Abstracts

Can a Blood-Sparing Arterial Blood Sampling Device Improve Glucose Meter Performance in the Pediatric Intensive Care Unit?

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Objective:
Bedside glucose meters have been reported to be insufficiently accurate in the hospital setting and their use to guide tight glycemic control (TGC) is controversial. Poor meter performance may be partly due to sample dilution, which can be addressed by using a blood-sparing sampling device. We assessed the precision and accuracy of meter blood glucose (BG) measurements aided by a blood-sparing device in a pediatric TGC trial.

Methods:
A total of 338 children received postsurgical TGC in the cardiac intensive care unit (ICU). The blood-sparing device (VAMP Jr., Edwards LifeSciences) was introduced after completion of 10 subjects. Glucose meters (LifeScan SureStep Flexx) were checked every 0.5–6 h and BG was measured in a central laboratory (Bayer RapidLab 860) according to ICU standard care. Arterial whole blood was used for all measurements. Precision was evaluated by calculating the mean absolute relative difference (MARD) between meter measurements of two consecutively drawn samples. Accuracy was evaluated by calculating the MARD between meter measurements and the hospital laboratory. All paired BG measurements were resulted within 5 min of each other.

Results:
After introduction of the device, the MARD of repeat glucose meter checks decreased from 10.1% (N = 52) to 6.24% (N = 131, p = 0.02). There was no change in MARD between the meter and the laboratory from before (6.86%, N = 40) to after use of the device (7.16%, N = 643, p = 0.79). Clarke error grid analysis revealed 621 comparisons in region A, 21 in B, and 1 in D. Correlation between laboratory and meter BG was R^2 = 0.94.

Conclusion:
A blood-sparing sampling device improved the precision but not the accuracy of glucose meter measurements. Centers performing TGC should consider whether higher quality blood samples can be obtained before abandoning the bedside glucose meter.

Mobile Self-Management Tools: Could They Be Part of the Specialists' Service?

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Objective:
People with type 1 diabetes regularly face difficulties in managing their disease, and many look for tools and methods through which they seek to optimize their health and get aid with the problems surrounding the disease. We aim to use already widespread devices to offer a nonobtrusive system for diabetes self-management to those who need it.

Method:
By involving patients throughout the entire design phase and using the wireless communication standard Bluetooth®, blood glucose and step-count data are automatically transferred to the patient's phone, while food habits and other data are entered with a few touches in the user interface. The accumulated data set is used for model building aiming at a statistical predictive model for blood glucose. Health care personnel are involved in the second phase of the project, which is integrating the patient-centered system as part of the specialists' service.

Result:
The mobile phone-based self-monitoring system application called Few Touch was originally developed for the needs and preferences of people with type 2 diabetes and is currently being adapted to type 1 diabetes. An easy way of entering insulin data via the phone's touch-sensitive screen has been added, making the system complete with regards to monitoring blood glucose in relation to nutrition, physical activity, and medication.

Conclusion:
We are currently fine tuning the system in a way that provides people with type 1 diabetes, with their individual needs and preferences, useful processed feedback via the mobile phone. Simultaneously, various routines for integrating the system with the specialists' service to the patients will be tested in real-life settings before the main trials in autumn 2010 (Seattle, WA) and spring 2011 (Tromsø, Norway).

Automated Computerized Hypoglycemia Protocol for Treatment, Prevention, and Awareness of Hypoglycemia in Non-Intensive Care Unit Hospitalized Patients

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Objective:
Hypoglycemia is a major limiting factor in the treatment of hyperglycemia. We introduced an automated computerized hypoglycemic protocol as part of the new computer provider diabetes order set.

Method:
This hypoglycemic protocol was implemented as a quality improvement project in a single medicine ward at the Veterans Affairs Medical Center. As a safety measure, this protocol was automatically activated as a nursing order when the diabetes order set was initiated. This included instructions for specific action for a hypoglycemic episode based on severity of hypoglycemia. A multidisciplinary team developed Web-based educational modules and pocket guides for providers. The pocket guides have easy mnemonics prompting a recheck and retreat approach with instructions to avoid undertreatment or overtreatment of hypoglycemia. A supply of glucose gel and glucagon was added to pharmacy stock on medical floors in addition to D50 to implement the protocol better. Hypoglycemia was defined as glucose levels less than 70 mg/dl to initiate protocol, but levels of 70–100 mg/dl were also vigilantly monitored to prompt an adjustment in regimen to avoid hypoglycemia. A computerized system was used to track high-risk patients discharged on a new insulin regimen to provide better follow-up.

Result:
The hypoglycemic protocol was well accepted by resident physicians and nurses. This automated protocol enables the nursing staff to act quickly to ensure patient safety during a hypoglycemic episode. The protocol also prompts physicians to adjust hyperglycemic regimen for persistent low normal blood glucose levels. The computerized tracking of patients enables appropriate follow-up after discharge.

Conclusion:
Automated hypoglycemic protocol with computerized order sets and Web-based education modules have reduced hypoglycemia and improved inpatient diabetes care.

Hospital Reimbursement for a Diabetes Self-Management Training/Education Program

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Objective:
The aim was to discuss coding and reimbursement issues with administration, contracting, and business office while providing a multidisciplinary approach to care coordination for a hospital-based diabetes self-management training/education (DSMT/E) program.

Method:
Coding, billing, and reimbursement continue to be an issue for hospitals across the country. Today's diabetes practice hospitals are closing DSMT/E programs at an alarming rate. Diabetes educators are reviewing their roles and responsibilities while thinking "outside the box" to provide diabetes education to these patients and to include adding medical nutrition therapy to compliment the DSMT/E. Developing different perspectives in managing the business of diabetes is essential to the survival of hospital diabetes programs. Developing relationships with insurance case management, seeking grants to provide funding for diabetes education, and other innovative measures are essential to a program's survival. This presentation will present case studies regarding these issues.

Result:
The American Association of Diabetes Educators and American Dietetic Association have published studies regarding DSMT/E and patient outcomes. Although outcome measures are improved, reimbursement, at this time, needs to be enhanced.

