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2018 Clinical Practice Guidelines

In-Hospital Management of Diabetes

Diabetes Canada Clinical Practice Guidelines Expert Committee

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KEY MESSAGES

- Hyperglycemia is common in hospitalized people, even among those without a previous history of diabetes, and is associated with increased in-hospital complications, longer length of stay and mortality.
- Insulin is the most appropriate pharmacologic agent for effectively controlling glycemia in hospital. A proactive approach to glycemic management using scheduled basal, bolus and correction (supplemental) insulin is the preferred method. The use of correction-only (supplemental) insulin, which treats hyperglycemia only after it has occurred, should be discouraged as the sole modality for treating elevated blood glucose levels.
- For the majority of noncritically ill hospitalized people with diabetes, preprandial blood glucose targets should be 5.0 to 8.0 mmol/L, in conjunction with random blood glucose values <10.0 mmol/L, as long as these targets can be safely achieved. For critically ill hospitalized people with diabetes, blood glucose levels should be maintained between 6.0 and 10.0 mmol/L.
- Hypoglycemia is a major barrier to achieving targeted glycemic control in the hospital setting. Health-care institutions should develop protocols for the assessment and treatment of hypoglycemia.

KEY MESSAGES FOR PEOPLE WITH DIABETES

- If your admission to hospital is planned, talk with your health-care providers (e.g. surgeon, anesthetist, primary care provider, diabetes health provider, etc.) before you are admitted in order to develop an in-hospital diabetes care plan that addresses such issues as:
  - Who will manage your diabetes in the hospital?
  - Will you be able to self-manage your diabetes?
  - What adjustments to your diabetes medications or insulin doses may be necessary before and after medical procedures or surgery?
  - If you use an insulin pump, are hospital staff familiar with pump therapy?
- Your blood glucose levels may be higher in hospital than your usual target range due to a variety of factors, including the stress of your illness, medications, medical procedures and infections.
- Your diabetes medications may need to be changed during your hospital stay to manage the changes in blood glucose, or if medical conditions develop that make some medications no longer safe to use.
- When you are discharged, make sure that you have written instructions about:
  - Changes in your dosage of medications or insulin injections or any new medications or treatments
  - How often to check your blood glucose
  - Who to contact if you have difficulty managing your blood glucose levels.

Introduction

Diabetes increases the risk for hospitalization for several reasons, including: cardiovascular (CV) disease, nephropathy, infection, cancer and lower-extremity amputations. In-hospital hyperglycemia is common. A review of medical records of over 2,000 adult patients admitted to a community teaching hospital in the United States (>85% were nonintensive care unit patients) found that hyperglycemia was present in 38% of patients (1). Of these patients, 26% had a known history of diabetes, and 12% had no history of diabetes prior to admission. Diabetes has been reported to be the fourth most common comorbid condition listed on all hospital discharges (2).

Acute illness results in a number of physiological changes (e.g. increases in circulating concentrations of stress hormones) or therapeutic choices (e.g. glucocorticoid use) that can exacerbate hyperglycemia. Hyperglycemia, in turn, causes physiological changes that can exacerbate acute illness, such as decreased immune function and increased oxidative stress. These lead to a complex cycle of worsening illness and poor glucose control (3). Although a growing body of literature supports the need for targeted glycemic control in the hospital setting, blood glucose (BG) continues to be poorly controlled and is frequently overlooked in general medicine and surgery services. This is largely explained by the fact that the majority of hospitalizations for patients with diabetes are not directly related to their metabolic state, thus diabetes management is rarely the primary focus of care. Therefore, glycemic control and other diabetes care issues are often not specifically addressed (4).

Screening for and Diagnosis of Diabetes and Hyperglycemia in the Hospital Setting

A history of diabetes should be elicited in all patients admitted to hospital and, if present, should be clearly identified on the medical record. In view of the high prevalence of inpatient hyperglycemia with associated poor outcomes, an admission BG measurement of all patients would help identify people with diabetes, even in the absence of a prior diagnosis (1,5). In-hospital hyperglycemia is defined as any glucose value >7.8 mmol/L. For hospitalized people with known diabetes, the glycated hemoglobin (A1C) identifies people who may benefit from efforts to improve glycemic control and tailor therapy upon discharge (6,7). In hospitalized people with newly recognized hyperglycemia, an A1C among those with diabetes risk factors or associated comorbidities (e.g. cardiovascular disease

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[CVD]) (8,9) may help differentiate people with previously undiagnosed diabetes and dysglycemia from those with stress-induced hyperglycemia and provides an opportunity to diagnose and initiate diabetes therapies (10–13). Among people admitted to an intensive care unit (ICU), an A1C drawn at admission allows identification of people with previously unknown diabetes, people at risk of glycemic management challenges and people at an increased risk of mortality (14,15). A1C has been found to be specific for diagnosis of diabetes in the hospital setting, although not as sensitive as in the outpatient setting (13,16). While the threshold for diagnosis of diabetes has not been established for hospitalized people, an A1C criteria of >6.0% has been found to be highly specific for the diagnosis of dysglycemia post-hospitalization (13,17).

