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Key elements from the Canadian Diabetes Association 2013 Clinical Practice Guidelines

Hyperglycemia is common in hospitalized patients, even those not previously known to have diabetes. Interventions that are common in hospital – intravenous and oral glucocorticoids, total parenteral nutrition and, enteral (tube) feeds – can predispose patients to hyperglycemia and are all associated with an increase in adverse outcomes when they are associated with hyperglycemia.

Hospital management of diabetes is focused on the prevention of short-term complications of diabetes: symptoms of hyper- and hypoglycemia, prevention of infections, and prevention of surgical complications. This is best done with intravenous insulin for critically ill patients and scheduled basal, bolus, and supplemental subcutaneous insulin program for non-critically ill patients.

A systems approach to the hospital care of patients with diabetes can be associated with improved outcomes. Components demonstrated to improve outcomes include: policies to recognize and treat hypoglycemia, targeted glycemic levels for acutely ill and critically ill patients, diabetes care teams, and clinic order sets or computer pharmacy order entry to facilitate optimal insulin ordering.

Hyperglycemia in hospital – how common is it?

In a review of the medical records of over 2,000 adult patients admitted to a community teaching hospital in the United States, hyperglycemia was present in 38% of patients. Of these patients, 26% had a known history of diabetes and 12% had no history of diabetes prior to admission (Umpierrez, 2002).

In a large clinical trial, 39% of patients in an intensive care unit required insulin treatment because they had one or more blood glucose levels over 11.9 mmol/L. Of the 783 subjects in that arm of the study, only 13% had a pre-existing diagnosis of diabetes and only 4% had been previously treated with insulin (van den Berghe, 2001).

A recent paper (Fong, 2013), evaluated 80 patients treated with high-dose steroids (prednisone 25 mg / day, dexamethasone 4mg / day, hydrocortisone 100mg / day, or more) and found 86% with one or more BG > 8 mmol/L and 70% with one or more BG > 10 mmol/L. Among those who developed hyperglycemia, it occurred within the first 48 hours in 94% of subjects. Multiple studies (Olveira G, et al, Diabetes Care 2013; Pasquel FJ, et al, Diabetes Care 2010) have shown that hyperglycemia occurring while on TPN is associated with an increase in multiple adverse outcomes, including death. In the Pasquel study, 10% of subjects had a mean daily blood glucose over 10.0 mmol/L and 30% had a mean daily blood glucose over 7.8 mmol/L. Ninety-five per cent of those subjects were treated with insulin.

Preventing diabetes-related complications in hospital

Critical Care
One study in critical care patients demonstrated improved outcomes, including decreased mortality, with an intravenous insulin strategy aiming for blood glucose levels of 4.4 – 6.1 mmol/L, compared to a strategy aiming for blood glucose levels of 10.0 – 11.1 mmol/L. The mean morning blood glucose values in the two groups were 5.7 and 8.5 mmol/L, respectively (van den Berghe, 2001). However, a subsequent study in critical care patients demonstrated worse outcomes, including increased mortality, with an intravenous insulin strategy aiming for blood glucose levels of 4.5 – 6.0 mmol/L, compared to a strategy aiming for blood glucose levels of 8.0 – 10.0 mmol/L. The mean morning blood glucose values in the two groups were 6.5 and 8.1 mmol/L, respectively (Finfer, 2009).

Therefore, the 2013 CDA CPG recommendation is:

for most medical/surgical ICU patients with hyperglycemia, a continuous IV insulin infusion should be used to maintain glucose levels between 7.8 and 10 mmol/L.

Post-operative
One clinical trial in a general surgery population compared a basal-bolus-supplement insulin program with a fairly aggressive sliding scale insulin program. The patients treated with the basal-bolus-supplement program had lower blood glucose at all times of day and had 1/3 of the major post-operative complications, compared to patients treated with sliding scale (short-acting) insulin only (Umpierrez, 2011).

Therefore, the 2013 CDA CPG recommendation is:

perioperative glycemic levels should be maintained between 5.0 and 11.0 mmol/L for most other surgical situations; with an appropriate protocol and trained staff to ensure the safe and effective implementation of this therapy and to minimize the likelihood of hypoglycemia.
General Medicine

One clinical trial in a general medical population compared a basal-bolus-supplement insulin program with a fairly aggressive sliding scale insulin program. The basal-bolus-supplement program lowered blood glucose at all times of day without an increase in hypoglycemia. No difference in outcomes was seen (Umpierrez, 2007).

