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How Low Can You Go? Reducing Rates of Hypoglycemia in the Non-critical Care Hospital Setting

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Abstract

Purpose of Review The purpose of this review is to discuss strategies to reduce rates of hypoglycemia in the non-critical care setting.

Recent Findings Strategies to reduce hypoglycemia rates should focus on the most common causes of iatrogenic hypoglycemia. Creating a standardized insulin order set with built-in clinical decision support can help reduce rates of hypoglycemia. Coordination of blood glucose monitoring, meal tray delivery, and insulin administration is an important and challenging task. Protocols and processes should be in place to deal with interruptions in nutrition to minimize risk of hypoglycemia. A glucose management page that has all the pertinent information summarized in one page allows for active surveillance and quick identification of patients who may be at risk of hypoglycemia. Finally, education of prescribers, nurses, food and nutrition services, and patients is important so that every member of the healthcare team can work together to prevent hypoglycemia.

Summary By implementing strategies to reduce hypoglycemia, we hope to lower rates of adverse events and improve quality of care while also reducing hospital costs. Future research should focus on the impact of an overall reduction in hypoglycemia to determine whether the expected benefits are achieved.

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Introduction

Inpatient hypoglycemia is a significant and often preventable problem. It has been associated with increased length of stay, hospital costs, mortality, and utilization of nursing resources during treatment as well as patient fear and dissatisfaction [1–4, 5•, 6]. With >10% of patients on a hypoglycemic agent suffering at least one hypoglycemic event and most of them being preventable, iatrogenic hypoglycemia in the hospital setting warrants attention and action [7]. The objective of this review is to present strategies to reduce hypoglycemia in the non-critical care setting and promote the safe and effective use of insulin throughout the hospital.

Scope of Problem

Adverse drug events are the most common cause of inpatient complications, affecting 1.9 million hospital stays annually [8] with an estimated cost of $4.2 billion per year. Over half of all ADEs are from hypoglycemia agents with the majority of these being preventable [7, 9]. Approximately 20–40% of patients in the inpatient setting have diabetes or hyperglycemia requiring glucose lowering medication and are at risk for iatrogenic hypoglycemia [10].

Why Hypoglycemia Matters

Hypoglycemia is associated with poor outcomes, increased costs, and increased mortality [1–4]. Inpatient hypoglycemia

leads to approximately 38% higher costs and increases length of stay by 3 days [3, 11]. It also results in higher mortality rates and greater odds of being discharged to a skilled nursing home compared to patients without hypoglycemia [11]. While a causative link between hypoglycemia and mortality has not definitively been made and hypoglycemia may be a marker of underlying disease rather than the cause, it is prudent to avoid hypoglycemia until that relationship is well established [12, 13]. In addition, hypoglycemia leads to increased use of nursing resources during treatment as well as patient dissatisfaction. A single hypoglycemic episode increases the risk of future hypoglycemic, with 44% of patients experiencing at least one recurrent hypoglycemic event [14, 15]. In another study, 84% of patients who had a severe hypoglycemic episode (defined as a blood glucose <40 mg/dL) had a prior hypoglycemic event (<70 mg/dL) [16]. With the large number of hospitalized patients with diabetes, the economic impact of hypoglycemia in the hospital can quickly escalate.

Definition of Hypoglycemia

The definition of clinically significant hypoglycemia has recently been updated by the American Diabetes Association (ADA) to a glucose concentration of <54 mg/dL [17]. The prior definition of hypoglycemia of ≤70 mg/dL is considered an alert value to allow time for patients and caregivers to react, either by treating the hypoglycemia or adjusting the diabetes regimen [17, 18]. There is no specific glucose threshold for severe hypoglycemia, rather it is defined as "hypoglycemia associated with severe cognitive impairment requiring external assistance for recovery," but blood glucose (BG) values <40 or <50 mg/dL have been commonly used to define severe hypoglycemia [17]. These clinical values are separate and different than the laboratory "critical value," which is the cutoff point of when the lab needs to notify the clinician. Critical values vary from institution to institution and are based on the need to take immediate action.