Conclusion:
Patient outcome data will continue to be collected to demonstrate the importance of DSMT/E programs. Organizational leadership is necessary to promote legislation for support of DSMT/E programs to improve reimbursement.

Computerized System to Monitor Point-of-Care Glucose in Hospitalized Patients in a Tertiary Care Center

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Objective:
Effective monitoring of glycemic excursions in hospitalized patients remains an area of active investigation, especially because patient-important outcomes are linked to both hyperglycemia and hypoglycemia. Such surveillance is challenging in a tertiary care center with a large and heterogenous inpatient population and diverse care providers. We conducted a quality improvement project aimed at identifying patients with point-of-care glucose levels significantly out of range and designed a process to communicate recommendations for glucose management to the care provider team.

Methods:
A computerized rule-based system was developed that scans the electronic laboratory database of Mayo Rochester Hospitals every 24 hours. The database includes all hospitalized patients. The following rules reflecting significant hyperglycemia and hypoglycemia were created: (a) glucose <40 mg/dl; (b) glucose >400 mg/dl; and (c) three successive glucoses >250 mg/dl. Electronic reports were generated daily at 0600 for each rule violation that includes patient identifiers, hospital location, glucose values, and primary service details. Reports were sent to a small group of diabetologists and diabetes nurse practitioners who then reviewed each case and provided remedial suggestions for glucose management through the internal electronic messaging system to primary providers to prevent recurrence of rule violations.

Results:
This project has been well received by hospital providers, including staff physicians, surgeons, and residents, as a valuable monitoring and educational tool. Based on enthusiastic support, we are upgrading the system to provide better tracking, data management, and evaluation and reporting of frequency of hypoglycemia/hyperglycemia in our hospitalized patients.

Conclusions:
A computerized monitoring system is a promising tool to monitor and potentially favorably impact glycemic control and morbidity in hospitalized patients.

Six-Sigma Team Develops an Electronic Order Set for Insulin Management and Dosing

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Objective:
The purpose of the Glucose Management Process Excellence Project (PEP) team was to improve and standardize insulin management practice. The team's goal was to increase the overall rate of adult inpatients managed within the optimal glycemic range of 80–180 mg/dl. The team utilized the hospital's overall glucometric data to establish the baseline rate of 62%. The challenge was to increase the percentage of patients managed in the goal range to 90% or higher.

Method:
Developing solutions for complex, chronic, systemic problems requires management commitment of resources coupled with using an improvement process such as Lean Six Sigma. The improvement team followed the Six-Sigma Define, Measure, Analyze, Improve, Control (DMAIC) methodology. One of the requirements of DMAIC is to include process experts from all necessary disciplines. The PEP team includes members from the following areas:

- Project champion—Vice President of Nursing
- Black belt—Process Engineer
- Physician champion—Endocrinologist
- Process owner—Director of Operations (heart service line)
- Senior systems analyst
- Pharmacist
- Two clinical nurse specialists
- Registered dietician
- Four registered nurses (various clinical units)
- Glucose point-of-care coordinator

Result:
The team developed an electronic physician order set (I-Form) connecting all components of this complex system. The connectivity includes: pharmacy orders, nursing orders, laboratory orders, nursing hand-held scanners, and physician order entry, including a weight-based insulin dosage calculator.

Conclusion:
The standardized best practice improvements thus far have increased the overall hospital glucometric rate by 20%. The team is confident in achieving by year end their 90% target of managing adult inpatients within the optimal glycemic range of 80–180 mg/dl.

Simplified Intravenous Insulin Infusion Protocol for Glycemic Control in Critical Care

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Objective:
Our aim was to evaluate the efficacy and safety of a simplified intravenous insulin infusion (IVII) protocol for glycemic control in critically ill patients in a nonteaching, community hospital.

Method:
Retrospective chart review of all intensive care unit (ICU) and critical care unit (CCU) patients at Centennial Medical Center treated in 2009 with a modified IVII protocol. The IVII protocol consists of a table of insulin infusion rates (IIR) in five columns (A–E) for specified blood glucose (BG) ranges. The IIR (U/h) were calculated using the formula IIR = (BG - 60) × ISF, where BG is the midpoint of the specified glucose range and ISF represents insulin sensitivity factor (columns A–E: 0.02, 0.03, 0.04, 0.06, and 0.08). All patients started in column B (unless otherwise specified by the ordering physician), and shifting between columns was specified according to subsequent BG response. Capillary BG was measured hourly. The specified BG target adapted from the 2006 American College of Endocrinology and American Diabetes Association consensus guidelines is 80–120 mg/dl.

Result:
We identified 58 ICU or CCU patients (mean ± standard deviation; age 63 ± 14 years; 27 male and 31 female) treated with the IVII protocol during the study period. Initial BG was 259 ± 140 mg/dl (range, 103–932). Duration of IVII treatment was 32 ± 25 h (range, 6–128). Time to achieve the BG target was 9 ± 14 h (range, 0–128) in the 55 patients who achieved target BG. After achieving target, 59% ± 24% and 72% ± 23% of subsequent BGs were maintained between 80 and 120 mg/dl and 80 and 140 mg/dl, respectively. The incidence of BG <60 and BG <40 was 10.3% and 0% of patients, respectively.

Conclusion:
The simplified IVII protocol described is safe and efficacious for achieving tight glucose control in hyperglycemic critically ill patients in a nonacademic community hospital setting. This IVII protocol does not require nurses to utilize complicated equations or rate-of-change calculations.

Telemedicine Treatment of Diabetic Foot Ulcer Patients: "The New Patient Way"

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Objective:
Diabetic foot ulcers remain a serious threat to diabetes patients, leading to diminished quality of life, a long-term course of treatment with frequent contact with health care professionals, and amputations. Not only is this an economic and resource-demanding burden on the system, but it is also demanding for the patients in terms of time, efforts, and the reduction in quality of life. A Danish study has shown that telemedicine is a new way of meeting the demand of the patient that has led to a current national demonstrator project.

Method:
A participatory design process was used (workshops, field studies, questionnaires, interviews, clinical experiments, and pilot tests), involving participants from the Danish primary and secondary sectors, industry, and patients/relatives.

