Inpatient Management of Hyperglycemia
Guillermo Umpierrez, MD, CDE
Saturday, February 10, 2018
10:30 a.m. – 11:15 a.m.

There are over 7.5 million hospital admissions for patients with diabetes in the US. About 20 to 30% of patients have prior history of diabetes. The prevalence of hyperglycemia is even higher and reported in 38% of patients in community hospitals, 41% of critically ill patients with acute coronary syndromes, and in 80% of patients after cardiac surgery. Diabetes imposes a substantial economic burden on society. The total estimated cost of diagnosed diabetes in 2012 in the US was $245 billion, of which $76 billion (41%) represented inpatient medical care. Extensive data from observational and randomized controlled trials indicate that inpatient hyperglycemia, in patients with or without a prior diagnosis of diabetes, is associated with an increased risk of complications and mortality. It is also well established that improvement in glucose control with goal-directed insulin regimens reduces hospital complications and mortality in critically ill, as well as in general medicine and surgery patients. Recent studies and meta-analyses have shown that intensive insulin therapy is associated with increased risk of hypoglycemia, which has been independently associated with increased morbidity and mortality in hospitalized patients.

In patients with adequate oral intake, the basal bolus approach is the preferred regimen as it addresses the three components of insulin requirement: basal, nutritional, and correctional doses. The use of basal-bolus insulin had greater improvement in blood glucose control than sliding scale alone. In general surgery patients, the basal bolus regimen resulted in significant improvement in glucose control and in a reduction in the frequency of the composite of postoperative complications including wound infection, pneumonia, respiratory failure, acute renal failure and bacteremia. In patients with reduced total caloric intake due to lack of appetite, acute illness, medical procedures or surgical interventions, the Basal Plus trial in patients with type 2 diabetes compared a standard basal bolus regimen with glargine once daily and glulisine before meals and a single daily dose of glargine and supplemental doses of glulisine for correction of hyperglycemia (>140 mg/dL) per sliding scale. There was similar improvement in glycemic control and in the frequency of hypoglycemia with Basal Plus regimen compared to basal bolus regimen.

The use of oral antidiabetic agents is generally not recommended in hospitalized patients due to the limited data available on their safety and efficacy. The safety and efficacy of sitagliptin, a DPP-4 inhibitor, for the management of inpatient hyperglycemia was recently evaluated in 3 randomized controlled studies in general medicine and surgery hospitalized patients with type 2 diabetes. These studies indicate that in patients with mild to moderate hyperglycemia (BG < 200 mg/dl), there was no difference in the mean BG concentration or in the occurrence of hospital complications.

Transition to an outpatient setting requires planning and coordination. Although insulin is used for most patients with diabetes in the hospital, many patients do not require insulin after discharge. Patients with acceptable diabetes control could be discharged on their pre-hospitalization treatment regimen (oral agents and/or insulin therapy). Patients with suboptimal control should have intensification of therapy, either by addition or increase in oral agents, addition of basal insulin, or a more complex insulin regimen as warranted by their admission glucose control. Our preliminary experience indicates that measurement of HbA1c on admission is useful in guiding treatment regimen at the time of hospital discharge in patients with type 2 diabetes. Patients admitted with a HbA1c <7% can be discharged on the same pre-admission diabetes therapy. Those with HbA1c between 7%-9% can be discharged on oral agents plus basal insulin at 50% of the hospital basal insulin and patients with HbA1c >9% should be discharged on basal bolus insulin or in the combination of metformin plus basal insulin at 80% of hospital dose.
This lecture will i) review the results of recent randomized control studies, in non-ICU patients with hyperglycemia and diabetes, ii) will present easy to follow insulin- and non-insulin-based treatment regimens for the management of inpatient hyperglycemia; iii) will discuss treatment regimens for the management of patients with diabetes after hospital discharge.
Management of Hyperglycemia and Diabetes in Non-ICU Settings: Current and Future Recommendations

Guillermo E. Umpierrez, MD, FACP, FACE
Professor of Medicine
Director, Clinical Research Diabetes & Metabolism Center
Emory University School of Medicine
Director, Diabetes & Endocrinology Section
Grady Health System