Metrics

Which Metrics to Follow

Despite compelling evidence associating hypoglycemia with increased morbidity, mortality, and cost, nearly one third of the hospitals have no metric to track quality of inpatient glycemic management [19]. Furthermore, for those hospitals that are tracking hypoglycemia rates, there is no widely accepted standardized metric, which makes benchmarking and comparison difficult. Both the glucose

value and unit of analysis are controversial, so currently, each institution establishes its own metrics. While BG <70 mg/dL is a common and widely accepted definition of hypoglycemia, some institutions only follow severe hypoglycemia, frequently defined as BG <40 or <50 mg/dL [18]. The unit of analysis is another variable at stake and while the glucose value is the simplest approach, the patient day option introduces patient-level analysis and controls for length of stay which is more clinically relevant and considered the most actionable metric by clinicians [20–22, 23•]. A group from Yale proposed a formal set of performance measures termed "glucometrics," to facilitate internal and external assessment of inpatient glycemic control and The Society of Hospital Medicine (SHM) provides a web-based data and reporting center that calculates glucometrics on blood glucose data uploaded by users [20, 23•].

Hospital Monitoring of Blood Glucose

Point of care (POC) BG monitoring has been the standard of care for inpatient BG monitoring and is an integral part of glycemic management in the hospital setting because of the quick turn-around time. However, glucose meters have accuracy limitations with significant discrepancies between capillary, venous and arterial plasma samples observed in patients with low or high hemoglobin concentrations and with hypoperfusion [17, 24]. Therefore, it is important that any BG reading that does not correlate with the patient's clinical status should be immediately repeated and/or confirmed through conventional laboratory glucose tests before clinical action is taken. Since initial FDA standards were developed for glucose meters used by lay persons in the community, they have now established a separate category for POC glucose meters for use in healthcare settings and the FDA has released a specific guidance on in-hospital use with stricter standards especially in critically ill patients [25]. However, immediate enforcement by the Centers for Medicaid and Medicare Services (CMS) could result in more harm than good given no immediately available, affordable, and timely alternatives [26].

Continuous glucose monitoring (CGM) provides a potential advantage over POC glucose monitoring in the inpatient setting. It provides frequent measurements of interstitial glucose levels with direction and magnitude of glucose trends, which can be advantageous in detecting and reducing the incidence of hypoglycemia in the inpatient setting. Several inpatient studies have shown that CGM use detected more hypoglycemic events, but did not show an overall improvement in glycemic control. While CGM holds promise for improving patient safety in the inpatient setting, its use is not recommended until more safety and efficacy data become available [27, 28].

Benchmarking

Since no specific set of glucometrics have been defined or endorsed by stakeholder groups including The Joint Commission, CMS, or the National Quality Forum (NQF), except for Surgical Care Improvement Project (SCIP) measures which are currently on hold, it is often difficult to compare performance outside your own institution [29]. There are a few external tools available for computing glucometrics, but only two provide benchmarking capabilities including RALS and SHM [30]. Some institutions also utilize internal benchmarking between units within one hospital, between hospitals within one health system, or between hospitals within a hospital engagement network. Standardized metrics are an important first step in establishing a platform for widespread comparison, followed by mandatory reporting. Hypoglycemic ADEs have been targeted by a major federal interagency work group and standardized metrics for both hyper and hypoglycemia have been submitted to NQF with recommendation for endorsement, but have not been finalized [31, 32].

Using Data to Guide Improvement Efforts

Metrics are an important first step in starting any quality improvement (QI) project and it is important to have an understanding of current processes as well as baseline performance and outcome measures to help guide improvement efforts. This baseline data will help identify gaps in care and prioritize efforts. SHM has a detailed implementation guide to help guide QI efforts to improve inpatient glycemic control [23•]. In addition to basic glucometrics measuring overall hyper- and hypoglycemia rates, drilling down data to identify specific causes of hypoglycemia will help further identify areas for targeting improvement efforts [5•, 33]. The Joint Commission recommends that all hypoglycemic events be evaluated for a root cause and the episodes be aggregated and reviewed to address system wide issues. There are several published examples of how institutions and health systems use metrics to guide improvement efforts to reduce hypoglycemia including implementation of "bundled" preventative therapies to reduce rate of hypoglycemia by 56–80% [5•, 33, 34].

