Workshop 1: Inpatient Management of Hyperglycemia

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Disclosures

- Sports: Patriots and Celtics fan
- Advisory Board: Astra Zeneca, Sanofi Aventis
- Research Support: National Dairy Council
- Consultant: Abbott Nutrition, Merck
- Shares: Healthimation
- Speaker bureau: None
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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Diabetes is a costly disease
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.

Blood Glucose >180 mg/dL

Prevalence of Hyperglycemia in 126 US Hospitals

ICU: 46%
Regular Wards: 32%
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

Robbins JM & Webb DA. Med Care 2006; 44:292-296
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>62%</td>
<td>26%</td>
<td>12%</td>
</tr>
<tr>
<td>Admission BG (mg/dL)</td>
<td>108</td>
<td>230</td>
<td>189</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

Objectives

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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.


n = 1585

HYPERGLYCEMIA AND RATE OF INFECTIONS IN CARDIAC SURGERY PATIENTS

Deep sternal wound infection rate (%) vs. Day 1 blood glucose (mg/dL)

- 100-150: 13%
- 150-200: 16%
- 200-250: 25%
- 250-300: 67%

P = 0.002

Hyperglycemia as Independent Marker of In-Hospital Death

- Normal blood glucose: 1.7%
- Known Diabetes: 3.0%
- New Hyperglycemia: 16.0%

* p<0.01

Umpierrez GE et al. J Clin Endocrinol Metab 2002; 87:978-982
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 REDUCTIONS IN COMPLICATIONS

Critically Ill Patients

Sepsis
46%
P = 0.003

Dialysis
41%
P = 0.007

Blood transfusion per patient
50%
P < 0.001

Polyneuropathy
45%
P < 0.001

N=1548

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
EDITORIAL

Continuing controversy in the intensive care unit: why tight glycemic control, nutrition support, and nutritional pharmacology are each necessary therapeutic considerations
Mette M. Berger\textsuperscript{a} and Jeffrey I. Mechanick\textsuperscript{b}

Figure 1 Mean daily energy deliveries normalized for weight over the first 2 weeks

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1}
\caption{Mean daily energy deliveries normalized for weight over the first 2 weeks.}
\end{figure}
Differences in Resource Utilization Between Diabetic Patients Receiving Diabetes-Specific Nutrition Formula Versus Standard Nutrition Formula In US Hospitals
Results

- Feeding DSF to patients with diabetes results in significant* improvement in patient efficiency and cost of care

<table>
<thead>
<tr>
<th></th>
<th>Tube Fed PWD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Length of Hospital Stay</td>
<td>0.9 days</td>
</tr>
<tr>
<td>Total Hospital Costs</td>
<td>$2,586</td>
</tr>
</tbody>
</table>

* Average LOS and hospital cost statistically significant at P < 0.001

When caring for hospitalized patients with diabetes, consider consulting with a specialized diabetes or glucose management team where possible.
Resource Utilization for Inpatient Diabetes Management and its Impact on 30-day Readmission and Overall Cost

Hospitalist  Specialist

Models of Inpatient Diabetes Management

**Primary Service Team (PST)**
- House staff
- General Discharge plan
- Follow up

**Diabetes Team (DT)**
- Endocrinologist
- Basic Diabetes Education
- Diabetes Discharge plan
- Transition of care

30-day Readmission Rate per Service among Diabetic Patients Managed by Primary Service Team (PST) versus Team (DT) in non-ICU

**Medical Service**
- All Readmission 2011: 16.6%
- All Readmission 2012: 15.1%
- BST: 32.4%
- DT: 22.5%

**Surgical Service**
- All Readmission 2011: 13.9%
- All Readmission 2012: 9.7%
- BST: 21.7%
- DT: 26.7%

30.5% Reduction

*p<0.05

<table>
<thead>
<tr>
<th>Total Diabetes Admissions to non-ICU</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicine</td>
<td>6695</td>
<td>5567</td>
</tr>
<tr>
<td>Surgery</td>
<td>1080</td>
<td>880</td>
</tr>
</tbody>
</table>
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What Diagnostic Criteria Should We Use for In-hospital Diagnosis of Hyperglycemia?

