Medical centers are faced with multiple competing priorities when deciding how to focus their improvement efforts and meet the ever-expanding menu of publicly reported and regulatory issues. In this article, we expand on the rationale for supporting inpatient glycemic control programs as a priority that should be moved near the top of the list. We review the evidence for establishing glycemic range targets, and also review the limitations of this evidence, acknowledging, as does the American Diabetes Association (ADA), that in "both the critical care and non-critical care venue, glycemic goals must take into account the individual patient’s situation as well as hospital system support for achieving these goals."\(^1,2\) We emphasize that inpatient glycemic control programs are needed to address a wide variety of quality and safety issues surrounding the care of the inpatient with diabetes and hyperglycemia, and we wish to elevate the dialogue beyond arguments surrounding adoption of one glycemic target versus another. The Society of Hospital Medicine Glycemic Control Task Force members are not in unanimous agreement with the American Association of Clinical Endocrinologists (AACE)/ADA inpatient glycemic targets. However, we do agree on several other important points, which we will expand on in this article:

1. Uncontrolled hyperglycemia and iatrogenic hypoglycemia are common and potentially dangerous situations that are largely preventable with safe and proven methods.
2. The current state of care for our inpatients with hyperglycemia is unacceptably poor on a broad scale, with substandard education, communication, coordination, and treatment issues.
3. Concerted efforts with changes in the design of the process of care are needed to improve this state of affairs.

**DIABETES AND HYPERGLYCEMIA ARE VERY COMMON INPATIENT CONDITIONS**

Diabetes mellitus (DM) has reached epidemic proportions in the United States. A reported 9.3% of adults over 20 years of age have diabetes, representing over 20 million persons. Despite increasing awareness, diabetes remains undiagnosed in approximately 30% of these persons.\(^3\) Concurrent with the increasing prevalence of diabetes in the U.S. population from 1980 through 2003, the number of hospital discharges with diabetes as any
listed diagnosis more than doubled, going from 2.2 to 5.1 million discharges. Hospital care for patients with diabetes and hyperglycemia poses a significant health economic burden in the United States, representing over 40 billion dollars in annual direct medical expenditures.

Hyperglycemia in the hospital may be due to known diabetes, to previously unrecognized diabetes, to prediabetes, and/or to the stress of surgery or illness. Deterioration in glycemic control in the hospital setting is most commonly associated with one or more factors, including stress-induced release of insulin counterregulatory hormones (catecholamines, cortisol, glucagon, and growth hormone), exogenous administration of high dose glucocorticoids, and suboptimal glycemic management strategies. In a Belgian medical intensive care unit (MICU) randomized controlled trial (RCT) of strict versus conventional glycemic control, mean blood glucose (BG) on admission to the unit in the intention to treat group was 162 ± 70 mg/dL (n = 1200), and in this group’s RCT of 1548 surgical intensive care unit (SICU) patients, BG > 110 mg/dL was observed in over 70% of subjects. Mean BG of >145 mg/dL has been reported in 39% and BG >200 mg/dL in anywhere from 11% to 31% of intensive care unit (ICU) patients. For general medicine and surgery, a study of 2030 patients admitted to a teaching hospital revealed that 26% of admissions had a known history of DM and 12% had new hyperglycemia, as evidenced by an admission or in-hospital fasting BG of 126 mg/dL or more or a random BG of 200 mg/dL or more on 2 or more determinations. National and regional estimates on hospital use maintained by the Agency for Healthcare Research and Quality include data concerning diabetes diagnoses alone, without hyperglycemia, and may be displayed by querying its Web site. In cardiovascular populations almost 70% of patients having a first myocardial infarction have been reported to have either known DM, previously unrecognized diabetes, or impaired glucose tolerance.

Although it is beyond the scope of this article to discuss these mechanisms in detail, research has broadly focused in the following areas: (1) immune system dysfunction, associated with a proinflammatory state and impaired white blood cell function; (2) metabolic derangements leading to oxidative stress, release of free fatty acids, reduction in endogenous insulin secretion, and fluid and electrolyte imbalance; and (3) a wide variety of vascular system responses (eg, endothelial dysfunction with impairment of tissue perfusion, a prothrombotic state, increased platelet aggregation, and left ventricular dysfunction).

