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# Transforming Diabetes Care

## Meeting the Challenge of Inpatient Glycemic Management in the Critical Care Setting

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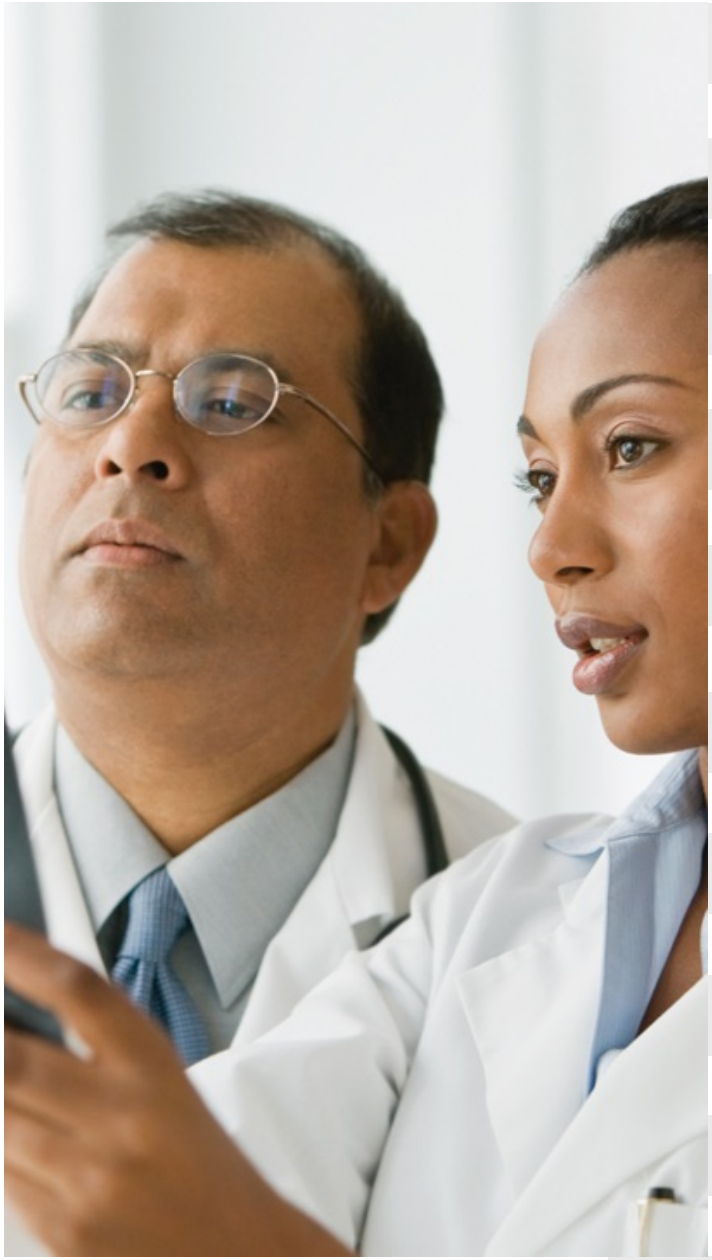

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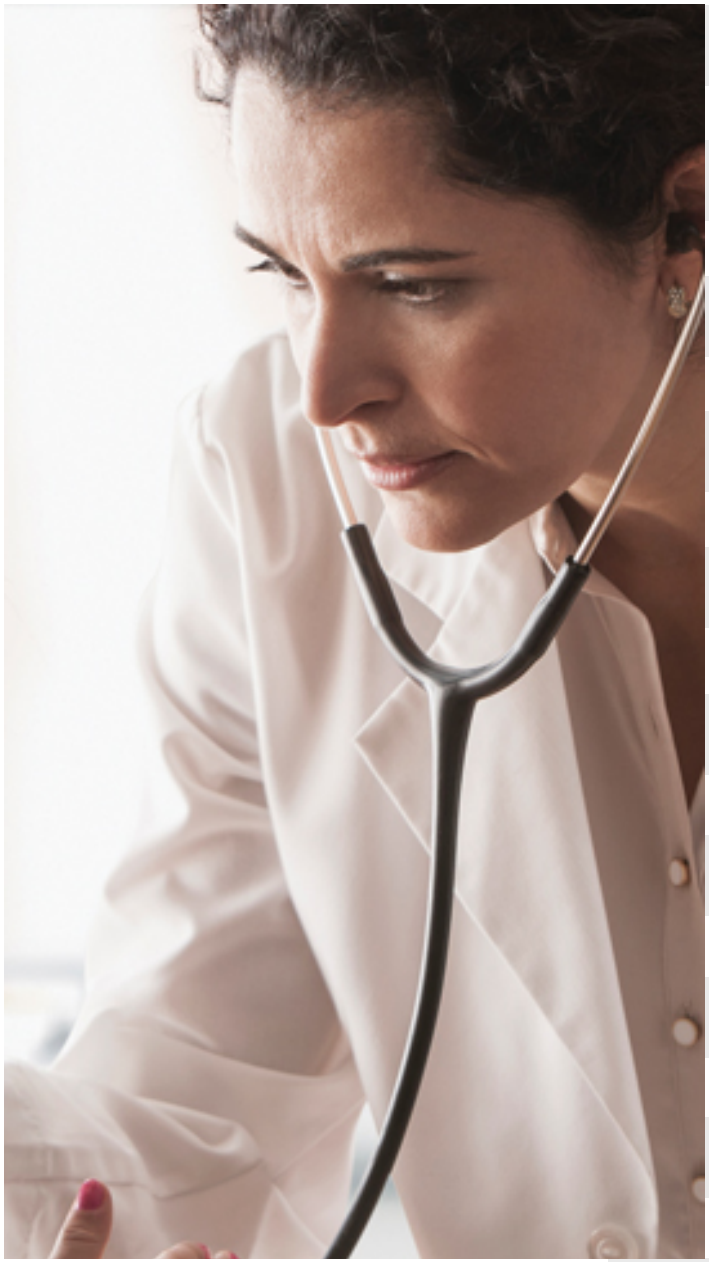
# Goals

