

EVOLUTION OF A DIABETES INPATIENT SAFETY COMMITTEE

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ABSTRACT

Objective: To develop a multidisciplinary team, the Diabetes Inpatient Safety Committee (DPSC), to effectively address the many barriers to achieving glycemic control in the inpatient setting.

Methods: The development, implementation, and successes of the DPSC are described.

Results: By focusing on prevention of severe hypoglycemia, the DPSC identified and addressed areas related to inpatient management that contributed to uncontrolled glucose levels. The introduction of a hypoglycemia treatment protocol was followed by the development of a standardized order set for use of sliding scale insulin, with the eventual introduction of an Insulin Order Set guiding the use of scheduled and correctional insulin. Protocols and guidelines addressing more specific areas of inpatient glycemic management (insulin pump therapy, perioperative management, diabetic ketoacidosis, intravenous insulin) also have been developed.

Conclusion: The successes of the DPSC to date have been directly related to strong institutional support, the dedication of a multidisciplinary team to address specific areas of glycemic management, the programmed introduction of order sets in conjunction with structured educational programs that accompany each protocol, and the use of quality improvement measures to evaluate the safety and efficacy of these protocols. Effective committees such as this will be instrumental in preventing errors and maximizing euglycemia. (*Endocr Pract.* 2006;12[Suppl 3]:91-99)

Abbreviations:

BG = blood glucose; **DKA** = diabetic ketoacidosis; **DPSC** = Diabetic Inpatient Safety Committee; **HTP** = hypoglycemia treatment protocol; **IV** = intravenous; **MEC** = Medical Executive Committee; **QI** = quality improvement; **SQ** = subcutaneous; **SSI** = sliding-scale insulin; **UPMC** = University of Pittsburgh Medical Center

INTRODUCTION

The evidence in support of goal-directed management of hyperglycemia in patients hospitalized with known diabetes, previously unrecognized diabetes, and hospital-related hyperglycemia continues to grow (1-4). Recently published guidelines recommend that glucose levels among hospital inpatients be maintained between 110 and 180 mg/dL, and even lower (80 to 110 mg/dL) for critically ill patients, as a way of reducing complications and hospital length of stay (1,5). Despite consensus among professional societies that inpatient hyperglycemia poses a major risk factor for adverse outcomes among hospitalized patients, there are many obstacles to the translation of these glycemic-control guidelines into the daily routine of hospitals.

From an illness perspective, factors contributing to difficulties in glycemic control include an increase in counter-regulatory hormones due to the stress associated with an illness and the need for hospitalization (1,6,7).

From a patient perspective, prolonged fasting in preparation for procedures, parenteral and enteral nutrition, and medications such as corticosteroids can contribute to unpredictable changes in blood glucose (BG) (8-10).

From an institutional perspective, dedication to established hospital routines by nursing and medical staff, inconsistent meal distribution, and lack of coordination between meals and insulin administration add to the difficulties of inpatient glucose control (11,12).

From a physician perspective, an overdependence on sliding-scale insulin (SSI) regimens, an underutilization of scheduled insulin, and a reluctance to implement

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Presented at the American College of Endocrinology and American Diabetes Association Consensus Conference, Washington, DC, January 30-31, 2006.

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intravenous (IV) insulin in critical care illnesses all present obstacles to achieving desired levels of glycemic control (13-15). The practice of discontinuing scheduled insulin and ordering SSI alone remains a deep-rooted practice of many physicians despite evidence demonstrating the contribution of SSI to severity of hyperglycemia. Although no studies exist that explore the rationale for these practices, many factors have contributed to the perpetuation of these practices, including an unfamiliarity with how to order and adjust scheduled insulin with basal, nutritional, and correctional components; the complexity of writing insulin orders that address the numerous contingencies that occur in hospitalized patients; and the fear of inducing hypoglycemia by trying to achieve recommended goals (16). Fear and occurrence of hypoglycemia represent major obstacles to appropriate inpatient glycemic management.