Conversely administration of insulin suppresses or reverses many of these abnormalities including generation of reactive oxygen species (ROS) and activation of inflammatory mechanisms, and leads to a fall in C-reactive protein, which accompanied the clinical benefit of intensive insulin therapy (IIT) in the Leuven, Belgium, ICU population, and prevents mitochondrial abnormalities in hepatocytes. In the same surgical ICU cohort, Langouche et al. report suppression of intracellular adhesion molecule-1 (ICAM-1) and E-selectin, markers of inflammation, and reduction in plasma nitric oxide (NO) and innate nitric oxide (iNOS) expression with insulin administration in patients treated with intravenous (IV) IIT. These data further support the role of insulin infusion in suppressing inflammation and endothelial dysfunction. The authors suggest that maintaining normoglycemia with IIT during critical illness protects the endothelium, thereby contributing to prevention of organ failure and death. Based on accumulating data in the literature such as that cited above, it has been suggested that a new paradigm in which glucose and insulin are related not only through their metabolic action but also through inflammatory mechanisms offers important potential therapeutic opportunities.

**Evidence: Epidemiology/Observational Studies/Non-RCT Interventional Studies**

A strong association between hospital hyperglycemia and negative outcomes has been reported in numerous observational studies in diverse adult medical and surgical settings. In over 1800 hospital admissions, those with new hyperglycemia had an in-hospital mortality rate of 16% compared with 3% mortality in patients with known diabetes treatments.
and 1.7% in normoglycemic patients ($P < 0.01$). These data suggest that hyperglycemia due to previously unrecognized diabetes may be an independent marker of in-hospital mortality.\(^{13}\)

Hyperglycemia has been linked to adverse outcomes in myocardial infarction, stroke,\(^{23-28}\) postoperative nosocomial infection risk, pneumonia, renal transplant, cancer chemotherapy, percutaneous coronary interventions, and cardiac surgery.\(^{29-38}\) These observational studies have the usual limitations inherent in their design. Demonstrating a strong association of hyperglycemia with adverse outcomes is not a guarantee that the hyperglycemia is the cause for the poor outcome, as hyperglycemia can reflect a patient under more stress who is at a higher risk for adverse outcome. By the same token, the strong association of hyperglycemia with the risk of poor outcomes seen in these studies does not guarantee that euglycemia would mitigate this risk.

Nonetheless, there are several factors that make the body of evidence for glycemic control more compelling. First, the association has a rational physiologic basis as described above. Second, the associations are consistent across a variety of patient populations and disease entities, and demonstrate a dose-response relationship. Third, in studies that control for comorbidities and severity of illness, hyperglycemia persists as an independent risk factor for adverse outcomes, whether the patient has a preexisting diagnosis of diabetes or not. Last, non-RCT interventional studies and RCTs largely reinforce these studies.

The Portland Diabetic Project has reported prospective, nonrandomized data over 17 years on the use of an IV insulin therapy protocol in cardiac surgery patients.\(^{38}\) This program has implemented stepped lowering of target BG, with the most recent data report implementing a goal BG $<150$ mg/dL.\(^{35}\) The current protocol uses a BG target of 70–110 mg/dL, but results have not yet been published.\(^{39}\) Mortality and deep sternal wound infection rates for patients with diabetes who remain on the IV insulin protocol for 3 days have been lowered to levels equivalent to those for nondiabetic patients. This group has also reported reductions in length of stay and cost-effectiveness of targeted glycemic control in the cardiac surgery population.\(^{35}\) Their data have to a large extent driven a nationwide movement to implement targeted BG control in cardiac surgery patients.