Therefore, the 2013 CDA CPG recommendations are:

- for the majority of non-critically ill patients treated with insulin, pre-meal glucose targets should generally be < 7.8 mmol/L in conjunction with random BG values < 10.0 mmol/L, as long as these targets can be safely achieved and; for hospitalized patients with diabetes treated with insulin, a proactive approach that may include basal, prandial, and correction-dose insulin, along with pattern management, is preferred over the “sliding scale” reactive approach using only short- or rapid-acting insulin.

What systems improve in-hospital care of patients with diabetes?

- A policy to aid in the recognition and treatment of hypoglycemia. This needs to be done before any policies or procedures to lower overall glycemia in hospitalized patients can be implemented.
- Clinical order sets to facilitate and encourage the use of insulin orders using basal, bolus, and supplemental insulin programs (Noschese, 2008).
- If available, computer pharmacy order entry for insulin (Wexler, 2010).
- Specialized teams, including specially trained nurses, regularly reviewing insulin orders and glucose records (Sampson, 2006; Donhi, 2011).

How to implement basal-bolus-supplemental insulin (and stop sliding scales) in your hospital – stepped approach

1. Gather a multi-disciplinary team with an interest in in-hospital diabetes management and improving clinical outcomes. This team could consist of: diabetes educators, ward nurses, pharmacists, dietitian, family doctors, hospitalists, internists, endocrinologists, and quality improvement associates.
2. Identify other “champions” within each of these groups who will help you get out your message.
3. Build a hypoglycemia recognition and treatment protocol, if you don’t already have one. This has to be in place first.
4. Consider a baseline review or chart audit to determine how you are doing currently.
5. Set initial goals: that less than 10% of all subcutaneous insulin orders are sliding scale only may be a reasonable initial goal; or a 50% reduction from your baseline audit.
6. Develop a clinical order set (or adapt your computer pharmacy order entry) to facilitate the ordering of basal-bolus-supplement insulin and discourage the ordering of sliding scale insulin. You may also want to develop a series of IV insulin clinical order sets for specific units (surgery, ICU, CCU).
7. Educate all team members on why you are doing this. Particular attention should be paid to physician groups who are high-volume insulin users in your hospital (hospitalists, internists) and nurses on high-volume insulin-using units (cardiology, oncology, etc.). Use your champions to support and encourage team members every day.
8. Review your progress after 6 months or a year. Are you making progress? What implementation strategies have worked or not worked? What groups have done better than others and why?
9. Re-educate groups who aren’t doing as well as others. Adapt your clinical order set(s) to facilitate ease of use. Celebrate those individuals or groups or units who are doing well.
10. Set new goals. Repeat.

Developing an basal-bolus-supplemental insulin in hospital

Outside of hospital, basal-bolus-supplemental insulin is commonly used for patients with type 1 diabetes and is occasionally used in patients with type 2 diabetes; it has also been called multiple daily insulin (MDI). The calculations are based on Umpierrez, 2007 and Umpierrez, 2011. Low Wang and Draznin (Diabetes Spectrum 2013) provide similar calculations.

Step 1:
- Estimate the patient’s total daily dose (TDD) of insulin
- If previously on insulin, use patient’s current TDD
- If not previously on insulin, use patient’s weight (in kg) times 0.4 – 0.5

Step 2:
- Order the basal insulin (insulin type, time of day, dose)
- Basal insulin type will be NPH, glargine, or detemir
- Basal insulin is typically given at bedtime
- Basal insulin dose will be TDD times 0.4 – 0.5
Step 3:

- Order the **bolus**, sometimes called prandial, insulin (insulin type, time of day, dose)
- Rapid acting insulin analogues (aspart, glulisine, lispro) are the preferred type of bolus insulin in hospital, but regular insulin can also be used
- Bolus insulin is typically given before each meal
- Bolus insulin dose will be TDD minus the basal insulin dose, evenly divided between the 3 meals or; TDD times 0.2 at each meal
- Bolus insulin should be held in patients who are temporarily not eating

Step 4:

- Order the **supplemental** or correction insulin (insulin type, time of day, dose)
- The supplemental insulin should be the same type as the bolus insulin; so usually a rapid acting insulin analogue.
- Supplemental insulin, if necessary, is typically given before each meal; it can also be given at bedtime
- The dose of supplemental insulin is added to the dose of bolus insulin and the two doses are given together. The supplemental insulin will typically only be given when the blood glucose is greater than 8 or 10 mmol/L; examples are shown in “Tools”.