Glucose Monitoring in the Hospital Setting

Bedside blood glucose monitoring

Currently, there are no studies that have examined the effect of the frequency of bedside BG monitoring on the incidence of hyper- or hypoglycemia in the hospital setting. The frequency and timing of bedside BG monitoring can be individualized; however, monitoring is typically performed before meals and at bedtime in people who are eating; every 4 to 6 hours in people who are NPO (nothing by mouth) or receiving continuous enteral feeding; and every 1 to 2 hours for people on continuous intravenous insulin or those who are critically ill. Some bedside BG monitoring is indicated in individuals without known diabetes but receiving treatments known to be associated with hyperglycemia (e.g. glucocorticoids, octreotide, parenteral nutrition and enteral nutrition) (18). The implementation and maintenance of quality control programs by health-care institutions helps to ensure the accuracy of bedside BG monitoring (19,20). The use of glucose meters with bar coding capability has been shown to reduce data entry errors in medical records (21). Data management programs that transfer bedside BG monitoring results into electronic records allow evaluation of hospital-wide glycemic control (22).

Capillary blood glucose (CBG) point of care testing (POCT) should be interpreted with caution in the critically ill patient population. Poor perfusion indices may yield conflicting capillary, arterial and whole BG values using POCT glucose meters (23–25). Venous or arterial samples are preferred when using a POCT meter for this patient population.

Clinical decision support system software integrating CBG POCT can aid in trend analysis, medication dosing, reduce prescription error and reduce length of stay (26). Electronic glucose metric data and web-based reporting systems may pose utility for monitoring glycemic management performance within an organization and enhance opportunities for external benchmarking (27).

Glycemic Control in the Non-Critically Ill Patient

A number of studies have demonstrated that inpatient hyperglycemia is associated with increased morbidity and mortality in noncritically ill hospitalized people (1,28,29). However, due to a paucity of randomized controlled trials on the benefits and risks of "conventional" vs. "tight" glycemic control in noncritically ill hospitalized people, glycemic targets for this population remain undefined. Current recommendations are based mostly on retrospective studies, clinical experience and judgement. Glycemic targets for hospitalized people with diabetes are modestly higher than those routinely advised for outpatients with diabetes given that the hospital setting presents unique challenges for the management of hyperglycemia, such as variations in patient nutritional status and the presence of acute illness. For the majority of noncritically ill hospitalized people, recommended preprandial BG targets are 5.0 to 8.0 mmol/L, in conjunction with random BG values <10.0 mmol/L, as long as these targets can be safely achieved (Table 1). Lower targets may be considered in clinically stable hospitalized people with a prior history of successful tight glycemic control in the outpatient setting, while higher targets may be acceptable in terminally ill people or in those with severe comorbidities. If BG values are ≤3.9 mmol/L, modification of antihyperglycemic therapy is suggested, unless the event is easily explained by other factors (e.g. a missed meal) (18,30).

Table 1
Recommended glycemic targets for hospitalized people with diabetes*

Hospitalized population with diabetes	Blood glucose targets (mmol/L)
Noncritically ill	Preprandial: 5.0–8.0 Random: <10.0
Critically ill	6.0–10.0
CABG intraoperatively	5.5–11.1
Perioperatively for other surgeries	5.0–10.0
Acute coronary syndrome†	7.0–10.0
Labour and delivery‡	4.0–7.0

CABG, coronary artery bypass grafting.
* Less stringent targets may be appropriate in terminally ill patients or in people with severe comorbidities (see Targets for Glycemic Control chapter, p. S42).
† See Management of Acute Coronary Syndromes chapter, p. S190.
‡ See Diabetes and Pregnancy chapter, p. S255.