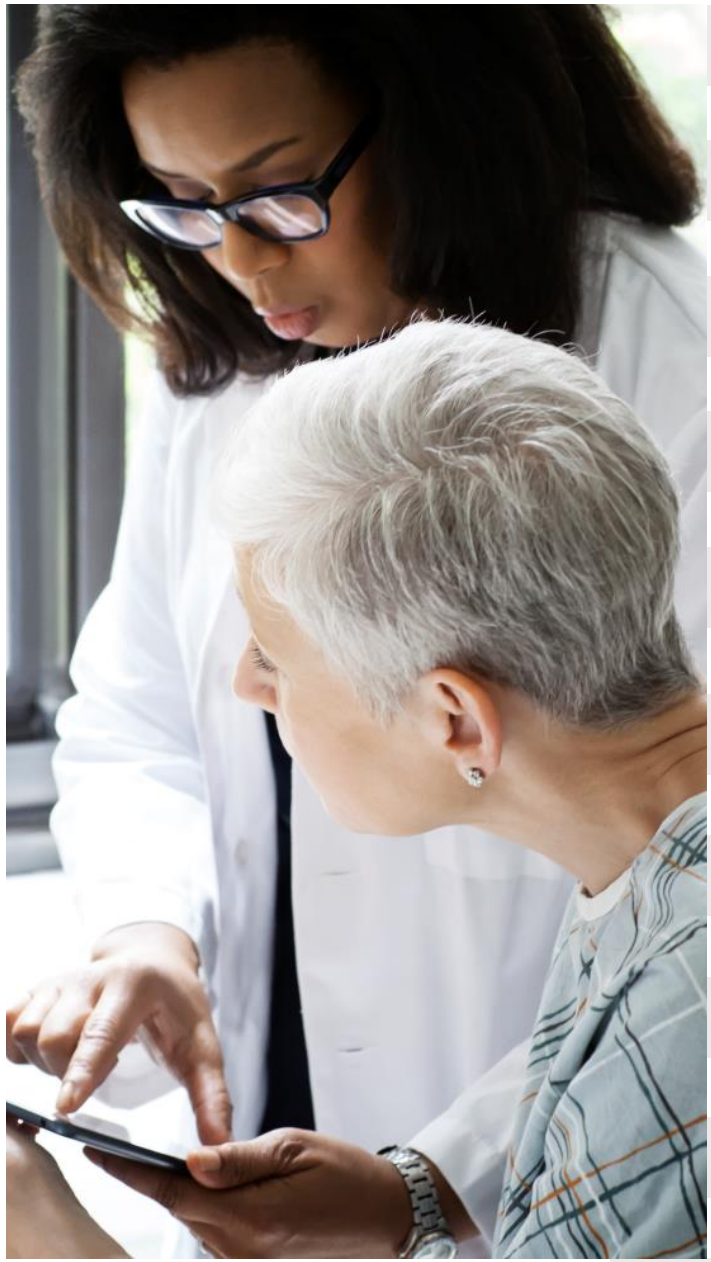
- Review the current guidelines for the management of hyperglycemia in the critical care setting
- Discuss potential strategies to assist clinicians in meeting the current guidelines



# Objectives

At the end of this program the participant will be able to:

- State current glycemic targets in the critical care setting
- Discuss several key components of a safe and effective insulin drip protocol
- List diagnostic criteria for diabetic ketoacidosis
- Describe when and how to transition patients from an insulin infusion to subcutaneous insulin therapy



# Polling Question

According to the American Diabetes Association, the current glycemic target for a critically ill patient is

A) 80-110 mg/dL

B) 110-140 mg/dL

C) 100-180 mg/dl

D) 140-180 mg/dL

# History of Glycemic Targets in the ICU

| **Up until 2001** | ***No recommendation* Average BG 200-240 mg/dL** |
|---|---|
| 2001-2008 | ADA/AACE Recommendation:<br>BG 80-110 mg/dL |
| 2009-2017 | ADA/AACE Recommendation:<br>BG140-180 mg/dl *for most critically ill patients*, tighter goals <140mg/dL in *select pts without hypoglycemia* |

# Polling Question

In critically ill patients, intensive glycemic control can significantly increase the risk of severe hypoglycemia

A) True

B) False

# Glycemic Control in the ICU: 1999-2004

| Study | Setting | Population | Clinical Outcome |
|---|---|---|---|
| Furnary, 1999 | ICU | DM undergoing open heart surgery | **65% ↓ infection** |
| Furnary, 2003 | ICU | DM undergoing CABG | **57% ↓ mortality** |
| Krinsley, 2004 | Medical/surgical ICU | Mixed, no Cardiac | **29% ↓ mortality** |
| Malmberg, 1995 | CCU | Mixed | **28% ↓ mortality After 1 year** |
| Van den Berghe, 2001* | Surgical ICU | Mixed, with CABG | **42% ↓ mortality** |
| Lazar, 2004 | OR and ICU | CABG and DM | **60% ↓ A Fib post op survival 2 yr** |

*Van den Berghe (2001) was only randomized clinical trial (RCT)

Kitabchi & Umpierrez. Metabolism. 2008;57:116-120.

# Glycemic Control in the ICU: 2006-2009

| Trial | N | Setting | Primary Outcome | ARR | RRR | Odds Ratio (95% CI) | P-value |
|---|---|---|---|---|---|---|---|
| Van den Berghe 2006 | 1200 | MICU | Hospital mortality | 2.7% | 7.0% | 0.94* (0.84-1.06) | N.S. |
| Glucontrol 2007 | 1101 | ICU | ICU mortality | -1.5% | -10% | 1.10* (0.84-1.44) | N.S. |
| Ghandi 2007 | 399 | OR | Composite | 2% | 4.3% | 1.0* (0.8-1.2) | N.S. |
| VISEP 2008 | 537 | ICU | 28-d mortality | 1.3% | 5.0% | 0.89* (0.58-1.38) | N.S. |
| De La Rosa 2008 | 504 | SICU MICU | 28-d mortality | -4.2% * | -13%* | NR | N.S. |
| NICE-SUGAR 2009 | 6104 | ICU | 3-mo mortality | -2.6% | -10.6 | 1.14 (1.02-1.28) | < 0.05 |

Recent studies in critical care were unable to replicate earlier studies and identified severe hypoglycemia as a significant risk of intensive glucose control. In Ghandi et al, intensive insulin therapy during cardiac surgery did not reduce perioperative death or morbidity. In the NICE-SUGAR study, critically ill patients treated in the intensive glucose control group (81-108 mg/dL) were 14% more likely to die (27.5% vs 24.9%) than those in the conventional glucose control group (144-180 mg/dL). Severe hypoglycemia (blood glucose ≤40 mg/dL) occurred in 6.8% of the intensive-control group versus 0.5% of the conventional-control group (P<.001).