Achieving and maintaining glycemic control in hospitalized patients while avoiding hypoglycemia is challenging, but this concern does not constitute authorization for uncontrolled hyperglycemia. In this article, we describe how these barriers are being addressed at the University of Pittsburgh Medical Center (UPMC) through the establishment of a multidisciplinary team that initially was created to reduce the frequency of and adverse outcomes caused by severe hypoglycemia in the inpatient population. In doing so, the committee has initiated a series of protocols and educational efforts that address many aspects of inpatient glycemic management.

FORMATION OF THE DIABETES PATIENT SAFETY COMMITTEE AT UPMC

UPMC Presbyterian, a 716-bed acute care adult medical/surgical referral hospital, is the flagship hospital of a network consisting of 19 hospitals and other care sites including doctors' offices, outpatient specialty treatment and imaging centers, rehabilitation facilities, and nursing homes.

In July 2000, the hospital's Medical Emergency Team (MET) identified several episodes of severe hypoglycemia among hospitalized patients, one of which was associated with poor outcome (17). The hospital Patient Safety Committee asked the Endocrine Division to create recommendations for both the treatment and prevention of severe hypoglycemia in the hospital.

A committee was formed, including representation from members of the Endocrine Division, community endocrinologists admitting patients to UPMC, medical and surgical Nursing Units, Nursing Administration, the Department of Medicine, Pharmacy, Case Management, Patient Safety, and Critical Care Medicine. The formation of this committee marked the beginning of the Diabetes Inpatient Safety Committee (DPSC) at UPMC.

Development and Implementation of a Hypoglycemia Protocol

The initial mission of the DPSC was to reduce harm due to hypoglycemia in the hospital. The strategy selected by the committee was to develop an algorithm for treatment of hypoglycemia, to foster acceptance and use by nurses and physicians at our institution and, if successful, to extend the use of this protocol to other facilities in the UPMC system.

The initial goals of the committee were to define hypoglycemia, to review the electronic hospital records to identify the frequency and location of hypoglycemic events within the hospital, and to review the literature for management algorithms.

The committee defined hypoglycemia as a BG <70 mg/dL. This decision was based on studies demonstrating the initiation of counter-regulatory hormone responses at an arterialized plasma glucose level of 65 to 70 mg/dL in nondiabetic individuals (18,19). This definition is consistent with that of the ADA Workgroup on Hypoglycemia (18). Given that the primary goal of this early initiative was to prevent harm caused by severe hypoglycemia, it was the consensus of this committee that early intervention in an individual receiving bedside BG monitoring would prevent deterioration to a more severe event. To address differences in severity of events, mild hypoglycemia was defined as BG between 50 and 69 mg/dL; moderate hypoglycemia as BG between 40 and 49 mg/dL; and severe hypoglycemia as any BG <40 mg/dL.

A retrospective review of electronic hospital records from January through August 2001 identified an average of 605 individual bedside BG values <70 mg/dL each month, with 418 defined as mild, 97 as moderate, and 90 as severe according to the established criteria. To avoid overcounting the hypoglycemia events (many patients had repeated measures done within a short time), this data set was refined to include all BG values <70 mg/dL occurring within a 4-hour interval as a single event (i.e., maximum of 6 events per patient per day) and normalized to patient days (i.e., all patients admitted during a specified month were monitored for the entire hospitalization). Using this methodology and eliminating episodes occurring in critical care areas, the frequency of hypoglycemic events was determined to be 28.5 episodes (18 mild, 5 moderate, 5.5 severe) per 1,000 patient days in 2001. Because these events were observed to occur on all hospital units, and because patients often are transferred between various hospital units during a single hospitalization, the DPSC felt it important to promote standard treatment for patients regardless of location, and therefore decided that a protocol for hypoglycemic management should be implemented hospital-wide.

A review of the literature using Medline and PubMed showed a paucity of published information regarding hypo-

glycemia detection or management. Several protocols for hypoglycemia treatment were published in nursing journals without data indicating the degree to which these protocols were accepted or used (1).