Risk Factors

There are several risk factors that predispose patients to hypoglycemia in the hospital. These risk factors can be classified as inherent or iatrogenic. Inherent risk factors include advanced age, renal failure, liver failure, heart failure, sepsis, and neoplasm [35]. Elderly patients are often more insulin sensitive and may not be able to communicate symptoms of hypoglycemia to hospital staff. Older patients also develop hypoglycemic symptoms at a significantly lower mean glucose compared to younger patients [36]. These factors often lead to more prolonged and more severe hypoglycemia in the elderly. Since the kidneys are the main organs that metabolize exogenous insulin, the risk of hypoglycemia increases in patients with acute or chronic renal insufficiency when insulin doses are not reduced or when anti-diabetic medications are not discontinued [37–41].

Iatrogenic risk factors include use of insulin, oral diabetic agents, NPO status, corticosteroid taper, and hospital nutrition. The use of insulin poses risk of hypoglycemia even with appropriate use, but that risk is greatly increased with inappropriate use or failure to match with nutritional intake [33, 42]. Oral diabetic agents, more specifically sulfonylureas, put hospitalized patients at higher risk of hypoglycemia given the frequent change in PO status and poor appetite as a side effect of medications and from being ill [14]. NPO status increases risk of hypoglycemia especially when a basal insulin dose is too high or when oral diabetic agents are not held. While corticosteroids cause hyperglycemia, corticosteroid tapers often result in hypoglycemia when insulin doses are not simultaneously tapered or tapered at a rapid enough rate. Hospital nutrition also puts patients at risk of hypoglycemia particularly when patients find the food to be unpalatable or their appetite is poor, and nutritional insulin is given without regard for amount of carbohydrates eaten per meal. Hypoglycemia in the hospitalized patient is frequently multifactorial, involving both inherent and iatrogenic risk factors. Keeping these risk factors in mind when starting and adjusting insulin regimens is the first step to reducing hypoglycemia rates.

Top Causes of Hypoglycemia

There have been several published studies identifying top causes of hypoglycemia in the inpatient setting [43, 44]. Table 1 highlights several common, preventable sources of iatrogenic hypoglycemia. These most common failure modes from the literature coupled with local metrics and case reviews should help prioritize efforts [5•, 33].

Strategies to Reduce Hypoglycemia

Inappropriate Prescribing

Inappropriate prescribing is likely the most common cause of both inpatient hyper- and hypoglycemia, and efforts to improve and standardize prescribing practices should be a high priority. There is good evidence supporting the creation and maintenance of standardized insulin order sets to reduce hypoglycemia as well as published guidance on how to dose insulin safely and effectively [23•, 45]. These order sets should be protocol driven, evidence based, and include

Table 1   Common, preventable sources of iatrogenic hypoglycemia

1. Inappropriate prescribing

2. Poor coordination of nutrition delivery, monitoring, and insulin delivery

3. Failure to adjust to unexpected interruption in nutrition

4. Lack of timely insulin adjustment as steroid doses taper

5. Inappropriate management of the 1st episode of hypoglycemia

6. Monitoring deficiencies and failure to proactively recognize and manage glycemic outliers

7. Storing and dispensing—too many insulin concentrations leads to error

8. Administering

   a. IV bolus and infusion insulin prepared outside of pharmacy prone to error

   b. Insulin pen errors

9. Use of insulin apart from glycemic control—ex-hyperkalemia

built-in clinical decision support to guide providers in ordering complex insulin regimens based on the patients' nutritional status [46••]. Key components to include in the subcutaneous insulin order set are outlined in Table 2.

In addition to subcutaneous insulin order sets, protocol-driven and evidence-based order sets for other specific uses of insulin such as transition from intravenous to subcutaneous insulin, administration via subcutaneous insulin pumps, post-discharge dosing, diabetic ketoacidosis, hyperosmolar states, hyperkalemia, and post-cardiac surgery care should be

developed and implemented as well [46••]. Hyperkalemia treatment is often an overlooked source of iatrogenic hypoglycemia and careful consideration of treatment modalities and dosing as well as integrated hypoglycemia protocol for monitoring and treatment should be included when addressing hyperkalemia [48].

Nutrition

Achieving good glucose control in the hospital is not only dependent on having the right insulin orders, but also on nurse and food service-driven processes that are necessary to ensure appropriate timing of blood glucose monitoring (BGM) and matching of the insulin and nutrition to avoid hyper- or hypoglycemia. Too often, glycemic control improvement efforts focus on the ordering of insulin and overlook processes that impact the underlying nutrition sources that dictate the insulin dosing.

