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A Comparison of Inpatient Glucose Management Guidelines: Implications for Patient Safety and Quality

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Abstract

Inpatient glucose management guidelines and consensus statements play an important role in helping to keep hospitalized patients with diabetes and hyperglycemia safe and in optimizing the quality of their glycemic control. In this review article, we compare and contrast seven prominent US guidelines on recommended glycemic outcome measures and processes of care, with the goal of highlighting how variation among them might influence patient safety and quality. The outcome measures of interest include definitions of glucose abnormalities and glycemic targets. The relevant process measures include detection and documentation of diabetes/hyperglycemia, methods of and indications for insulin therapy, management of non-insulin agents, blood glucose monitoring, management of special situations (e.g., parenteral/enteral nutrition, glucocorticoids, surgery, insulin pumps), and appropriate transitions of care. In addition, we address elements of quality improvement, such as glycemic control program infrastructure, glucometrics, insulin safety, and professional education. While most of these guidelines align with respect to outcome measures such as glycemic targets, there is significant heterogeneity among process measures, which we propose might introduce variation or even confusion in clinical practice and possibly affect quality of care. Guideline-related factors, such as rigor of development, clarity, and presentation, may also affect provider trust in and adherence to guidelines. There is a need for high-quality research to address knowledge gaps in optimal glucose management practice approaches in the hospital setting.

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Conflict of Interest Nestoras Mathioudakis and Sherita Hill Golden declare that they have no conflict of interest.

Compliance with Ethics Guidelines

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Keywords

Diabetes mellitus; Hyperglycemia; Hospitalized; Inpatient; Glucose management program; Quality improvement

Introduction

Clinical practice guidelines (CPGs) have a fundamental role in improving the quality of care delivered to hospitalized patients with diabetes or hyperglycemia by standardizing processes of care and outcome measures based upon the best available evidence. The first inpatient glucose management recommendations were published a decade ago through a joint consensus statement by the American Association of Clinical Endocrinologists (AACE) and the American Diabetes Association (ADA) [1]. Since then, several professional organizations have put forth glycemic control guidelines in the non-intensive care unit (ICU) [2•, 3, 4•], ICU [5, 6•], surgical [7, 8], and obstetrical settings [9, 10]. On the whole, these guidelines are in alignment with respect to outcome measures (e.g., glycemic targets), but they vary with respect to process measures (e.g., management approaches). Despite being derived from the same body of evidence, the guidelines may differ not only in their content but also in rigor of development, emphasis, clarity, and presentation. These differences, sometimes subtle, have the potential to affect provider adherence and/or introduce unnecessary variation in clinical care processes that could influence quality of care. The objective of this review article is to compare and contrast several prominent inpatient glucose management guidelines. Our aim is not to debate the scientific merits of the selected guidelines, but rather to highlight how variation among them might have implications for patient safety and quality.

Overview of Guidelines

We limited our review to a selection of US adult inpatient glucose management guidelines or consensus statements published in the last 5 years targeting critically ill (ICU), noncritically ill (non-ICU), and surgical patients, excluding the obstetric population (Tables 1 and 2). Four of these qualify as “clinical guidelines” [2•, 5, 6•, 7] and three as “consensus” or “position” statements [3, 4•, 8] (Table 1). Throughout this article, we will use the term guideline to refer to both guidelines and consensus statements (except when pointing out inherent differences between the two) and will refer to the guidelines using the abbreviations listed in Table 1.

A target patient population and purpose statement is provided in all of the guidelines and a majority of them define a target audience (Table 2). Guideline development methodology is described in one out of three consensus statements and three out of four guidelines; grading of the evidence is provided for two of the three consensus statements and all four guidelines, while the strength of the recommendations is available for one out of three consensus statements and three out of four guidelines. As expected, there was more rigor of development in guidelines compared to consensus statements, and this is an inherent difference that could affect implementation, since lack of transparency regarding guideline

development or disagreement with interpretation of evidence are cited as barriers to physician adherence [11].

Without a summary of recommendations, extensive searching is required to locate the actual recommendations within the body of the text, which may impair implementation. A summary of recommendations, followed by a synthesis of the evidence (as used by the Endocrine Society (ENDO) and ADA), is in our opinion the most effective approach since recommendations are easily identifiable and supported by evidence. Generally, the more “user-friendly” guidelines include a summary of recommendations at the beginning, rather than within or at the end, of the document. Physicians often do not use guidelines that they describe as “difficult to use” or “inconvenient” [11].

Measures

We classified outcome measures as objective and quantifiable measures of glycemic status or control and process measures as any actions or activities required to attain these outcome measures. These are summarized in Table 3.