Based on these findings, the DPSC developed a nurse-directed Hypoglycemia Treatment Protocol (HTP) (Appendix), divided according to severity of hypoglycemia and patient condition (alert, obtunded, dysphagic, fasting) (20). Sulfonylurea-associated hypoglycemia, which can be prolonged and require specialized treatment, also was addressed.

Prior to hospital-wide implementation, the protocol was piloted on 2 nursing units and revised based on recommendations. The HTP was approved by the hospital Medical Executive Committee (MEC) and the Pharmacy and Therapeutics Committee for use as a standing order to be implemented by nursing personnel for any bedside BG <70 mg/dL.

It was recognized that proper introduction and implementation of the HTP depended on the ability of bedside nurses to recognize signs and symptoms of hypoglycemia, to initiate treatment without delay, and to retest at prescribed time intervals following treatment. For this reason, an educational initiative was implemented on all hospital units and included baseline and follow-up assessment of knowledge and confidence in the ability to recognize and treat in-hospital hypoglycemia. An effort was made to reach all nurses on all shifts.

The process of developing, introducing, and implementing the HTP throughout the hospital served to increase awareness of practices associated with the occurrence of hypoglycemia in the hospital, such as use of SSI regimens and changes in nutritional status without associated changes in insulin regimens. Requests were submitted to the committee to address each of these issues.

Development and Implementation of an Insulin Order Set

Early in 2002, the Adverse Drug Event (ADE) Subcommittee of the Pharmacy and Therapeutics Committee asked the DPSC to address the 11 reported moderate-to-severe adverse drug events and 25 medication errors involving insulin during the previous year. Since the reported incidence of medication errors is known to be much less than the true incidence, the DPSC was asked to intervene (21).

Following the initial review, several issues were identified as contributing to the frequency of reported insulin errors. Use of the abbreviation "U" for units on handwritten insulin orders resulted in inaccurate transcriptions of intended doses by unit clerks and nursing personnel. Other omissions were related to use of the brand name Humulin without indication as to the type of insulin to be administered (R, N, U, or L; designating regular, NPH, ultralente, or lente insulin, respectively).

Of the described insulin medication errors, 32% were directly related to prescribing and administering SSI. On any given day, approximately 40% of inpatients had one of 20 different handwritten SSI regimens to treat hyperglycemia caused by diabetes or resulting from use of medications such as corticosteroids. The majority of patients had SSI prescribed as monotherapy, without scheduled oral glucose-lowering medications or insulin.

It was also observed that SSI orders were more frequently physician-specific rather than patient-specific. Variability in the minimum BG requiring insulin, as well as in number of insulin units to be administered for a given BG, was observed. For example, insulin coverage in some regimens did not start until BG exceeded 200 or 250 mg/dL.

Based on the assumption that the variability in SSI orders contributed to the frequency of both insulin errors and adverse drug events, a staged approach to improving insulin use at UPMC was initiated. Several clinical services voiced resistance to abandoning the use of SSI. This prompted a phased approach to the creation of guidelines for use of scheduled basal/bolus insulin (when appropriate) in combination with correction insulin. The overall objective was to gradually eliminate the use of SSI as monotherapy.

The objective of the first phase was to create and implement a standardized preprinted SSI order form as a means of reducing medication errors related to insulin use. The second phase focused on educating house staff and other hospital personnel on the use of scheduled insulin as a means of achieving and maintaining glycemic control. The third phase entailed developing and implementing an order form for use of subcutaneous (SQ) insulin, which would guide rational insulin therapy in the inpatient setting.

First Phase: Creation of a Standardized SSI Order Set

The DPSC developed and implemented a standardized preprinted SSI order form with 3 standardized (i.e., mild, moderate, high) regimens initiating insulin coverage for BG >130 mg/dL. The goal of the preprinted form was to eliminate prescribing errors related to use of "U" for unit and type of insulin as well as to standardize the initiation point and treatment doses. An accompanying medication administration record (MAR) form also was developed and implemented with the order set to allow for ease of documentation of insulin doses by nursing personnel.