Another large ICU study (mixed medical-surgical, $n = 1548$ patients) also supports a benefit through targeted BG control ($130.7$ versus $152.3$ mg/dL, $P < 0.001$) when compared with historical controls. This study demonstrated reduction in in-hospital mortality (relative risk reduction 29.3%, $P = 0.002$), duration of ICU stay (10.8%, $P = 0.04$), acute renal failure (75%, $P = 0.03$), and blood transfusions (18.7%, $P = 0.002$),\(^{40}\) representing a similar magnitude of effect as was demonstrated by the Belgian group.

**Evidence: RCTs**

Evidence is accumulating that demonstrates an advantage in terms of morbidity and mortality when targeted glycemic control using intravenous insulin infusion is implemented in the hospital. The most robust data have been reported from ICU and cardiac surgery settings. The largest randomized, controlled study to date enrolled 1548 patients in a surgical ICU in Leuven, Belgium who were randomized to either intensive (IT) or conventional (CT) insulin therapy. Mean glucose attained was 103 ± 19 and 153 ± 33 mg/dL in each arm, respectively. The intensive insulin group demonstrated a reduction in both ICU (4.6% versus 8.0%) and in-hospital mortality (7.2% versus 10.9%), as well as bloodstream infections, acute renal failure, transfusions, and polyneuropathy, the latter being reflected by duration of mechanical ventilation ($P < 0.01$ for all). Although a similar study in an MICU did not achieve statistical significance in the overall intention-to-treat analysis, it did demonstrate reductions in mortality (from 52.5% to 43.0%) in patients with at least 3 days of ICU treatment. It should also be noted that in this MICU population hypoglycemia was higher and level of glycemic control attained not as rigorous as in the same group’s SICU cohort, factors which may have had an impact on observed outcomes. A meta-analysis of these two Leuven, Belgium, studies demonstrated a reduction in mortality (23.6% versus 20.4%, absolute risk reduction [ARR] 3.2%, $P = 0.004$) in all patients treated with IIT, with a larger reduction in mortality (37.9% versus 30.1%, ARR 7.8%, $P = 0.002$) observed in patients with at least 3 days of IIT, as well as substantial reductions in morbidity.\(^{5,10,41,42}\)

Several other studies must be mentioned in this context. A small ($n = 61$), randomized study in another SICU did not show a mortality benefit, perhaps because the number of subjects was not
adequate to reach statistical significance, but did result in a significant reduction in nosocomial infections in patients receiving IIT (BG = 125 versus 179 mg/dL, P < 0.001).43 Two international multicenter studies recently stopped enrollment due to excess rates of hypoglycemia. The Volume Substitution and Insulin Therapy in Severe Sepsis (VISEP) study, in a mixed medical and surgical sepsis population, showed no significant reduction in mortality in the intensively-treated group. Serious adverse events were reported according to standard definitions. Enrollment was stopped before the full number of subjects had been randomized. Among the 537 evaluable cases, hypoglycemia (BG < 40 mg/dL) was reported as 17.0% in the IT group and 4.1% (P < 0.001) in the control group,14 and the rate of serious adverse events was higher in the IT group (10.9% versus 5.2%, P = 0.01). It is notable that the rate of hypoglycemia was comparable to the 18.7% rate seen in the IT group in the Leuven, Belgium, medical ICU study.9

The Glucontrol study enrolled 855 medical and surgical ICU patients and was similarly terminated because of hypoglycemia (BG < 40 mg/dL) at a rate of 8.6% compared to 2.4% in the control group (P < 0.001). Insulin infusion protocols and outcome data have not yet been published.42,45

These studies with very high hypoglycemia rates each used an algorithm based on the Leuven, Belgium, protocol. The rates of severe hypoglycemia are 3–4× that reported by a variety of others achieving similar or identical glycemic targets. Hypoglycemia should not be construed as a reason to not use a standardized insulin infusion protocol. In comparing protocols that have been published, it is apparent that rates of hypoglycemia differ substantially and that performance results of some algorithms are not necessarily replicable across sites.40 Dose-defining designs can be substantively more sophisticated than those used in the trials mentioned, in some cases incorporating principles of control engineering. The variability of hypoglycemia rates under differing insulin infusion protocols is a compelling reason to devote institutional effort to monitoring the efficacy and safety of the infusion protocols that are used.