Outcomes Measures

Definitions of Glucose Abnormalities

The definition of *hypoglycemia* is uniform among those guidelines that include this information. On the other hand, a definition of *hyperglycemia* is only provided in the non-ICU guidelines [2•, 3, 4•]. Sometimes a threshold blood glucose (BG) for treatment is provided, but this is not defined as a hyperglycemia threshold per se [6•, 7]. In the non-ICU setting, the definition and indication for treatment of hyperglycemia are the same (i.e., BG >140 mg/dl) [2•, 3, 4•]; however, in the ICU setting, only glycemic targets are provided. Obviously, if the definition of abnormal BG and indications for treatment are not synonymous, these two measures would serve different purposes as quality improvement (QI) indicators. For example, hyperglycemia defined as a BG >140 mg/dl might be used to identify the denominator of hospitalized patients for whom process measures should be applied or to describe the case mix of a hospital for benchmarking purposes, whereas the proportion of patients with an indication for treatment of hyperglycemia (i.e., BG >180 mg/dl) who receive appropriate treatment could be used as a performance measure.

Glycemic Targets

BG treatment targets are uniform among non-ICU guidelines, but variable among ICU guidelines. For non-ICU patients, a pre-meal BG of <140 mg/dl and random BG of <180 mg/dl is recommended, and it is assumed that the lower limit BG is equal to the definition of hypoglycemia (i.e., 70 mg/dl) [2•, 3, 4•]. For ICU patients, recommended glycemic targets range from 110 to 140 [3, 4•], 140 to 180 [3, 4•], 140 to 200 [5], 100 to 150 [6•], <150 [7], and <180 mg/dl [6•, 7]. An intraoperative BG target of <180 mg/dl is recommended for both ambulatory surgical [8] and most cardiac surgical patients [7].

There are several points of variation with respect to glycemic targets, including (1) whether both upper and lower limits of BG are provided, (2) the selected BG targets, and (3) patient

selection criteria for specific targets. The Society of Critical Care Medicine (SCCM) treatment target of <150 mg/dl, the corollary to the ADA stringent ICU target of 110–140 mg/dl, applies to the majority of “critically ill (trauma)” patients. This guideline permits a more liberal upper BG target <180 mg/dl, but it is not entirely clear for whom this target might be considered [6•]. Most importantly, there is ambiguity regarding the lower BG target, which can only be inferred to be 80 mg/dl. The only patients for whom a clear lower BG target is provided are those with acute stroke, where a goal of 100–150 mg/dl is advised to avoid further brain injury from iatrogenic hypoglycemia. While SCCM references the less-aggressive ADA target of 140–180 mg/dl, it does not clearly state whether a lower BG limit should be raised to 140 mg/dl when a more liberal treatment approach is considered. The lack of a lower BG treatment target creates confusion about the goals of the therapy and may de-emphasize risks associated with hypoglycemia. Similarly, the Society of Thoracic Surgeons (STS) recommends an upper BG of <180 mg/dl, but does not specify a lower treatment target, which may result in higher rates of hypoglycemia in the cardiac surgery population compared to other ICU settings, particularly given pressures for cardiac surgical ICUs to meet the nationally recognized Surgical Care Improvement Project (SCIP) measure for controlled postoperative fasting BG [12].

Assuming a lower limit target BG of 100 mg/dl, the SCCM target range of 100–150 mg/dl for select ICU patients differs from the AACE/ADA recommendation (i.e., 110–140) by ± 10 mg/dl. According to the SCCM, “this difference is not likely to be clinically significant” [6•]. While we agree that a BG difference of 10 mg/dl might not be clinically significant at the patient level, there may nevertheless be consequences at a health system level of having such approximate BG targets. First, the stringent AACE/ADA target range is a more narrow therapeutic window compared to the SCCM target range (i.e., 30 vs. 50 mg/dl), which may be more difficult to achieve with insulin infusion protocols, so it would be important to know which guideline an institution follows for benchmarking purposes. Second, the lower BG target of 100 mg/dl might increase (albeit marginally) the incidence of hypoglycemia. Third, since these two guidelines may be targeting different patient populations (i.e., surgical vs. medical ICU), this could introduce variation in practice within a given hospital. For example, SCCM might apply more to the surgical ICU, where trauma patients would be more likely to be cared for, whereas AACE/ADA might apply more to the medical ICU. The use of different insulin infusion protocols and targets within a hospital introduces unnecessary complexity that may increase staff confusion and require more resources to develop and implement different protocols.