Result:
The telemedicine treatment was found satisfactory among patients and health professionals. For the patients, the time saved for visits to the outpatient clinic was a major improvement. In addition to avoiding waiting time and transportation costs, maintaining employment was an essential issue for the patients and their quality of life. Furthermore, the patients and their relatives were far more active in the consultation—while sitting in their own chair. This involvement provided a better basis for decision making for the doctor. The new collaboration between sectors translated to far better treatment of the ulcers.

Conclusion:
The upcoming generations will expect health care systems to organize services in a way that is convenient and flexible for patients and that will involve themselves as a resource. The mobile and simple technological setup for telemedicine treatment of foot ulcers is one method—a method speaking to the young generations who have problems seeing themselves as traditional patients in an outpatient clinic.

Connectivity Informatics to Assess Inpatient Glucose Control: An Update on 576 Hospitals in the United States

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Background:
Hospital hyperglycemia management has been ongoing in most U.S. hospitals. Inpatient glucose quality improvement initiatives can be supported with better reporting for clinician understanding. We previously described the utility of connectivity informatics to evaluate inpatient glucose control in a smaller sample of U.S. hospitals, and now provide data from 576 hospitals.

Methods:
The Remote Automated Laboratory System-Plus was used to extract point-of-care bedside glucose (POCBG) tests from 576 hospitals (533 intensive care units [ICUs]) from January to December 2009. Mean POCBG and hypoglycemia/hyperglycemia rates were calculated for ICU and non-ICU. The relationship of POCBG levels with hospital characteristics was determined.

Results:
A total of 49,191,313 POCBG measurements were analyzed: 12,176,299 from ICU and 37,015,014 from non-ICU patients. Mean POCBG was 167 mg/dl for ICU and 166 mg/dl for non-ICU. Mean hyperglycemia (>180 mg/dl) prevalence was 32.2% of patient days for ICU and 32.0% for non-ICU patient days. Hospital hypoglycemia (one measure of <70 mg/dl) prevalence was 6.3% for ICU and 5.7% for non-ICU. For ICU and non-ICU, there was a significant relationship between number of beds and hospital type and mean POCBG levels, with larger (≥400 beds) and academic hospitals having lower mean POCBG than smaller, (<400 beds) rural and community hospitals ($p < .001$).

Conclusions:
In this largest sampling reported to date, POCBG data captured through automated laboratory data management software can support hospital efforts to monitor inpatient glycemic control and examine disparities among hospital characteristics. Increased hospital participation in RALS reporting supports a national benchmarking process for the development of inpatient hyperglycemia management best practices.

Glucommander™, a Computerized Intravenous Insulin Controller (CIIC) Produces Over a Magnitude Less Hypoglycemia Than Published Protocols: -0.3% versus 12.6%

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Objective:
The aim was to compare hypoglycemia between a computerized insulin controller (CIIC) and paper protocols, and also to compare between CIIC and Normoglycemia in Intensive Care Evaluation Survival Using Glucose Algorithm Regulation (NICE-SUGAR) trial. Many randomized controlled trials (RCTs) have concluded that normoglycemia is the ideal target range for intravenous (IV) insulin treatment, but a large number of these studies have failed to achieve this goal without severe hypoglycemia (5.2% to 28.6% of patients in the studies reviewed). NICE-SUGAR observed significantly higher mortality in the intensively managed group. Considering that the reason for the higher mortality may be the hypoglycemia, the recommended target ranges of ADA/AACE have been revised from 80–120 to 140–180 mg/dl.

Method:
ACIIC advises IV insulin infusion settings to control blood glucose (BG) to any desired target with a low standard deviation and with very limited hypoglycemia. When BG does drop, insulin is phased out while enteral or parenteral nutrition continues. Additionally, carbohydrate intake is augmented with a D50 correcting dose to raise BG to mid-target range. CIIC has been used in more than 100 hospitals and is currently available to any investigators proposing a publishable trial.

The four versions of CIIC and data:

- Version 4, used since 1992: 3095 runs having 0.3% <40 mg/dl, BG mean = 115 ± 18.
- Surg ICU, cardiovascular surgery study by authors: 238 runs, having zero% <40 mg/dl, BG mean = 103 ± 19.
- Med ICU, multicenter medical ICU RCT: 79 runs, having 2.9% <40 mg/dl, BG mean = 102 ± 26.
- G+, a multicenter commercial version: 1019 runs, having 0.49% <40 mg/dl, BG mean = 104 ± 18.

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Davidson cont. ⟶

Results:

- CIIC, pooled from 10 hospitals: 5082 runs with 0.3% <40 mg/dl.
- Paper algorithms: 5135 patients, having 12.6% with BG <40 mg/dl.
- NICE-SUGAR: 3034 patients, having 6.8% with BG <40 mg/dl.

Conclusion:
All CIIC versions show BG mean in normoglycemic range. Chi-squared analysis showed that hypoglycemia is significantly less (p <0.0001) than either NICE-SUGAR or the paper protocols.

The Science of Inpatient Diabetes Communication: Health Care Provider to Health Care Provider and Health Care Provider to Patient

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Objective:
Effective communication between health care providers and between providers and patients is key to positive outcomes. Communication should not be ignored or left to old habits proven counterproductive. We review the literature and discuss practical examples.

Method:
Literature review of diabetes communication research, including 2010 evidence-based American Diabetes Association Clinical Practice Recommendations, demonstrates improved glycemic, quality-of-life, and costs outcomes. Negative outcomes of language between health care providers, including the terms "noncompliant" and "sliding scale insulin," are noted. Medical research and adult learning theory expose misconceptions that influence providers. Specific, time-saving patient examples are demonstrated, such as, "Will you tell me more about what you've heard about starting insulin?" which provides opportunities for solicited advice, collaboration, and teach back rather than an often drawn-out confrontation or persuasion model for inconsistent obedience, not optimal outcomes. Additionally, "Let's look at your blood sugar records and decide on our next move" employs scientific self-determination and motivational methodology.

Result:
The empowerment-based model in diabetes has become standard of practice, and research uses models such as motivational interviewing. Despite endorsements by professional bodies that these models are foundational for care delivery, these techniques may still be viewed by some as primarily for professionals without prescriptive authority rather than as critical tools for all diabetes experts.