High-level evidence from randomized, controlled trials demonstrating outcomes benefit through targeted BG control outside the ICU is lacking at this point in time, but it must be noted that feasibility is suggested by a recent randomized control trial (RABBIT2) that demonstrated the superiority of basal bolus insulin regimens to sliding scale insulin in securing glycemic control, without any increase in hypoglycemia.47

**Summing Up the Evidence**

It is clear that hyperglycemia is associated with negative clinical outcomes throughout the hospital, and level A evidence is available to support tight glucose control in the SICU setting. However, in view of the imperfect and incomplete nature of the evidence, controversy persists around how stringent glycemic targets should be in the ICU, on whether glycemic targets should differ between SICU and MICU patients, and especially what the targets should be in the non-ICU setting. There should be hesitancy to extrapolate glycemic targets to be applied beyond the populations that have been studied with RCTs or to assume benefit for medical conditions that have not been examined for the impact of interventions to control hyperglycemia. Institutions might justifiably choose more liberal targets than those promoted in national recommendations/guidelines2,48–50 until safe attainment of more moderate goals is demonstrated. However, even critics agree that uncontrolled hyperglycemia exceeding 180–200 mg/dL in any acute care setting is undesirable. Moreover, strong observational data showing the hazards of hyperglycemia in noncritical care units (even after adjustment for severity of illness) combined with the high rate of adverse drug events associated with insulin use, argue strongly for a standardized approach to treating diabetes and hyperglycemia in the hospital. Even though no RCTs exist demonstrating outcomes benefits of achieving glycemic target on wards, the alternatives to control of hyperglycemia using scheduled insulin therapy are unacceptable. Oral agent therapy is potentially dangerous and within the necessary timeframe is likely to be ineffective; sliding scale management is inferior to basal-bolus insulin therapy, as shown in an RCT,47 and is unsafe; and on the wards improved glycemic control can be achieved simultaneously with a reduction in hypoglycemia.51

**Inpatient Glycemic Control is Increasingly Incorporated into Public Reporting, Guidelines, Regulatory Agency, and National Quality Initiative Priorities**

National quality initiatives, public reporting, pay-for-performance, and guideline-based care con-
continue to play an increasingly important role in the U.S. healthcare system. Over the years these initiatives have focused on various disease states (venous thromboembolism, congestive heart failure, community-acquired pneumonia, etc.) in an attempt to standardize care and improve patient safety and quality. Inpatient hyperglycemic control is also increasingly being incorporated into public reporting, regulatory compliance, and national quality initiatives.

Professional organizations such as the ADA and AACE have published guidelines supporting improved glycemic control, the safe use of insulin, and other measures to improve care for hyperglycemic inpatients. The AACE has a Web site dedicated to hospital hyperglycemia. The Society of Hospital Medicine has created a resource room on its Web site and a workbook for improvement on optimizing the care of inpatients with hyperglycemia and diabetes. The guidelines and Web sites help raise awareness and educate physicians and healthcare workers in inpatient glucose management. The American Heart Association has incorporated specific recommendations regarding inpatient diabetic management in its “Get With the Guidelines.”

The Joint Commission has developed an advanced disease-specific certification on inpatient diabetes. Disease management programs are important components of complex healthcare systems that serve to coordinate chronic care, promote early detection and prevention, and reduce overall healthcare costs. Certification is increasingly important to providers, payers, and healthcare institutions because it demonstrates a commitment to quality and patient safety. The Joint Commission disease-specific care certification is a patient-centered model focusing on the delivery of clinical care and relationship between the practitioner and the patient. The evaluation and resulting certification by the Joint Commission is based on 3 core components: (1) an assessment of compliance with consensus-based national standards; (2) the effective use of established clinical practice guidelines to manage and optimize care; and (3) an organized approach to performance measurement and improved activities. For inpatient diabetes, the Joint Commission program has 7 major elements following the ADA recommendations, including general recommendations regarding diabetic documentation, BG targets, preventing hypoglycemia, diabetes care providers, diabetes self-management education, medical nutrition therapy, and BG monitoring. This mirrors the Call to Action Consensus Conference essential elements for successful glycemic control programs.