# Glycemic Targets in Critical Care Setting

**American Diabetes Association** (2017)

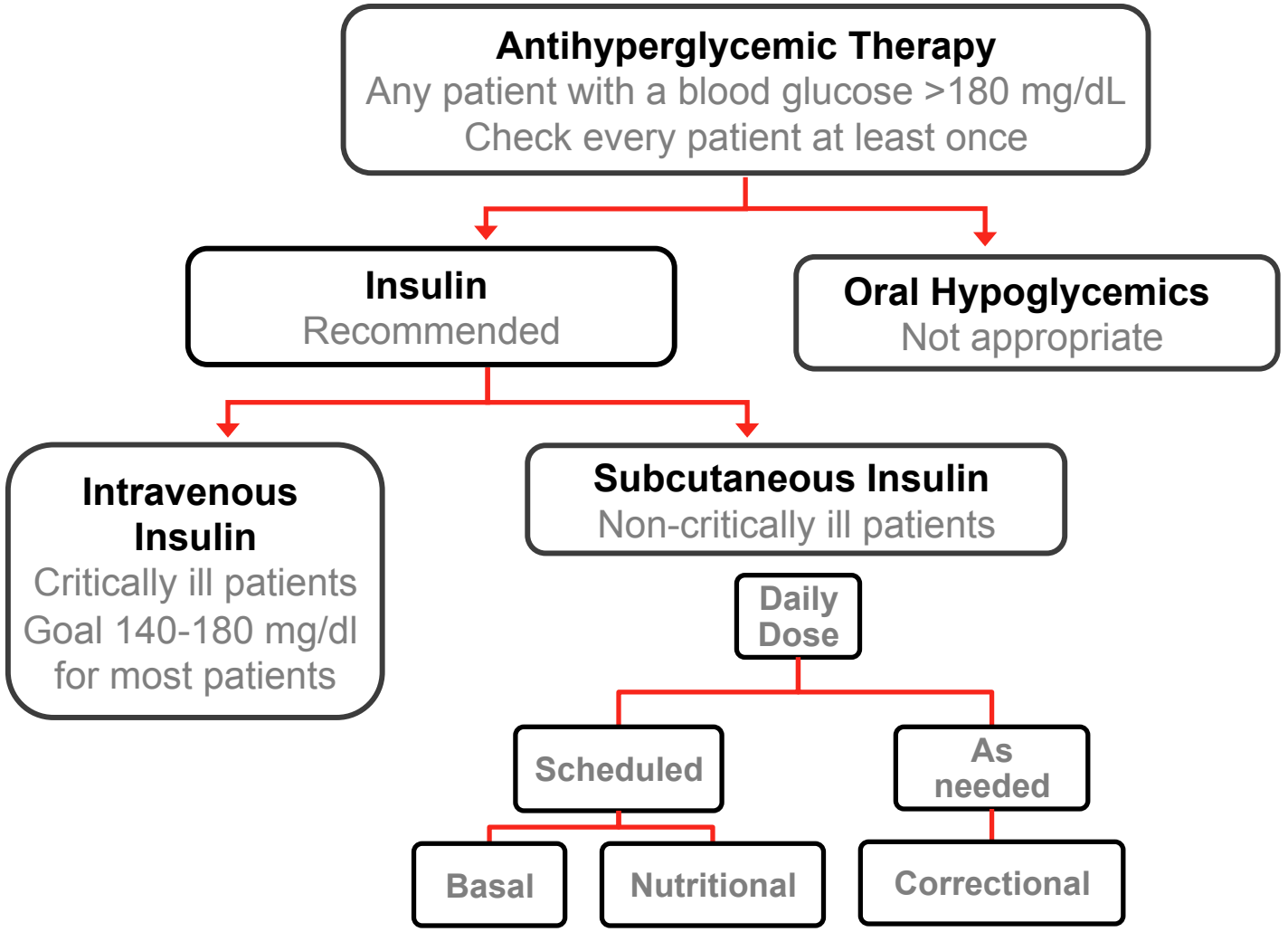
- Starting blood glucose (BG) threshold of >180 mg/dL
- Once IV insulin started, BG level should be maintained between 140-180 mg/dL
- Lower BG targets (110-140 mg/dL) may be appropriate in selected patients
- Targets <110 mg/dL or >180 mg/dL are not recommended

**Society of Critical Care Medicine** (2012)

- Starting threshold of >150 mg/dL, absolutely at 180 mg/dL
- Use protocol to achieve low rate of hypoglycemia <70 mg/dL
- Minimal excursions of <100 mg/dL

| Not recommended | Acceptable | Recommended | Not recommended |
|---|---|---|---|
| <100-110 | 110-150 | 140-180 | >180 |

# Insulin Therapy in Inpatient Setting



# ADA Recommendations (2017):

## Intravenous Insulin Infusion Protocols

**Intravenous insulin infusions should be administered:**

- using validated written or computerized protocols
- that allow for predefined adjustments in the insulin infusion rate
- based on glycemic fluctuations and insulin dose

# Ingredients for Insulin Infusion Order Sets and Protocols

**Table 2. Components of a Safe and Effective Insulin Infusion Protocol**

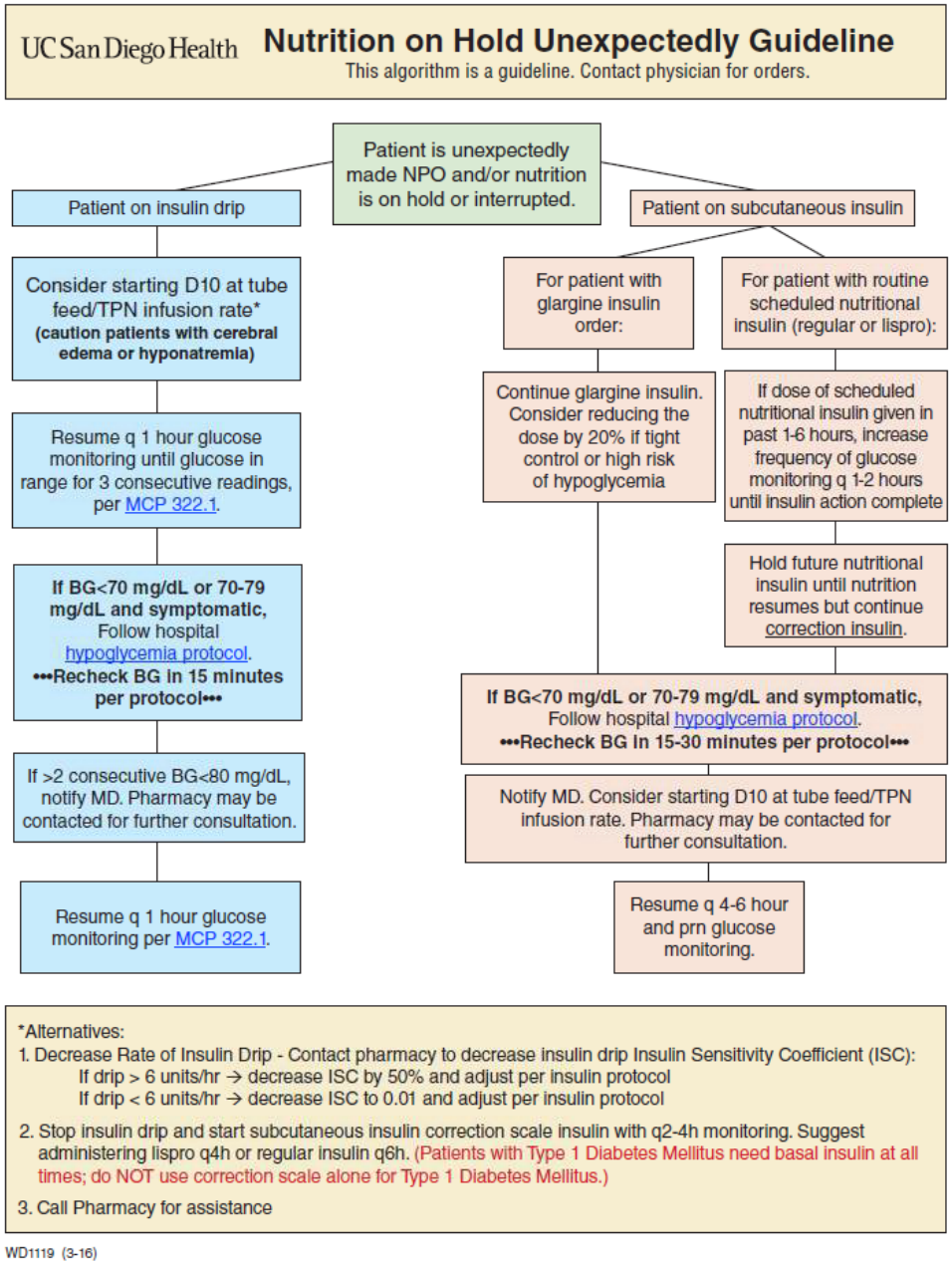
- Includes appropriate glycemic targets
- Identifies threshold for implementation
- Is nurse-managed and easy to implement
- Provides clear, specific directions for blood glucose monitoring and titration
- Includes titration based on both current blood glucose level and rate of change*
- Is safe: carries a low risk for hypoglycemia and includes an embedded protocol for treatment of hypoglycemia should it occur
- Is effective: gets patients to target quickly and maintains blood glucose within the target range with minimal titration
- Includes a plan for transition to subcutaneous insulin