Conclusion:
No physician or other provider has the time to try to undo the effects from acute illness model communication habits, which are often demonstrated for patients and health care provider learners. Since over 98% of care is carried out by patients, one of our most important inpatient tools is to role model appropriate problem solving in order that patients are helped with skill enhancement for daily decision making.

Serum Glucose: An Independent Predictor of Outcome in Aneurysmal Subarachnoid Hemorrhage Patients

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Introduction:
Hyperglycemia is common after aneurysmal subarachnoid hemorrhage (aSAH). Admission hyperglycemia and postoperative hyperglycemic episodes may predispose a patient to poor outcome after aSAH. However, it remains unclear if a single episode of hyperglycemia and/or persistent hyperglycemia is an independent predictor of outcome in aSAH patients.

Methods:
A retrospective institutional-review-board-approved chart review was undertaken of patients who had an aSAH. The Hunt and Hess (H–H) grade for the individual patients, admission serum and cerebral glucose, serum glucose on the day of surgery and 14 days postoperation, and the extended Glasgow Outcome Scale (GOS-E) at discharge were obtained.

Results:
Between January 2005 and January 2010, 1192 aSAH patients were identified. Hyperglycemia (serum glucose >140mg/dl) on admission and elevated mean serum glucose (serum glucose >140mg/dl) during hospital course was associated with poor outcome (GOS-E ≤6) and increased risk of mortality. No mortalities occurred in aSAH patients without hyperglycemia on admission. Patients with higher serum glucose on admission were associated with higher H–H grades (Spearman's $\rho = 0.36$). Admission serum glucose >151.58 mg/dl (95% confidence interval: 141.36–160.63) was associated with the most statistically significant effect on outcome. Greater period of hyperglycemia leads to poorer outcome. Hyperglycemia ≥5 days was associated with 100% poor outcome (GOS-E ≤6).

Conclusion:
Both hyperglycemia on admission and elevated mean serum glucose during hospital course were independent predictors of poor outcome in aSAH patients. Serum glucose >150mg/dl may be a cutoff point for poor outcome. Greater period of hyperglycemia leads to poorer outcome.

Utilizing Certified Diabetes Nurse Educators (Registered Nurses/Certified Diabetes Educators) to Improve Inpatient Care Beyond the Typical Patient Education Role

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Objective:
Certified diabetes educators (CDEs) meet academic and professional requirements set forth by the National Certification Board for Diabetes Educators. Certified diabetes educators have been associated with patient education interventions; however, could CDEs improve inpatient management, length of stay, readmission rates, and returns to outpatient education centers?

Method:
At Baptist Hospital of Miami, a 578-bed community, not-for-profit hospital, a CDE sees patients with diabetes or hyperglycemia to provide survival skill education. Despite preprinted medical protocols, we had not improved our glycemic control (70–150 mg/dl) since 2009. Despite mandatory nursing and physician in-services, misinformation still existed among our nursing and physician staff.

We assigned a registered nurse/CDE to a 48-bed, medical–surgical unit for 4 h/day for 3 months to evaluate every patient on that unit with either known diabetes or hyperglycemia. Of the 232 patients seen, 12 had type 1 diabetes, 186 had type 2 diabetes, 9 had prediabetes, and 25 were hyperglycemic but undiagnosed. Daily interventions included review of chart, blood glucose control, and hemoglobin A1c results. Medical needs were alerted to the advanced registered nurse practitioner or physician. Discharge planning and patient and staff education took place as needed in a timely fashion.

Result:
There was a significant difference in blood glucose scores (p = .000), a mean reduced length of stay of 0.716 days, and a reduced readmission rate from 22% to 16%. Returns to the outpatient education center remained the same.

Conclusion:
Reduced expense of shorter lengths of stay, reduced readmissions, and improved glucose control all led to the conclusion that employing a CDE in all inpatient units could be financially advantageous as well as the right thing to do for improving patient care.

Management of Postoperative Hyperglycemia in Diabetic and Non-Diabetic Patients with a Non-Critical Care Insulin Infusion Protocol

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Objective:
Creation and implementation of a nurse-driven insulin infusion protocol to maintain postoperative hyperglycemic patients within a blood glucose range of 80–180mg/dl for at least 24 h after surgery.

Method:
All postoperative patients admitted for a 1-month period were screened by Glucoscan for inclusion. Any patient with a Glucoscan greater than 150 mg/dl in the recovery room was initiated on the insulin infusion protocol. The insulin infusion was titrated to maintain a target blood glucose range of 80–180 mg/dl for at least 24 h postoperatively. Patients who were eating received supplemental insulin coverage for food consumed.

Result:
A total of 303 patients were screened in the recovery room, with 54 patients initiated on the insulin infusion protocol. The average age, weight, number of Glucoscans, and time on infusion were 59.6 years (range 22–91), 92.8 kg (range 49–145 kg), 15.7/patient, and 16.3 h/patient, respectively; 61% of patients had no history of diabetes. Glucoscans were maintained in the 80–180 mg/dl range 76% of the time (66% diabetes, 84% no diabetes). Three patients had a Glucoscan less than 80 mg/dl, but none had Glucoscans less than 60 mg/dl. The average time to achieve a Glucoscan of less than 180 mg/dl was 1.5 h (average 2.6 h for diabetes patients, 0.67 h for patients without diabetes).

Conclusion:
The postoperative insulin infusion protocol is safe and effective for management of postoperative hyperglycemia in both diabetic and non-diabetic patients.

Practice Makes Perfect: Improvement in Management of Blood Glucose in Surgical and Burn Intensive Care Units as a Function of Experience

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Objective:
We previously reported an increased survival rate in surgical intensive care unit (ICU) and burn ICU patients with the initiation of intensive insulin therapy (IIT) to achieve tight glycemic control (a day 3 average blood glucose level of ≤150 mg/dl). Four years after IIT protocol implementation, we reviewed its effect over time on sepsis and mortality rates.

Methods:
From October 2006 to February 2010, 3977 patients were admitted to surgical/burn ICUs. A total of 388 patients admitted to the ICUs required IIT, and 86 remained on IIT for 72 h. We evaluated the effect of prolonged use and expertise of IIT with regard to the prevalence of sepsis and mortality as a function of four successive 10-month intervals.