Other organizations such as the Surgical Care Improvement Partnership (SCIP) and National Surgical Quality Improvement Program (NSQIP) have included perioperative glycemic control measures, as it impacts surgical wound infections. The University HealthSystem Consortium (UHC) has benchmarking data and endorses perioperative glycemic control measures, whereas the Institute for Healthcare Improvement (IHI) has focused on safe use of insulin practices in its 5 Million Lives campaign.

HOSPITALIZATION IS A MOMENT OF OPPORTUNITY TO ASSESS AND INTERVENE

The benefits of outpatient glycemic control and quality preventive care are well established, and the reduction of adverse consequences of uncontrolled diabetes are a high priority in ambulatory medicine. Hospitalization provides an opportunity to identify previously undiagnosed diabetes or prediabetes and, for patients with known diabetes, to assess and impact upon the long term course of diabetes.

As a first step, unless a recent hemoglobin A1C (HbA1c) is known, among hospitalized hyperglycemic patients an HbA1c should be obtained upon admission. Greci et al. showed that an HbA1c level >6.0% was 100% specific (14/14) and 57% sensitive (12/21) for the diagnosis of diabetes.

Among patients having known diabetes, an HbA1C elevation on admission may justify intensification of preadmission management at the time of discharge. If discharge and postdischarge adjustments of preadmission regimens are planned in response to admission A1C elevations, then the modified long-term treatment strategy can improve the A1C in the ambulatory setting. Moreover, the event of hospitalization is the ideal “teachable moment” for patients and their caregivers to improve self-care activities. Yet floor nurses may be overwhelmed by the tasks of patient education. For ideal patient education, both a nutritionist and a diabetes nurse educator are needed to assess compliance with medication, diet, and other aspects of care.

There also is need for outpatient follow-up education. Finally, at the time of discharge, there is a
duty and an opportunity for the diabetes provider to communicate with outpatient care providers about the patient’s regimen and glycemic control, and also, based on information gathered during the admission, to convey any evidence that might support the need for a change of long-term strategy. Unfortunately, the opportunity that hospitalization presents to assess, educate, and intervene frequently is underused.1,8,51,65

LARGE GAPS EXIST BETWEEN CURRENT AND OPTIMAL CARE

Despite the evidence that inpatient glycemic control is important for patient outcomes, and despite guidelines recommending tighter inpatient glycemic control, clinical practice has been slow to change. In many institutions, inpatient glycemic management has not improved over the past decade, and large gaps remain between current practice and optimal practice.

Studies of individual institutions provide several insights into gaps in care. For example, Schnipper et al.66 examined practices on the general medicine service of an academic medical center in Boston in 2004. Among 107 prospectively identified patients with a known diagnosis of diabetes or at least 1 glucose reading >200 mg/dL (excluding patients with diabetic ketoacidosis, hyperglycemic hyperosmolar state, or pregnancy), they found scheduled long-acting insulin prescribed in 43% of patients, scheduled short-acting/rapid-acting insulin in only 4% of patients, and 80 of 89 patients (90%) on the same sliding scale insulin regimen despite widely varying insulin requirements. Thirty-one percent of glucose readings were >180 mg/dL compared with 1.2% of readings <60 mg/dL (but 11% of patients had at least 1 episode of hypoglycemia). Of the 75 patients with at least 1 episode of hyperglycemia or hypoglycemia, only 35% had any change to their insulin regimen during the first 5 days of the hospitalization.

Other studies have confirmed this concept of clinical inertia (ie, recognition of the problem but failure to act).57 A study by Cook et al.58 of all hospitalized non-ICU patients with diabetes or hyperglycemia and length of stay of 3 days between 2001 and 2004 showed that 20% of patients had persistent hyperglycemia during the hospitalization (defined as a mean glucose >200 mg/dL). Forty-six percent of patients whose average glucose was in the top tertile did not have their insulin regimen intensified to a combination of short-acting/rapid-acting and long-acting insulin, and 35% of these patients either had no change in their total daily insulin dose or actually had a decrease in their dose when comparing the last 24 hours with the first 24 hours of hospitalization, a concept they term “negative therapeutic momentum.”

