, then round to nearest 0.5 units for bolus AND initial infusion rate.

   Examples: 1.) Initial BG = 325 mg/dL: 325 + 100 = 3.25, round ↑ to 3.5: IV bolus 3.5 units = start infusion @ 3.5 units/hr.

   2.) Initial BG = 274 mg/dL: 274 + 100 = 2.74, round ↓ to 2.5: IV bolus 2.5 units = start infusion @ 2.5 units/hr.

8. **CAUTION:** If enteral/parenteral (TPN, PPN, Tube feeds) nutrition abruptly stopped, reduce infusion rate by 50%.

9. **Patients requiring IV insulin are usually NPO. In the rare patient who is eating, consider giving SQ Aspart PC to “cover” the meal (administer 1 unit/15 grams carbohydrates consumed (usual dose 3-6 units). In this circumstance don’t increase infusion rate during the first 3 hrs PC.

10. **Patients with T1DM, insulin requiring T2DM, and those requiring >1 unit/hr should be transitioned to SQ insulin prior to discharge from ICU.”

While on infusion, use glucose meter to check BG hourly. Once stable (3 consecutive values in target range), may reduce checks to q 2 hr. If stable for 12-24 hrs, may space checks to q 4 hr. Resume hourly checks until stable again if: any BG out of range; any change in insulin infusion rate; any significant change in clinical condition; initiation/discontinuation of steroids, pressors, TPN/PPN/tube feeds, dialysis, CVHV, or CAVH. In patients who are vasoconstricted/hypotensive, capillary BG (i.e., fingersticks) may be inaccurate; venous or arterial blood is preferred in this setting.

Adjusting Infusion Rate

If BG < 50 mg/dL:
D/C INSULIN INFUSION & administer 1 amp (25 g) D50 IV; recheck BG q 15 minutes until >90 mg/dL
  Then, recheck BG q 1 hr; when ≥ 140 mg/dL, wait 30 min, restart infusion at 50% of most recent rate.

If BG 50-74 mg/dL:
D/C INSULIN INFUSION & administer 1/2 Amp (12.5 g) D50 IV; recheck BG q 15 minutes until >90 mg/dL
  Then, recheck BG q 1 hr; when ≥ 140 mg/dL, wait 30 min, then restart infusion at 50% of most recent rate.

If BG 75-99 mg/dL:
D/C INSULIN INFUSION. Recheck BG q 15 minutes until BG reaches or remains ≥ 90 mg/dL
  Then, recheck BG q 1 hr; when ≥ 140 mg/dL, wait 30 min, then restart infusion at 75% of most recent rate.

If BG 100 mg/dL:

**STEP 1** Determine the CURRENT BG LEVEL - identifies a COLUMN in the table:

<table>
<thead>
<tr>
<th>BG 100-119 mg/dL</th>
<th>BG 120-159 mg/dL</th>
<th>BG 160-199 mg/dL</th>
<th>BG ≥ 200 mg/dL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG rises by &gt; 40 mg/dL/hr</td>
<td>BG rises by 1-40 mg/dL/hr OR BG unchanged</td>
<td>BG rises by 1-20 mg/dL/hr</td>
<td>BG rises by &gt; 60 mg/dL/hr</td>
</tr>
<tr>
<td>BG unchanged</td>
<td>BG unchanged</td>
<td>BG unchanged</td>
<td>BG rises by &gt; 60 mg/dL/hr</td>
</tr>
<tr>
<td>BG drops by 1-40 mg/dL/hr</td>
<td>BG drops by 1-20 mg/dL/hr</td>
<td>BG drops by 21-60 mg/dL/hr</td>
<td>BG drops by 21-60 mg/dL/hr</td>
</tr>
<tr>
<td>BG drops by 21-40 mg/dL/hr</td>
<td>BG drops by 41-60 mg/dL/hr</td>
<td>BG drops by 61-80 mg/dL/hr</td>
<td>NO INFECTION CHANGE</td>
</tr>
<tr>
<td>BG drops by &gt; 20 mg/dL/hr see below</td>
<td>BG drops by &gt; 20 mg/dL/hr see below</td>
<td>BG drops by &gt; 80 mg/dL/hr</td>
<td>HOLD x 30 min, then ↓ infusion by 2x</td>
</tr>
</tbody>
</table>

**STEP 2** Determine the RATE OF CHANGE from the prior BG level - identifies a CELL in the table. Then move right for INSTRUCTIONS:
(For: If the last BG was measured 2 or more hrs before the current BG, calculate the hourly rate of change. Example: If the BG at T1 was 150 mg/dL and the BG at T2 was 120 mg/dL, the total change over 2 hrs is: -30 mg/dL; however, the hourly change is: -15 mg/dL, 2 hours = -30 mg/dL/hr.)

**STEP 3**: CHANGES IN INFUSION RATE ("#") are determined by the current rate:

<table>
<thead>
<tr>
<th>Current Rate (Units/hr)</th>
<th># = Rate Change (Units/hr)</th>
<th>2f = 2x Rate Change (Units/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3.0 - 6.0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6.5 - 9.5</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>10.0 - 14.5</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>15.0 - 19.5</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>20.0</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

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Dose calculation if transition from IV to SC?

