Safe Implementation of a Hyperglycemic Crises Protocol by Utilizing a Conversion Table

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Disclosures

Authors have nothing to disclose
Lenox Hill Hospital – New York City
USA

Lenox Hill Hospital is a comprehensive acute care hospital facility located in New York City. It is recognized nationally for its outstanding patient care, as well as its innovative medical/surgical modalities.

Our Mission
To improve the health and quality of life for the people and communities we serve by providing world-class service and patient-centered care.

Our Vision
To be a national health care leader, committed to excellence, compassion and improving the health of the community.

Our Values
Excellence  Innovation  Caring  Integrity
Diabetes Mellitus - Definition

- Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both.¹

- The name 'diabetes mellitus' is derived from:
  - Greek: ‘diabetes’ – “siphon” or “to pass through”
  - Latin: 'mellitus' – “honeyed” or “sweet”²
**β-cell dysfunction and insulin resistance produce hyperglycemia in type 2 diabetes**

**βCell Dysfunction**

- Pancreas
  - Islet βCell Degranulation; Reduced Insulin Content
  - Increased Glucose Output
  - Reduced Plasma Insulin

**Insulin Resistance**

- Liver
  - Glucose Production
  - Elevated Plasma FFA
  - Glucose Uptake

- Adipose Tissue
  - Increased Lipolysis

- Muscles
  - Decreased Glucose Transport & Activity (expression) of GLUT4

**Hyperglycemia**
Diabetes Mellitus

- Type 1 Diabetes
- Type 2 Diabetes
- Gestational Diabetes Mellitus
- Maturity Onset Diabetes of Young (MODY)
- Latent Autoimmune Diabetes Adult
- Flatbush Diabetes-Type 1B Idiopathic
- Endocrinopathies
- Drug Induced
Insulin Mechanism

http://southsidediabetes.com/patients/controlling-your-diabetes/
Intravenous Insulin vs Subcutaneous

OF NOTE: Only Regular Insulin can be given intravenously (in the treatment of hyperglycemic crises).

Regular Insulin has an IMMEDIATE onset of action with a half life of 9 minutes.
Diabetic ketoacidosis (DKA) and Hyperosmolar hyperglycemic state (HHS) are medical emergencies associated with increased morbidity, mortality and healthcare costs (Joslin, 2013).

Prompt identification and proper management of these emergencies are imperative to improve patient outcomes and prevent death (Juneja, et al., 2009).


Insulin use is renowned for positive clinical outcomes however the risk of hypoglycemia and its accompanying negative sequelae are inherent.

IV insulin drips necessitate enhanced critical thinking skills, vigilant monitoring of lab values, titration of fluid, electrolytes and insulin.
Diabetic Ketoacidosis (DKA)

- Occurs when the body does not get the glucose needed for energy because there is no insulin to get the glucose in the cells.
- Without glucose, the body starts to burn fat for energy, which produces ketones.
- When ketones build up in the blood, they make it more acidic.
- Seen usually with Type 1 diabetics and in rare cases, Type 2.
- Can be seen even when blood glucose is only > 250.
- Usually precipitated by missing insulin doses or infection/illness.
**Diabetic Ketoacidosis (DKA)**

- DKA is characterized by hyperglycemia, ketosis/ketonemia, acidosis and volume depletion. The diagnosis of DKA should be made based on the 3 of the 4 following criteria:
  - a. hyperglycemia with blood glucose (BG) > 250 mg/dL
  - b. arterial pH < 7.30 and/or serum bicarbonate < 18 mEq/L
  - c. anion Gap > 12
  - d. presence of ketonemia and/or moderate ketonuria

- Treatment is electrolyte management & insulin drip infusion with some dextrose containing hydration to prevent a rapid decrease in blood glucose
Hyperosmolar Hyperglycemic State (HHS)

- In HHS, blood sugar levels rise, and the body tries compensate by getting rid of the excess sugar by passing it into the urine.
- Eventually the longer the blood sugar goes uncontrolled, the less one urinates because they are becoming dehydrated after putting out so much urine initially.
- HHS can lead to severe dehydration if not caught and treated manifesting as seizures, coma and eventually death.
- HHS can take days or weeks to develop.
- Often BG is > 600, have altered mental status, but no ketones are present because of some insulin being secreted from the pancreas.
- Treatment is more fluids than insulin.
- Some pts may be glucose toxic and require high doses of insulin before hyperglycemia resolves.
Hyperosmolar Hyperglycemic State (HHS)