Introduction of the SSI protocol was accompanied by guidelines recommending that SSI be used as a supplement to scheduled oral glucose-lowering medications or for short-term use (24 to 48 hours) as monotherapy in patients with an unknown insulin requirement. The MEC and Pharmacy & Therapeutics committees approved implementation of the SSI protocol on all non-intensive care units. Approval was obtained from the UPMC Patient Safety Committee to assess the impact of implementation as a quality improvement (QI) project.

Within 2 months of implementation, the order form was used for 63% of all SSI orders, and after 1 year, for 91% of these orders. Chart reviews performed before and after implementation of this order set showed a 10-fold reduction in prescribing errors. The incidence of hypoglycemia remained the same, but the incidence of hyperglycemia defined as a BG >300 mg/dL declined significantly from baseline (22). Although it was not anticipated that the standardization of SSI in the hospital would eliminate the occurrence of hyperglycemia, the reduction in events was encouraging.

Second Phase: Education of House Staff and Other Hospital Personnel

To investigate the working hypothesis that insufficient knowledge regarding use of glucose-lowering therapy contributes to hyperglycemia in the hospital, residents in several specialties were asked to complete a 15-item questionnaire requesting information regarding the confidence and knowledge specific to inpatient glycemic management (prior to implementing educational sessions addressing this topic). Low knowledge scores were prevalent in all specialties and were unrelated to the degree of expressed confidence. Based on these findings, the DPSC has begun to create educational modules for medical and nursing personnel, focusing on use of scheduled insulin in the hospital.

Third Phase: Developing of an Insulin Order Set

As part of the ongoing effort to decrease, and possibly eliminate, practices contributing to the frequency of medication errors with insulin, the DPSC created and implemented a SQ Insulin Order Set that includes discrete sections for basal, bolus or nutritional, and correctional insulin (Fig. 1) (1,15,22). The order set was designed to serve as both a guideline and a physician order form for insulin therapy in the hospital. To minimize confusion by pharmacy and nursing when a change in one component of the scheduled insulin is made, a prechecked box at the top of the form states that all previously ordered insulin is discontinued, mandating that the prescriber rewrite all insulin doses. The ease of completing the order form reduces this aspect as a barrier to its use. To address areas previously observed to be associated with the incidence of severe hypoglycemia, standing orders are included for initiation of dextrose-containing IV fluids in the event of unanticipated discontinuations of oral, enteral, or parenteral nutrition in patients receiving basal insulin.

Following extensive discussions with members of the Department of Nursing, Hospitalists in the Division of General Internal Medicine, and the Pharmacy and Therapeutics Committee, the Insulin Order Set was introduced in 2005 to one service at a time. Currently, more than half of the inpatient general medical and surgery units are using this form. The acceptance of this order set by the units where it has been introduced caused the MEC to grant permission to implement the protocol throughout the

hospital in December 2005. A QI project investigating the appropriateness of insulin orders written with and without the order set is currently being conducted.

Diabetes Management in Specialty Areas

The DPSC continued to monitor adverse outcomes due to glycemic management. The committee soon recognized that, although there is a need for standardized practice guidelines in specialty areas where the volume of at-risk patients may be low and the impact of targeted glycemic control may not be well recognized, developing and implementing protocols in these areas presented unique challenges and barriers. Herein we describe how the DPSC addressed inpatient diabetes initiatives in 3 specialty areas: insulin pump therapy, perioperative glycemic management, and diabetic ketoacidosis (DKA). In addition, a brief discussion of the development of an IV insulin infusion protocol in the medical intensive care unit (MICU) is included.