Lecture Agenda

➢ Scope of the Problem
  ▪ Prevalence and impact of hyperglycemia
  ▪ Glycemic targets in non-ICU

➢ Management of Hyperglycemia in Non-ICU
  ▪ Basal Bolus Insulin Regimen
  ▪ Alternatives to Basal Bolus
    • Basal Plus (basal + correction)
    • DPP4-inhibitors
  ▪ Hospital Discharge Regimens

Case Presentation:

➢ 68 y/o male with an 8 yr history of DM admitted with SOB and CHF. Treated with metformin and sitagliptin.
➢ Lab: BG 172 mg/dL, A1c: 7.8%; serum creatinine 1.3 mg/dL, eGFR: 45 ml/min

➢ 42 y/o male with an 10 yr history of DM with diabetic foot and osteomyelitis left toe. Treated with metformin and glipizide.
➢ Lab: BG 294 mg/dL, A1c: 9.2%; serum creatinine 1.4 mg/dL, eGFR: 60 ml/min

What is the best treatment option for glycemic control? Should both patients be treated with insulin and to the same glucose target?

Diabetes Epidemic in the U.S.

US Population

Inpatient Diabetes

- 30.1 million people
- 8.9-9.5 million hospital discharges

Diabetes Prevalence quadrupled, from 5.5 million to 21.9 million between 1980-2014

CDC’s Division of Diabetes Translation.
http://www.cdc.gov/diabetes/statistics

Distribution of patient-day-weighted mean POC-BG values for ICU

Data from ~12 million BG readings from ~63,959 ICU patients - mean POC-BG: 167 mg/dL

Swanson et al. Endocrine Practice, October 2011
Hyperglycemia and Pneumonia Outcomes

Admission glucose (mg/dl)

<table>
<thead>
<tr>
<th>BG (mg/dl)</th>
<th>%</th>
<th>Mortality</th>
<th>Hospital Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 110</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>110 - &lt;198</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>198 - &lt;250</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥250</td>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p: < 0.05 vs BG < 198 mg/dl (11 mmol/L)
N= 2,471 patients with CAP


Thirty Day Mortality and Inhospital Complications in diabetic and non-diabetic subjects Undergoing Non-Cardiac Surgery

<table>
<thead>
<tr>
<th>Complication</th>
<th>No diabetes</th>
<th>Diabetes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>*</td>
<td>#</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>*</td>
<td>#</td>
</tr>
<tr>
<td>Sepsis</td>
<td>*</td>
<td>#</td>
</tr>
<tr>
<td>Renal failure</td>
<td>*</td>
<td>#</td>
</tr>
<tr>
<td>Death</td>
<td>*</td>
<td>#</td>
</tr>
</tbody>
</table>

Tp = 0.1
* p= 0.001
#p=0.017

A Fresh & Umpierrez et al, Diabetes Care, May 2010

Adverse Events Stratified by Perioperative Hyperglycemia

<table>
<thead>
<tr>
<th>Event</th>
<th>Diabetes</th>
<th>No Diabetes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital Death</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Reoperations</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Composite Infections</td>
<td>⬤</td>
<td>⬤</td>
</tr>
</tbody>
</table>

Proportion of Patients (%)

* P <0.01
† p <0.05


What Glucose Level Predicts Hospital Complications?

N= 55,530 patients records in ICU and non-ICU, Emory University Hospitals.
Composite of complications: pneumonia, acute renal or respiratory failure, acute MI, bacteremia, and death.