Step 5:

- Review the patient’s diabetes and insulin record daily and make changes according to the blood glucose pattern(s).

**Developing Intravenous (IV) Insulin Clinical Order Sets (COS)**

Intravenous insulin is appropriate for hospitalized patients who are not eating but who require insulin to control hyperglycemia.

Those patients could include:

1. Patients with a hyperglycemic emergency – diabetic ketoacidosis (DKA) or hyperosmolar hyperglycemic state (HHS). CDA 2013 CPG (chapter 15)
2. Patients with hyperglycemia in an intensive care unit (ICU). CDA 2013 CPG (chapter 16)
3. Patients with hyperglycemia newly admitted with a myocardial infarction (MI) or acute coronary syndrome (ACS). CDA 2013 CPG (chapter 26)
4. Patients having surgery. CDA 2013 CPG (chapter 16)
5. Patients receiving continuous enteral (EN) or parenteral (TPN) nutrition. CDA 2013 CPG (chapter 16)

Note that these patients may or may not have a pre-existing diagnosis of diabetes. Patients with type 1 diabetes should not have IV insulin interrupted unless and until they are started on subcutaneous insulin which includes a basal insulin.

**Writing an IV insulin COS**

1. Add a set amount of regular human insulin (Humulin R®, Novolin Toronto®) to a set amount of normal saline. For purposes of continuity and patient safety, this concentration should be consistent within a hospital or within a unit. Examples are 50 units in 250mL saline (0.2 units / mL) or 50 units in 100mL saline (0.5 units / mL). The first concentration is appropriate for most non-critically ill patients; the second concentration is often used in critically ill patients where minimization of infused IV fluid volume may be important.

2. Set a target blood glucose (BG). The attached COS have a target BG of 6.0 – 10.0 mmol/L for non-critically ill patients; the same for critically ill patients in ICU; and 7.0 – 10.9 for patients with an ACS.

3. Set a starting insulin infusion rate. This can be set based on current BG, patient’s weight, or patient’s previous subcutaneous (SC) insulin requirements. The attached ACS COS recommends starting the IV insulin at 5 units / hour. This was the starting dose used and proven to be effective in the DIGAMI trial (Malmberg, 1997).

4. Insulin rate adjustments are then generally taken care of within the COS algorithm. Generally speaking, the insulin rate will “auto correct”. If the BG is above target, the insulin infusion rate will increase. If the BG is below target or dropping rapidly, the insulin infusion rate will decrease. Generally, the algorithm will also determine when the next bedside blood glucose monitoring (BBGM) check should occur. If the BG is stable and at target, the interval between tests is extended, but never beyond 4 hours. If the BG is unstable and / or not at target, the interval between tests is shortened, often to 30 or 60 minutes.

5. Safety measures must be in place for any patient receiving IV insulin. With the exception of patients being treated for a hyperglycemic emergency, all patients receiving IV insulin should be receiving at least some IV glucose (or continuous EN or TPN). A plan should be in place for nursing staff to recognize and treat symptomatic or asymptomatic hypoglycemia. This could involve IV glucose or oral glucose tablets, depending on the clinical situation.
In-Hospital Management of Diabetes

Frequently asked questions

**What are the goals for in-hospital glycemic control?**
The 2013 CDA CPG suggest trying to obtain fasting and pre-meal BG between 5.0 and 8.0 mmol/L for most hospitalized patients with diabetes, whether treated with oral anti-diabetic therapy or SC insulin.

**When is subcutaneous insulin not used for a hospitalized patient?**
Patients with good pre-existing glycemic control with non-insulin medications and in whom those medications are not contra-indicated (metformin with acute renal failure, metformin after contrast dye administration) could be continued on their current, out-of-hospital therapy, while in hospital, while keeping a close eye on their bedside blood glucose monitoring (BBGM). Insulin could be started if these medications failed to continue to provide adequate glycemic control. (See CPG in-hospital chapter – role of oral anti-diabetic drugs).

