Inpatient Diabetes Management

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Objectives

1- Magnitude of the Inpatient Diabetes Problem
2- Hyperglycemia and Hospital Outcomes
3- Potential Benefits of Glycemic Control
4- Recommendations from Professional Societies
5- Protocols for Inpatient Diabetes Management
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- Total estimated cost of diabetes in 2012 was $245 billion (41% up from 2007), with $176 billion direct cost and 69 billion reduced productivity.

- Largest component of medical expenditures attributed to diabetes was hospital inpatient care (~43% of costs).
The management of diabetes in the hospital was generally considered to be of secondary importance versus the condition that prompted the patient’s admission.
Prevalence of Hyperglycemia in 126 US Hospitals

Blood Glucose >180 mg/dL

Prevalence of Hyperglycemia in Medical-Surgical Patients

- Normal blood glucose: 62%
- Known Diabetes: 26%
- New Hyperglycemia: 12%

Umpierrez GE et al. J Clin Endocrinol Metab 2002; 87:978-982
Failure to identify diabetes is an independent predictor of rehospitalization.
Based on 2030 consecutive hospitalized patients whose charts were reviewed

<table>
<thead>
<tr>
<th></th>
<th>Normoglycemia</th>
<th>Known Diabetes</th>
<th>New Hyperglycemia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission BG</td>
<td>108 mg/dL</td>
<td>230 mg/dL</td>
<td>189 mg/dL</td>
</tr>
<tr>
<td>Length of Stay</td>
<td>4.5 days</td>
<td>5.5 days</td>
<td>9 days</td>
</tr>
<tr>
<td>Mortality</td>
<td>1.7%</td>
<td>3.0%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Medical, Surgical, and ICU Patients

Average Length of Stay in Hospital

![Bar chart showing average length of stay in hospital for different chronic complications of diabetes.](chart.png)

- **Neurological**: 10 inpatient days
- **Peripheral vascular**: 14 inpatient days
- **Cardiovascular**: 12 inpatient days
- **Renal**: 10 inpatient days
- **Metabolic**: 6 inpatient days
- **Other**: 10 inpatient days
- **General medical conditions**: 12 inpatient days

Legend:
- ■ ALOS for admissions where diabetes is a secondary diagnosis
- □ Predicted ALOS if diabetes were not a complicating factor

The average cost of admission in 2010 for patients with diabetes incurred an average of $3337 more in hospital costs.
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30-day Mortality and In-hospital Complication Rates in Patients with and without Diabetes:

*P < 0.001; †NS; ‡P < 0.017.

n= 3,184
Source: Emory University Hospital (Atlanta, GA) between January 1st, 2007 and June 30th, 2007

Frisch A et al. Diabetes Care 2010; 33:1783-1788
There is an association between postoperative blood glucose levels and the rate of deep sternal wound infections.

Glycemic Variability: a Strong Independent Predictor of Mortality in Critically Ill Patients.
**Association Between Hyperglycemia and Death**

<table>
<thead>
<tr>
<th>Documented *</th>
<th>No association</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>COPD</td>
</tr>
<tr>
<td>Sepsis</td>
<td>DKA</td>
</tr>
<tr>
<td>Unstable angina</td>
<td>Gastrointestinal neoplasm</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>Musculoskeletal disease</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>Hip fracture</td>
</tr>
<tr>
<td>Stroke</td>
<td>Liver failure</td>
</tr>
<tr>
<td>Gastrointestinal bleeding</td>
<td>Prostate surgery</td>
</tr>
<tr>
<td>Acute renal failure</td>
<td></td>
</tr>
<tr>
<td>Respiratory failure</td>
<td></td>
</tr>
</tbody>
</table>

* High risk patients: Recommended better glycemic control

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GLYCEMIC CONTROL AND REDUCED MORTALITY (Leuven 1)

Surgical ICU Patients

Intensive treatment per protocol reduced the risk of mortality\(^1\)

**ICU survival (%)**

**In-hospital survival (%)**

34% reduction in mortality with intensive treatment; \(P<0.01\)

GLYCEMIC CONTROL AND REDUCED MORTALITY ((Leuven 2))

Intensive treatment per protocol reduced the risk of mortality. But how do you know which patients will be in MICU > 3 days?