Umpierrez et al. Endocrine Society Annual Meeting, 2014

Glycemic Targets in Non-Critical Care Setting

1. Premeal BG target of <140 mg/dl and random BG <180 mg/dl for the majority of patients

2. 2016 American Diabetes Association – glucose target 140-180 mg/dl for most patients with T2D

3. Glycemic targets be modified according to clinical status.
   - Patients with terminal illness <180-200 mg/dl

4. For avoidance of hypoglycemia, therapy should be reassessed when BG<100 mg/dl

ADA/AACE, Guidelines, Diabetes Care 2009;
Endocrine Society, J Clin Endocrinol Metab, 2012; Under Revision 2018;
2018 Standard of Diabetes Care, # 14, Hospital Management of Diabetes, Diabetes Care 2018

Diagnosis & recognition of hyperglycemia and diabetes in the hospital setting

<table>
<thead>
<tr>
<th>Admission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assess all patients for a history of diabetes</td>
</tr>
<tr>
<td>Obtain laboratory BG testing on admission</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>History of diabetes</th>
</tr>
</thead>
<tbody>
<tr>
<td>No history of diabetes</td>
</tr>
<tr>
<td>No history of diabetes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Start POC Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG monitoring x 24-48h Check A1C</td>
</tr>
</tbody>
</table>

| A1C ≥ 6.5% |

A1C for Diagnosis and Management of Hyperglycemia in the Hospital

- Measure HbA1c in non-DM subjects with persistent BG >140 mg/dl and in DM subjects if not done within 2-3 mo.
- Implementation of A1C testing can be useful:
  - Assess glycemic control prior to admission
  - Assist with differentiation of newly diagnosed diabetes from stress hyperglycemia
  - Predicts inpatient glycemic control and hypoglycemia
  - Design an optimal regimen at hospital discharge

ADA Standard of Care, 14. Hospital Management of Diabetes. Diabetes Care January, 2018
Umpierrez et al. J Clin Endocrinol Metab. February 2012
Pasquell et al. Diabetes Care 2014

Recommendations for Managing Patients With Diabetes in Non-ICU Setting

- **Antihyperglycemic Therapy**
  - **Insulin** Recommended
  - **OADs** Not Generally Recommended

SC Insulin Administration

**Scheduled**

Basal + Bolus (Prandial) + Correction

Long-acting insulin + Rapid-acting insulin

SC Insulin Administration


Randomized Basal Bolus versus Sliding Scale Regular Insulin in patients with type 2 Diabetes Mellitus (RABBIT-2 Trial)

- D/C oral antidiabetic drugs on admission
- Starting total daily dose (TDD):
  - 0.4 U/kg/d x BG between 140-200 mg/dL
  - 0.5 U/kg/d x BG between 201-400 mg/dL
- Half of TDD as basal insulin and half as rapid-acting insulin
  - Insulin glargine - once daily, at the same time/day.
  - Glulisine- three equally divided doses (AC)

Umpierrez et al, Diabetes Care 30:2181–2186, 2007
• Before meal: Supplemental Sliding Scale Insulin (number of units)
  – Add to scheduled insulin dose

• Bedtime: Give half of Supplemental Sliding Scale Insulin

<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>&gt;141-180</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>181-220</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>221-260</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>261-300</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>301-350</td>
<td>12</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>&gt;400</td>
<td>12</td>
<td>16</td>
<td>18</td>
</tr>
</tbody>
</table>


Rabbit 2 Trial: Changes in Glucose Levels With Basal-Bolus vs. Sliding Scale Insulin

<table>
<thead>
<tr>
<th>BG, mg/dL</th>
<th>Sliding Scale Insulin</th>
<th>Basal Bolus Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;141-180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>181-220</td>
<td></td>
<td></td>
</tr>
<tr>
<td>221-260</td>
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<tr>
<td>261-300</td>
<td></td>
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</tr>
<tr>
<td>301-350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;400</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hypoglycemia rate:
- Basal Bolus Group:
  • BG < 60 mg/dL: 3%
  • BG < 40 mg/dL: none
- SSRI:
  • BG < 60 mg/dL: 3%
  • BG < 40 mg/dL: none


RABBIT-2 Surgery Trial:
- Research Question:
  T2DM on diet, oral agents or insulin treatment, does treatment with basal bolus regimen with glargine and glulisine is superior to SSRI?