Patients who are critically ill (intensive care, immediately post-myocardial infarction) are usually better treated with a continuous IV insulin infusion. Patients who are NPO for a brief period of time, like for surgery, are usually treated with a continuous IV insulin infusion. Patients receiving total parenteral nutrition (TPN) or continuous (enteral) tube feeds could be treated with either a continuous IV insulin infusion or scheduled subcutaneous insulin.

**What's wrong with sliding scale insulin?**
Sliding scale insulin is rapid- or fast-acting insulin alone, without basal insulin, and given only if the BBGM is above a certain level. It has been shown to be associated with worse glycemic outcomes and worse clinical outcomes than a scheduled basal-bolus-supplement insulin program (Miller, 2011; Umpierrez, 2007; Umpierrez, 2011). Sliding scale insulin treats hyperglycemia only after it has occurred and is not recommended. By contrast, a “supplemental” or “correction” insulin dose, in addition to scheduled basal +/- bolus or prandial insulin is recommended. An insulin COS should discourage / prevent the use of sliding scale insulin while making it easier to order basal-bolus-supplement insulin.

**Where do these insulin doses come from?**
Patients previously treated with insulin, at home, will usually continue on their same dose in hospital. The BBGM can be followed closely and insulin dose adjustments can be made daily. Most hospital patients require QID insulin for optimal flexibility, minimization of hypoglycemia, and best outcomes.

Clinical trials of basal-bolus-supplement insulin have generally started insulin-naïve patients on a total daily dose of insulin of 0.3 – 0.6 units / kg / day. The lower doses are appropriate for older patients (over 70 years), patients with only modestly elevated BBGM on admission, or patients with impaired renal function. The higher doses are appropriate for younger patients, obese patients, patients with significantly elevated BBGM on admission, patients receiving glucocorticoids, or patients receiving TPN or enteral tube feeds.

Once the total daily dose is established, the individual doses can be set in one of three ways. Some authors recommend 50% of the total daily dose (TDD) of insulin be administered as basal and then the rest divided evenly between the three meals – this is the 50:50 approach. Some authors recommend administering the insulin in a 1:1:1:2 ratio with the 1’s representing the meal insulin doses (20% each) and the 2 representing the basal insulin at hs (40% of the TDD) – this is the 1:1:1:2 approach. Some authors recommend simply calculating the meal / bolus insulin as 0.1 units / kg for each meal and the bedtime / basal insulin as 0.2 units / kg. This is the 1:1:1:2 approach at a TDD of 0.5 units / kg / day. In all cases, these are simply the starting insulin doses that then need to be adjusted daily based on the BBGM pattern and the patient’s clinical condition.

The supplemental insulin dose is calculated in this way: the insulin sensitivity factor (ISF) is the degree of BG lowering expected from one unit of insulin. The ISF is calculated by dividing 100 by the TDD; so a patient receiving 50 units of insulin per day would have an ISF of 2.0 – 1 unit of insulin would be expected to lower the BG by 2.0 mmol/L. A patient receiving 100 units of insulin per day would have an ISF of 1.0 – 1 unit of insulin to lower the BG by 1.0 mmol/L. When there are choices given for supplemental / correction insulin those choices are usually based on the TDD and these sorts of calculations.

**What types of insulin should be used in hospital?**
Generally, rapid-acting insulin analogues are recommended for the bolus / prandial insulin and the supplemental insulin, in preference to regular human insulin. In all cases, the bolus and supplemental insulin should be the same. Any of the rapid-acting insulin analogues (insulin aspart, glulisine, lispro) can be used and they are roughly equivalent to one another. The basal / long-acting insulin can be NPH, insulin detemir, or insulin glargine and is generally given once a day at hs. Intravenous insulin should be regular human insulin diluted in normal saline (0.9% NaCl).

**What about the patient who isn’t eating?**
Generally, these patients should still receive their basal long-acting and their supplemental rapid-acting insulins, but not receive a scheduled bolus / prandial insulin. Some facilities have a separate COS for the fasting / NPO patient; other facilities simply have an order box stating something like “hold prandial, give basal and supplemental insulin if patient is NPO for test / procedure”.

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References