**Rate of change is calculated based on the slope of the blood glucose trend line and is frequently incorporated into column-based protocols by movement to a more aggressive algorithm if blood glucose is not declining by ~ 40–75 mg/dl or to a less aggressive algorithm if blood glucose is declining too rapidly.*

# UC San Diego Guideline:

## When Nutrition is on hold unexpectedly

Delineates Steps

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# Yale Insulin Drip Protocol

*The following insulin drip protocol is intended for use in hyperglycemic adult patients in an ICU setting, but is not specifically tailored for those individuals with diabetic emergencies, such as diabetic ketoacidosis (DKA) or hyperglycemic hyperosmolar states (HHS). When these diagnoses are being considered, or if BG≥ 500 mg/dL, an MD should be consulted for specific orders. Also, please notify an MD if the response to the insulin drip is unusual/unexpected, or if any situation arises that is not adequately addressed by these guidelines.*

## Initiating An Insulin Drip

1) INSULIN INFUSION: Mix 1 U Regular Human Insulin per 1 cc 0.9 % NaCl. Administer via infusion pump (in increments of 0.5 U/hr).
2) PRIMING: Flush 50 cc of Insulin/NS drip through all IV tubing, before infusion begins (to saturate the insulin binding sites in the tubing)
3) TARGET BLOOD GLUCOSE (BG) LEVELS: **100-139 mg/dL**
4) BOLUS & INITIAL INSULIN DRIP RATE: Divide initial BG level (mg/dL) by 100, then round to nearest 0.5 U for bolus AND initial drip rate
   Examples: 1) Initial BG = 325 mg/dL: 325 ÷ 100 = 3.25, rounded ↑ to 3.5: IV bolus 3.5 U + start drip @ 3.5 U/hr.
   2) Initial BG = 174 mg/dL: 174 ÷ 100 = 1.74, rounded ↓ to 1.5: IV bolus 1.5 U + start drip @ 1.5 U/hr.

## Fingerstick (FS) Blood Glucose Monitoring

1) Check FS hourly until stable (= 3 consecutive values in target range)
2) Then check FS q 2 hours; once stable x 12-24 hours, FS checks can be spaced to q 4 hours if:
   a) No significant change in clinical condition AND b) No significant change in nutritional intake
3) If ANY of the following occur, consider the temporary resumption of hourly FS monitoring, until BG is again stable (= 2-3 consecutive BG values in target range).
   a) Any change in insulin drip rate (i.e. BG out of target range)
   b) Significant changes in clinical condition
   c) Initiation or cessation of pressor therapy
   d) Initiation or cessation of renal replacement therapy (hemodialysis, CVVH, etc.)
   e) Initiation, cessation, or rate change of nutritional support (TPN, PPN, tube feedings, etc.)

## Changing the Insulin Drip Rate

If BG < 50 mg/dL:
**D/C INSULIN DRIP** — **Give 1 Amp (25 g) D50 IV**; **recheck BG q 15 minutes**
⇒ When BG ≥ 100 mg/dL, wait 1 hour, then restart insulin drip at 50% of original rate

If BG 50-74 mg/dL:
**D/C INSULIN DRIP** — **If symptomatic (or unable to assess), give 1 Amp (25 g) D50 IV**; **recheck BG q 15 minutes**
**If asymptomatic, give 1/2 Amp (12.5 g) D50 IV or 8 ounces Juice; recheck BG q 15-30 minutes**
⇒ When BG ≥ 100 mg/dL, wait 1 hour , then restart drip at 75% of original rate

**Changing the Insulin Drip Rate *(cont'd.)***

# Yale Insulin Drip Protocol (continued)

| BG 75-99 mg/dL | BG 100-139 mg/dL | BG 140-199 mg/dL | BG ≥ 200 mg/dL | INSTRUCTIONS* |
|---|---|---|---|---|
| | | BG ↑ by > 50 mg/dL/hr | BG ↑ | ↑ DRIP by "2Δ" |
| | BG ↑ by > 25 mg/dL/hr | BG ↑ by 1-50 mg/dL/hr *OR* BG UNCHANGED | BG UNCHANGED *OR* BG ↓ by 1-25 mg/dL/hr | ↑ DRIP by "Δ" |
| BG ↑ | BG ↑ by 1-25 mg/dL/hr, BG UNCHANGED, *OR* BG ↓ by 1-25 mg/dL/hr | BG ↓ by 1-50 mg/dL/hr | BG ↓ by 26-75 mg/dL/hr | NO DRIP CHANGE |
| BG UNCHANGED *OR* BG ↓ by 1-25 mg/dL/hr | BG ↓ by 26-50 mg/dL/hr | BG ↓ by 51-75 mg/dL/hr | BG ↓ by 76-100 mg/dL/hr | ↓ DRIP by "Δ" |
| BG ↓ by > 25 mg/dL/hr *see below*** | BG ↓ by > 50 mg/dL/hr | BG ↓ by > 75 mg/dL/hr | BG ↓ by > 100 mg/dL/hr | HOLD DRIP x 30 min, then ↓ DRIP by "2Δ" |

**D/C INSULIN DRIP; √BG q 30 min; when BG ≥ 100 mg/dl, restart drip @75% of original rate.

*CHANGES IN DRIP RATE ("Δ") are determined by the current drip rate:

| Current Drip Rate (U/hr) | Δ = Rate Change (U/hr) | 2Δ = 2X Rate Change (U/hr) |
|---|---|---|
| < 3.0 | 0.5 | 1 |
| 3.0 - 6.0 | 1 | 2 |
| 6.5 - 9.5 | 1.5 | 3 |
| 10 - 14.5 | 2 | 4 |
| 15 - 19.5 | 3 | 6 |
| 20 - 24.5 | 4 | 8 |
| ≥ 25 | ≥ 5 | 10 *(Consult MD)* |

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# Goal BG 100-140

## Insulin Infusion: Adult ICU Protocol
## NOT for DKA/HYPERGLYCEMIC HYPEROSMOLAR NON-KETOTIC SYNDROME (HHS)

1. **For blood glucose (BG) above 140 mg/dL**, start regular insulin infusion: 100 units/100 mL NS (1 unit = 1 mL) per table

| INITIAL INFUSION | BG (mg/dL) | 141-180 | 181-240 | 241-300 | 301-399 | ≥400 |
|---|---|---|---|---|---|---|
| | Insulin Rate | 1 unit/hour | 2 units/hour | 3 units/hour | 4 units/hour | 6 units/hour |