Another issue is patient selection for specific BG targets in the ICU. While SCCM recommends a BG <150 mg/dl following cardiac surgery, STS restricts this BG target to cardiac surgical patients who “require 3 days of ICU care due to prolonged ventilatory support, inotropic or mechanical support, renal insufficiency, or need for anti-arrhythmic therapy.” [6•, 7] The risk of iatrogenic hypoglycemia would be expected to be greater if a BG target of <150 mg/dl were applied generally to all cardiac surgical patients, rather than only to those at highest risk from hyperglycemia. AACE/ADA states that “occasional clinically stable patients with a prior history of successful tight glycemic control in the outpatient setting may be maintained with a BG range below the aforementioned cut points” [3]; however, while a lower BG limit of 110 mg/dl is provided, an upper BG target is not

clearly specified for this scenario. ADA states that “more stringent goals, such as 110–140 mg/dl may be appropriate for selected patients” [4•], but does not provide clear guidance on who these patients might be. These ambiguities in the guidelines may hinder physician adherence [11].

Process Measures

Documentation of Diabetes Diagnosis

Documentation of a diagnosis of diabetes should be a universal practice; however, when this is not the case, omission of this information can have serious consequences. For example, failure to identify a patient as having type 1 diabetes could result in diabetic ketoacidosis if basal insulin is inadvertently withheld. Moreover, being able to appropriately identify patients with diabetes is necessary for any inpatient glucose QI initiative. We recently reviewed a large number of hypoglycemic events at our institution (unpublished data) and were surprised by the number of cases in which there was no documentation of a diabetes diagnosis despite clear evidence that the diagnosis was present. Recognizing this potential patient safety risk, both ADA and ENDO recommend that providers evaluate patients for a history of diabetes and document this clearly in the medical record [2•, 4•]. We propose that this recommendation also specify that providers document the type of diabetes, when known.

BG Testing on Admission

Only one guideline (ENDO) recommends universal BG testing at the time of admission [2•]. ENDO cites the high prevalence of inpatient hyperglycemia and the opportunity to detect unrecognized diabetes in the hospital setting as justification to expand the ADA recommendation, which limits BG testing for those without diabetes to only those patients at high risk (e.g., those receiving high-dose glucocorticoids, enteral or parenteral nutrition, or medications known to cause hyperglycemia) [4•]. Consequences of broadening screening for hyperglycemia might include increased cost of monitoring and treatment or possible increased patient dissatisfaction from discomfort.

Hemoglobin A1C on Admission

Four of the guidelines [2•, 4•, 7, 8] recommend obtaining a hemoglobin A1C (A1C) on admission. ENDO is the most emphatic, recommending that “all inpatients with known diabetes or hyperglycemia be assessed with a [A1C],” [2•] while the ADA is less firm: “consider obtaining an [A1C] in patients with diabetes... and in patients with risk factors for undiagnosed diabetes who exhibit hyperglycemia in the hospital.” Both the Society for Ambulatory Anesthesia (SAMBA) and STS echo the ADA and advise A1C testing for general surgery and cardiac surgery patients, respectively. As with BG testing, A1C testing has the potential to identify patients with uncontrolled or undiagnosed diabetes and, together with BG values, can help distinguish diabetes from stress hyperglycemia.

Pharmacologic Management

Insulin Delivery Method—For non-ICU patients, the “basal-bolus” insulin method is universally recommended [2•, 3, 4•]. Only ENDO provides specific details about how to

administer insulin in this manner: “we recommend that scheduled sc [subcutaneous] insulin therapy consist of a basal or intermediate-acting insulin given once or twice a day in combination with rapid- or short-acting insulin administered before meals in patients who are eating” [2••].

In the ICU, continuous insulin infusion (CII) is the recommended method of insulin delivery [3, 4•, 5, 6••, 7]; however, subcutaneous (SC) insulin might be considered in clinically stable patients [6••]. STS recommends that post cardiac surgery patients be maintained on CII while in the ICU and transitioned to a scheduled basal-bolus regimen “when they are ready to be discharged from the ICU.” [7] Since “ready for discharge” leaves room for interpretation (e.g., bed is physically available for transfer, patient is clinically suitable for downgrade in status), the timing of transition from CII to SC insulin is likely to vary. This transition is a critical period when glycemic control is prone to fluctuate, and the timing of transition could affect early postoperative glycemic control. On the one hand, earlier transition to SC basal insulin could help to promptly identify patients in whom the SC insulin doses are insufficient and who may need to be reinitiated on a CII. On the other hand, later transition in the ICU could lead to better glycemic control in the immediate postoperative period, when there may be inherently greater risks of complications.