Insulin Pump Therapy

Hospital care providers seldom encounter patients who use an insulin pump, and caregivers may be intimidated by the technology (23). Therefore, patients with an insulin pump have been variably treated, based on individual practitioner preference. In some cases, insulin pump therapy was continued but not addressed by the primary team. In other cases, it was discontinued without adequate attention to the need for basal insulin coverage. At our institution, nurse leaders were hesitant to endorse a protocol that required bedside nurses to oversee an insulin delivery system that the nurses did not fully understand or know how to operate. To address this, the DPSC developed and implemented a guideline with an accompanying order set and nurse MAR for inpatients. This was accompanied by an educational program directed toward nurses involved in caring for patients who use insulin pump therapy. The guideline created the following rules for insulin pump therapy in the hospital:

1. An insulin pump should never be discontinued without first giving SC insulin.
2. Endocrine/diabetes service consultation is strongly recommended for all hospital patients on insulin pump therapy.
3. This type of insulin delivery should be limited to patients who have the ability to safely self-manage their insulin and pump while hospitalized.
4. Insulin pump therapy should be converted to SQ insulin in patients who are unable to safely manage or who undergo testing or procedures for which this type of therapy is contraindicated (e.g., magnetic resonance imaging).
5. Communication between the patient using a pump and the nursing staff, with documentation of bolus and basal insulin doses, is essential to the safety of pump therapy in the hospital.


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Fig. 1. Subcutaneous Insulin Order Set.

To enable prompt involvement of the Diabetes Service, we are currently exploring procedures that will allow for immediate identification of admitted patients who use pump therapy.

These rules were implemented in April 2004. The DPSC is now in the process of creating an automated system to identify patients admitted with a pump to and notify the Diabetes Service so they can provide expert practice more reliably. As the initial order form and MAR for insulin pump therapy undergo revision to decrease the detail and improve ease of use, there is growing acceptance and respect for use of insulin pump therapy as standard practice at our hospital.

Perioperative Glycemic Management

Despite abundant evidence supporting the benefits of intraoperative BG control, practical application can be complex and idiosyncratic among physicians and nurse anesthetists (1,24). The DPSC has worked with members of the Department of Anesthesia to develop and implement a management plan that allows for flexibility on the part of the anesthesiologist while promoting the coordination of glycemic control with communication through multiple hospital departments.

The process of glycemic management of the patient with diabetes undergoing surgery can begin prior to admission. The DPSC has developed a list of preoperative instructions for patients treated with oral agents or insulin. These instructions have been made available to all those involved in communicating with patients preoperatively. Guidelines for the arrival of these patients in the preoperative holding area, the operating room, recovery room with contingency plans for discharge to a hospital unit, critical care area, or home have been developed and discussed. Although anesthesiologists are the driving force in the implementation of guideline recommendations, administrative and clinical support together with educational efforts are ongoing to achieve wider acceptance in this specialty area of the hospital.

A QI project is currently underway to measure consistency of compliance with guideline use, BG control, hypoglycemia events, operating room delays, and provider satisfaction.

Diabetic Ketoacidosis

DKA is a common acute metabolic emergency usually managed by house-staff physicians. Variability in DKA management, particularly in the transition from IV to SQ insulin, prompted the DPSC to develop and implement a comprehensive approach to DKA management that initially was introduced as 3 separate management order sets: acute management, maintenance, and transition phases. Recently, at the request of the hospitalist service, these 3 order sets were reviewed and condensed to a single set to facilitate acceptance and use by the medicine house staff.

IV Insulin Protocol

The medical director of the MICU at UPMC approached the DPSC, requesting assistance in the development of an IV insulin infusion protocol that would be acceptable to nursing staff and help decrease the mean BG of the MICU patient population. Early discussions showed reluctance on the part of MICU physicians and nurses to use a target BG of 80 to 110 mg/dL (previously reported to be associated with improved outcomes) because of concerns about hypoglycemia, but a willingness to accept a target of <150 mg/dL (25).

A protocol was developed with instructions for modifying infusion rates based on the current BG, the previous BG, and the current rate of infusion, utilizing favorable aspects of previously published protocols (25-27). Over a period of several months, the protocol was tested and modified according to nurse and physician recommendations and is now used for all mechanically ventilated patients with more than one BG >150 mg/dL. The mean BG achieved with this protocol is 121 mg/dL (5,28). As a result of the positive findings, and as the comfort of the MICU staffed has increased, the protocol has been modified to target BGs of 80 to 130 mg/dL. Effectiveness and safety will continue to be reassessed, with consideration given to further modify the protocol to target a BG range of 80 to 110 mg/dL, as currently recommended (5).