Results:
Of the 86 patients who were on IIT, 45 achieved a day 3 average blood glucose level ≤150 mg/dl. Hospital deaths were significantly reduced in the tight control group at every interval. Frequency of hypoglycemia (blood glucose <60 mg/dl) was <1% throughout the 4 years in both groups.

Conclusion:
A larger percentage of patients achieved tight glycemic control each year following implementation of IIT. This is primarily because of increased familiarity in adjustment of insulin administration by the ICU staff. Significant reduction in sepsis and mortality is observed when tight glycemic control is achieved.

Insensitivity of Hemoglobin A1c to Assess Preoperative Diabetes Risk

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Objective:
The American Diabetes Association has revised the diagnostic criteria for impaired glucose tolerance (IGT) and type 2 diabetes mellitus (T2DM), with the inclusion of the hemoglobin A1c (HbA1c). We evaluated the performance of the HbA1c (commonly checked preoperatively in cardiac surgery patients at our institution) compared with the standard oral glucose tolerance test (OGTT) for detecting IGT and T2DM.

Methods:
Preoperative OGTT and HbA1c were obtained in 200 cardiac surgery patients with no history of T2DM. Pearson coefficient of correlation was calculated using SAS (SAS Institute, Cary, NC).

Results:
Preliminary data obtained in 65 patients—64% male, mean age of 60.8 ± 13.6 years, and body mass index of 29.3 ± 5.9 kg/m^2—show a mean fasting blood glucose of 100.2 ± 14.8 mg/dl, a 2 h mean blood glucose after OGTT of 113.1 ± 38.7mg/dl, and a HbA1c of 5.8% ± 0.5%. By OGTT criteria, 51% of patients had IGT, 4.6% had T2DM, and 45% of patients had normal glucose tolerance. By the new HbA1c criteria, 55% had IGT, 9% had T2DM, and 34% of patients were normal. The Pearson Correlation Coefficient between fasting glucose and HbA1c was 0.4 (p = .001), indicating a significant weak positive correlation, while that of 2 h post OGTT glucose and HbA1c was 0.2 (p = .18). Twenty-seven percent of patients identified with IGT by OGTT were missed, and 54% of patients with normal OGTT were classified as IGT when using the HbA1c criteria.

Conclusion:
These preliminary data suggest that a preoperative HbA1c alone is less sensitive for detecting IGT in cardiac surgery patients. Ongoing analyses are evaluating the performance of the HbA1c in the rest of the cohort.

Improvement of Diabetes Care in a Large University Tertiary Care Hospital

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Objective:
Hackensack University Medical Center is a 781-bed university teaching hospital with tertiary services for cardiothoracic surgery as well as renal and stem cell transplantation. Twenty percent of our inpatients have diabetes and a smaller percentage are hyperglycemic. After establishing an inpatient diabetes team in 2006, we expanded to combine our inpatient and outpatient staffs in an attempt to improve diabetes care. We aim to identify uncontrolled diabetes patients, improve and standardize their care throughout the medical center, educate staff in diabetes care, identify and treat hypoglycemia appropriately, obtain diet counseling, and refer for continued outpatient education.

Method:
We created a team with a medical and administrative director, clinical coleaders, and staff for implementation. A multidisciplinary performance improvement (PI) team was created to report to our Joint Commission Steering Committee regularly. The PI team comprised representatives from information technology, medical administration, departments of nursing administration, nursing staff, clinical education, nutrition, pathology, PI, pharmacy, and rapid response team.

We chose four performance measures:

1. Hemoglobin A1c during hospitalization or within 60 days prior
2. Survival skills education
3. Hypoglycemia treatment and documentation
4. Nutrition assessment within 3 days for hemoglobin A1c >7%.

Results:
Our results for 1 year (January 2009–December 2009) showed the following degree of improvement:

First quarter through fourth quarter:

1. 54% to 88%
2. 32% to 74%
3. 25% to 45%
4. 88% to 95%

Giangola cont. ⟶

Giangola cont. ⟶

Conclusion:
Obtaining Joint Commission Inpatient Diabetes Certification improved diabetes care at Hackensack University Medical Center. The involvement from executive administration to personnel delivering the food trays was necessary. We are certain that we have "changed the culture" with respect to diabetes care at our medical center.

Technology Can Translate to Quality: Use of Computerized Physician Order Entry to Achieve Optimal Glycemic Control

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Objective:
Improving all levels of care associated with the patient who is hyperglycemic and hospitalized is a focused priority at Summa Akron City and St. Thomas Hospitals. These efforts were escalated through the development and implementation of three electronic order sets that incorporate basal, prandial, and correctional options. These order sets were piloted on a 30-bed medical telemetry unit. As a result of the successful outcomes identified during this pilot, mandatory use of these order sets have been implemented throughout the organization.

Method:
The basis of this project is patterned after the RABBIT 2 Trial, in which patients were given a basal–bolus insulin program that was compared to a program of only sliding scale insulin for efficacy in terms of glycemic control and hypoglycemia. That trial demonstrated superiority in terms of the ability to control blood glucose level and demonstrated that basal–bolus ordering is safe. At Summa, through computer-based technology, clinical decision support features were embedded into the order sets. These features facilitate appropriate basal and prandial dosing. Two order sets are weight-based and autocalculate appropriate basal and prandial doses. Another clinical decision support feature includes a physician prompt that requires the physician to document variance from established standards of care.

Result:
Pilot findings demonstrated overall improvement in hyperglycemic management. This included improvement in achieving target blood glucose range and a decrease in sole use of sliding scale insulin. The implementation of computerized physician order entry (CPOE) has enhanced the ability to deliver coordinated, evidenced-based care.

Conclusion:
The use of CPOE technology has been an enormous and transformational change for the organization. It is a key mechanism to assure delivery of evidence-based care and the achievement of exceptional quality outcomes.

The Importance of Correcting Anion Gap for Albumin and Evaluation of Hyperchloremia in the Management of Diabetic Ketoacidosis

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Background and Objectives:
In diabetic ketoacidosis (DKA), the routine approach to assess and to guide insulin therapy has been the calculation of anion gap (AG). However, AG is markedly affected by serum albumin levels and infusion of large volumes of saline.