Composite of hospital complications: wound infection, pneumonia, respiratory failure, acute kidney injury, and bacteremia

Umpierrez et al, Diabetes Care 34(2):1-6, 2011

Mean BG before meals and at bedtime during basal bolus and SSI therapy

- Basal Bolus Insulin Analogs
- Sliding Scale Regular Insulin

Umpierrez et al, Diabetes Care 34(2):1-6, 2011

Postoperative Complications

- Composite of hospital complications: wound infection, pneumonia, respiratory failure, acute renal failure, and bacteremia

Umpierrez et al, Diabetes Care 34(2):1-6, 2011

Hospitalization Outcomes and Costs

<table>
<thead>
<tr>
<th>Outcome</th>
<th>All (n=180)</th>
<th>Basal Bolus (n=88)</th>
<th>SSI (n=92)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of hospital stay, days</td>
<td>7.9 ± 5.5</td>
<td>7.3 ± 5.1</td>
<td>8.5 ± 5.9</td>
<td>0.15</td>
</tr>
<tr>
<td>Patients with complications, n (%)</td>
<td>28 (16%)</td>
<td>6 (7%)</td>
<td>22 (24%)</td>
<td>0.002</td>
</tr>
<tr>
<td>Postoperative ICU admission, n (%)</td>
<td>23 (13%)</td>
<td>10 (11%)</td>
<td>13 (14%)</td>
<td>0.66</td>
</tr>
<tr>
<td>Total hospitalization costs, USD</td>
<td>24457 ± 18359</td>
<td>23226 ± 18745</td>
<td>25641 ± 17991</td>
<td>0.09</td>
</tr>
<tr>
<td>Inpatient cost per day</td>
<td>4541 ± 18359</td>
<td>3907 ± 6606</td>
<td>3724 ± 4020</td>
<td></td>
</tr>
</tbody>
</table>

Treatment with BB compared with SSI reduced average total inpatient costs per day by $95751 (14%; 95% confidence interval 20-4).

Data presented as mean ± SD
*Wound infections, pneumonia, acute respiratory failure, acute renal failure, bacteremia

Basal Bolus with Insulin Analogs vs. Sliding Scale Insulin regimen in Non-ICU Patients With Type 2 Diabetes

Inpatient Management in non-ICU Setting

Basal Bolus Insulin Analogs

Sliding Scale Regular Insulin

DEAN Trial: Detemir + Aspart vs. NPH + Regular

Data are means ±SEM.

Basal Bolus regimen: detemir was given once daily; aspart was given before meals.
NPH/regular regimen: NPH and regular insulin were given twice daily, two thirds in AM, one third in PM.

RCT- Insulin Analogs (glargine + glulisine) vs. Human (NPH + regular) Insulin

Prevalence of Hypoglycemia in Patients Treated with Human and Analogs

<table>
<thead>
<tr>
<th></th>
<th>ALL N=134</th>
<th>Analogs N=66</th>
<th>Human n=68</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild Hypoglycemia</td>
<td>37</td>
<td>35</td>
<td>38</td>
<td>0.68</td>
</tr>
<tr>
<td>Severe hypoglycemia</td>
<td>16</td>
<td>7.6</td>
<td>25</td>
<td>0.08</td>
</tr>
<tr>
<td>Patients with ≥2 episodes, n (%)</td>
<td>19</td>
<td>10</td>
<td>16</td>
<td>0.2</td>
</tr>
</tbody>
</table>


Similar BG control, but less severe hypoglycemia with analogs.
Management of Patients With Diabetes in the Non-ICU Setting

Insulin Recommended

1. Basal Bolus preferred over SSI
2. Analogs vs. Human Insulin: Similar BG control, but less severe hypoglycemia with analogs

Limitations:
- Hypoglycemia Risk
- Regimen - Multiple injections
  - Over-treatment in many patients

Alternatives to Basal Bolus Insulin Regimen in Non-ICU Settings

- Basal Plus (basal + correction)
- DPP4-inhibitors

Basal Plus Trial
Basal + Correction vs. Basal Bolus

Basal Plus (n=150)
- Glargine once daily
- 0.25 U/kg
- Glulisine 50%
- Adjust as needed

Basal Bolus
- TDD: 0.5 U/kg
- Glargine 50%
- Glulisine 50% (AC)
- Correction for BG >140 mg/dl per sliding scale