PEARLS FOR CREATING AND IMPLEMENTING HOSPITAL-WIDE PROTOCOLS

We have found that certain essential elements are required for successful protocol design and implementation. First, the support and backing of hospital administration is required. After our Hypoglycemia Protocol was implemented, the medical director of the hospital Patient Safety Committee helped disseminate the protocol and ensure its success by personally sending communication about it to all physicians at UPMC. He has subsequently supported our other protocols in a similar manner.

Second, it is essential to establish a multidisciplinary team, with representation from each department that plays a role in caring for the hospitalized patient. The contributions of physicians, pharmacists, nurses, dieticians, and institutional safety officials in the development and design of our protocols ensure that the needs of all disciplines are addressed and that communications are carried between the DPSC and each discipline.

Third, prior to implementation of any protocol, evidence-based educational presentations to those who will be using this in their clinical practice help convey the rationale for standardizing care, and thus contribute to the acceptance of a new approach.

Finally, QI assessment provides a means for investigating the safety and efficacy of implemented protocols and can contribute to ongoing acceptance as benefits are demonstrated.

How Does the DPSC Help the Hospitalist?

The goal of a good physician is to keep current with medical knowledge and apply it to patient care. This is a difficult task because medical knowledge increases exponentially, but the time and ability to learn does not. Generalists frequently rely on experts in medicine subspecialties to review new information and make recommendations that the generalist can incorporate into clinical practice. The order sets for glycemic management at our institution have allowed for changes that maintain consistency with current recommendations (1,5) as well as enhance the ability of physicians to deliver quality care in a timely manner.

Good diabetes care requires more than just “good” doctors. Diabetes care requires a team of providers all working within a specified practice realm. That is, the multidisciplinary team addresses the major aspects of glycemic management, including the development of treatment algorithms, order sets, and MARS; the ongoing evaluation of practices in pharmacy and clinical areas to reduce errors; and most importantly, the ongoing education of nurses, physicians, and patients. The DPSC has been responsible for the formulation of new rules, guidelines, and procedures to lead a program of inpatient glycemic management. The goal of this committee is to create more consistent glycemic management with fewer glycemic excursions, better compliance with ADA and hospital guidelines, and fewer errors.

A Generalist Observation of How These Order Sets Have Changed Care

The role of the hospitalist on the DPSC is to bring an internist’s perspective to the committee and to communicate with and inform colleagues about new protocols and their rationale. Our institution has more than 30 general internists who spend time teaching and caring for inpatients in the hospitalist service. The Diabetes Management Order Sets have helped these physicians improve the delivery of care to their patients with diabetes and hyperglycemia.

Included with many of the order sets are instructions that address the contingencies associated with insulin therapy. For example, the Insulin Order Set instructs nursing staff to hold nutritional insulin for a patient who is NPO without the need to call the physician for additional orders. For patients receiving enteral nutrition, dextrose-containing IV fluids are started without delay, helping reduce the risk of a hypoglycemic event. This has contributed to a greater comfort level for physicians and nurses in their attempt to achieve tighter diabetes control.

As teaching attending personnel, hospitalists are involved in conveying information regarding inpatient glycemic management to the house staff in their service. The introduction of order sets has increased house-staff attention to patient BG values and insulin orders. The inclusion of spacing for basal and nutritional insulin, together with correctional or SSI, on the Insulin Order Form reduces the tendency for ordering SSI alone as the primary form of insulin therapy.

As a result of the work of the DPSC, the culture of our institution has changed. As physicians modify current practice to achieve tighter glycemic control, it is hoped that there will be associated reductions in morbidity and hospital length of stay. Instructions to continue correctional insulin, even when a patient is not eating, have decreased the frequency with which nurses hold insulin. Overall, these order sets have contributed to the more consistent use of insulin in the hospital.