ADA / AACE Guidelines

Perform A1C for all patients with diabetes or hyperglycemia (blood glucose >140 mg/dL on admission or during hospitalization) if not performed within 3 months

Measuring A1c for differentiation

- >6.5% (preceded diabetes)
  - OGGT after discharge
  - Sensitivity 44-66%
  - Specificity 76-99%

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

ADA. Diabetes Care. 2019;42 (suppl 1):S173-S181
– 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.
CURRENT IN-HOSPITAL BLOOD GLUCOSE RANGE

– While an association between hyperglycemia and poor outcomes has been reported, the optimal target BG that would provide maximum outcome improvement is unknown

– Several clinical studies suggest that it is reasonable to aim to reduce BG levels to <180 mg/dL

ADA. Diabetes Care. 2019;42 (suppl 1):S173-S181
Plasma Glucose (mg/dL)

<table>
<thead>
<tr>
<th>Organization</th>
<th>ICU</th>
<th>Medical/Surgical Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AACE/ADA</td>
<td>140-180 mg/dL</td>
<td>Premeal: &lt;140 mg/dL&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Random: &lt;180 mg/dL&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

- More stringent goals such as 110-140 mg/dL may be appropriate for selected patients if this can be achieved without significant hypoglycemia.

ADA. Diabetes Care. 2019;42 (suppl 1):S173-S181
Insulin should be administered using validated written or computerized protocols that allow for predefined adjustments in the insulin dosage based on glycemic fluctuations. (CPOE = computerized physician order entry)

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

Safety and efficacy of non-insulin antihyperglycemic therapy is an area of active research.

ADA. Diabetes Care. 2019;42 (suppl 1):S173-S181
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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
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)
Calculating Basal-Bolus Insulin

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

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)

(A multiplier of 0.2 to 0.5 may be considered based on the home insulin regimen and the degree of insulin resistance)
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): \( \frac{1700}{TDD} \)
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 \( 75 \times 0.2 = 15 \) (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: \( \frac{340 - 100}{40} = 6 \) units of short acting insulin
## Hypoglycemia Management

<table>
<thead>
<tr>
<th>Location</th>
<th>Target Blood Glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU:</td>
<td>&gt;140 mg/dl</td>
</tr>
<tr>
<td>Regular ward and postpartum:</td>
<td>&gt;100 mg/dl</td>
</tr>
<tr>
<td>Labor:</td>
<td>&gt;80 mg/dl</td>
</tr>
</tbody>
</table>

- If patient is conscious and on oral feeding give 15-20 grams of sugars or carbohydrates.
  - Example: Glucose tablets, 4 oz (1/2 cup) of juice or regular soda, 4 or 5 saltine crackers, 4 teaspoons of sugar.

- ICU patients on insulin infusion:
  1. Stop insulin infusion.
  2. Give a bolus of D50 cc = (100 – BG) x 0.4 followed by IV infusion of D10W 50 cc/hr.
  3. After reaching the target blood glucose, resume IV insulin at 1/2 previous rate.

- Patients on SC insulin and NPO:
  1. Give a bolus of D50 cc = (100 – BG) x 0.4 followed by IV infusion of D10W 50 cc/hr.
  2. After reaching the target blood glucose, resume insulin regimen after appropriate insulin adjustment if needed.

- Glucagon 1mg SC if unconscious and no IV line.
Day Before the surgery

Maintain usual meal plan and insulin dose, insulin via pump (CSII), or oral anti-diabetes medications.

<table>
<thead>
<tr>
<th>Pre-Operative and NPO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day Before the surgery</td>
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</table>
• 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.
SUMMARY
– 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

– Using protocols for inpatient diabetes management by specialized diabetes team is recommended