Only two guidelines [7, 8] address the method of insulin delivery during surgery. STS recommends CII for all cardiac surgical patients [7], while SAMBA favors SC insulin for ambulatory surgical patients [8]. Prolonged use of “sliding scale” insulin is widely discouraged, except during ambulatory surgery. In fact, SAMBA provides a detailed description of how to calculate correctional SC insulin doses (i.e., using “rule of 1500 or 1800”). Acknowledging the concern for insulin stacking, SAMBA cautions that repeated correctional doses of insulin should not be given until “the time to peak effect has passed” (listed as 30–90 min) [8]. Accordingly, a rapid-acting insulin analogue could be re-dosed within 2 h after an injection; however, given the 4–6 h duration of action of rapid-acting insulin analogues, this approach still carries a risk of insulin stacking. More research is needed in the area of intraoperative glucose management to validate these recommendations.

Indication for Insulin Therapy—When specified, in the non-ICU setting, the BG threshold for initiation of insulin therapy is equal to the lower limit of the target BG (i.e., 140 mg/dl), whereas in the ICU setting, it is generally equal to the upper limit of the target BG (i.e., 150 or 180 mg/dl depending on the guideline) (Table 3).

Insulin dosing (Decision Support)—For non-ICU patients, only ENDO provides concrete instructions on how to calculate insulin doses according to the patient’s body weight and how to distribute insulin into basal, nutritional, and correctional components. In the ICU guidelines, outside of recommending that validated infusion protocols be used, no dosing instructions are provided. When transitioning from CII to SC insulin, a frequently emphasized principle is the importance of overlapping SC insulin and discontinuation of the CII by 1–4 h to prevent hyperglycemia [2••, 3, 6••]. In addition, ENDO advises that scheduled SC insulin be given to “patients without a history of diabetes who have hyperglycemia requiring more than 2 units/h” [2••].

Non-insulin Agents—There is consensus that non-insulin agents should be generally discontinued for most patients with type 2 diabetes in the non-ICU setting, although they may be used in select stable patients without contraindications. For surgical patients, SAMBA recommends holding most non-insulin agents the day of surgery and resuming after surgery if the patient is eating. Similarly, for cardiac surgical patients, STS recommends holding non-insulin agents the day prior to surgery and encourages their use after surgery in patients who have achieved glycemic targets and in whom there are no contraindications. At our institution, we have noted a disproportionately higher rate of sulfonylurea-associated hypoglycemia in the postoperative cardiac surgical setting. This observation may be attributable to the fact that, unlike other guidelines, STS advocates resumption of oral hypoglycemic agents after surgery. On the one hand, early resumption of oral medications could facilitate discharge planning, may be associated with increased patient satisfaction, and is less costly. On the other hand, there may be an increased incidence of hypoglycemia given the higher likelihood of comorbid conditions that increase this risk (e.g., acute renal failure, change in nutritional status), as well as the potential for deterioration in glycemic control with oral therapy compared to insulin.

Glucose Monitoring

Frequency—For patients who are eating in the non-ICU setting, BG monitoring is recommended with meals and at bedtime [2•, 3] or timed to match carbohydrate exposure [4•]. In the ICU setting, only one guideline (SCCM) addresses the frequency of BG monitoring in patients eating meals while receiving CII. For patients receiving continuous parenteral nutrition (CPN) or peripheral parenteral nutrition (PPN), BG monitoring every 4–6 h is recommended [2•, 3]. For non-ICU patients without any source of nutrition, BG monitoring is also recommended every 4–6 h [2•, 3, 4•]; for ICU patients on CII, BG monitoring is recommended every 1–2 h [6•]. In the operating room, BG monitoring is recommended anywhere from every 15 to 60 min for cardiac surgery patients [7] and every 1–2 h for ambulatory surgery cases [8]. Outside the operating room, BG monitoring is advised every 0.5, 1, or 2 h in patients on CII [3, 4•].

Method—In the ICU [1, 2•, 4•], non-ICU [6•], and surgical [8] settings, bedside BG monitoring with the use of point-of-care (POC) glucometers is recommended as a quick method of assessing a patient's glycemic status. Most guidelines acknowledge limitations in accuracy of POC glucometers compared to plasma glucose [2•, 3, 4•, 6•, 8] and call attention to the possible clinical consequences of discordant POC and plasma BG readings. This is an area of particular concern in critically ill patients and has recently prompted the US Food and Drug Administration to investigate the issue further [13].

Nutrition

Medical nutrition therapy (MNT) is encouraged for non-ICU patients; however, it is not specifically mentioned in ICU or surgical guidelines [2•, 4•]. While consistent carbohydrate meal plans are advised [2•, 4•], no specific meal plans or macronutrient percentages are endorsed by the ADA [4•]. Timing of meal and insulin delivery is identified as an important systematic safety issue [3].