Some protocols have received variable acceptance among services and individual practitioners. For example, it was perceived that the DKA order set would interfere with the house staff’s ability to learn and understand the pathophysiology of DKA by reducing the likelihood that they would turn to well-accepted and highly regarded textbooks of internal medicine to guide their management. Countering opinions prevail. For example, a review of DKA in *Harrison’s Textbook of Internal Medicine* mentions that a relative or absolute insulin deficiency, combined with counter-regulatory hormone excess, is the cause of this disorder. Although this is important basic information for all physicians to know, the detailed description of the metabolic and enzymatic alterations in phosphofructokinase, pyruvate kinase, phosphoenolpyruvate carboxykinase, and the GLUT4 glucose transporter would not necessarily contribute to the management of a metabolically decompensated patient during an on-call day. The goal of the order sets is to make it easier to manage the many details involved in the glycemic management of a patient with diabetes or hyperglycemia. The primary purpose is to provide quality care to patients and to convey these messages to house staff, who will carry these learned lessons to their own practices.

CONCLUSION

Prior to establishment of the DPSC, the occurrence of hypoglycemia and hyperglycemia was not being reliably addressed despite the frequency with which it occurred. This fact was recognized following analysis of MET events, and spawned the formation of a committee initially focused on just one particular problem: the adverse consequences of hypoglycemia. From that narrow beginning, with the help of professionals from many fields, a comprehensive diabetes management program has evolved that is designed to prevent errors and promote euglycemia. This requires input from hospital administration, physicians, nurses, and pharmacists, representing many disciplines and specialties, and ongoing educational programs. We have generated data showing efficacy in terms of processes. In addition, we hope to show outcome benefit in the future.

ACKNOWLEDGMENT

This work was sponsored by funding from the United States Air Force, administered by the US Army Medical

Research Acquisition Activity, Fort Detrick, Maryland, Award No. W81XWH-04-2-0030.

We thank Glory Koerbel for her very careful manuscript review, and Tracey Banks for her technical assistance in preparing the manuscript.

Appendix
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RERERENCES

1. **Clement S, Braithwaite S, Magee MF, et al.** Management of diabetes and hyperglycemia in hospitals. *Diabetes Care.* 2004;27:553-591.
2. **Bhatia V, Wilding GE, Dhindsa G, et al.** Association of poor glycemic control with prolonged hospital stay in patients with diabetes admitted with exacerbation of congestive heart failure. *Endocr Pract.* 2004;10:467-471.
3. **Jeremitsky E, Omert LA, Dunham CM, Wilberger J, Rodriguez A.** The impact of hyperglycemia on patients with severe brain injury. *J Trauma.* 2005;58:47-50.
4. **Umpierrez GE, Isaacs SD, Bazargan N, You X, et al.** Hyperglycemia: an independent marker of in-hospital mortality in patients with undiagnosed diabetes. *J Clin Endocrinol Metab.* 2002;87:978-982.
5. **Garber AJ, Moghissi ES, Bransome ED Jr (American College of Endocrinology Task Force on Inpatient Diabetes Metabolic Control).** American College of Endocrinology position statement on inpatient diabetes and metabolic control. *Endocr Pract.* 2004;10:77-82.
6. **Trence DL, Kelly JL, Hirsch IB.** The rationale and management of hyperglycemia for in-patients with cardiovascular disease: time for change. *J Clin Endocrinol Metab.* 2003;88:2430-2437.
7. **Cely CM, Arora P, Quartin AA, Kett DH, Schein RM.** Relationship of baseline glucose homeostasis to hyperglycemia during medical critical illness. *Chest.* 2004;126:879-887.
8. **Pancorbo-Hidalgo PL, Garcia-Fernandez FP, Ramirez-Perez C.** Complications associated with enteral nutrition by nasogastric tube in an internal medicine unit. *J Clin Nurs.* 2001;10:482-490.
9. **McMahon MM, Rizza RA.** Nutrition support in hospitalized patients with diabetes mellitus. *Mayo Clin Proc.* 1996;71:587-594.
10. **Donihi AC, Rival D, Saul M, Korytkowski MT, DeVita MA.** Prevalence and predictors of corticosteroid-related hyperglycemia in hospitalized patients. *Endocr Pract.* 2006;12:358-362.
11. **Metchick LN, Petit WA Jr, Inzucchi SE.** Inpatient management of diabetes mellitus. *Am J Med.* 2002;113:317-323.
12. **Montori VM, Bistrrian BR, McMahon MM.** Hyperglycemia in acutely ill patients. *JAMA.* 2002;288:2167-2169.
13. **Magee MF, Clement S.** Subcutaneous insulin therapy in the hospital setting: issues, concerns, and implementation. *Endocr Pract.* 2004;10(Suppl 2):81-88.
14. **Baldwin D, Villanueva G, McNutt R, Bhatnagar S.** Eliminating inpatient sliding-scale insulin: a reeducation project with medical house staff. *Diabetes Care.* 2005;28:1008-1011.