2. Check BG every 1 hour until stable (100-140 mg/dL x 2 consecutive readings), then check every 2 hours if insulin rate is <10 units/hour and there are no changes in feedings, IV glucose, vasopressors or glucocorticoids. Resume every 1 hour monitoring if any of above parameters change.
3. Titrate insulin infusion to achieve a **goal BG of 100-140 mg/dL**. Select row according to current BG level. Determine rate of change from prior BG result. Match to column of current insulin rate. Follow recommendations to corresponding cell. Round to nearest 0.5 units/hour.
4. If nutrition (e.g., tube feeding) is held or discontinued, notify prescriber to either hold insulin infusion or add/increase dextrose-containing IV order.
5. Any deviation from protocol requires prescriber order. When the subsequent BG returns to goal, may resume following the protocol from the current insulin rate.

| | | **Current Insulin Rate (unit/hour)** | | | | | |
|---|---|---|---|---|---|---|---|
| **Current BG Level** (mg/dL) | **BG change from previous BG** (mg/dL) | **≤ 3** | **3.5-6** | **6.5-9.5** | **10-14.5** | **15-19.5** | **≥ 20** |
| **< 40** | | STOP INSULIN INFUSION (EXCEPT for patients with Type 1 DM, see footnote[a])<br>Give 25 G (50 mL) D50 IVP Q 15 min, repeat PRN for BG < 40 mg/dL. Notify prescriber<br>Re-check BG Q 15 minutes until BG > 80 mg/dL then Q 1 hour x 1, then Q 2 hours<br>When BG > 100 mg/dL, restart at 50% previous rate unless BG change from previous BG is > 100 mg/dL, then restart per Initial Infusion Table | | | | | |
| **40-69** | | As above (refer to row < 40 mg/dL), EXCEPT give 12.5 G (25 mL) D50 IVP Q 15 min PRN BG 40 -69 mg/dL | | | | | |
| **70-99** | | STOP INSULIN INFUSION(EXCEPT for patients with Type 1 DM, see footnote[a]) for 1 hour (continue glucose containing fluid)<br>Check BG Q 1 h x 1, then Q 2 h. When BG > 100 mg/dL, restart at 50% previous rate unless BG change from previous BG is > 100 mg/dL, then restart per Initial Infusion Table | | | | | |
| **100-140 (GOAL)** | No Δ. Decreased by 1-20 or any Increase | ★Continue same rate<br>(If 2 consecutive BG levels are between 100-140 mg/dL, continue at the same rate and decrease BG checks to Q 2 hours) | | | | | |
| | Decreased by ≥ 21 | ★Decrease by 1 | ★Decrease by 2 | ★Decrease by 3 | ★Decrease by 4 | ★Decrease by 6 | ★ Decrease by 50% |
| **141-199** | No Δ. Decreased by ≤ 20 or any Increase | Increase by 0.5 | Increase by 1 | Increase by 1.5 | Increase by 2 | Increase by 2.5 | Increase by 3 |
| | Decreased by 21-50 | ★Continue same rate | | | | | |
| | Decreased by ≥ 50 | ★Decrease by 1 | ★Decrease by 2 | ★Decrease by 3 | ★Decrease by 4 | ★Decrease by 6 | ★ Decrease by 50% |
| **≥200** | No Δ. Decreased by 1-20 or any Increase | Increase by 2 | Increase by 2 | Increase by 3 | Increase by 4 | Increase by 6 | Increase by 8 |
| | Decreased by 21-75 | Continue same rate | | | | | |
| | Decreased by ≥76 | Hold x 1 hour, then decrease rate as indicated: | | | | | |
| | | Decrease by 1 | Decrease by 2 | Decrease by 3 | Decrease by 4 | Decrease by 6 | Decrease by 50% |
| Notify prescriber if BG > 400 mg/dL x 2 or insulin rate > 10 units/hour<br>If adjustment recommendations result in insulin rate of ≤ 0 units/h, hold insulin (If Type 1 DM reduce insulin to 0.5 unit/h), check BG Q 2 hours and resume per Initial Infusion Table | | | | | | | |

[a]For patients with Type 1 DM: DO NOT STOP INSULIN (Continue glucose-containing fluid), reduce insulin to 0.5 unit/hour and notify prescriber to write orders to increase glucose intake. Δ = Change
Note (★): For patients when insulin resistance is suspected (e.g., insulin rates > 10 units/h, high catecholamine needs, typically postoperative), decrease insulin rate to 0.5 unit/h and notify prescriber

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# Goal BG 140-180

## Insulin Infusion: Adult ICU Protocol

## NOT for DKA/HYPERGLYCEMIC HYPEROSMOLAR NON-KETOTIC SYNDROME (HHS)

1. **For blood glucose (BG) above 180 mg/dL**, start regular insulin infusion: 100 units/100 mL NS (1 unit = 1 mL) per table

| INITIAL INFUSION | BG (mg/dL) | 180-216 | 217-270 | 271-324 | >324 |
|---|---|---|---|---|---|
| | Insulin Rate | 1 unit/hour | 2 units/hour | 3 units/hour | 4 units/hour |

2. Check BG every 1 hour until stable (140-180 mg/dL x 2 consecutive readings), then check every 2 hours if insulin rate is <10 units/hour and there are no changes in feedings, IV glucose, vasopressors or glucocorticoids. Resume every 1 hour monitoring if any of above parameters change.
3. Titrate insulin infusion to achieve a **goal BG of 140-180 mg/dL**. Select row according to current BG level. Determine rate of change from prior BG result. Match to column of current insulin rate. Follow recommendations to corresponding cell. Round to nearest 0.5 units/hour.
4. If nutrition (e.g., tube feeding) is held or discontinued, notify prescriber to either hold insulin infusion or add/increase dextrose-containing IV order.
5. Any deviation from protocol requires prescriber order. When the subsequent BG returns to goal, may resume following the protocol from the current insulin rate.