Special Situations

Parenteral/enteral Nutrition—Most guidelines identify these forms of nutrition as a hyperglycemic risk factor [2•, 3, 4•, 6•], highlight the need for increased BG monitoring (including in those without diabetes) [2•, 4•, 6•], and recommend insulin treatment if hyperglycemic [2•, 3, 4•, 6•]. However, there is no concrete advice offered on insulin dosing or delivery methods for this situation.

Glucocorticoids—Aside from emphasizing the risk of hyperglycemia in patients receiving high-dose steroids, little to no specific management advice about steroid-induced hyperglycemia is provided. ENDO suggests CII for patients with difficult-to-control hyperglycemia while receiving high-dose glucocorticoids. A weight-based insulin dose of 0.3 to 0.5 units/kg/day is suggested, with tapering of insulin in parallel with the steroid taper. At our institution, insulin requirements in patients with diabetes on high-dose steroids average ~0.8 units/kg/day, and as expected, there is an increase in the amount of nutritional relative to basal insulin needed given the exaggerated postprandial glycemic response induced by steroids [14]. Despite proposed strategies in the literature [14–17], there are no randomized controlled trials to inform treatment of this common clinical problem.

Surgery—Several pre-operative glucose management considerations are addressed in the guidelines, including the importance of continuing basal insulin in patients with type 1 diabetes [2•], how to adjust pre-operative insulin doses [2•, 7, 8], what to do with oral agents and non-insulin therapy [2•, 7, 8], when to postpone surgery in the context of uncontrolled hyperglycemia [8], and how to treat hyperglycemia in the pre-operative area [8] or hospital [7] prior to surgery. For patients on insulin pumps, SAMBA recommends continuing basal rates according to “‘sick day’ or ‘sleep’ basal rates.” For patients on basal insulin, SAMBA recommends continuing 75–100 % of the usual morning dose, but advises reducing the “nighttime dose” for patients with a history of nocturnal or morning hyperglycemia, whereas ENDO recommends continuing the full dose in patients with uncontrolled hyperglycemia prior to surgery. For patients on intermediate-acting insulin (e.g., NPH), a 25–50 % [2•] or 33–50 % [7, 8] reduction is recommended. Only SAMBA provides instructions for pre-operative management of pre-mixed insulin, suggesting 50–70 % of the usual morning dose given as NPH on the day of surgery to avoid hypoglycemia from the rapid-acting component [8]. Oral and non-insulin therapy are advised to be stopped either “before,” [2•] 24–48 h before (for metformin) [8], 24 h before [7], or on the day of [8] surgery.

These recommendations, while likely to maintain acceptable perioperative control in the majority of patients, may pose some patient safety risks that merit discussion. First, the recommendation to continue the full dose of basal insulin even in uncontrolled patients still carries a risk of fasting hypoglycemia, particularly if the patient’s outpatient basal dose is excessive (i.e., “over-basalization”). In our experience, many patients with poor glycemic control in the outpatient setting are treated for various reasons with excessively high doses of basal insulin (i.e., over 100 units) with minimal to no prandial insulin coverage. These patients, whose poor glycemic control is likely due to inadequate nutritional insulin and/or poor diet, frequently become hypoglycemic when transitioned to a hospital “carbohydrate-

restricted” diet or are made NPO (i.e., during surgery). Second, there is little evidence to guide management of insulin pump therapy during surgery. The use of nighttime basal rates when insulin requirements are typically at their lowest in theory should provide adequate insulin to prevent hyperglycemia while avoiding hypoglycemia, but this recommendation has not been studied. Another issue is that the effects of anesthesia might impair a patient’s ability to manage his or her pump in the postoperative setting.

Insulin Pumps—According to the guidelines, the decision to allow insulin pump self-management in the hospital should be based on the following factors: (1) patient’s mental/physical capacity to operate the pump [2•, 3, 4•], (2) nursing personnel to document basal/bolus rates [2•, 3, 4•], (3) staff with expertise in insulin pumps [2•, 3, 4•], and (4) clear institutional pump policies [2•]. Otherwise, no specific pump management decision support is provided in the guidelines.

Transitions of Care

Home to Hospital—Most guidelines cover some aspect of the transition from the home to hospital setting, but only ENDO uses the term “transition from home to hospital” [2•]. This term emphasizes the concept of hospitalization as a “window of opportunity” [18] to make therapeutic changes for patients. There is a tendency towards “clinical inertia” in inpatient glucose management [19], and unfortunately, dysglycemia can often be attributed to failure to adjust home medications. Clinical decision support tools are needed to help guide providers on how to adjust outpatient insulin doses based on various clinical factors (e.g., renal function, nutritional status, steroid dose, age, outpatient glycemic control, and home insulin doses) at the time of admission.