15. **Davidson MB, Dulan S, Duran P, Bazargan M.** Indirect support for the use of supplemental insulin in hospitalized insulin-requiring diabetic patients. *Diabetes Care.* 2004;27:2260-2261.
16. **Smith WD, Winterstein AG, Johns T, Rosenberg E, Sauer BC.** Causes of hyperglycemia and hypoglycemia in adult inpatients. *Am J Health Syst Pharm.* 2005;62:714-719.
17. **Braithwaite RS, DeVita MA, Mahidhara R, et al.** Use of medical emergency team (MET) responses to detect medical errors. *Qual Saf Health Care.* 2004;13:255-259.
18. **Workgroup on Hypoglycemia ADA.** Defining and reporting hypoglycemia in diabetes: a report from the American Diabetes Association Workgroup on Hypoglycemia. *Diabetes Care.* 2005;28:1245-1249.
19. **Mitrakou A, Ryan C, Veneman T, et al.** Hierarchy of glycemic thresholds for counterregulatory hormone secretion, symptoms, and cerebral dysfunction. *Am J Physiol.* 1991;260(1 Pt 1):E67-E74.
20. **DiNardo M, Donihi AC, DeVita M, Siminerio L, Rao H, Korytkowski M.** A nurse directed protocol for the recognition and treatment of hypoglycemia in hospitalized patients. *Pract Diabetol.* 2005;22:37-40.
21. **Grasso BC, Rothschild JM, Jordan CW, Jayaram G.** What is the measure of a safe hospital? Medication errors missed by risk management, clinical staff, and surveyors. *J Psychiatr Pract.* 2005;11:268-273.
22. **Donihi AC, DiNardo MM, DeVita MA, Korytkowski MT.** Use of a standardized protocol to decrease medication errors and adverse events related to sliding scale insulin. *Qual Saf Health Care.* 2006;15:89-91.
23. **Cook CB, Boyle ME, Cisar NS, et al.** Use of continuous subcutaneous insulin infusion (insulin pump) therapy in the hospital setting: proposed guidelines and outcome measures. *Diabetes Educ.* 2005;31:849-857.
24. **Furnary AP, Gao G, Grunkemeier GL, et al.** Continuous insulin infusion reduces mortality in patients with diabetes undergoing coronary artery bypass grafting. *J Thorac Cardiovasc Surg.* 2003;125:1007-1021.
25. **Van Den Berghe G, Wouters P, Weekers F, et al.** Intensive insulin therapy in critically ill patients. *N Engl J Med.* 2001;345:1359-1367.
26. **Goldberg PA, Siegel MD, Sherwin RS, et al.** Implementation of a safe and effective insulin infusion protocol in a medical intensive care unit. *Diabetes Care.* 2004;27:461-467.
27. **Krinsley JS.** Association between hyperglycemia and increased hospital mortality in a heterogeneous population of critically ill patients. *Mayo Clin Proc.* 2003;78:1471-1478.
28. **Donihi AC, Rea R, DiNardo M, Korytkowski MT.** Development and implementation of an intravenous insulin infusion protocol in the medical intensive care unit. *Diabetes.* 2005;54(Suppl 1):A116. Abstract.