Glycemic Control in the Critically Ill Patient

Acute hyperglycemia in the intensive care setting is not unusual and results from a number of factors, including stress-induced counter-regulatory hormone secretion and the effects of medications administered in the ICU (31). Glycemic targets for people with pre-existing diabetes who are in the critical care setting have not been firmly established. Early trials showed that achieving normoglycemia (4.4 to 6.1 mmol/L) in cardiac surgery patients or patients in postoperative surgical ICU settings reduced mortality (32). However, subsequent trials in mixed populations of critically ill patients did not show a benefit of targeting BG levels of 4.4 to 8.3 mmol/L. A meta-analysis of trials of intensive insulin therapy in the ICU setting suggested benefit of intensive insulin therapy in surgical patients, but not in medical patients (33). Conversely, the Normoglycemia in Intensive Care Evaluation—Survival Using Glucose Algorithm Regulation (NICE-SUGAR) study, the largest trial to date of intensive glucose control in critically ill medical and surgical patients, found an increase in 90-day all-cause mortality (hazard ratio [HR] 1.14; 95% confidence interval [CI] 1.02–1.28; p=0.02) amongst participants randomized to the intensive glycemic control arm that targeted BG levels of 4.5 to 6.0 mmol/L (34). Furthermore, intensive insulin therapy has been associated with an increased risk of hypoglycemia in the ICU setting (33). Therefore, maintaining a BG level <10.0 mmol/L in critically ill hospitalized people with diabetes is considered a safe target (Table 1). The lower limit for the BG target is less well established but generally should remain >6.0 mmol/L in order to minimize the risks of both hypoglycemia and mortality. The use of insulin infusion protocols with proven efficacy and safety minimizes the risk of hypoglycemia (35–38).

Role of Intravenous Insulin

There are few occasions when intravenous insulin is required, as most people with type 1 or type 2 diabetes admitted to general

medical wards can be treated with subcutaneous insulin. Intravenous insulin, however, may be appropriate for people who are critically ill (with appropriate BG targets), people who are not eating and in those with hyperglycemia and metabolic decompensation (e.g. diabetic ketoacidosis [DKA] and hyperosmolar hyperglycemic state [HHS]) (see Hyperglycemic Emergencies in Adults chapter, p. S109). The evidence to date suggests there is no benefit to intravenous insulin over subcutaneous insulin post-acute stroke (3,39).

Health-care staff education is a critical component of the implementation of an intravenous insulin infusion protocol. Intravenous insulin protocols should take into account the patient's current and previous BG levels (as well as the rate of change in BG), and the patient's usual insulin dose. Several published insulin infusion protocols appear to be both safe and effective, with low rates of hypoglycemia; however, most of these protocols have only been validated in the ICU setting, where the nurse-to-patient ratio is higher than on medical and surgical wards (3,36). BG determinations can be performed every 1 to 2 hours until BG has stabilized. With the exception of the treatment of hyperglycemic emergencies (e.g. DKA and HHS), consideration should be given to concurrently providing people receiving intravenous insulin with some form of glucose (e.g. intravenous glucose or through parenteral or enteral feeding).

Transition from IV insulin to SC insulin therapy

Hospitalized people with type 1 and type 2 diabetes may be transitioned to scheduled subcutaneous insulin therapy from intravenous insulin. Short- or rapid- or fast-acting insulin can be administered 1 to 2 hours before discontinuation of the intravenous insulin to maintain effective blood levels of insulin. If intermediate- or long-acting insulin is used, it can be given 2 to 3 hours prior to intravenous insulin discontinuation. People without a history of diabetes, who have hyperglycemia requiring more than 2 units of intravenous insulin per hour, likely require insulin therapy and can be considered for transition to scheduled subcutaneous insulin therapy.

The initial dose and distribution of subcutaneous insulin at the time of transition can be determined by extrapolating the intravenous insulin requirement over the preceding 6- to 8-hour period to a 24-hour period. Administering 60% to 80% of the total daily calculated dose as basal insulin has been demonstrated to be safe and efficacious in surgical patients (40). Dividing the total daily dose as a combination of basal and bolus insulin has been demonstrated to be safe and efficacious in medically ill patients (40,41).

Perioperative glycemic control

The management of individuals with diabetes at the time of surgery poses a number of challenges. Acute hyperglycemia is common secondary to the physiological stress associated with surgery. Pre-existing diabetes-related complications and comorbidities may also influence clinical outcomes. Acute hyperglycemia has been shown to adversely affect immune function (42) and wound healing (43) in animal models. Observational studies have shown that hyperglycemia increases the risk of postoperative infections (44,45), renal allograft rejection (46), and is associated with increased health-care resource utilization (47).