Hospital to Home—During the critical transition from hospital to home, multiple care processes must converge to ensure patient safety, and these are comprehensively addressed by most of the guidelines. Recommended components of patient education include (1) definition, recognition, treatment, and prevention of hyperglycemia and hypoglycemia; (2) proper medication administration; (3) meal planning; (4) sick day management; and (5) proper use and disposal of needles/syringes. Provider-specific actions include (1) medication reconciliation, (2) structured discharge communication, (3) prescribing BG test strips and medications, (4) medication reconciliation, and (5) referral for continued outpatient education.

Glucose Management Programs

Given the complex processes of care involved in inpatient glucose management, structured glucose management programs have emerged in US hospitals over the last two decades to organize care delivery and oversee QI efforts. In 2006, AACE/ADA released a “call to action” consensus statement highlighting the need for dedicated inpatient glucose management programs [20]. Most of the guidelines echo the viewpoints expressed by this consensus statement and suggest that hospitals create multidisciplinary glucose committees guided by local diabetes experts (e.g., hospitalists, endocrinologists, intensivists). Beyond this, however, there are no regulatory or consensus guidelines on the optimal infrastructure

of effective glucose management programs according to the size or case mix of a patient population.

Glucometrics relate to objective metrics of inpatient glycemic control and have been described by groups such as the Society of Hospital Medicine (SHM) [21] and Yale [22]. Only two of the reviewed guidelines [3, 6••] suggest any specific glucometrics. These include mean and median BG, percentage of BG readings above or below a defined value, time-weighted mean BG, and hyperglycemic index (area under curve of BG values above a certain goal vs. time). The ideal glucometric method to assess the quality of inpatient glycemic control has not been defined and more research is needed to determine which metrics are most meaningful from a quality and outcome standpoint.

A majority of the guidelines advocate the use of standardized order sets, whether in written form or computerized, but few of them recommend that hospitals also have the ability to track insulin prescribing practices. The Centers for Medicare and Medicaid Services recently solicited public comments for developing glucometrics as quality measures [23], and it is anticipated that such measures will soon be added to the growing list of quality measures by which hospitals are evaluated. The capability to track both insulin prescribing and glucometric data will require robust integration of IT systems and could represent a barrier to implementation from a resource perspective for some healthcare institutions. Because QI is a continuous process, the guidelines recommend ongoing education to all staff involved in the care of patients with diabetes to ensure that they have accurate and up-to-date information about standards of care as well as hospital policies.

Conclusions

The goal of CPGs is to improve quality of care by minimizing the use of ineffective or harmful interventions while maximizing the use of proven, effective, and ideally cost-effective interventions. There are several factors that can influence implementation of CPGs, including characteristics of the guidelines themselves [24]. It has been shown that CPGs that are “easy to understand, can easily be tried out, and do not require specific resources have a greater chance of being used” [24]. We found significant variability in the ease of use of the guidelines, with ENDO being the most user-friendly and SCCM being the least user-friendly. From a resource standpoint, investment in IT will likely be the greatest expenditure for hospitals to implement the QI components in the guidelines. A recent systematic review of CPG recommendations on oral medications for type 2 diabetes found significant variability in the level of scientific rigor used to develop the guidelines [25]. We found similar variation in the quality of the inpatient diabetes guideline development process, a factor that could diminish effectiveness of the guidelines. The variability in outcome measures is most prominent in the ICU setting, where unfortunately the stakes are higher. Process measures differ both in content, depth of detail, and clinical applicability. Differences or contradictions in these guidelines, as in other clinical situations [19, 26], are likely to create variable practice patterns, which may have implications (still unknown) on patient outcomes. Overall, the guidelines would be more valuable if they contained more concrete detail about care protocols and decision support; however, we recognize that this lack of detail stems from the lack of research in the inpatient setting. It is worth noting that

the evidence base for the non-ICU guidelines is very weak and the majority of the recommendations are derived from expert opinion. High-quality research is still needed in this area to develop effective and practical inpatient glucose CPGs and, most importantly, to assess the impact of these guidelines on patient outcomes [27••].