| | | **Current Insulin Rate (unit/hour)** | | | | | |
|---|---|---|---|---|---|---|---|
| **Current BG Level (mg/dL)** | **BG change from previous BG (mg/dL)** | **≤ 3** | **3.5-6** | **6.5-9.5** | **10-14.5** | **15-19.5** | **≥ 20** |
| **< 40** | | STOP INSULIN INFUSION (EXCEPT for patients with Type 1 DM, see footnote[a])<br>Give 25 G (50 mL) D50 IVP Q 15 min, repeat PRN for BG < 40 mg/dL. Notify prescriber<br>Re-check BG Q 15 minutes until BG > 80 mg/dL then Q 1 hour x 1, then Q 2 hours. When BG > 100 mg/dL, restart at 50% previous rate unless BG change from previous BG is > 100 mg/dL, then restart per Initial Infusion Table | | | | | |
| **40-69** | | As above (refer to row < 40 mg/dL), EXCEPT give 12.5 G (25 mL) D50 IVP Q 15 min PRN BG 40 -69 mg/dL | | | | | |
| **70-99** | | STOP INSULIN INFUSION(EXCEPT for patients with Type 1 DM, see footnote[a]) for 1 hour<br>Check BG Q 1 h x 1, then Q 2 h. When BG > 100 mg/dL, restart at 50% previous rate unless BG change from previous BG is > 180 mg/dL, then restart per Initial Infusion Table | | | | | |
| **100-139** | | ★Decrease rate by 50% | | | | | |
| **140-180 (GOAL)** | No Δ. Decreased by 1-20 or any Increase | ★Continue same rate<br>(If 2 consecutive BG levels are between 140-180 mg/dL, continue at the same rate and decrease BG checks to Q 2 hours) | | | | | |
| | Decreased by ≥ 21 | ★Decrease by 1 | ★Decrease by 2 | ★Decrease by 3 | ★Decrease by 4 | ★Decrease by 6 | ★ Decrease by 50% |
| **181-251** | Decreased by ≤ 20 or any Increase | Increase by 0.5 | Increase by 1 | Increase by 1.5 | Increase by 2 | Increase by 2.5 | Increase by 3 |
| | Decreased by 21-50 | ★Continue same rate | | | | | |
| | Decreased by ≥ 50 | ★Decrease by 1 | ★Decrease by 2 | ★Decrease by 3 | ★Decrease by 4 | ★Decrease by 6 | ★ Decrease by 50% |
| **≥ 252** | No Δ. Decreased by 1-20 or any Increase | Increase by 2 | Increase by 2 | Increase by 3 | Increase by 4 | Increase by 6 | Increase by 8 |
| | Decreased by 21-75 | Continue same rate | | | | | |
| | Decreased by ≥76 | Hold x 1 hour, then decrease rate as indicated: | | | | | |
| | | Decrease by 1 | Decrease by 2 | Decrease by 3 | Decrease by 4 | Decrease by 6 | Decrease by 50% |
| Notify prescriber if BG > 400 mg/dL x 2 or insulin rate > 10 units/hour<br>If adjustment recommendations result in insulin rate of ≤ 0 units/h, hold insulin (If Type 1 DM reduce insulin to 0.5 unit/h), check BG Q 2 hours and resume per Initial Infusion Table | | | | | | | |

[a]For patients with Type 1 DM: DO NOT STOP INSULIN (Continue glucose-containing fluid), reduce insulin to 0.5 unit/hour and notify prescriber to write orders to increase glucose intake. Δ = Change
Note (★): For patients when insulin resistance is suspected (e.g., insulin rates > 10 units/h, high catecholamine needs, typically postoperative), decrease insulin rate to 0.5 unit/h and notify prescriber

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# Polling Question

According to the American Diabetes Association guidelines, an intravenous insulin infusion protocol must be:

A) Computerized

B) Nurse managed

C) Validated

D) Reaching blood glucose target within 3-4 hours

# NYPH Insulin Infusion:

## Adult ICU Protocol Goal BG 100-140 mg/dL: General Instructions

- **NOT for DKA/ HYPERGLYCEMIC HYPEROSMOLAR NON-KETOTIC SYNDROME (HHS)**
- **For blood glucose (BG) above 140 mg/dL,** start regular insulin infusion: 100 units/100 mL NS (1 unit = 1 mL) per table
- **Check BG every 1 hour until stable** (100-140 mg/dL x 2 consecutive readings), **then check every 2 hours if insulin rate is <10 units/ hour** and there are *no changes in feedings, IV glucose, vasopressors or very glucocorticoids*
- Resume every 1 hour monitoring if any of above parameters change

# NYPH Insulin Infusion:

## Adult ICU Protocol Goal BG 100-140 mg/dL: General Instructions

- Titrate insulin infusion to achieve **a goal BG of 100-140 mg/dL.**
- Select row according to current BG level and determine rate of change from prior BG result.
- Match to column of current insulin rate. Follow recommendations to corresponding cell. Round to nearest 0.5 units/hour.
- **If nutrition (e.g., tube feeding) is held or discontinued, notify prescriber** to either hold insulin infusion or add/ increase dextrose-containing IV order.
- **Any deviation from protocol requires prescriber order.** When the subsequent BG returns to goal, may resume following the protocol from the current insulin rate.

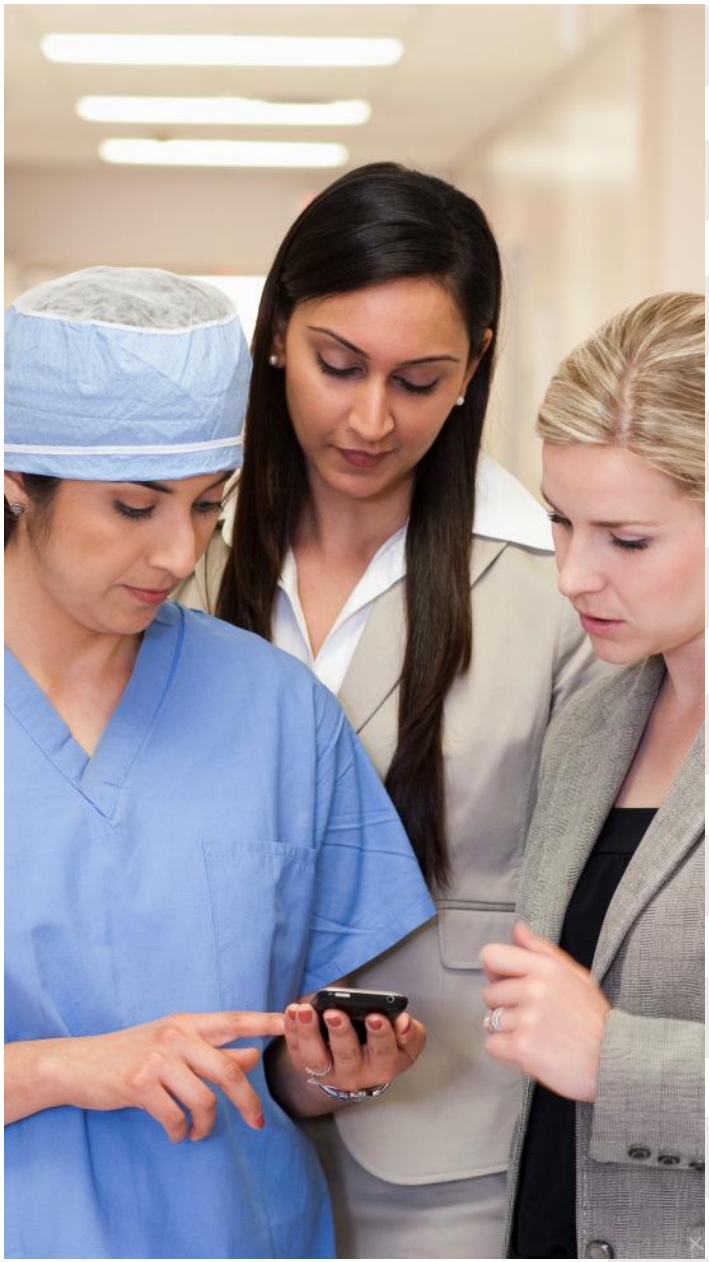
# NYPH Hypoglycemia Treatment

in Insulin Infusion Protocols

EXAMPLE of Hypoglycemia Treatment:
**BG <40 mg/dL:**

- STOP INSULIN INFUSION (EXCEPT for patients with Type 1 DM). **Give 25 G (50 mL) D50** IVP Q 15 min, repeat PRN for BG <40 mg/dL. Notify prescriber Re-check BG Q 15 minutes until BG >80 mg/dL then Q 1 hour x 1, then Q 2 hours