Cardiovascular surgery

In people undergoing coronary artery bypass grafting (CABG), a pre-existing diagnosis of diabetes has been identified as a risk factor for postoperative sternal wound infections, delirium, renal dysfunction, respiratory insufficiency and prolonged hospital stays (48–50). Intraoperative hyperglycemia during cardiopulmonary bypass has been associated with increased morbidity and mortality rates in individuals with and without diabetes (51–53). A systematic review of randomized controlled trials supports the use of intravenous insulin infusion targeting a blood glucose of 5.5 to 11.1 mmol/L over correction (supplemental) subcutaneous insulin for perioperative glycemic control in CV surgery patients (Table 1). This was demonstrated by a marked reduction in surgical site infections (odds ratio 0.13) (54).

Minor and moderate surgery

The perioperative glycemic targets for minor or moderate surgeries are less clear. Older studies comparing different methods of achieving glycemic control during minor and moderate surgeries did not demonstrate any adverse effects of maintaining perioperative BG levels between 5.0 to 11.0 mmol/L (55–57). Attention has been placed on the relationship between postoperative hyperglycemia and surgical site infections. While the association was well documented, the impact and risks of intensive management was less clear. A recent meta-analysis of 15 randomized controlled trials demonstrated that intensive perioperative glycemic control (BG target of <8.3 mmol/L) resulted in decreased odds of surgical site infections when compared to conventional control (BG target of <12 mmol/L). The risk of hypoglycemia was increased but there was no increased risk of stroke or death. The included studies looked at the intraoperative and immediate postoperative period and used intravenous insulin to achieve intensive targets. The included studies were mostly cardiac and gastrointestinal and were found to have a moderate risk of bias (58).

Rapid institution of perioperative glucose control must be carefully considered in patients with poorly controlled type 2 diabetes undergoing monocular phacoemulsification cataract surgery with moderate to severe nonproliferative diabetic retinopathy because of the possible increased risk of postoperative progression of retinopathy and maculopathy (59). The outcome of vitrectomy, however, does not appear to be influenced by perioperative control (60).

Given the data supporting tighter perioperative glycemic control during major surgeries and the compelling data showing the adverse effects of hyperglycemia, it is reasonable to target glycemic levels between 5.0 to 10.0 mmol/L for minor and moderate surgeries in patients with known diabetes (Table 1). The best way to achieve these targets in the postoperative patient is with a basal bolus insulin regimen (61,62). This approach has been shown to reduce postoperative complications, including wound infections. Despite this knowledge, surgical patients are often treated with correction (supplemental) rapid-acting insulin alone (63) which may not adequately control BG.

The benefits of improved perioperative glycemic control must be weighed against the risk of perioperative hypoglycemia. Anesthetic agents and postoperative analgesia may alter the patient's level of consciousness and awareness of hypoglycemia. The risk of hypoglycemia can be reduced by frequent BG monitoring and carefully designed management protocols.

Role of Subcutaneous Insulin

In general, insulin is the preferred treatment for hyperglycemia in hospitalized people with diabetes (35). People with type 1 diabetes must be maintained on insulin therapy at all times to prevent DKA. Scheduled subcutaneous insulin administration that consists of basal, bolus (prandial) and correction (supplemental) insulin components is the preferred method for achieving and maintaining glucose control in noncritically ill hospitalized people with diabetes or stress hyperglycemia who are eating (35,64). Bolus insulin can be withheld or reduced in people who are not eating regularly; however, basal insulin should not be withheld. Stable people

can usually be maintained on their home insulin regimen with adjustments made to accommodate for differences in meals and activity levels, the effects of illness and the effects of other medications. In the hospital setting, rapid-acting insulin analogues are the preferred subcutaneous bolus and correction insulins (65). Insulin programs that only react to, or correct for, hyperglycemia have been demonstrated to be associated with higher rates of hyperglycemia (61,66–69). Insulin is often required temporarily in hospital, even in people with type 2 diabetes not previously treated with insulin. In these insulin-naive people, there is evidence demonstrating the superiority of basal-bolus-correction insulin regimens (61,66).

A number of protocols have been published as part of studies (61,66,69–72). These studies have typically started insulin-naive people on 0.4 to 0.5 units of insulin per kilogram of body weight per day, with 40% to 50% of the total daily dose (TDD) given as basal insulin (detemir, glargine, neutral protamine Hagedorn [NPH]) and the balance given as bolus (rapid- or short-acting) insulin divided equally before each meal (i.e. breakfast, lunch and dinner); correction doses of the bolus insulin are provided if BG values are above target. Daily review of the person's BG measurements and modification of insulin doses, as required, facilitates the achievement of target blood glucose measurements.