Carbohydrate-Controlled Diet

A carbohydrate-controlled diet is the preferred meal plan for most hospitalized patients with diabetes or hyperglycemia and helps to improve the matching of carbohydrates and nutritional insulin administration [49, 50]. The carbohydrate content of food should be labeled clearly on the ordering and tray menus and appropriate steps in the kitchen need to be made to ensure the carbohydrate portions on the tray match those labeled on

Table 2   Key components to include in subcutaneous insulin order set

Component	
Actionable glycemic target	Target range 140–180 mg/dL widely accepted, but more or less stringent goals such as <140 or <200 mg/dL may be appropriate for selected patients [10].
Timely A1C ordering	A1C should be obtained on admission if not already done within 60 days prior to admission (joint commission certification). A1C testing should be hardwired or pre-selected whenever possible [33].
Prompt to consider discontinuation of oral anti-hyperglyemic medications	Basal bolus physiologic insulin dosing is preferred in the inpatient setting in most cases [10].
Weight-based dosing with guidance	Weight-based insulin dosing strategies using 0.4–0.5 units/kg/day as a total daily dose for basal bolus insulin are recommended with a lower dose of 0.1–0.3 units/kg/day for patients at increased risk of hypoglycemia such as those with lean body habitus, age >65 years, renal or hepatic insufficiency, post-pancreatectomy, or a history of severe hypoglycemic events [10, 47].
Insulin regimens for different nutritional statuses	Nutrition is integral to the management of diabetes and hyperglycemia and can be complex in the inpatient setting with the use of tube feeds, TPN, PO diet, PO supplements, or NPO status. Therefore, it is important to have different insulin regimens that can account for such complexity as well as flexibility as each of these components is often changing.
Built-in indication and holding parameters	Indication and holding parameters for each insulin order are essential when dealing with complex insulin regimens necessary to accommodate often complex nutrition patterns.
Nurse-driven hypoglycemia protocol	There should be a standardized hospital-wide, nurse-driven hypoglycemia treatment protocol built into each order set to immediately address blood glucose levels of ≤70 mg/dL as well as individualized plans to prevent a recurrent event [10].
Prompt for diabetes education	Diabetes education should be offered to all patients with diabetes or hyperglycemia and/or care partners including recognition and treatment of hypoglycemia as well as other survival skills.

the menu. This not only helps with appropriate matching of insulin and nutrition, but is a helpful tool to improve patient's understanding of carbohydrates, assists them in selecting appropriate foods and making appropriate substitutions with outside food. The achievement of glycemic goals and patient satisfaction is more likely when patients, nurses, and meal service staff understand carbohydrate counting, the rationale behind the meal plan, and the importance of matching BGM, insulin, and nutrition [51].

Regarding enteral nutritional therapy, diabetes specific formulas are superior to standard formulas in controlling glucose and insulin [52]. A patient's nutritional needs in the hospital are often complex and multifactorial, so a registered dietitian who is knowledgeable and skilled in medical nutrition therapy should be involved whenever possible. This person can serve as a resource and guide when integrating patient's clinical condition, food preferences, and often multiple dietary restrictions into a unified nutrition plan.

Coordination of Blood Glucose Monitoring, Tray Delivery, and Insulin

Meal delivery, BGM, and insulin administration should be well coordinated and standardized [46••]. While it is easy to state the goals of having these three distinct processes done in a coordinated and timely manner, achieving this in the complex inpatient environment can be quite challenging. As many as four to five people might play a role and often times not realize the impact their part has on the overall goal. Common issues encountered include inconsistent meal delivery times, BGM done far before mealtime, trays delivered to rooms without coordination of either BGM or insulin, blood glucoses being checked after the patient has started the meal, and nurse concerned about hypoglycemia and unwilling to give insulin until completion of meal which is often delayed more than 1 h after meal consumption [23•]. The goal should be for BGM, meal delivery, and insulin administration to occur within a 30–60 min time frame.