Basal/Bolus insulin dose calculation for a patient who started on diet who was receiving 2 units/hour of Insulin while NPO

Step 1  **Basal dose calculation:**  
Patient's hourly insulin infusion rate while NPO = 2 units/hour  
24-hour basal insulin dose during stress = 24 × 2 = 48 units  
Adjusted basal dose accounting for stress reduction = 2/3 × 48 =32 units of basal insulin

Step 2  **TDD calculation:**  
TDD = 2 x adjusted basal dose = 2 x 32 = 64 units  
Basal insulin dose = 50% of TDD = 32 units  
Mealtime bolus dose = 50% of TDD = 32 units

Step 3  **Mealtime bolus dose adjustment:**  
Patient just started to eat, so 10% of mealtime bolus dose can be started with each meal = 0.1 × 32 = 3 units with each meal

Step 4  **Correctional scale estimation:**  
A moderate-level correctional scale is most appropriate for an estimated TDD of 64 units

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AACE–ADA consensus in inpatient glycaemic control

**ICU - CCU setting**

- Maintain BG 140–180 mg/dl  
  (greater benefit likely at lower end of this range)
- Lower targets may be appropriate in selected patients as long as this can be achieved without significant hypoglycaemia
- BG <110 mg/dl not recommended (not safe)
- Start insulin infusion if BG over 180 mg/dl

**Non-ICU setting**

- Most patients:  
  - pre-meal BG <140 mg/dl  
  - random BG <180 mg/dl  
- More stringent targets may be appropriate in stable patients
- Less stringent targets may be appropriate in patients with severe co-morbidities
- Scheduled SC insulin with basal–bolus (nutritional-correction) is preferred
- Avoid prolonged Regular Insulin Sliding Scale (RISS) therapy alone

AACE, American Association of Clinical Endocrinologists; ADA, American Diabetes Association; BG, blood glucose; ICU, intensive care unit; SC, subcutaneous; RISS, Regular Intravenous Insulin Sliding Scale.
Intensive versus Conventional Glucose Control in Critically Ill Patients


Table 1. Summary Data from Randomized Clinical Trials of Intensive Insulin Therapy in Critically Ill Patients.

<table>
<thead>
<tr>
<th>Trial Name (Source)</th>
<th>No. of Patients</th>
<th>Type of ICU</th>
<th>Blood Glucose Level Targeted</th>
<th>Blood Glucose Level Achieved</th>
<th>Primary Outcome</th>
<th>Rate of Outcome</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leuven 1 (Van den Berghe et al.)</td>
<td>1548</td>
<td>Surgical</td>
<td>80-110</td>
<td>100-200</td>
<td>103</td>
<td>153</td>
<td>Death in ICU</td>
</tr>
<tr>
<td>Leuven 2 (Van den Berghe et al.)</td>
<td>1200</td>
<td>Medical</td>
<td>80-110</td>
<td>100-200</td>
<td>111</td>
<td>153</td>
<td>Death in hospital</td>
</tr>
<tr>
<td>Glucotrol (Deus et al., Preiser, J.C., personal communication)</td>
<td>1101</td>
<td>General</td>
<td>80-110</td>
<td>140-180</td>
<td>118</td>
<td>144</td>
<td>Death in ICU</td>
</tr>
<tr>
<td>VISEP (Bromek et al.,*)</td>
<td>537</td>
<td>General</td>
<td>80-110</td>
<td>100-200</td>
<td>112</td>
<td>151</td>
<td>Death at 28 days</td>
</tr>
<tr>
<td>NICE-SUGAR*</td>
<td>6104</td>
<td>General</td>
<td>81-108</td>
<td>144-180</td>
<td>118</td>
<td>145</td>
<td>Death at 90 days</td>
</tr>
</tbody>
</table>
Suggested guidelines In the cath lab setting.

- **Anti-diabetic medications, especially insulin, and fasting** may cause iatrogenic hypoglycemia. (Therefore, dosing needs to be coordinated around the NPO period that begins pre-cath.)

- **Blood glucose monitoring** pre and post cath. to reduce chances of hypoglycemia, and patients should resume a normal diet as soon as possible post catheterization.

- **Metformin** is usually discontinued 1 day pre procedurally and 2 days post cath due to the possibility of causing lactic acidosis and acute nephropathy.

- **Pre-procedural labs, especially renal function tests** like creatinine and eGFR, should be performed as close to the procedure time as possible, because there is a strong clinical correlation between chronic kidney disease and diabetes.

- **Limit contrast and hydrate diabetics** whenever possible to prevent cath lab-induced nephropathies.
physical assessment, comprehensive pulse assessments, and assess the integrity of the skin to ensure that there are no ulcers, skin lesions.

Access site selection should consider metabolic syndrome. Radial access as they are at significantly higher risks for leg complications and infections than the general population, because micro vascular dysfunction may compromise circulation and the wound healing processes are prolonged.

Anti-coagulation therapy needs to be carefully managed in diabetic patients, as insulin may inhibit the reversal effect of protamine. Patients exposed to protamine through the use of protamine-containing insulin or during heparin neutralization may experience life-threatening reactions and fatal anaphylaxis upon receiving large doses of protamine intravenously.

Suggested guidelines In the cath lab setting

CCU insulin regimens

(sliding-scale alone)  (Bad)

(Conventional - Twice premixed insulins)  (Not recommended)

(Basal / bolus +/- correction)  (intravenous insulin infusion)  (Best)