When comparing effective protocols, the following was observed. One study compared basal-bolus (plus correction) insulin with glargine and glulisine vs. premixed insulin (30/70) (73). The study, although small (a total of 72 patients), had to be stopped early because of a tripling of the rate of hypoglycemia, BG <3.8 mmol/L, in the premixed insulin group. Average BG levels were not different, but rates of hypoglycemia were. Another study (74) found no difference in BG levels or rates of hypoglycemia when comparing insulin glargine vs. detemir, when used as the basal insulin in a basal-bolus program. Yet another study (71) found that using a weight-based algorithm to titrate insulin glargine resulted in obtaining target BG levels faster than a glucose-based algorithm, with no difference in the rates of hypoglycemia.

More recently, a study compared a basal-bolus (plus correction) insulin regimen with a program that was basal plus correction (69). The basal-bolus group had slightly lower BG through the day, which was not statistically significant, with no difference in FBG or in rates of hypoglycemia. Taken together with the earlier studies from this group (61,66), it would appear that successful management of in-hospital diabetes requires early and aggressive administration of basal insulin combined with bolus insulin, typically in the form of rapid-acting insulin analogue, similar to the approach used in the outpatient setting.

Role of Noninsulin Antihyperglycemic Agents

To date, no large studies have investigated the use of noninsulin antihyperglycemic agents on outcomes in hospitalized people with diabetes. There are often short- and/or long-term contraindications to the use of noninsulin antihyperglycemic agents in the hospital setting, such as irregular eating, acute or chronic renal failure, and exposure to intravenous contrast dye (75). Stable hospitalized people with diabetes without these contraindications can often have their home antihyperglycemic medications continued while in the hospital. However, if contraindications develop or if glycemic control is inadequate, these drugs should be discontinued and consideration given to starting the patient on a basal-bolus-supplemental insulin regimen. The advantages and disadvantages of various noninsulin antihyperglycemic therapies in hospital are discussed in detail in a recent review article (76).

A recent randomized but unblinded study compared sitagliptin plus basal (and correctional) insulin with a more traditional basal-bolus-correctional insulin program in hospitalized people with diabetes (77). The glycemic outcomes were similar between the 2 groups; however, the basal-bolus-correctional group had a higher mean glucose than similarly insulin-treated subjects in other studies (61,66). This less-aggressive treatment may explain the lack of difference between the sitagliptin and the bolus insulin groups.

Role of Medical Nutrition Therapy

Medical nutrition therapy including nutritional assessment and individualized meal planning is an essential component of inpatient glycemic management programs. A consistent carbohydrate meal planning system may facilitate glycemic control in hospitalized people and facilitate matching prandial insulin doses to the amount of carbohydrate consumed (61,66,75,78–80).

Special Clinical Situations

Hospitalized people with diabetes receiving enteral or parenteral feedings

In hospitalized people with diabetes receiving parenteral nutrition, insulin can be administered in the following ways: as scheduled regular insulin dosing added directly to the parenteral solution; or as scheduled intermediate- or long-acting subcutaneous insulin doses (81). A separate intravenous infusion of regular insulin may be an alternative method to achieve glycemic control in critical care (82). For scheduled subcutaneous insulin dosing or regular insulin added directly to parenteral solutions, the selected starting insulin dose may be based on the current estimated TDD of insulin, the composition of the parenteral nutrition solution and the patient's weight (81). Considering the patient's individual clinical situation is important when determining insulin dosing. Subcutaneous correction (supplemental) insulin may be used in addition to scheduled insulin dosing and dose adjustments made to scheduled insulin should be adjusted based on the BG pattern.

For hospitalized people with diabetes on enteral feeding regimens, there are few prospective studies examining insulin management. In 1 randomized controlled trial, low-dose basal glargine insulin with regular insulin correction dosing was compared against regular insulin correction (supplemental) insulin dosing with the addition of NPH in the presence of persistent hyperglycemia and demonstrated similar efficacy for glycemic control (83). The type of feed solution and duration of feed (cyclical vs. continuous) should be considered. People with diabetes receiving bolus enteral feeds may be treated in the same manner as people who are eating meals. Approximately 50% of the TDD can be provided as basal insulin and 50% as bolus insulin, which is administered in divided doses to match feed times (75). Correction (supplemental) insulin can be administered, as needed; added to the same bolus insulin. An insulin with a shorter half-life, such as NPH, may be preferred for intermediate duration feeding schedules (i.e. overnight), while regular or rapid-acting insulin may be more appropriate to manage hyperglycemia induced by bolus feeding schedules.

In the event that the parenteral or enteral nutrition is unexpectedly interrupted, intravenous dextrose may be required to prevent hypoglycemia depending on the last dose and type of insulin administered. When parenteral or enteral feeding schedules are adjusted in terms of carbohydrate content or duration, the insulin type and dose will need to be re-assessed.