Patients and their caregivers should be educated to request administration of mealtime insulin when the patient begins his/her meal [46••]. In patients with variable nutritional intake, mealtime insulin should be delayed, but ideally, not more than 15–30 min after the first bite of the meal in order to avoid stacking of insulin dosing with the next meal. It is also important that the dose be tied to the carbohydrate intake. Other recommended quality improvement interventions to address this complex task include adapting a practice to recheck blood glucose if a meal is not delivered within 30 min of the first glucose check, implementing practice of food service calling to announce tray delivery to serve as a sign that blood glucose monitoring should begin, alerting nurses to tray arrival so the cascade of events can occur in a timely manner, educating nurses to give insulin with tray delivery as default except in

select patients with unpredictable meal intake and to incorporate prandial carbohydrate intake into the patient's insulin order [53–56]. Several groups have demonstrated improved glycemic control and reduction in hypoglycemia by establishing a standardized, coordinated process that improves timing of blood glucose monitoring and meal and insulin delivery [55]. Providing basic carbohydrate counting education to all staff involved in taking orders and delivering meals to patients as well as the bedside nurses is worthwhile.

Troubleshooting for Interruptions

Planned and unplanned interruptions in nutrition occur in the hospital setting on a daily basis and need to be accounted for when establishing protocols and processes. For planned NPO, if indications and holding parameters are built into order sets and the insulin is dosed appropriately, the insulin orders do not necessarily need to be changed, especially for brief periods of NPO, see Table 3 for examples. For periods of prolonged NPO or for patients at high risk of hypoglycemia, low-dose dextrose containing IVFs can be started to reduce the risk of hypoglycemia, but this is not required in the majority of hospitalized patients with diabetes [23•]. Some institutions also have separate eating and NPO order sets for easy transition between the two clinical scenarios. For example, in some institutions, the nutritional and correction insulin doses are combined into one order and therefore need to be changed to correction only during times of NPO which can be done easily with separate eating and NPO order sets.

Table 3　Examples of indication and holding parameters included in insulin order sets

Basal insulin:
- Basal insulin should still be administered even if the patient is temporarily NPO for a procedure, or if the patient has temporary interruption of nutrition.
- Hold if BG <100 mg/dL. Notify MD for dose adjustment. *Do not hold* for NPO.

PO nutritional insulin coverage:
- Give with first bite of food (or up to 30 min after first bite of food if patient is nauseated or has poor appetite). Give 0 units if patient ate less than 2 carb servings, give half of the scheduled dose if patient ate 2 carb servings, and give the full dose if patient ate more than 2 carb servings.
- Hold if BG <100 mg/dL. Notify MD for dose adjustment. *Hold* if NPO.

Continuous nutritional insulin coverage:
- Do not administer scheduled regular insulin if nutrition is interrupted. This regular insulin is intended to cover the calorie intake due to TPN or continuous tube feeds (drop-down box for provider to choose one).

Examples courtesy of UCSD and Virginia Mason

For unplanned interruptions in nutrition, a standardized troubleshooting plan should be in place and easily accessible for routine use. As many of the steps that can be hardwired or nurse driven, the better as waiting for provider response or action can often lead to delays in care and the window of time required for action can be missed, resulting in potentially avoidable hypoglycemia. One example would be to have an order for D10 to run at tube feed rate PRN interruption in tube feed built into the insulin order set for continuous nutrition. If no clinical contraindications, the provider could include that option so the RN had the ability to start the D10 anytime there is an interruption in continuous nutrition source to prevent hypoglycemia. Since unexpected interruption in nutrition is a top source of hypoglycemia, it warrants dedicated efforts to develop algorithms, protocols, order sets, and educational efforts targeting this important issue.

Adjustments

A well-thought-out insulin regimen ordered on admission is just a start as patient's insulin requirements, nutritional intake, and medications are often changing throughout their hospitalization. Blood glucose values will need to be evaluated daily and necessary adjustments to insulin regimens made according to blood glucose trends and expected changes in other contributing factors such as nutrition plan, renal function, and steroid dose changes.

Electronic Health Record Tools

Most electronic health records (EHR) come with a glucose management page "out of the box" that can be easily customized to an institution's needs and preferences. Building such a "one stop shop" can significantly reduce clinical inertia in evaluating blood glucose trend and adjusting insulin doses, see Fig. 1. A real-time hypoglycemia risk alert has also shown significant improvement in reducing severe hypoglycemic events [57]. Some institutions have also developed a color-coded dashboard of all patients with a quick indicator of the patient being in, above or below target range to help prioritize evaluation. The more information the provider has in one place and the fewer number of clicks it takes to get there, the more likely such a page will be utilized to identify glycemic patterns and make smart adjustments in the insulin regimen [33, 46••, 53].