* Reduce TDD to 0.3 U/kg in patients ≥70 yrs and/or serum creatinine ≥ 2.0 mg/dL

Basal-PLUS vs Basal Bolus: Medicine and Surgery Patients

Medicine
Daily BG

Surgery
Daily BG

Patients treated with diet, oral agents or with low-dose insulin ≤ 0.4 U/Kg/Day

**Insulin Treatment in Non-ICU Setting**

T2DM with BG > 140 mg/dl (7.7 mmol/l)

- NPD (Uncertain oral intake)
- Basal insulin: Start at 0.2-0.25 U/Kg/day
  - Correction doses with rapid acting insulin AC
  - Adjust basal as needed
- Basal Bolus: TDD: 0.4-0.5 U/Kg/day
  - ½ basal, ½ bolus
  - Adjust basal as needed

ADA Standard of Care. Diabetes Care, January 2017

**Management of Patients With Diabetes with Oral Agents in Non-ICU Settings**

- Inpatient Management in non-ICU
  - Basal Bolus Regimens
    - 50% Basal
    - 50% Prandial
- Oral Agents: DPP-4-Inhibitors

**DPP-4 Therapy in Hospitalized Patients**

- **Study Type**: Multicenter, prospective, open-label randomized clinical trial
- **Patient Population**: Patients with T2D admitted to general medicine and surgery services at 3 hospitals: Emory University, Grady, and University of Michigan
- **Treatment Groups**
  - Group 1. Sitagliptin once daily (n=30)
  - Group 2. Sitagliptin plus glargine insulin once daily (n=30)
  - Group 3. Basal bolus regimen with glargine once daily and lispro before meals (n=30)

*All groups received supplemental doses of lispro for BG > 140 mg/dl before meals*


**Mean Daily BG During Treatment**

- Basal Bolus
- Sitagliptin
- Sitagliptin + Glargine


**Randomization Blood Glucose (<180 mg/dl and >180 mg/dl) and Mean Daily Glucose concentration**

- Basal Bolus
- Sitagliptin
- Sitagliptin + Glargine

*P= 0.91*


**Sita Hospital Trial Research Design and Methods**

- **Study Type**: Multicenter, prospective, open-label randomized clinical trial
- **Patient Population**: Patients with T2D admitted with BG between 140-400 mg/dl, treated with diet, OADs and insulin at TDD < 0.6 Unit/kg
- **Treatment Groups**
  - Group 1. Sitagliptin plus glargine once daily (n=140)
  - Group 2. Basal bolus regimen with glargine once daily and rapid-acting insulin before meals (n=140)

*Both groups received supplemental (correction) doses of rapid-acting insulin for BG > 140 mg/dl before meals*

Pasquel et al. Lancet Diabetes & Endocrinology. 5 (2) 125-133, 2017
Sita-Hospital Trial: Mean Daily BG During Treatment

Pasquel et al. Lancet Diabetes & Endocrinology, 5 (2) 125-133, 2017

Insulin Dose and # Injections/day

<table>
<thead>
<tr>
<th></th>
<th>Sitagliptin + Basal</th>
<th>Basal Bolus</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total daily dose, U/kg/day</td>
<td>0.2 ± 0.1</td>
<td>0.3 ± 0.2</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Total daily dose, U/day</td>
<td>24.1 ± 16.2</td>
<td>34.0 ± 20.1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Basal–Glargine, U/day</td>
<td>17.9 ± 12.5</td>
<td>16.8 ± 10.4</td>
<td>0.94</td>
</tr>
<tr>
<td>Prandial–aspart/lispro, U/day</td>
<td>11.7 ± 7.9</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>Supplements–U/day*</td>
<td>5.8 ± 5.7</td>
<td>5.5 ± 4.7</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Number of Injections

<table>
<thead>
<tr>
<th></th>
<th>Hospital stay</th>
<th>Day 2–10</th>
</tr>
</thead>
<tbody>
<tr>
<td># injections/day</td>
<td>2.2 ± 1.0</td>
<td>2.9 ± 0.9</td>
</tr>
<tr>
<td># injections/day</td>
<td>2.1 ± 1.4</td>
<td>2.9 ± 1.1</td>
</tr>
</tbody>
</table>