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Table 1

Selection of reviewed US inpatient glucose management guidelines

	Organization (year)	Abbreviation	Title
Clinical practice guidelines	Endocrine Society (2012)	ENDO	Management of hyperglycemia in hospitalized patients in non-critical care setting [2••]
	American College of Physicians (2011)	ACP	Use of intensive insulin therapy for the management of glycemic control in hospitalized patients [5]
	Society of Critical Care Medicine (2011)	SCCM	Guidelines for the use of an insulin infusion for the management of hyperglycemia in critically ill patients [6••]
	Society of Thoracic Surgeons (2009)	STS	Practice guideline series: blood glucose management during adult cardiac surgery [7]
Consensus/position statements	American Association of Clinical Endocrinologists and American Diabetes Association (2009)	AACE/ADA	American Association of Clinical Endocrinologists and American Diabetes Association Consensus Statement (AACE/ADA) on inpatient glycemic control [3]
	American Diabetes Association	ADA	American Diabetes Association (ADA) standards of medical care [4•]
	Society for Ambulatory Anesthesia (2010)	SAMBA	Society for Ambulatory Anesthesia (SAMBA) consensus statement on perioperative blood glucose management in diabetic patients undergoing ambulatory surgery [8]

Table 2

Overview and comparison of glucose management guidelines

	AACE/ADA [3] (2009)	ADA [4•] (2014)	ENDO [2••] (2012)	ACP [5] (2011)	SCCM [6••] (2012)	SAMBA [8] (2010)	STS [7] (2009)
Patient population	ICU, non-ICU	ICU, non-ICU	Non-ICU	ICU	ICU	Ambulatory surgery	Cardiac surgery
Target audience	Health care professionals, supporting staff, hospital administrators, other stakeholders	Clinicians, patients, researchers, payers	Endocrinologists and other health care professionals	All clinicians	Not defined	Not defined	Not defined
Purpose	To identify reasonable, achievable, and safe glycemic targets and to describe methods to facilitate implementation	To provide general treatment goals and tools to evaluate quality of care	To formulate practice guidelines on the management of hyperglycemia in the non-critical care setting	To evaluate the benefits and harms associated with intensive insulin therapy	To identify important aspects of insulin therapy that facilitate safe and effective insulin infusion therapy	To develop a consensus on perioperative glycemic management in patients undergoing ambulatory surgery	To provide specific guidelines for cardiac surgeons as to optimal level of glucose during perioperative period
Methods described	No	No	Yes	Yes	Yes	Yes	No
Grading of evidence	No	Yes	Yes	Yes	Yes	Yes	Yes
Strength of recs	No	No	Yes	Yes	Yes	Yes	No
Format	1 Question 2 Lit rev & rec 3 Summary recs	1 Summary recs 2 Lit rev	1 Summary recs 2 Lit rev	1 Summary of questions 2 Lit rev 3 Summary recs	1 Question 2 Lit rev 3 Rec	1 Question 2 Lit rev 3 Rec	1 Lit rev 2 Rec 3 Comment
Clarity	Summary table at end, but hard to identify recs within lit rev	Clear bulleted recs at beginning of section	Useful summary outline at beginning	Summary recs in abstract and table within document	No summary table; hard to identify recs within lit review	Recs follow specific questions, but hard to find them within body of document; no summary of recs; contains other useful tables	Bulleted recs scattered within document; no summary of recs

AACE/ADA American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control [3], ADA American Diabetes Association 2014 standards of medical care [4•], ENDO management of hyperglycemia in hospitalized patients in non-critical care setting [2••], ACP use of intensive insulin therapy for the management of glycemic control in hospitalized patients [5], SCCM guidelines for the use of an insulin infusion for the management of hyperglycemia in critically ill patients [6••], SAMBA Society for Ambulatory Anesthesia consensus statement on perioperative blood glucose management in diabetic patients undergoing ambulatory surgery [8], STS practice guideline series: blood glucose management during adult cardiac surgery [7], Lit rev literature review, Rec recommendations