Insulin Dosing Adjustments

An ADA consensus report suggests that an insulin regimen be reassessed when BG values fall <100 mg/dL and that modification is usually necessary when BG values fall <70 mg/dL because such readings often predict imminent severe hypoglycemia [10]. In fact, fasting BG <100 mg/dL is a strong predictor of a hypoglycemic event the next day and should serve as a warning sign to adjust insulin doses [58]. Modification can be done by reducing basal doses for fasting hypoglycemia, nutritional doses for post-prandial hypoglycemia, despite appropriate insulin and nutrition matching, or reducing total daily dose by 10–20% while maintaining the preferable 50:50 basal:bolus ratio [53, 58–60]. One institution even restricted high-dose glargine doses >0.5 units/kg/day to endocrine staff to help reduce the "creeping basal" phenomenon or providers continuing inappropriately high home basal doses in the hospital. They were able to reduce hypoglycemia rates without an increase in hyperglycemia rates by implementing these dosing restrictions [61].

Active Surveillance

Despite EHR tools available to help identify patients out of the target range or to consolidate data needed for insulin adjustments, blood glucose management often remains one of the many problems on the problem list and may not be considered a priority. In order to help reduce clinical inertia even further, The American Society of Health-System Pharmacists (ASHP) Expert Consensus panel recommends real-time, institution-wide glucose reports to ensure appropriate surveillance and management of patients with unexpected hypo- and hyperglycemia [46••]. Identifying and addressing outliers in real time is a form of active surveillance, or *measure-vention* (coupling real-time measurement with concurrent intervention) [62–64] and has been used successfully to help reduce hospital-wide hypoglycemia rates [33, 65–67].

Active surveillance requires three steps: (1) identifying patients in the hospital with a potential deficit in care, (2) triaging the case, and (3) implementing real-time intervention to bring the patient into target range. EHR tools can help to hasten this process, but institutions without an EHR have been able to successfully implement active surveillance as well. Depending on resources available, these cutoffs can be adjusted accordingly. Examples of cutoffs include BG <50 mg/dL, BG <70 mg/dL, and BG <70 mg/dL on basal insulin. At our institution, we use a cutoff of BG <80 mg/dL and on insulin to identify patients at risk of hypoglycemia so we can intervene to prevent an event <70 mg/dL. Interventions vary depending on resources; examples include paging the provider, face-to-face communication, note in the medical record, or patient consult.