Hospitalized people with diabetes receiving corticosteroid therapy

Hyperglycemia is a common complication of corticosteroid therapy, with a prevalence between 20% and 50% among people

without a previous history of diabetes (84). Although the optimal management of hyperglycemia in people receiving high-dose oral corticosteroids has not been clearly defined, glycemic monitoring for 48 hours after initiation of steroids may be considered for people with or without a history of diabetes (35,84). For management of hyperglycemia, treatment with a basal-bolus with correction insulin regimen was more effective and safer than a correction (supplemental) insulin-only regimen (85), although addition of NPH (dosed variably from once a day at time of glucocorticoid administration to every 6 hours depending on glucocorticoid used) was not demonstrated to improve glycemic outcomes (86,87).

Self-management of diabetes in hospital

Although data for self-management in the hospitalized setting is limited, self-management in hospital may be appropriate for people who are mentally competent and desire more autonomy over their diabetes. The majority of evidence pertains to continuous subcutaneous insulin infusion (CSII) therapy, where continuation of patient-managed insulin delivery has been associated with reduced episodes of severe hyperglycemia and hypoglycemia (88) and high levels of patient satisfaction (89). In general, any person requiring insulin therapy who is self-managing diabetes in the hospital setting should be able to physically self-administer insulin and perform self-monitoring of blood glucose (SMBG) independently, be familiar with the recommended insulin routine, understand sick-day management guidelines and utilize a flowsheet to facilitate communication of BG results and insulin dosing between the patient and health-care providers. The person with diabetes and the health-care provider, in consultation with nursing staff, must agree that patient self-management is an appropriate strategy while hospitalized. Hospitals should have policies and procedures for the assessment of suitability for self-management.

Hospitalized people with diabetes using CSII

Although the data are limited, it appears that CSII can be safely continued in the hospital setting under certain circumstances (90). People maintained on CSII may have decreased length of stay (90); however, this may reflect the severity of illness rather than a glycemic control advantage. People maintained on CSII may have less hypoglycemia than those managed by the admitting clinician. People on CSII are encouraged to continue this form of therapy whenever safe and feasible in hospital. Successful published inpatient protocols include assessment of pump specific self-management skills (i.e. how to adjust their basal rate, administer a bolus dose, insert an infusion set, fill a reservoir, suspend the pump and correct a CBG result outside their target range), pre-printed orders, flow sheets and patient consents (88,91,92). If the patient cannot demonstrate and/or describe the above-mentioned actions and desires to continue CSII, appropriate education and supports can be provided. If appropriate supports are not available, CSII may be discontinued and a basal-bolus-subcutaneous insulin regimen or intravenous insulin infusion may be initiated.

An increasing number of people are being maintained on CSII during short elective surgical procedures without any reported adverse events (93), necessitating close collaboration between anesthesia and diabetes management teams. Different pump manufacturers will recommend discontinuing pumps for certain hospital-based procedures (e.g. radiology, cautery, external beam radiation). To promote a collaborative relationship between the hospital staff and the patient, and to ensure patient safety, hospitals must have clear policies and procedures in place to guide the use of CSII in the inpatient setting (92). Documents that stipulate contraindications for continued CSII, procedures to guide medical management of CSII and a consent form outlining the inpatient terms of use (92) support the safe use of CSII use in hospital. Specific algorithms and order sets for management of CSII peri-operatively and during labour and delivery have been published (93,94).

Organization of Care

Institution-wide programs to improve glycemic control in the inpatient setting include the formation of a multidisciplinary steering committee, professional development programs focused on inpatient diabetes management (95,96), policies to assess and monitor the quality of glycemic management, interprofessional team-based care (including comprehensive patient education and discharge planning) as well as standardized order sets, protocols and algorithms for diabetes care within the institution. Implementation of such a program can result in improvements in in-hospital glycemic control (97,98).

Algorithms, order sets and decision support

Order sets for basal-bolus-correction insulin regimens, insulin management algorithms (70,96,99–102), and computerized order entry systems (101,103) have been shown to improve glycemic control and/or reduce adverse outcomes in hospitalized people with diabetes. Computerized and mobile decision support systems (that provide suggestions for insulin dosing) have also been used and have been associated with lower mean BG levels (26,104–106); hypoglycemia can be an unintended consequence of tighter glycemic control (70,105).

Interprofessional team-based approach

The timely consultation of glycemic management teams has also been found to improve the quality of care provided, reduce the length of hospital stay and lower costs (107,108), although differences in glycemic control were minimal (109). Deployment of nurses (110,111), nurse practitioners and physician assistants (112) with specialty training has been associated with greater use of basal-bolus insulin therapy and lower mean BG levels. A provincial survey of over 2,000 people with diabetes admitted to hospital found that people were more likely to be satisfied with their diabetes care in hospital if they had confidence that the team was knowledgeable about diabetes, presented a consistent message and acknowledged them in their diabetes care (113).