The objective was to evaluate the extent of hyperchloremia and the impact of correcting for hypoalbuminemia during evaluation of acid–base status in DKA management.

Methods:
A total of 60 patients with DKA were reviewed (January 2007–October 2008) in a 450-bed acute care hospital. Hyperchloremia and hypoalbuminemia are defined as the ratio of chloride (Cl)/ sodium (Na) >0.79, and albumin <3.4 g/dl, respectively.

Results:
There were 37 males (62%) and 23 females (38%) with an overall mean age of 41 years (19–75). The chief complaint was nausea and vomiting. Noncompliance was the major precipitating factor (63%). Initial (T_0) mean serum albumin, Cl, and glucose were 3.9g/dl, 99 mEq/liter, and 623 mg/dl, respectively. At the end of insulin infusion (T_1) mean serum albumin, Cl, and glucose were 2.9 g/dl, 112.5 mEq/liter, and 167 mg/dl, respectively. Anion gap and corrected AG to albumin were 26 and 25.9 at T_0 and 6.8 mEq/liter and 10.8 mEq/liter at T_1. The number of patients with hypoalbuminemia and hyperchloremia increased from 17/60 (28%) to 40/60 (66%) and 8/60 (13%) to 47/60 (78%), respectively ($p < .001$).

Conclusion:
After fluid resuscitation, a majority of patients will reduce albumin levels substantially, markedly altering AG. Due to the marked increase in Cl from 99 at T_0, to 112.5 at T_1, the "Na-Cl" increased 9 mEq/liter. Thus the normalization of AG at T_1 is partially due to the elevation of plasma Cl due to the infusion of saline. We suggest that correction of AG for hypoalbuminemia is crucial to assess acid–base status in DKA patients.

A "BBIT" of Change: An Intervention Promoting the Use of Basal Bolus Insulin Therapy in Hospitalized Patients with Diabetes

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Objective:
The aim was to implement and evaluate an educational and technological initiative promoting basal bolus insulin therapy (BBIT). We hypothesized that BBIT would reduce the frequency of hyper- and hypoglycemic events and reduce the length of hospital stay as BBIT provides a logical transition to home insulin regimens when compared to sliding scale insulin (SSI) use.

Methods:
Analysis of the electronic health records for patients admitted to the Medical Teaching Unit (MTU) prompted us to introduce a new diabetes management tool on the MTU emphasizing BBIT as a replacement for the commonly used prescription of SSI. Implementation involved a multidisciplinary educational initiative, including seminars for nursing and resident staff, and the development of a Web-based teaching tool focusing on BBIT prescription and adjustment. A subsequent evaluation of the number of patient-days that met the recommended glycemic targets, the frequency of hyper- and hypoglycemia, and the length of hospital stay were compared to patients treated with SSI. Development of simplified electronic ordering and clinical decision support tools are underway.

Results:
Pre-intervention, SSI had an increased frequency of extreme hyperglycemia (BG >18 mmol/liter, 4.4% versus 8.1%, $p < 0.0001$), an increased incidence of hypoglycemia (BG <4 mmol/liter, 3.5% vs. 3.1%, $p = 0.045$), and a longer length of stay (27.7 days versus 16.0 days, $p = 0.0002$) when compared to those not treated with SSI. Initial post-intervention data suggested that BBIT, when compared to SSI, was associated with a 65% reduction in hypoglycemic events, a 51% reduction in hyperglycemic events, and a 28% increase in patient-days entirely within glycemic targets.

Conclusion:
The BBIT protocol reduces hyper- and hypoglycemic events in the hospital and our hope is that this will translate into decreased length of hospital stay.

User Study of an Inline Blood Glucose Monitor

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Objective:
The goal of this study was to evaluate the ease of use and *in vitro* performance of an inline glucose measurement system of healthy human donor blood under the operation of multiple users with various levels of device experience.

Method:
The Luminous blood glucose monitor [(LBGM), Luminous Medical, Inc., Carlsbad, CA] consists of a flow-through glucose oxidase sensor positioned in an arterial, central venous, or peripheral venous line with a patient-dedicated extracorporeal sensor set and a blood-conserving device. Whole blood samples were collected from three healthy human donors under informed consent and spiked with glucose to achieve native, 200, and 400 mg/dl target levels. Two LBGM systems were evaluated in this 3-day study. A total of 240 glucose measurements were made by four users: two experienced with the system and two new to the system. New users received 15 min of hands-on training and one page of written instructions prior to testing. The LBGM results were compared with YSI 2700 (YSI, Inc., Yellowstone, OH) reference measurements.

Results:
The LBGM results met ISO 15197 accuracy requirements (232/240 measurements within limits). Ninety-five percent of the results (228/240) were within either ±9% for values less than 72 mg/dl or ±12.5% for values greater than 72 mg/dl. No statistically significant difference in performance between experienced users and new users was observed.

Conclusion:
Luminous glucose sensing technology provides highly accurate glucose measurements when performed by multiple users at various levels of experience with the system.

Automated Blood Glucose Monitoring in the Operating Room/Intensive Care Unit

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Objective:
Dexcom, Inc. and Edwards Lifesciences, LLC, collaborated to develop an intravenous blood glucose monitoring system for use in critical care patients. This study compared the performance of the system to laboratory analyzers when used in the operating room (OR) and intensive care unit (ICU) and included typical drugs used in the critical care setting.

Method:
This was a blinded multicenter study evaluating 22 adult patients presenting to the OR and ICU. Eligible subjects included adults scheduled for elective-emergent surgery or admitted to the medical/surgical ICU with an anticipated stay of at least 24 h. Each patient was monitored for up to 72 h with reference samples taken at 4 h intervals and measured with a YSI 2300 laboratory analyzer. Data are from initial roll-in patients used for training and assessing protocol complications. Reference blood samples were taken from either a peripheral vein, central venous catheter, or an arterial line. Glucose values were calculated prospectively but not displayed during the study.