Perhaps the most well-balanced view of the current state of medical practice comes from the UHC benchmarking project.69 UHC is an alliance of 90 academic health centers. For the diabetes project, each institution reviewed the records of 50 randomly selected patients over 18 years of age with at least a 72-hour length of stay, 1 of 7 pre-specified Diagnosis Related Group (DRG) codes, and at least 2 consecutive glucose readings >180 mg/dL or the receipt of insulin any time during the hospitalization. Patients with a history of pancreatic transplant, pregnant at the time of admission, receiving hospice or comfort care, or receiving insulin for a reason other than glucose management were excluded. The study showed widespread gaps in processes and outcomes (Table 1). Moreover, performance varied widely across hospitals. For example, the morning glucose in the ICU on the second measurement day was 110 mg/dL in 18% of patients for the median-performing hospital, with a range of 0% to 67% across all 37 measured hospitals. In the non-ICU setting on the second measurement day, 26% of

<table>
<thead>
<tr>
<th>Key Performance Measure</th>
<th>Results for Median-Performing Hospital (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documentation of diabetes</td>
<td>100</td>
</tr>
<tr>
<td>HbA1c assessment within 30 days</td>
<td>36.1</td>
</tr>
<tr>
<td>Glucose measurement within 8 hours of admission</td>
<td>78.6</td>
</tr>
<tr>
<td>Glucose monitoring ≥ 4 times a day</td>
<td>85.4</td>
</tr>
<tr>
<td>Median glucose reading &gt; 200 mg/dL</td>
<td>10.3</td>
</tr>
<tr>
<td>Effective insulin therapy*</td>
<td>44.7</td>
</tr>
<tr>
<td>ICU day 2 morning glucose ≤ 110 mg/dL</td>
<td>17.7</td>
</tr>
<tr>
<td>Non-ICU day 2 all glucose readings ≤ 180 mg/dL</td>
<td>26.3</td>
</tr>
<tr>
<td>Patient-days with at least 1 glucose reading &lt; 50 mg/dL</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Abbreviation: ICU, intensive care unit.

* Combination of short-acting/rapid-acting and long-acting subcutaneous insulins, continuous insulin infusion, or subcutaneous insulin pump.
patients had all BG measurements = 180 mg/dL in the median-performing hospital, with a range of 7% to 48%. Of note, hypoglycemia was relatively uncommon: in the median hospital, 2.4% of patient-days had 1 or more BG readings <50 mg/dL (range: 0%–8.6%). Finally, in the median-performing hospital, effective insulin therapy (defined as short-acting/rapid-acting and long-acting subcutaneous insulin, continuous insulin infusion, or subcutaneous insulin pump therapy) was prescribed in 45% of patients, with a range of 12% to 77% across measured hospitals.

**FREQUENT PROBLEMS WITH COMMUNICATION AND COORDINATION**

Those who work closely with frontline practitioners striving to improve inpatient glycemic management have noticed other deficiencies in care.¹⁻⁷⁰ These include: a lack of coordination between feeding, BG measurement, and insulin administration, leading to mistimed and incorrectly dosed insulin; frequent use of sliding-scale only regimens despite evidence that they are useless at best and harmful at worst;⁶,⁴⁷,⁶⁰,⁷¹ discharge summaries that often do not mention follow-up plans for hyperglycemic management; incomplete patient educational programs; breakdowns in care at transition points; nursing and medical staffs that are unevenly educated about the proper use of insulin; and patients who are often angry or confused about their diabetes care in the hospital. Collectively, these gaps in care serve as prime targets for any glycemic control program.