Comprehensive patient education

Programs that include self-management education, such as assessment of barriers and goal setting, have also been associated with improvements in glycemic control (97,111).

Metrics for evaluating inpatient glycemic management programs

Institutional implementation of hospital glycemic management programs require metrics to monitor progress, assess safety, length of stay and identify opportunities for improvement (27). Implementation of inpatient hyperglycemia quality improvement programs evaluated with real-time metrics have been shown to improve glycemic control and safety of insulin ordering (97,114). To date, metrics for monitoring glycemic control programs in hospitals have not been established (115). This lack of standardization limits the ability for benchmarking and comparison of different quality-improvement programs and protocols. Further study into the development and implementation of appropriate

standardized metrics for hospital glycemic management programs is warranted.

Transition from hospital to home

Interventions that ensure continuity of care, such as arranging continuation of care after discharge (97), telephone follow up and communication with primary providers at discharge (111), have been associated with a post-discharge reduction in A1C (111). Providing people with diabetes and their family or caregivers with written and oral instructions regarding their diabetes management at the time of hospital discharge will facilitate transition to community care. Comprehensive instructions may include recommendations for timing and frequency of home glucose monitoring; identification and management of hypoglycemia; a reconciled medication list, including insulin and other antihyperglycemic medications; and identification and contact information for health-care providers responsible for ongoing diabetes care and adjustment of glucose-lowering medications. Communication of the need for potential adjustments in insulin therapy that may accompany adjustments of other medications prescribed at the time of discharge, such as corticosteroids or octreotide, to people with diabetes and their primary care providers is important.

Safety

Hypoglycemia

Hypoglycemia remains a major barrier to achieving optimal glycemic control in hospitalized people with diabetes. Standardized treatment protocols that address mild, moderate and severe hypoglycemia may help mitigate this risk. Education of health-care workers about factors that increase the risk of hypoglycemia, such as sudden reduction in oral intake, discontinuation of parenteral or enteral nutrition, unexpected transfer from the nursing unit after rapid-acting insulin administration or a reduction in corticosteroid dose (78) are important steps to reduce the risk of hypoglycemia.

Insulin administration errors

Insulin is considered a high-alert medication and can be associated with risk of harm and severe adverse events. A systems approach that includes pre-printed, approved, unambiguous standard orders for insulin administration and/or a computerized order entry system may help reduce errors in insulin ordering (22).

RECOMMENDATIONS

1. An A1C should be measured if not done in the 3 months prior to admission on:
   a. All hospitalized people with a history of diabetes to identify individuals that would benefit from glycemic optimization [Grade D, Consensus]
   b. All hospitalized people with newly diagnosed hyperglycemia or those with diabetes risk factors to identify individuals at risk for ongoing dysglycemia [Grade C, Level 3 (16)]
   c. Repeat screening should be performed 6 to 8 weeks post-hospital discharge for individuals with an A1C 6.0–6.4% [Grade D, Consensus]
   d. In-hospital CBG monitoring should be initiated for individuals with an A1C ≥6.5% [Grade D, Consensus].
2. The frequency and timing of bedside CBG monitoring should be individualized for all in-hospital people with diabetes. Monitoring should typically be performed:
   a. Before meals and at bedtime in people who are eating [Grade D, Consensus]
   b. Every 4 to 6 hours in people who are NPO or receiving continuous enteral feeding [Grade D, Consensus]
   c. Every 1 to 2 hours for people on continuous intravenous insulin or those who are critically ill [Grade D, Consensus].
3. Provided that their medical conditions, dietary intake and glycemic control are stable, people with diabetes should be maintained on their pre-hospitalization noninsulin antihyperglycemic agents or insulin regimens [Grade D, Consensus].
4. For hospitalized people with diabetes treated with insulin, a proactive approach that includes basal, bolus and correction (supplemental) insulin, along with pattern management, should be used to reduce adverse events and improve glycemic control, instead of only correcting high BG with short- or rapid-acting insulin [Grade A, Level 1A (61,66,102)].
5. For the majority of noncritically ill hospitalized people with diabetes, preprandial BG targets should be 5.0 to 8.0 mmol/L in conjunction with random BG values <10.0 mmol/L, as long as these targets can be safely achieved [Grade D, Consensus].
6. For most medical/surgical critically ill hospitalized people with diabetes with hyperglycemia, a continuous intravenous insulin infusion should be used to maintain BG <10.0 mmol/L [Grade B, Level 2 (34)] and >6.0 mmol/L [Grade D, Consensus].
7. For people with diabetes undergoing CABG, a continuous intravenous insulin infusion protocol targeting intraoperative glycemic levels between 5.5 and 11.1 mmol/L should be used, rather than subcutaneous insulin, to prevent postoperative infections [Grade A, Level 1A (54)].
8. In hospitalized people with diabetes requiring insulin therapy, protocols using basal insulin with/without bolus insulin should be used for post-operative glycemic management [Grade B, Level 2 (61)].
9. In hospitalized people with diabetes, hypoglycemia should be minimized. Protocols for hypoglycemia avoidance, recognition and management should be implemented with nurse-initiated treatment, including glucagon for severe hypoglycemia when intravenous access is not readily available [Grade D, Consensus]. Hospitalized people with diabetes at risk of hypoglycemia should have ready access to an appropriate source of glucose (oral or IV) at all times, particularly when NPO or during diagnostic procedures [Grade D, Consensus].
10. Programs consisting of the following elements should be implemented for optimal inpatient diabetes care:
    a. Interprofessional team-based approach [Grade B, Level 2 (107,108,112)]
    b. Health-care professional development regarding in-hospital diabetes management [Grade D, Level 4 (95)]
    c. Algorithms, order sets and decision support [Grade C, Level 3 (26,99,105)].
    d. Comprehensive quality assurance initiatives, including institution-wide BG monitoring systems, inpatient education, and transition/continuity of care and discharge planning [Grade D, Consensus].