Nurses' Role in Glycemic Management

In addition to having a standardized hospital-wide, nurse-initiated hypoglycemia treatment protocol to immediately address blood glucose levels <70 mg/dL, hospitals should also have a hypoglycemia prevention plan to address causes of hypoglycemia and take action to reduce subsequent episodes.
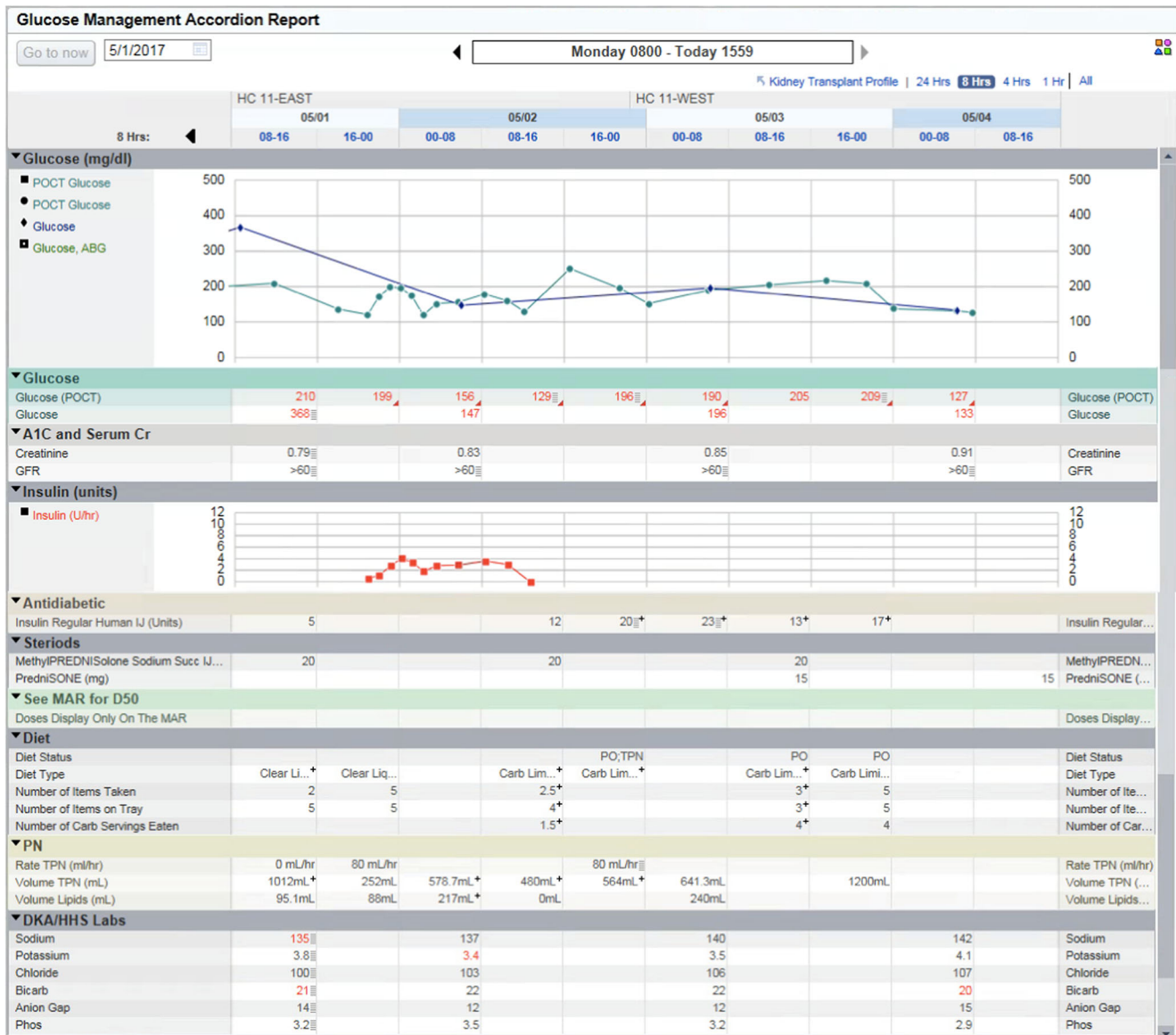
Glucose Management Accordion Report

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Kidney Transplant Profile | 24 Hrs | **8 Hrs** | 4 Hrs | 1 Hr | All

	HC 11-EAST					HC 11-WEST				
	05/01		05/02			05/03			05/04	
8 Hrs:	08-16	16-00	00-08	08-16	16-00	00-08	08-16	16-00	00-08	08-16

▾ Glucose (mg/dl)

Line chart (scale 0–500): POCT Glucose, POCT Glucose, Glucose, Glucose, ABG

▾ Glucose

	08-16	16-00	00-08	08-16	16-00	00-08	08-16	16-00	00-08	
Glucose (POCT)	210	199	156	129	196	190	205	209	127	Glucose (POCT)
Glucose	368		147		196				133	Glucose

▴ A1C and Serum Cr

Creatinine	0.79		0.83			0.85			0.91	Creatinine
GFR	>60		>60			>60			>60	GFR

▾ Insulin (units)

Line chart (scale 0–12): Insulin (U/hr)

▴ Antidiabetic

Insulin Regular Human IJ (Units)	5			12	20	23	13	17		Insulin Regular...

▾ Steriods

MethylPREDNISolone Sodium Succ IJ...	20			20		20				MethylPREDN...
PredniSONE (mg)						15			15	PredniSONE (...

▾ See MAR for D50

Doses Display Only On The MAR										Doses Display...

▾ Diet

Diet Status				PO;TPN		PO	PO			Diet Status
Diet Type	Clear Li..⁺	Clear Liq..		Carb Lim..⁺	Carb Lim..⁺	Carb Lim..⁺	Carb Limi..			Diet Type
Number of Items Taken	2	5		2.5⁺		3⁺	5			Number of Ite...
Number of Items on Tray	5	5		4⁺		3⁺	5			Number of Ite...
Number of Carb Servings Eaten				1.5⁺		4⁺	4			Number of Car...