Figure 4. Kaplan–Meier Curves for In-Hospital Survival.
The effect of intensive insulin treatment on the time from admission to the intensive care unit (ICU) until death is shown for the intention-to-treat group (Panel A) and the subgroup of patients staying in the ICU for three or more days (Panel B). Patients discharged alive from the hospital were considered survivors. P values calculated by the log-rank test were 0.40 for the intention-to-treat group and 0.02 for the subgroup staying in the ICU for three or more days. P values calculated by proportional-hazards regression analysis were 0.30 and 0.02, respectively.
GLYCEMIC CONTROL AND REDUCTIONS IN COMPLICATIONS

<table>
<thead>
<tr>
<th>Complication</th>
<th>Percent Reduction (%)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sepsis</td>
<td>46%</td>
<td>0.003</td>
</tr>
<tr>
<td>Dialysis</td>
<td>41%</td>
<td>0.007</td>
</tr>
<tr>
<td>Blood transfusion per patient</td>
<td>50%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Polyneuropathy</td>
<td>45%</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

N=1548

Critical Ill Patients

THE NORMOGLYCEMIA IN INTENSIVE CARE EVALUATION—SURVIVAL USING GLUCOSE ALGORITHM REGULATION (NICE-SUGAR) TRIAL
Nice Sugar

### Table 1. (Continued.)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intensive Glucose Control</th>
<th>Conventional Glucose Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical ventilation — no./total no. (%)</td>
<td>2825/3014 (93.7)</td>
<td>2793/3014 (92.7)</td>
</tr>
<tr>
<td>Renal-replacement therapy — no./total no. (%)</td>
<td>179/3014 (5.9)</td>
<td>165/3014 (5.5)</td>
</tr>
<tr>
<td>History of diabetes mellitus — no./total no. (%)</td>
<td>615/3014 (20.4)</td>
<td>596/3014 (19.8)</td>
</tr>
<tr>
<td>Type I diabetes</td>
<td>50/615 (8.1)</td>
<td>42/596 (7.0)</td>
</tr>
<tr>
<td>Type II diabetes</td>
<td>565/615 (91.9)</td>
<td>554/596 (93.0)</td>
</tr>
<tr>
<td>Previous treatment with insulin</td>
<td>183/615 (29.8)</td>
<td>163/596 (27.3)</td>
</tr>
<tr>
<td>Previous treatment with systemic corticosteroids — no./total no. (%)</td>
<td>393/3014 (13.0)</td>
<td>378/3014 (12.5)</td>
</tr>
<tr>
<td>Subgroup classification — no./total no. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe sepsis at randomization</td>
<td>676/3014 (22.4)</td>
<td>626/3014 (20.8)</td>
</tr>
<tr>
<td>Trauma</td>
<td>422/3014 (14.0)</td>
<td>466/3014 (15.5)</td>
</tr>
<tr>
<td>APACHE II score ≥25</td>
<td>929/3013 (30.8)</td>
<td>945/3012 (31.4)</td>
</tr>
</tbody>
</table>

Nutrition Support in the ICU

- Target 20-25 kcal/kg/d
  - > 25 increases risk of overfeeding and hepatopathy
  - < 20 increases risk of underfeeding and starvation-induced catabolism
- Protein targets are generally 1.2 – 1.5 g/kg/d
- Prevent critical energy debt by ICU day 3-5
- Positive nitrogen balance is generally not possible
- Early combined enteral and parenteral nutrition to meet these evidence-based requirements
Continuing controversy in the intensive care unit: why tight glycemic control, nutrition support, and nutritional pharmacology are each necessary therapeutic considerations

Mette M. Berger and Jeffrey I. Mechanick
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What Diagnostic Criteria Should We Use for In-hospital Diagnosis of Hyperglycemia?

ADA / AACE Guidelines

Blood glucose >140 mg/dL on admission or during hospitalization?
Pre-existing diabetes or stress hyperglycemia

Measuring A1c for differentiation

- >6.5% (preceded diabetes)
- <6.5% (? Stress hyperglycemia)
  Does not exclude diabetes

OGTT after discharge

Sensitivity 44-66%
Specificity 76-99%

Moghissi ES at al. Diabetes Care 2009; 32:1119-1131
– In one report, about 60% of patients who had hyperglycemia during hospitalization were likely to have diabetes at follow-up testing 1 month after discharge

**Target Blood Glucose**

<table>
<thead>
<tr>
<th>Organization</th>
<th>ICU</th>
<th>Medical/Surgical Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AACE/ADA³</td>
<td>140-180 mg/dL</td>
<td>Premeal: &lt;140 mg/dL³</td>
</tr>
</tbody>
</table>

³Provided these targets can be safely achieved. An individual patient’s medical condition should determine target goals.
AACE/ADA RECOMMENDATIONS FOR MANAGING PATIENTS WITH DIABETES IN THE HOSPITAL SETTING

– In the hospital setting, insulin therapy is the preferred method for achieving glycemic control

– In the ICU, IV infusion is the preferred route of insulin administration. Outside of critical care units, subcutaneous administration is frequently used

– Orally administered agents have a limited role in the inpatient setting

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Protocols for Hospital Management

- ICU unit (IV insulin infusion)
- Non-Critical Care unit (Basal-Bolus Insulin)
- Hypoglycemia
- Pre-operative and NPO
- Parenteral Nutrition
- Enteral Nutrition
IV Insulin Infusion