- HHS is characterized by:
  - a. hyperglycemia (usually BG > 600 mg/dL)
  - b. **volume depletion (usually 8-10 liters)**
  - c. hyperosmolality* (serum Osm > 320 mOsm/kg)
  - d. altered mental status
  - e. normal pH and serum bicarbonate > 15 mEq/L
  - f. small to absent ketonemia/ketonuria.
  - g. normal anion gap
Methods

- An inter-professional collaborative effort, based on evidenced based studies (DeSalvo, Greenberg, Henderson, & Cogen, 2012; Myers, Zilch & Rodriquez, 2013) developed and sought to pilot a hyperglycemic crises protocol (on the critical care units) that facilitated an appropriate and timely management of patients presenting with DKA or HHS.

- Such interventions contribute to length of stay reductions and associated complications of an ICU admission.

- Every effort to restore patients to diabetic control must be advocated for.

- Preliminary hyperglycemic crises protocol drafts, piloted on critical care units, required nursing estimation for insulin titration thus impacting accuracy and patient safety.

- Estimation of insulin could have had the potential to cause nurses to erroneously administer IV insulin drips. Immediate efforts to address this injurious practice were necessitated prior to patient harm occurrence.
Methods

- This hyperglycemic crises protocol was presented to the nursing critical care collaborative council, an interdisciplinary team, for consideration, input, approval and stakeholder buy-in.

- The Chief Nursing Officer strongly advocated for clarification regarding scope of practice regarding IV insulin titration, by registered nurses, in the ICU setting.

- As a response, the New York State Office of Professional Licensure indicated that these tasks are definitely within critical care nurses scope of practice when accompanied by the facility to decrease medication errors.

- A conversion table was developed (by S. Patterson) in order to assure accuracy of insulin drip calculation while fostering an environment of safety for both staff and patients alike.

- Buy-in from staff was essential in the successful implementation of the pilot program which lead to the establishment of the protocol as an adjunct in the clinical management of patients presenting with DKA and HHS.
**DKA/HHS TREATMENT: INSULIN INFUSION ALGORITHM**

*DO NOT ABRUPTLY STOP INSULIN DRIP AS THIS WILL RESULT IN PERSISTENT DKA.*

<table>
<thead>
<tr>
<th>Blood Glucose</th>
<th>Insulin Infusion</th>
</tr>
</thead>
</table>
| 0-150 mg/dL   | 1. Hold insulin infusion.  
2. If BG < 60 mg/dL, give 25g D50W IV push and recheck BG in 15 minutes. Repeat until BG > 60 mg/dL.  
3. If BG between 60-99 mg/dL, give 12.5g D50W IV push and recheck BG in 15 minutes. Repeat until BG > 99 mg/dL.  
4. Once BG > 100 mg/dL, check BG q1hour.  
5. When BG > 200 mg/dL, resume insulin infusion at 50% of the previous infusion rate (i.e. prior to holding the infusion). |
| 151-250 mg/dL | Start Dextrose-containing infusion and titrate dextrose to maintain BG 150-250 mg/dL  
Continue insulin drip per titration below*  
*Do not use less than 0.05 units/kg/hr until DKA/HHS completely resolve |

**Change in Blood Glucose UP**

<table>
<thead>
<tr>
<th>Change in Blood Glucose</th>
<th>Increase drip by 1 unit/hr</th>
<th>Increase drip by 2 units/hr</th>
<th>Increase drip by 3 units/hr</th>
<th>Increase drip by 4 units/hr</th>
<th>Bolus current rate then INCREASE drip by 2 units/hr</th>
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<td>[15% increase?]</td>
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</tr>
<tr>
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<td></td>
<td>[30% increase?]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 - 74 mg/dL</td>
<td></td>
<td>[40% increase?]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75 - 100 mg/dL</td>
<td></td>
<td>[50% increase?]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 100 mg/dL</td>
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**Change in Blood Glucose DOWN**