▾ PN

Rate TPN (ml/hr)	0 mL/hr	80 mL/hr		80 mL/hr						Rate TPN (ml/hr)
Volume TPN (mL)	1012mL⁺	252mL	578.7mL⁺	480mL⁺	564mL⁺	641.3mL		1200mL		Volume TPN (...
Volume Lipids (mL)	95.1mL	88mL	217mL⁺	0mL		240mL				Volume Lipids...

▾ DKA/HHS Labs

Sodium	135		137			140			142	Sodium
Potassium	3.8		3.4			3.5			4.1	Potassium
Chloride	100		103			106			107	Chloride
Bicarb	21		22			22			20	Bicarb
Anion Gap	14		12			12			15	Anion Gap
Phos	3.2		3.5			3.2			2.9	Phos

Fig. 1 EPIC glucose management page example. In addition to the line items noted in figure above, A1C, other insulin or oral anti-diabetic agents used, hypoglycemia treatment such as dextrose, glucose tabs/gel or glucagon, supplement intake, carb intake from supplement, tube feeding type, rate and volume as well as ketone values also populate the report above when present. (Example courtesy of UCSD)

Unfortunately, hypoglycemia documentation and adherence to hypoglycemia protocols are often poor [14, 68, 69]. However, studies show that improved documentation and notification of a first hypoglycemic event can lead to a lower rate of recurrence [70–72]. The ADA also recommends that each episode of hypoglycemia in the hospital be documented in the medical record and tracked, which provides an opportunity to empower nurses to help identify potential triggering events and respond with appropriate preventative actions [10]. In one institution, implementation of a standardized hypoglycemia documentation tool, which included assessment of possible reasons for the event, led to a significant reduction in hypoglycemia rates [70]. Nurses at the bedside are well positioned to play a valuable role in identifying possible contributing factors as well as timely notification to the primary care team. Improving this crucial communication surrounding a hypoglycemic event can create opportunities for immediate treatment modification and reduction in subsequent events.

Education

Staff education is a key component of any quality improvement effort and the target audience related to reducing hypoglycemia should include members of the care team, e.g., physicians, nurse practitioners, physician assistants, trainees, pharmacists, nurses, dietitians, food service, and patients. Several education modalities for providers have proved

effective, including case-based learning tutorials, online modules, grand rounds, and unit-based lectures. Most lead to increased knowledge and confidence, improved prescribing practices and reduced hyperglycemia without an increase in hypoglycemia. Focused education with nursing staff on the cause, documentation, and importance of provider notification of hypoglycemia has been shown to reduce rates of hypoglycemia [70, 73–78].

The patient is also a valuable target for educational efforts to reduce hypoglycemia. ASHP recommends educating patients and their caregivers to request administration of rapid-acting insulin when the meal is served to improve the timing of meal consumption and insulin administration [46••]. At our institution, we also encourage the patients to count the carbohydrate servings on their tray, estimate likely consumption, and communicate with the nurse so the nutritional insulin dose is adjusted accordingly. It is also helpful to educate patients on the signs and symptoms of hypoglycemia so they can notify their nurse in a timely manner should they begin to experience symptoms. If a patient brings their home blood glucose meter to the hospital, it is important to explain that the hospital meter must be used for all treatments and charting in the medical record. Diligent patients may feel more comfortable having the capacity to monitor their blood glucose at any time during their hospital stay, but must call the nurse for confirmation with the hospital meter if the result is out of range.

Conclusion

Hypoglycemia is a significant, but often overlooked problem in the inpatient setting, with the majority of iatrogenic hypoglycemic events being preventable. Targeting hypoglycemia in the non-critical care setting can potentially reduce patient morbidity and mortality as well as reduce hospital costs. Having reliable metrics, the ability to compare performance with other institutions and targeting the most common causes of iatrogenic hypoglycemia is a good place to start a hypoglycemia prevention program. Implementing the strategies outlined here to reduce hypoglycemia, either individually or as a bundled approach, can lead to significant reductions in hypoglycemia rates, improvement in patient safety and overall quality of care in the inpatient setting.

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•• Of major importance

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