Result:
Of 211 paired blood glucose measurements, 94.3% were within Clarke error grid A, 5.7% in B, and 0% in C, D, and E. The mean absolute relative difference (MARD) was 6.5%. No significant errors due to drugs were measured. These results compare favorably to a previous study of 50 subjects who were monitored continuously for up to 72 h in a diabetes in-clinic study where large excursions of blood glucose could be safely evaluated. That study acquired 2815 data points and resulted in a MARD of 6.6% with 95.1% within the accuracy requirements of ISO 15197.

Conclusion:
The results of this study help illustrate the capability of the system to provide safe, accurate, automated glucose measurements in critical care patients.

Hyperglycemic Patients Not Previously Known to Have Diabetes Are Less Likely to Receive Variable Insulin Glucose Infusions during Admission into Coronary Care Units

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Objective:
Achieving normoglycemia during myocardial infarction has been shown to improve clinical outcomes. A variable insulin glucose (VIG) protocol was established to assist staff in a coronary care unit (CCU) to manage patients admitted with hyperglycemia (glucose >11 mmol/liter) and acute coronary syndromes (ACS). The aim of this retrospective analysis was to assess the staff attitude, compliance, and application of the VIG protocol in the management of hyperglycemia in these patients during their admission in CCU.

Method:
A database of patients aged between 18 and 85 years who were admitted to the CCU with ACS and hyperglycemia in a U.K. hospital between January and December 2007 were examined for the use of VIG. Patients with severe heart failure (New York Heart Association class IV) and severe renal failure (glomerular filtration rate <30) were excluded from the study.

Results:
One hundred and six patients (69% male; mean age 59 years) were identified; 66 (62%) were not previously known to have diabetes (NkD), and of the 40 known diabetes patients, 16 (40%) were on insulin. Only 53 (50%) had VIG infusion commenced, and of these, only 10 (20%) were NkD patients. None of these patients were referred to the diabetes team after 48 h of VIG infusion for consideration of long-term insulin therapy. Only 13 NkD patients were referred to their primary care physician for postdischarge glucose tolerance test and possible lifestyle modification measures.

Conclusion:
This study demonstrates that the use of the VIG protocol by staff in the CCU needs improvement. Crucially, NkD patients are less likely to be administered VIG and do not have their admitting hyperglycemia communicated to primary care physicians. This could contribute to the higher inpatient and long-term mortality already observed in this group of patients in several studies.

Improving Care for Patients with Insulin Pumps in the Hospital

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Objective:
The aim is to improve systems and processes that facilitate multidisciplinary efforts to care for patients who maintain the use of their own insulin pumps in a hospital setting.

Method:
A quality-improvement process was undertaken in the fall of 2009 using the Plan-Do-Check-Act methodology. The availability of insulin pump resources was assessed, and a plan was identified for improvement.

Results:
A variety of resources were developed, many of which were improvements within the electronic medical record. A new policy provides direction about the appropriateness of patients remaining on pumps and specifies how to assess and document pump competence. It dictates which new order sets must be utilized and outlines nursing documentation requirements. A nursing practice guideline was written that led to the creation of other nursing-specific resources for assessment, management, and patient and family education. Staff education about all these resources is in process.

Conclusion:
The use of insulin pumps by those with all types of diabetes is growing; naturally, the number of patients admitted to acute care settings using insulin pumps may also increase. Very little guidance exists in the literature about how to provide safe care for these patients. Clinical practice recommendations can be helpful in guiding organizations and care providers toward improved systems and processes. Standardization of provider orders, clearly written policies, assessment and documentation tools, and patient and staff education have great potential to improve the care provided.

An AutoSampler for Blood Analysis

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Objective:
An automated blood sampling system (AutoSampler) was integrated with a conventional glucose analyzer to overcome several of the known bottlenecks in implementing tight glycemic control protocols in critical care settings.

Method:
The AutoSampler assembly consists of a novel male luer lock, a self-sealing quick-release adapter, a miniaturized valve module, and a specialized microbore tube set. A touch-screen controller is used to adjust the various sampling parameters. The AutoSampler was interfaced with a commercial blood analyzer that consists of a flow-through glucose sensor and a reagent pack. The sequence of steps includes blood withdrawal from a peripheral vein, glucose determination by the analyzer, rinsing of the tubing with normal saline, and, finally, the calibration of the glucose sensor. The integrated unit was evaluated under varying sampling frequencies over a 6 h period.

Result:
The primary goal of the study was to evaluate the success in automating the process of venous blood sampling. The use of the aforementioned specialized low dead volume fluidic components and methodology validated the automation of blood sampling. The system also eliminated the need for use of anticoagulants, such as heparin. The blood volume consumed was less than 200 µl per measurement cycle.

Conclusion:
The AutoSampler has provided an effective means for automating the blood sampling from a peripheral vein site for glucose determinations. This represents a promising and reliable alternative to current repetitive manual blood sampling methods. The study has also set the stage for expanded clinical trials in the intensive care environment.

Enhancing the Efficacy of Diabetes Disease Management with Remote Biometric Telemonitoring

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Objective:
The aim was to improve clinical and utilization outcomes for a Medicaid managed care diabetes population through intensive care management utilizing remote biometric telemonitoring.

Method:
Remotely collected biometric data—whether a threshold value in blood glucose or blood pressure or a rapid increase in weight—was used to detect pre-acute trends, as well as to draw immediate associations for enrollees between very specific behaviors and the biometric progress seen. Telemonitoring data were also routinely shared with physicians to determine if a regimen change was warranted and to fill in critical elements of the disease narrative.

Results:
For enrollees with both a baseline and followup hemoglobin A1c (HbA1c) test (n = 442), 347, or 78%, saw an average HbA1c reduction of 2.0% (from an average of 9.8% down to 7.8%). The higher the baseline HbA1c, the greater the improvement (for those with an HbA1c >14%, the average improvement was 4.7%). For the subset of those with HbA1c improvement who had hypertension at baseline (n = 181), 68% saw an average improvement in systolic pressure of 7 mm Hg. For the subset of those with no HbA1c improvement (n = 95) who had hypertension at baseline (n = 53), 65% saw an average improvement in systolic pressure of 3 mm Hg.