- When BG >100 mg/dL, restart at 50% previous rate unless BG change from previous BG is > 100 mg/dL, then restart per Initial Infusion Table



# NYPH Hypoglycemia Treatment

in Insulin Infusion Protocols

**BG 40-69 mg/dL**

- As above (refer to row <40 mg /dL), EXCEPT **give 12.5 G (25 mL)** D50 IVP Q 15 min PRN BG 40 -69 mg/dL

**BG 70-99 mg/dL**

- **STOP INSULIN INFUSION for 1 hour (continue glucose containing fluid**) Check BG Q 1 h x 1, then Q 2 h. When BG >100 mg/dL, restart at 50% previous rate unless BG change from previous BG is >100 mg/dL, then restart per Initial Infusion Table

- **For patients with Type 1 DM: DO NOT STOP INSULIN** (continue glucose-containing fluid), **reduce insulin to 0.5 unit/hour and notify prescriber to write orders to increase glucose intake.**

# Transition From IV to Subcutaneous (SC) Insulin

| DKA | HHS | Hyperglycemia |
|---|---|---|
| BG <200 mg/dL | BG <300 mg/dL | Resolution of critical illness |
| Two of the following:<br>Gap <12<br>Bicarbonate >15<br>pH >7.3 | Normal osmolality | Off vasopressors |
| | Normal mentation | Stable infusion rate for ~6hrs |

Kitabchi Diabetes Care 2006

- If SC basal insulin is required, give 1-2 hrs before stopping IV insulin
- Calculate dose by stable infusion rate e.g. average stable hourly rate over the last 6hrs X 20 (80% of dose)
- OR weight based depending on patient's expected requirements (e.g. A1c, diabetes requiring insulin)

# What is Diabetic Ketoacidosis (DKA)

- DKA: reduction in *relative effective action of circulating insulin* with rise in counter-regulatory hormones, e.g. catecholamines, cortisol, glucagon & growth hormone
- Alterations in hormones leads to increased gluconeogenesis, greater renal & hepatic glucose production and impairment in glucose utilization in the peripheral tissues
- Insulin deficiency and increased counter-regulatory hormones leads to release of ketone bodies (beta-hydroxybutyrate and acetoacetate) with resulting ketonemia and metabolic acidosis
- Control of glycosuria in DKA is key, if left unchecked it leads to osmotic diuresis with subsequent loss of water and electrolytes.

# Diagnosing Diabetic Ketoacidosis (DKA)

- Over 100,000 patients admitted to U.S. hospitals each year
- Costs over $1 billion/year
- Most have T1DM
- T2DM at risk during severe stress e.g. surgery, infection, or trauma
- New risk factor: euglycemic DKA when taking SGLT-2s

**Diagnostic criteria for DKA:**

- Plasma glucose >250 mg/dL
- Positive serum and/or urine ketones
- Elevated anion gap >10
- Serum HCO3 < 15mmol/L
- Arterial or venous pH <7.3

# Polling Question

Treatment of diabetic ketoacidosis (DKA) centers around insulin therapy, replacing fluids and electrolytes and determining the cause.

A) True

B) False

# Diabetic Ketoacidosis Guidelines

## Definition: Metabolic anion-gap acidosis due to elevated serum ketones

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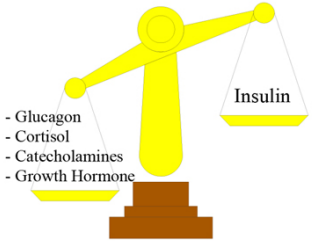
- Clinical judgment always supersedes pathway recommendations
- Review all medications, fluids/elctrolytes and procedures for specific contraindications

**Diagnostic Criteria:**
- Blood glucose > 250 mg/dL
- Arterial pH <7.3
- Serum Bicarbonate < 18 mEq/L
- Anion Gap > 10
- Ketonuria and/or ketonemia

### PATHOPHYSIOLOGY




**1) Ketonemia** → **Acidemia**

**2) Hyperglycemia** → **Osmotic Diuresis** → Volume Depletion; Free Water Depletion; Hypokalemia

### GOALS OF TREATMENT

- Replace volume deficit*
- Correct ketosis and acidosis with continuous insulin
- Replace electrolyte deficits*
- Replace free water deficit*
- Prevent hypoglycemia
- Determine inciting condition for the DKA
- Correct hyperglycemia (secondary goal)
- When DKA resolved: begin appropriate SQ insulin before stopping Insulin drip

### INITIAL CARE

**ENSURE:**
- Secure airway and adequate ventilation/oxygenation

**MONITOR:**
- Orthostatic hypotension (If not hypotensive)
- Continuous EKG monitoring
- Urine output
- Frequent Vital signs

**PLACE:**
- Adequate IV access (may require 3 ports)
- Foley catheter

**CALCULATE:**
- Anion Gap
- Serum Osmolality
- Free Water Deficit
- Corrected Serum Sodium

**LABS:**
- Basic metabolic panel, Serum phosphate level, hepatic enzymes, $A1_C$
- beta-HCG. Urine (for women of child bearing age)
- CBC w/differential
- Cardiac enzymes
- Serum ketones/acetone/Beta-hydroxybutyrate
- PT/PTT
- Venous/Arterial blood gas
- UA/Urine micro/Urine culture

**ORDER:**
- EKG
- CXR
- Venous thromboembolism prophylaxis: Heparin 5,000 units SQ BID or TID (unless contraindicated)

**CONSIDER, as indicated:**
- Further Infectious work up
- Amylase/Lipase to rule out pancreatitis
- Head CT/LP if encephalopathic
– Consider Central access

**PROCEED TO MANAGEMENT**

### CALCULATIONS

- **Anion Gap (AG) [<12-16]:**
  $AG = [Na+] – [Cl^- + HCO_3]$
- **Serum Osmolality [275-295 mOsm/L]:**
  = 2 X Serum $Na^+$ (mEq/L) + [Glucose (mg/dL)/18] + [BUN (mg/dL)/2.8]
- **Free Water Deficit:**
  = Dosing Factor X wt (Kg) X [(Serum $Na^+$/140) – 1]
  {Dosing Factor = 0.6 (Male) and 0.5 (Female)}
- **Corrected Serum Sodium:**
Corrected $Na^+$ = Serum $Na^+$ mEq/L + (1.6 mEq/L for each 100 mg/dL glucose > 100 mg/dL)

* Patients with ESRD/Anuria may not require volume and $K^+$ repletion.