Pasquel & Umpierrez et al. www.thelancet.com/diabetes-endocrinology Published online December 6, 2016

Linagliptin Surgery Trial

A Randomized Controlled Trial on the Safety and Efficacy of Linagliptin Therapy for the Inpatient Management of General Surgery Patients with Type 2 Diabetes

Vellanki & Umpierrez et al. ADA 2017 Scientific Meeting

Linagliptin Inpatient Trial

A Randomized Controlled Trial on the Safety and Efficacy of Linagliptin Therapy for the Inpatient Management of General Surgery Patients with Type 2 Diabetes

- Linagliptin*: Linagliptin: 5 mg/day
- Basal Bolus Regimen*: Total daily insulin dose: 0.4 unit/kg/day for BG between 140-200 mg/dl and 0.5 unit/kg/day for BG between 201-400 mg/dl
- Half of total daily dose (TDD) given as glargine once daily
- Half of TDD given as lispro in three equal doses before meals
  * Supplemental (correction) doses of rapid-acting insulin analog per sliding scale given as needed before meals for BG > 140 mg/dl or bedtime > 200 mg/dl

Vellanki & Umpierrez et al. ADA 2017 Scientific Meeting

Lina Surgery Trial: Daily Glucose Levels

Vellanki & Umpierrez et al. ADA 2017 Scientific Meeting

Lina Surgery Trial: Daily Glucose Levels

Vellanki & Umpierrez et al. ADA 2017 Scientific Meeting
**Saxagliptin in Non-Critically ill Hospitalized Patients with T2D and Mild Hyperglycemia**

Mean Blood Glucose During Study

- Basal Group
- Saxa Group

**Management of General Medicine Patients With T2D**

- Glucose <200 mg/dl
  - Basal*
  - Basal* or DPP4-I*

- Glucose >200 mg/dl
  - Basal* + DPP4-I
  - Basal Bolus

Basal*: Basal Insulin once daily PLUS correction per sliding scale

DPP4-I*: Sitagliptin or linagliptin PLUS correction per sliding scale

**Management of Patients With Diabetes a**

**Recommendations for Managing Patients With Diabetes After Hospital Discharge**

- Use admission A1C to adjust therapy at discharge

- A1C < 7%
  - Re-start outpatient treatment regimen (OAD and/or insulin)

- A1C 7%-9%
  - Re-start outpatient oral agents and D/C on glargine once daily at 50% of hospital dose

- A1C >9%
  - D/C on basal bolus at same hospital dose.
  - Alternative: re-start oral agents and D/C on glargine once daily at 80% of hospital dose

**Discharge Insulin Algorithm**

**Hospital Discharge Algorithm Based on Admission HbA1C for the Management of Patients with T2DM**
Hospital Discharge Algorithm Based on Admission HbA1C for the Management of Patients with T2DM

**Primary outcome:**
- change in A1C at 4 wks and 12 wks after discharge

<table>
<thead>
<tr>
<th></th>
<th>All Patients</th>
<th>OAD</th>
<th>OAD + Glargine</th>
<th>Glargine+ Glulisine</th>
<th>Glargine</th>
</tr>
</thead>
<tbody>
<tr>
<td># patients, n (%)</td>
<td>224</td>
<td>81</td>
<td>61</td>
<td>54</td>
<td>20</td>
</tr>
<tr>
<td>A1C Admission, %</td>
<td>8.7±2.5</td>
<td>6.9±1.5</td>
<td>9.2±1.9</td>
<td>11.1±2.3</td>
<td>8.2±2.2</td>
</tr>
<tr>
<td>A1C 4 Wks F/U, %</td>
<td>7.9±1.7*</td>
<td>7.0±1.4</td>
<td>8.0±1.46g</td>
<td>8.8±1.8ψ</td>
<td>7.7±1.7</td>
</tr>
<tr>
<td>A1C 12 Wks F/U, %</td>
<td>7.3±1.5*</td>
<td>6.6±1.1</td>
<td>7.5±1.65*</td>
<td>8.0±1.6*</td>
<td>6.7±0.8*</td>
</tr>
</tbody>
</table>