<table>
<thead>
<tr>
<th>Change in Blood Glucose</th>
<th>LEAVE drip at current rate</th>
<th>Decrease drip by 2 units/hr</th>
<th>Decrease drip by 4 units/hr</th>
<th>CUT DRIP RATE IN HALF*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 49 mg/dL</td>
<td></td>
<td>[15% decrease?]</td>
<td>[30% decrease?]</td>
<td></td>
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</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Conversion Table**

**DKA/HIBN TREATMENT: INSULIN INFUSION ALGORITHM (PAGE 1 OF 2)**

**INSULIN INFUSION TITRATION FOR BLOOD GLUCOSE Greater than 250 mg/dL**

<table>
<thead>
<tr>
<th>Change in Blood Glucose UP</th>
<th>LEAVE drip at current rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 24 mg/dL</td>
<td>0 - 49 mg/dL</td>
</tr>
<tr>
<td>25 - 49 mg/dL</td>
<td>Increase drip by 30%</td>
</tr>
<tr>
<td>50 - 74 mg/dL</td>
<td>Increase drip by 40%</td>
</tr>
<tr>
<td>75 - 100 mg/dL</td>
<td>Increase drip by 50%</td>
</tr>
<tr>
<td>&gt; 100 mg/dL</td>
<td>Bolus current rate then INCREASE drip by 30%</td>
</tr>
</tbody>
</table>

**INSULIN INFUSION TITRATION (% to UNITS/HOUR CONVERSION CHART)**

<table>
<thead>
<tr>
<th>Change in Blood Glucose UP</th>
<th>Current Rate (units/hour)</th>
<th>Change in Blood Glucose DOWN</th>
<th>Decrease by this amounts in units/hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase by this amounts in units/hour</td>
<td>+15%</td>
<td>+30%</td>
<td>+40%</td>
</tr>
<tr>
<td>+0.3</td>
<td>+0.6</td>
<td>+0.8</td>
<td>+1.0</td>
</tr>
<tr>
<td>+0.5</td>
<td>+0.9</td>
<td>+1.2</td>
<td>+1.5</td>
</tr>
<tr>
<td>+0.6</td>
<td>+1.2</td>
<td>+1.6</td>
<td>+2.0</td>
</tr>
<tr>
<td>+0.8</td>
<td>+1.5</td>
<td>+2.0</td>
<td>+2.5</td>
</tr>
<tr>
<td>+0.9</td>
<td>+1.8</td>
<td>+2.4</td>
<td>+3.0</td>
</tr>
<tr>
<td>+1.1</td>
<td>+2.1</td>
<td>+2.8</td>
<td>+3.5</td>
</tr>
<tr>
<td>+1.2</td>
<td>+2.4</td>
<td>+3.2</td>
<td>+4.0</td>
</tr>
<tr>
<td>+1.4</td>
<td>+2.7</td>
<td>+3.6</td>
<td>+4.5</td>
</tr>
<tr>
<td>+1.5</td>
<td>+3.0</td>
<td>+4.0</td>
<td>+5.0</td>
</tr>
</tbody>
</table>

**NOTIFY PROVIDER WHEN HOURLY INSULIN RATE EXCEEDS 12 UNITS / HOUR**

SEE TABLE ON NEXT PAGE FOR INSTRUCTIONS RE: BG < 250 mg/dL.
**Lenox Hill DKA/HHS Protocol**

**DKA/HHS TREATMENT ALGORITHM: FOR MD/NP/PA USE**

**IV Fluids**
- Determine Volume Status
- Give 1 liter of 0.9% NS or LR over 15-20 minutes
- *Hyperosmolar with a potassium less than 3 and LR*

**Potassium Replacement**
- Check serum BMP q2 hours (excludes ESRD/Anuria)

**Serum K+**

<table>
<thead>
<tr>
<th>Level</th>
<th>Total Replacement Dose and Insulin Adjustments</th>
<th>IV Fluids</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 3.5 mEq/L</td>
<td>Hold insulin until K+ &gt; 3.5 mEq/L</td>
<td>Max Peripheral Line KCl IV: 10 mEq in 100 cc H2O</td>
</tr>
<tr>
<td>3.4–3.9 mEq/L</td>
<td>20–40 mEq PO or 10-20 mEq/hr IV to keep serum K+ between 4.0 mEq/L</td>
<td>Max Central/telemetry KCl IV: 20 mEq in 100 cc H2O</td>
</tr>
<tr>
<td>4.0–5.3 mEq/L</td>
<td>30–60 mEq PO or 15-20 mEq/hr IV to keep serum K+ between 5.0 mEq/L</td>
<td>10 mEq in 50 cc H2O</td>
</tr>
<tr>
<td>≥ 5.4 mEq/L</td>
<td>No Potassium Replacement</td>
<td>20 mEq in 50 cc H2O</td>
</tr>
</tbody>
</table>