**HYPOGLYCEMIA IS A PROMINENT INPATIENT SAFETY CONCERN**

Hypoglycemia is common in the inpatient setting and is a legitimate safety concern. In a recently reported series of 2174 hospitalized patients receiving antihyperglycemic agents, it was found that 9.5% of patients experienced a total 484 hypoglycemic episodes (defined as ≤60 mg/dL).⁷² Hypoglycemia often occurred in the setting of insulin therapy and frequently resulted from a failure to recognize trends in BG readings or other clues that a patient was at risk for developing hypoglycemia.⁷³ A common thread is the risk created by interruption of carbohydrate intake, noted by Fischer et al.⁷³ and once again in the recent ICU study by Vriesendorp et al.⁷⁴ Sources of error include: lack of coordination between feeding and medication administration, leading to mistiming of insulin action; lack of sufficient frequency in BG monitoring; lack of clarity or uniformity in the writing of orders; failure to recognize changes in insulin requirements due to advanced age, renal failure, liver disease, or change in clinical status; steroid use with subsequent tapering or interruption; changes in feeding; failure to reconcile medications; inappropriate use of oral antihyperglycemic agents, and communication or handoff failures.

It has been difficult to sort out whether hypoglycemia is a marker of severity of illness or whether it is an independent factor leading to poor outcomes. Observational studies lend credibility to the concept that patients having congestive heart failure or myocardial infarction may be at risk for excessive mortality if their average BG resides in the low end of the normal range.⁷⁵⁻⁷⁸ Sympathetic activation occurs as the threshold for hypoglycemia is approached, such as occurs at BG = 70 or 72 mg/dL.⁷⁹ Patients living with BG levels observed to be in the low end of the normal range might experience more severe but unobserved and undocumented episodes of neuroglycopenia. Arrhythmia and fatality have been directly attributed to strict glycemic control.⁸⁰,⁸¹ We are confronted with the need to interpret well conducted observational studies, evaluating subgroups at risk, and using multivariate analysis to assess the impact of hypoglycemia upon outcomes.⁸² In such studies, we will need to examine high-risk subgroups, including cardiac patients, in particular, for the possibility that there is a J-shaped curve for mortality as a function of average BG.

Unfortunately, clinical inertia exists in response to hypoglycemia just as it does with hyperglycemia. One recent study examined 52 patients who received intravenous 50% dextrose solution for an episode of hypoglycemia.⁸³ Changes to insulin regimens were subsequently made in only 21 patients (40%), and diabetes specialists agreed with the changes for 11 of these patients. The other 31 patients (60%) received no changes in treatment, and diabetes specialists agreed with that decision for only 10 of these patients.

Although some increase in hypoglycemia might be expected with initiation of tight glycemic control efforts, the solution is not to undertreat hyperglycemia. Hyperglycemia creates an unsafe setting for the treatment of illness and disease. Sliding-scale–only regimens are ineffective in securing glycemic control and can result in
increases in hypoglycemia as well as hyperglycemic excursions. Inappropriate withholding of insulin doses can lead to severe glycemic excursions and even iatrogenic diabetic ketoacidosis (DKA). Systems approaches to avoid the errors outlined above can minimize or even reverse the increased risk of hypoglycemia expected with tighter glycemic targets.

A SYSTEMS APPROACH IS NEEDED FOR THESE MULTIPLE COMPLEX PROBLEMS

Care is of the hyperglycemic inpatient is inherently complex. Previously established treatments are often inappropriate under conditions of altered insulin resistance, changing patterns of nutrition and carbohydrate exposure, comorbidities, concomitant medications, and rapidly changing medical and surgical status. Patients frequently undergo changes in the route and amount of nutritional exposure, including discrete meals, continuous intravenous dextrose, nil per orem (nothing by mouth status; NPO) status, grazing on nutritional supplements or liquid diets with or without meals, bolus enteral feedings, overnight enteral feedings with daytime grazing, total parenteral nutrition, continuous peritoneal dialysis, and overnight cycling of peritoneal dialysis. Relying on individual expertise and vigilance to negotiate this complex terrain without safeguards, protocols, standardization of orders, and other systems change is impractical and unwise.

Transitions across care providers and locations lead to multiple opportunities for breakdown in the quality, consistency, and safety of care. At the time of ward transfer or change of patient status, previous medication and monitoring orders sometimes are purged. At the time of discharge, there may be risk of continuation of anti-hyperglycemic therapy, initiated to cover medical stress, in doses that will subsequently be unsafe.