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# Example of Insulin Dosing Recommendations

in Non Nurse-Driven DKA Protocol

**Insulin Algorithm When Serum Glucose <250 mg/dL**

- Add Dextrose (D51/2NS or D5NS*) to IVF @ 150-250 mL/h to maintain serum glucose 150-200 mg/dL and continue insulin at same rate
- Titrate insulin to a minimum 0.1 Units/kg/hr and glucose goal between 150-200 mg/dL until ketosis and anion gap resolves
- If patient can tolerate PO, encourage consistent carbohydrate diet

* Use D5NS if corrected [Na+] < 140 or remains volume depleted

# Key Points About Insulin Infusions

- **Per guidelines, insulin infusions are indicated for:**
  - DKA/HHS
  - Critically ill patients with a BG >180 mg/dL
- Treatment of DKA centers around the four pillars of hydration, electrolytes, insulin, and appropriate diagnostic evaluation for etiology
- Safe and effective insulin infusion protocols are clear, concise, account for the trajectory of BG values and address hypoglycemia
- The transition from insulin infusion to a subcutaneous regimen is complex and involves a delicate balance of art and science

# Polling Question

All hospital point of care blood glucose meters are approved for use in both non-critical care and critical care settings.

A) True

B) False

SPECIAL FEATURE

Position Statement

# PRIDE Statement on the Need for a Moratorium on the CMS Plan to Cite Hospitals for Performing Point-of-Care Capillary Blood Glucose Monitoring on Critically Ill Patients

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J Clin Endocrinol Metab, October 2015, 100(10):3607-3612

# Current Recommendations

## for BG Monitoring in the ICU

**FDA** regulates product labels of laboratory tests

**CMS** regulates use of lab testing equipment

- Hospitals can continue to use POC BG monitors if they perform validation studies, certify staff and apply for a moderate to high complexity certificate from CLIA
- Hospitals can use FDA approved cartridge based analyzers such as epoc or i-stat with critically ill patients
- Since the Jan 2014 memo from NYSDOH, many hospitals have either performed validation studies or use NovaStat. NovaStat is *not approved* for use with capillary blood.

# In Conclusion

- Current glycemic targets in the critical care setting are 140-180 mg/dL for most patients
- A safe & effective insulin drip protocol should be validated, have clear instructions and take into account special situations such as hypoglycemia, T1DM and a transition algorithm to SQ insulin
- Strict adherence to a DKA protocol with careful transition off the insulin drip once stable is key to prevent recurrence of DKA
- Hypoglycemia is a serious consequence of intravenous insulin therapy. Blood glucose monitoring and adequate treatment are essential components of both treatment and prevention of future episodes.

# References


American Diabetes Association. Diabetes care in the hospital. Diabetes Care 2017;40(suppl 1):S120–S127.

Clement S, Braithwaite SS, Magee MF, Ahmann A, Smith EP, et al. Management of diabetes and hyperglycemia in hospitals (Technical Review). Diabetes Care 2004;27:553–591.

Jacobi J, Bircher N, Krinsley J, Agus M, Braithwaite SS, Deutschman C, Freire AX, Geehan D, Kohl B, Nasraway SA, Rigby M, Sand K, Schallom L, Taylor B, Umbierrez GE, Mazuski J, Schunemann H. Guidelines for the use of an insulin infusion for the management of hyperglycemia in critically ill patients. Crit Care Med 2012;40:3251–3276

Moghissi ES, Korytkowski MT, DiNardo M, et al.; American Association of Clinical Endocrinologists; American Diabetes Association. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. Diabetes Care 2009;32:1119–1131

Umpierrez GE, Hellman R, Korytkowski M, Kosiborod M, Maynard G, Montori VM, Seley JJ, Van den Berghe G. Management of hyperglycemia in hospitalized patients in non-critical care setting: An Endocrine Society clinical practice guideline. J Clin Endocrinol Metab 2012;97:16–38

Guidelines for the use of an insulin infusion for the management of hyperglycemia in critically ill patients. Crit. Care Med 2012 Vol 40, No 12

American Diabetes Association. Diabetes care in the hospital. Diabetes Care 2017;40(suppl 1):S120–S127.
Umpierrez, GE; Hellman, R; Korytkowski, M; Kosiborod, M; Maynard, G; Montori, VM, Seley, JJ; Van den Berghe, G. (2012). Management of Hyperglycemia in Hospitalized Patients in Non-Critical Care Setting: An Endocrine Society Clinical Practice Guideline. (2012). J Clin Endocrinol Metab 97: 16–38

Kelly JL. Continuous insulin infusion: What, where, and how? Diabetes Spect 2014;27;218–223
Maynard, G., Kulasa, K., Ramos, P., Childers, D., Clay, B., Sebasky, M., ... & Choe, C. (2014). Impact of a hypoglycemia reduction bundle and a systems approach to inpatient glycemic management. Endocrine Practice, 21(4), 355-367.

# References


Yale New Haven Hospital. (n.d.). Yale insulin drip protocol. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=6&ved=0ahUKEwizktOpt8fPAhWCVz4KHaWMDWMQFghAMAU&url=https%3A%2F%2Fwww.hospitalmedicine.org%2FCMDownload.aspx%3FContentKey%3D34f24a77-df56-4e61-bd1c-3834662b48fb%26ContentItemKey%3Dacf4bc7f-bb8e-49e8-90a4-a72723310674&usg=AFQjCNGmI1QFGOYGJNHi6upkuvXmjlAU0g&sig2=nCxghRglVRLSibATqBuZFw

Umpierrez G, Korytkowski M. Diabetic emergencies: ketoacidosis, hyperglycaemic hyperosmolar state and hypoglycaemia. Nature Reviews Endocrinology 2016;12(4):222-232.

Seaquist, E. R., Anderson, J., Childs, B., Cryer, P., Dagogo-Jack, S., Fish, L., ... & Vigersky, R. (2013). Hypoglycemia and diabetes: a report of a workgroup of the American Diabetes Association and the Endocrine Society. Diabetes care, 36(5), 1384-1395.

Gupta D, Kirn M, Jamkhana Z, et al. A unified Hyperglycemia and Diabetic ketoacidosis (DKA) insulin infusion protocol based on an Excel algorithm and implemented via Electronic Medical Record (EMR) in Intensive Care Units. Diabetes & Metabolic Syndrome: Clinical Research & Reviews 2016.

Fusco N, Gonzales J, Yeung SY. Evaluation of the treatment of diabetic ketoacidosis in the medical intensive care unit. American Journal of Health-System Pharmacy 2015;72(3):177-182.

Gosmanov AR, Gosmanova EO, Dillard-Cannon E. Management of adult diabetic ketoacidosis. Diabetes Metab Syndr Obes 2014;7:255-264.

NewYork-Presbyterian Hospital. (n.d.). Diabetic ketoacidosis guidelines. Retrieved from http://www.healthcare.uiowa.edu/familymedicine/fpinfo/Docs/DKA%20Protocol.pdf

Seley, J. J., Diaz, R., & Greene, R. (2016). Blood Glucose Meters in ICUs. AJN The American Journal of Nursing, 116(4), 46-49

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