- May use PO potassium as tolerated ≤ 3.3 mEq/L
- Hold insulin until K+ > 3.3 mEq/L
- 40 mEq PO or 10-20 mEq/hr IV until K+ > 3.3 mEq/L

**Serum Glucose ≤ 250 mg/dL in DKA/HHS**
- *Switch to a Dextrose-containing fluid @ 150-250 mL/h and continue insulin infusion at a minimum of 0.05 units/kg/hour for DKA to avoid prolongation or exacerbation of DKA state*
- *Titrate dextrose infusion to maintain SERUM GLUCOSE 150-250 mg/dL by increasing the rate of dextrose fluid, the concentration of dextrose, or both*

*In HHS, when serum glucose is > 250, evaluate for resolution of HHS (see below). If HHS has resolved, transition patient off of IV insulin

**RESOLUTION OF DKA**
- Normal Anion Gap (AG) on 2 consecutive BMPs
- Glucose < 250 mg/dL
- Serum bicarbonate > 18 mEq/L and/or pH > 7.2
- Patient able to eat if others is no evidence of other intra-abdominal process (i.e. infection, bleeding, etc.)

**RESOLUTION OF HHS**
- Serum osmolality has normalized
- Glucose < 250 mg/dL
- Mental status has returned to baseline
- Patient able to eat if others is no evidence of other intra-abdominal process (i.e. infection, bleeding, etc.)

**Follow-up Algorithm**

**Insulin**

- Do not start insulin drip until K+ > 3.3 mEq/L
- Do not start insulin infusion until at least 1 liter of fluid has been administered

**Regular Insulin**
- 100 units/100 mL NS
- Bolus 0.1 units/kg IV
- Hourly infusion rate is 0.1 units/kg/hr
- *Do not use less than 0.05 units/kg/hr. Prescriber must sign next to this rate on DKA flowsheet*

**Severe Hypovolemia**

1. Bolus second liter of 0.9% NS or LR over 15-20 minutes
2. Start continuous infusion 0.9% NS @ 250-500 mL/h until volume depletion is mild

**Mild Hypovolemia**

**FOLLOW INSULIN ALGORITHM** (Pg 8)

**PROCEED TO "Transition to subcutaneous (SC) insulin"** See pg 9-10
Results

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dx Type 1</td>
<td>75%</td>
</tr>
<tr>
<td>Dx Type 2</td>
<td>25%</td>
</tr>
<tr>
<td>1 Day LOS</td>
<td>54%</td>
</tr>
<tr>
<td>2 Days LOS</td>
<td>46%</td>
</tr>
<tr>
<td>Hypoglycemia Incidence</td>
<td>0%</td>
</tr>
<tr>
<td>Readmission (30 days)</td>
<td>0%</td>
</tr>
</tbody>
</table>
Conclusion

- Resulting evidence, from internal diabetes dashboard, included:
  - decreased length of stay – which facilitated availability of precious ICU beds for other patients that warranted a higher level of care
  - decreased incidence of hypoglycemia in DKA or HHS patients admitted to the ICU.
  - ongoing education and competency evaluation is maintained annually via skills fairs, briefs, and huddles.
References

- Diagnosis and Classification of Diabetes Mellitus. (2009)American Diabetes Association Diabetes Care
References

- Diagnosis and Classification of Diabetes Mellitus. (2004). American Diabetes Association Diabetes Care 27(1) S5-S10

- Fourlanos S; Perry C; Stein MS; Stankovich J; Harrison LC; Colman PG. (2006). A clinical screening tool identifies autoimmune diabetes in adults. Diabetes Care, 5, 970-5

- Joslin Diabetes Center and Beth Israel Deaconess Medical Center. Guideline for Management of Uncontrolled Glucose in the Hospitalized Adult, 05/20/2013.


Thank You So Very Much