100 units Regular Insulin into 100 cc NS (1.0 unit/ml)

Test blood glucose every hour

Starting Rate 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)

2. Adjust Multiplier to keep in desired glucose target range (140 to 180 mg/dl)

- If BG 140 - 180 mg/dl, no change in Multiplier
- If BG > 180 mg/dl, increase by 0.01
- If BG < 140 mg/dl, decrease by 0.01

Example: Current BG is 120 mg/dl, last multiplier 0.02 units/hr and last rate 2 units/hr
(120 - 60) X 0.01 = 0.6 units/hour (0.6 ml/hour)
Starting dose = Body weight (kg) x 0.2
- Glargine insulin: One dose at bedtime
- Detemir insulin: One dose at bedtime (Type 2) or split to 2 equal doses AM and bedtime (Type 1)
- NPH insulin: 2/3 AM and 1/3 bedtime

Example: Type 2 and body weight 100 kg: Glargine or Detemir 20 units at bedtime or NPH 14 units AM and 6 units BEDTIME

1. If fasting blood glucose >140 mg/dl, increase bedtime dose by 2 units (an increase of 1-4 units may be considered)
2. If pre-supper >140 mg/dl, increase the AM dose by 2 units (an increase of 1-4 units may be considered)
Starting dose = **Body weight (kg) x 0.2** divided equally for the 3 meals (for a blood glucose >80 mg and eating a meal)

**Calculate Correction Factor**
1. For previously known total daily dose (TDD): \( \frac{1700}{\text{TDD}} \)
2. For unknown total daily dose: \( \frac{3000}{\text{Body weight (Kg)}} \)
3. Build the scale by increasing insulin dose by 1-2 units for every correction factor.

**Example:** 75 Kg person with unknown previous insulin dose. Starting insulin = 75 X 0.2 = 15 (5 units for each meal). Correction: \( \frac{3000}{75} = 40 \text{ mg/dl} \)

Scale:
- 80-120 mg/dl = 5 units
- 120-160 mg/dl = 6 units
- 160-200 mg/dl = 7 units

**STAT Dose**
\( \frac{\text{Current blood glucose} - 100}{\text{CF}} \)

**Example:** Current BG 340 and CF 40: \( \frac{340 - 100}{40} = 6 \text{ units of short acting insulin} \)
ICU:  >140 mg/dl
Regular ward and postpartum:  >100 mg/dl
Labor:  >80 mg/dl
<table>
<thead>
<tr>
<th>Day Before the surgery</th>
<th>Maintain usual meal plan and insulin dose, insulin via pump (CSII), or oral anti-diabetes medications.</th>
</tr>
</thead>
</table>

Pre-Operative and NPO
• Regular insulin at a dose of 0.1 unit/gram of carbohydrates in TPN
• Correction dose of regular insulin q6 hr or rapid acting analog insulin q4 hr

Example:
• Patient in the ICU with TPN of 1600 cal, 60% carbohydrates, weigh 75 Kg
• Amount of carbs in grams = 1600 * 0.6 / 4 = 240 grams
• Regular insulin in TPN = 240 * 0.1 = 24 units
• Correction dose = 3000/75 = 40 (1 units for every 40 mg above target q4-6 hrs)

Transition to oral feeding

Previous TDD divided into 50% basal and 50% as boluses before meals
Continuous tube feeding

- TDD = 0.3-0.6 unit/kg body weight as basal insulin (2 doses of Glargine or Detemir or 2-3 doses of NPH)
- Correction dose of regular insulin q6 hr or rapid acting analog insulin q4 hr
- Basal insulin is adjusted by adding 80% of the previous day's correctional insulin

Cyclic overnight tube feeding

- TDD = 0.3-0.6 unit/kg body weight as NPH insulin given 3-4 hours before the start of the feeding
- If patients on nocturnal tube feedings are eating meals, they may require mealtime bolus insulin

Bolus tube feedings

- Covered the same as ingested meals with basal insulin and a dose of rapid-acting analog insulin for each bolus feeding
Interruption of tube feedings

• Insulin should be adjusted appropriately if there is a planned withholding of feedings.

• If the enteral feeding is unexpectedly interrupted for more than 2 hours, stop all insulins and give DW10% IV at the same rate as that of the enteral feedings to prevent hypoglycemia.

• Monitoring electrolytes and providing adequate free water to prevent dehydration.
– New hyperglycemia in hospital is associated with high 30-day readmission rate and, if missed, significantly increased mortality

– There is a strong association between the degree on hyperglycemia and in-hospital complications and mortality

– Wide glucose variability is associated with increased mortality at all ranges of blood glucose level

– Tight diabetes control in the ICU is controversial but seems to be of value in surgical ICU than in medical ICU. Medical nutrition therapy is a modifier of the outcomes