In the face of this complexity, educational programs alone will not suffice to improve care. Institutional commitment and systems changes are essential.

MARKED IMPROVEMENT IS POSSIBLE AND TOOLS EXIST: A ROADMAP IS IN PLACE

Fortunately, a roadmap is in place to help us achieve better glycemic control, improve insulin management, and address the long list of current deficiencies in care. This is imperative to develop consistent processes in order to achieve maximum patient quality outcomes that effective glycemic management offers. This roadmap entails 4 components: (1) national awareness, (2) national guidelines, (3) consensus statements, and (4) effective tools. As mentioned above, the first two components of this roadmap are now in place.

As these national guidelines become more widely accepted, the next step will be the incorporation of this into programs like Pay-for Performance and the Physician Quality Reporting Initiative (PQRI), which will impact reimbursement to both hospitals and providers.

Regarding the third component, a recent multidisciplinary consensus conference outlined the essential elements needed for successful implementation of an inpatient glycemic control program which include:

- An appropriate level of administrative support.
- Formation of a multidisciplinary steering committee to drive the development of initiatives and empowered to enact change.
- Assessment of current processes, quality of care, and barriers to practice change.
- Development and implementation of interventions including standardized order sets, protocols, policies and algorithms with associated educational programs.
- Metrics for evaluation of glycemic control, hypoglycemia, insulin use patterns, and other aspects of care.

Finally, extensive resources and effective tools are now available to help institutions achieve better inpatient glucose control. The Society of Hospital Medicine (SHM), in conjunction with the ADA, AACE, the American College of Physicians (ACP), the Case Management Society of America (CMSA), the American Society of Consultant Pharmacists, nursing, and diabetic educators have all partnered to produce a comprehensive guide to effective implementation of glycemic control and preventing hypoglycemia. This comprehensive workbook is a proven performance improvement framework and is available on the SHM website. Details and examples of all essential elements are covered in this workbook along with opportunities for marked improvement bolstered by integration of high reliability design features and attention to effective implementation techniques. The remainder of this supplement crystallizes a substantial portion of this material. The
GLYCEMIC CONTROL INITIATIVES CAN BE COST-EFFECTIVE

Achieving optimal glycemic control safely requires monitoring, education, and other measures, which can be expensive, labor intensive, and require coordination of the services of many hospital divisions. This incremental expense has been shown to be cost-effective in a variety of settings.\(^1,84,85\)

The costs of glycemic control initiatives have demonstrated a good return on investment via:

- Improved LOS, readmission rates, morbidity, and mortality.
- Improved documentation of patient acuity and related payment for acuity.
- Income generated via incremental physician and allied health professional billing.

CONCLUSION AND SUMMARY

Evidence exists that appropriate management of hyperglycemia improves outcomes, whereas the current state of affairs is that most medical centers currently manage this suboptimally. This is concerning given the magnitude of diabetes and hyperglycemia in our inpatient setting in the United States. To bring awareness to this issue, multiple initiatives (guidelines, certification programs, workbooks, etc.) are available by various organizations including the ADA, AACE, SCIP, NSQIP, IHI, UHC, the Joint Commission, and SHM. However, this is not enough. Change occurs at the local level, and institutional prioritization and support is needed to empower a multidisciplinary steering committee, with appropriate administrative support, to standardize and improve systems in the face of substantial cultural issues and complex barriers. Improved data collection and reporting, incremental monitoring, creation of metrics, and improved documentation are an absolutely necessary necessity to achieve breakthrough levels of improvement.

Now the time is right to make an assertive effort to improve inpatient glycemic control and related issues, and push for appropriate support at your institution to help achieve this in the interest of patient safety and optimal outcomes.

Address for correspondence and reprint requests: Susan S. Braithwaite, MD, FACP, FACE, Clinical Professor of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599; E-mail: sbraithwaite@med.unc.edu

Received 10 January 2008; revision received 13 July 2008; accepted 17 July 2008.

REFERENCES