Abbreviations:
BG, blood glucose; *CBG*, capillary blood glucose; *CABG*, coronary artery bypass grafting; *CSII*, continuous subcutaneous insulin infusion; *ICU*, intensive care unit; *NPH*, neutral protamine Hagedorn; *POC*, point of care; *TDD*, total daily dose.

Other Relevant Guidelines

Glycemic Management in Adults With Type 1 Diabetes, p. S80
Pharmacologic Glycemic Management of Type 2 Diabetes in Adults, p. S88
Hyperglycemic Emergencies in Adults, p. S109
Management of Acute Coronary Syndromes, p. S190
Treatment of Diabetes in People With Heart Failure, p. S196

Author Disclosures

Dr. Halperin reports personal fees from Dexcom, Novo Nordisk, and QHR technologies, outside the submitted work. Dr. Miller reports personal fees from Eli Lilly, Novo Nordisk, Sanofi, and AstraZeneca; and grants and personal fees from Boehringer Ingelheim, Janssen, Merck, outside the submitted work. Sarah Moore reports personal fees from Diabetes Care Alliance (Boehringer Ingelheim Eli Lilly Alliance), and Merck Canada, outside the submitted work. No other authors have anything to disclose.

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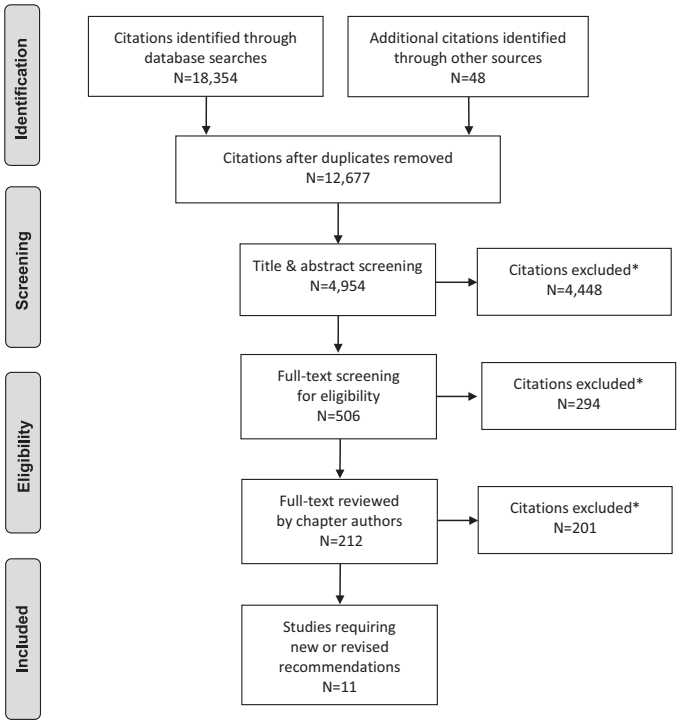
Literature Review Flow Diagram for Chapter 16: In-Hospital Management of Diabetes



*Excluded based on: population, intervention/exposure, comparator/control or study design.

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