Table 3

Comparison of glucose management guidelines: outcome and process measures

	AACE/ADA [3] (2009)	ADA [4•] (2014)	ENDO [2••] (2012)	ACP [5] (2011)	SCCM [6••] (2012)	SAMBA [8] (2010)	STS [7] (2009)
Outcome measures:	Definitions of glucose abnormalities						
Hypoglycemia	<70	<70	<70	Absent	<70	<70	<70
Hyperglycemia	>140	>140	>140	Absent	Absent	Absent	Absent
Glycemic targets							
Non-ICU							
• Pre-meal	<140	<140	<140	N/A	N/A	N/A	N/A
• Random	<180	<180	<180	N/A	N/A	N/A	N/A
ICU							
• Majority of patients	140–180	140–180	N/A	140–200	<150	N/A	<180
• Select patients	Lower targets may be appropriate, but <110 mg/dl not recommended	110–140	N/A		100–150 in stroke; <180	N/A	<150
Operating room	N/A	N/A	N/A	N/A	N/A	<180	<180
Process measures:	Detection/diagnosis						
Documentation of diabetes diagnosis	Absent	Present	Present	Absent	Absent	Present	Absent
BG testing on admission	Absent	Present	Present	Absent	Absent	Present	Absent
A1C on admission	Absent	Present	Present	Absent	Absent	Present	Present
Pharmacologic management							
Insulin delivery method							
• Non-ICU	Basal-bolus	Basal-bolus	Basal-bolus	N/A	N/A	N/A	N/A
• ICU	CII	CII	N/A	CII	CII; SC in stable patients	N/A	CII
• Intraoperative	N/A	N/A	N/A	N/A	N/A	SC; may use SSI	CII
• SSI	Avoid prolonged use	Avoid prolonged use	Avoid prolonged use	Absent	Absent	Use "rule of 1800"	Absent
Indication for insulin therapy							
• Non-ICU	>140	>140	>140	N/A	N/A	ND	N/A
• ICU	>180	>180	N/A	ND	150	ND	>180
Insulin dosing decision support							
• Non-ICU	None	None	High	N/A	N/A	N/A	N/A

	AACE/ADA [3] (2009)	ADA [4•] (2014)	ENDO [2•] (2012)	ACP [5] (2011)	SCCM [6••] (2012)	SAMBA [8] (2010)	STS [7] (2009)
• ICU	None	Minimal	N/A	Minimal	Minimal	N/A	Minimal
• Transition from CII to SC insulin	Moderate	None	High	None	High	None	Minimal
Non-insulin agents (recommendation)	Avoid in most; may be appropriate in select stable patients	Limited role; may use in select stable patients	Avoid in most; may use in select stable patients	Absent	Absent	Hold day of surgery; resume eating after surgery if	Hold day prior to surgery; may resume after surgery
Glucose monitoring							
Frequency							
• PO (meals)	AC, HS	Match carb exposure	AC, HS	Absent	Scheduled to avoid measuring postprandial BG	N/A	Absent
• CPN/PPN	Q 4–6 h	Absent	Q 4–6 h	Absent	Absent	N/A	Absent
• No nutrition	Q 4–6 h	Q 4–6 h	Q 4–6 h	Absent	Q 1–2 h in patients CII	N/A	Absent
• Intraoperative	Absent	Absent	N/A	Absent	Absent	Q 1–2 h	Q 15–60 min.
• IV insulin	Q 0.5–2 h	Q 0.5–2 h	Absent	Absent	Q 1–2 h	Absent	Q 15–60 min.
Method	POC	POC	POC	Absent	POC	POC	Absent
Nutrition							
Medical nutrition therapy	None	Moderate	Moderate	None	None	None	None
Special situations							
Parenteral nutrition	Minimal	Minimal	Moderate	None	Moderate	None	None
Glucocorticoids	Minimal	Minimal	Moderate	None	Minimal	None	Minimal
Surgery							
• Preoperative	None	None	High	None	None	High	High
• Intraoperative	None	None	None	None	None	High	High
• Postoperative	None	None	Minimal	None	Minimal	High	High
Insulin pumps	Moderate	Moderate	Moderate	None	None	Minimal	None
Transitions of care							
Home to hospital	None	None	Moderate	None	None	None	None
Hospital to home	High	High	Moderate	None	None	Moderate	Moderate
Glycemic control program							
Program infrastructure	Present	Present	Present	Present	Present	Absent	Absent
Glucometrics described	Present	Absent	Absent	Absent	Present	Absent	Absent
Insulin safety							

	AACE/ADA [3] (2009)	ADA [4•] (2014)	ENDO [2••] (2012)	ACP [5] (2011)	SCCM [6••] (2012)	SAMBA [8] (2010)	STS [7] (2009)
• Standardized order sets	Present	Present	Present	Absent	Present	Absent	Absent
• Hypoglycemia tracking	Present	Present	Present	Absent	Present	Absent	Present
• Hypoglycemia protocols	Present	Present	Present	Absent	Present	Absent	Absent
• Tracking insulin use	Present	Absent	Present	Absent	Present	Absent	Absent
Professional education	Present	Absent	Present	Present	Present	Absent	Absent

Level of detail qualified as either present/absent or none, minimal, moderate, or high

N/A not applicable, BG blood glucose, A1C hemoglobin A1C, BB/basal/bolus insulin, SS/sliding scale insulin, POC point-of-care glucometer, CPN continuous parenteral nutrition, PPN peripheral parenteral nutrition, CIH continuous insulin infusion, SC subcutaneous, Rec recommendation, Q every, ac with meals, hs at bedtime