* p< 0.001 vs. Admission A1C; ψp=0.08

Umpierrez et al, ADA Scientific Sessions, 2012

**Revised Discharge Insulin Algorithm**

- **OAD and/or insulin**
- **OAD + Glargine**
- **Glargine + Glulisine**

<table>
<thead>
<tr>
<th>A1C &lt; 7%</th>
<th>A1C 7%-9%</th>
<th>A1C &gt;9%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-start outpatient treatment regimen (OAD and/or insulin)</td>
<td>Re-start outpatient oral agents and D/C on glargine once daily at 50% of hospital dose</td>
<td>D/C on basal bolus at same hospital dose. Alternative: re-start oral agents and D/C on glargine once daily at 80% of hospital dose</td>
</tr>
</tbody>
</table>


**Sitagliptin-Discharge Trial**

- **A1C < 7%**
- **A1C 7%-9%**
- **A1C >9%**

- Sitagliptin ± metformin and/or previous antidiabetic regimen OAD or insulin
- Sitagliptin ± metformin plus glargine once daily at 50% of hospital dose
- Sitagliptin ± metformin plus glargine once daily at 80% of hospital dose

Gianchandani et al, ADA 2016

**Sitagliptin-Discharge Trial**

- Admission 8.7%
- 3 months 7.31% 7.32%
- 6 months 7.1%

HbA1c, Duration of Follow-Up

Gianchandani et al, ADA 2016

**Management of diabetes in non-critical care setting**

So... What really have we learned?

**Case Presentation:**

- 68 y/o male with an 8 yr history of DM admitted with SOB and CHF. Treated with metformin and sitagliptin.
  - Lab: BG 172 mg/dL, A1c: 7.8%; serum creatinine 1.3 mg/dL, eGFR: 45 ml/min

- 42 y/o male with an 10 yr history of DM with diabetic foot and osteomyelitis left toe. Treated with metformin and glipizide.
  - Lab: BG 294 mg/dL, A1c: 9.2%; serum creatinine 1.4 mg/dL, eGFR: 60 ml/min

What is the best treatment option for glycemic control? Should both patients be treated with insulin and to the same glucose target?
What Glucose Level Predicts Hospital Complications?

Rabbit 2 Trial: Changes in Glucose Levels With Basal-Bolus Insulin, Glucagon, and Glucagon-Like Peptide 1 (GLP1) Administration to Normal Rabbits

Postoperative Complications

<table>
<thead>
<tr>
<th>Glucose Level</th>
<th>Outcome Frequency, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite</td>
<td>16.3</td>
</tr>
<tr>
<td>Mortality</td>
<td>16.3</td>
</tr>
<tr>
<td>Wound infection</td>
<td>8.6</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>6.8</td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>6.8</td>
</tr>
</tbody>
</table>

* Composite of hospital complications: wound infection, pneumonia, respiratory failure, sepsis, renal failure, and bacteremia.

Umpierrez et al. Diabetes Care 34(12), 2011

Future Research

Hospital Management of Diabetes: Future Research

- Low-cost Oral agents
- Insulin Pumps
- GLP1-RA
- Prevention stress hyperglycemia
- Continuous glucose monitoring
- Future Areas of Research
- Close Loop

Diabetes Mellitus in the Hospital Setting

Basal-PLUS vs Basal Bolus:

DPP4-inhibitors for the Inpatient Management of General Medicine and Surgery Patients with T2D

646 meal-oct patients, BG between 140 and 400 mg/dl treated with diet, DAAC or total insulin dose ≥5.0 mg/kg/day received DPP4 alone (n=164), DPP4 plus basal (n=162) or basal bolus (n=320). All groups received correction doses with rapid-acting insulin for BG>140 mg/dl.

Basal Bolus
- Basal
- Basal + DPP4
- Basal + DPP4 + Glucagon

Blood Glucose (mg/dL) vs Duration of Treatment (days)

Thank you!

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