Conclusions:
Biometric data from remote telemonitoring provide elements essential to facilitating both professional consultation across disparate clinical settings and more effective patient counseling. Clearly linking biometric patterns and symptomology to specific behavior fosters better disease literacy, enhances physician involvement, and speeds regimen changes when necessary.

Glucose Variability Is Associated with Increased Length of Stay among Hospital Inpatients with Diabetes Mellitus

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Objective:
Hyperglycemia in hospitals has been associated with poor clinical outcomes, directing best practice guidelines to promote tighter glucose control. Evidence suggests that the benefits of tight glucose control may be partially offset by the increased risk of hypoglycemia. The aim of this study was to assess whether blood sugars within the range of 4.0–11.0 mmol/liter in diabetes patients hospitalized in the general medicine wards are associated with better outcomes.

Method:
This is a retrospective cohort study of patients admitted to the general medicine wards at Sunnybrook Health Sciences Centre between November 2009 and April 2010 with diabetes as a comorbidity. The associations between good blood glucose control (4.0–11.0 mmol/liter) with length of stay (LOS) and inpatient mortality were examined.

Result:
A total of 522 patients with point-of-care glucose readings on the general wards have been identified. Complete data are currently available for 288 patients. A total of 26.8% of patients achieved good control their entire stay in hospital, while the remaining 73.2% experienced both hyperglycemia and hypoglycemia (22.8%), hyperglycemia (42.1%), or hypoglycemia (8.3%) episodes. In univariate analysis, mean LOS was significantly longer for patients with poor glucose control versus patients achieving good control (14.4 versus 9.5 days, $p = .01$). In multivariable analysis, LOS increased by 1.55 days for each additional day with a hypoglycemic episode ($p < .001$) and increased by 0.69 days for each additional day with a hyperglycemic episode ($p < .001$). Data will be presented for inpatient mortality and LOS for the entire cohort.

Conclusion:
Good blood glucose control is associated with shorter LOS compared to patients experiencing variable blood glucose. In achieving tighter glucose control among inpatients with diabetes, care must be taken to avoid both hypoglycemic and hyperglycemic episodes.

Computer Provider Insulin Order Sets and a Multidisciplinary Approach to Improve Glycemic Control of Non-Intensive Care Unit Hospitalized Patients

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Objective:
Our primary objective was to improve non-intensive care unit (ICU) inpatient glycemic control by introducing new computer provider insulin order sets along with extensive Web-based educational modules to facilitate the use of weight-based insulin regimens. We are improving coordination among health care providers, nursing, pharmacy, and dietary service by using Web-based tools with a multidisciplinary team approach.

Method:
A quality improvement project was started in the internal medicine ward at the Veterans Affairs Medical Center. The multidisciplinary team comprised endocrinologists, hospitalists, pharmacists, dieticians, nurses, nurse educators, advanced nurse practitioners, and social workers. The education for inpatient diabetes management was provided using online mandatory training focused on insulin administration, glucose testing, and managing patients with unpredictable oral intake. Pocket cards with easy-to-remember mnemonics were provided to the resident physicians. The computer provider insulin order sets were introduced, allowing providers to select diabetic regimen, including basal–bolus, long- or intermediate-acting insulin, or continuation of home regimen based on patient criteria. Resident physicians were educated about insulin adjustment based on daily assessment. Weekly meetings were held with the multidisciplinary team to identify, monitor, and resolve issues at any level. Results pertaining to timing of glucose checked, meal consumed, and insulin administered along with bedside glucose readings is collected and reviewed periodically.

Result:
This multidisciplinary approach and computerized order sets with mandatory Web-based education improved coordination of insulin administration with glucose check and meal intake. Resident physician orders became more consistent, enabling increased use of the basal–bolus insulin regimen as opposed to the poor practice of using only sliding scale insulin.

Conclusion:
The incorporation of new software tools has reduced hyperglycemia and improved coordination among services involved in non-ICU inpatient glycemic management.

Transition to Target: A Prospective Randomized Trial Comparing Three Formulas for Determination of Subcutaneous Basal Insulin Dosing at the Time of Transition from Intravenous Insulin Therapy Following Cardiac Surgery

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Objective:
No study of transition from intravenous insulin therapy (IIT) to subcutaneous (SC) insulin after cardiac surgery has reported a clearly superior regimen for achieving blood glucose (BG) control. We compared three strategies for determining the first basal insulin glargine dose given at the time of transition to evaluate the mean proportion by group of BG values in the target range of 80–140mg/dl during a 3-day study period.

Method:
Cardiac surgery patients at two hospitals were randomized to one of three formulas for determining the transition dose of SC insulin glargine: 60% or 80% times estimated total daily insulin (TDI) dose (sum of drip rate in 4 h preceding transition × 6) and one incorporating TDI and a graded multiplier for body weight. Insulin glulisine was given before meals (10% of daily glargine dosage) and for correction doses.

Result:
N = 233. Transition was effected at 27.4 ± 6.6 h after surgery. Mean proportion of BGs within 80 to 140 mg/dl were 0.34 ± 0.24, 0.35 ± 0.24, and 0.36 ± 0.22 in the 60%, 80%, and weight-based groups, respectively (not significant). Significantly more insulin corrections were needed in the 60% group than in the weight-based group. There was one incidence of hypoglycemia (BG <40 mg/dl).

Conclusion:
No SC insulin regimen implemented one day after cardiac surgery showed significantly better BG control. Few BG levels were within target. Results highlight the high insulin requirements immediately post-cardiac surgery. Findings are consistent with earlier reports that support the safety of an 80% of TDI first glargine insulin dose. Further study is needed to investigate optimal timing and dosage of SC insulin in cardiac surgery patients with diabetes being transitioned off IIT.

Quality of Care Initiative: Blood Glucose Timing, Food Delivery, and Insulin Administration

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Objective:
The primary objective was to evaluate the timing of our hospital's current inpatient process between blood glucose (BG) monitoring, insulin administration, and bedside meal delivery. A second objective was to create workflows that would allow for this process to be completed within a 30-minute window.

Method:
This was a quality improvement workflow project in an adult inpatient service at an academic tertiary care medical center where approximately one-third of patients receive insulin. We used time-in-motion studies and process mapping to quantitate and define our current process and to assist in creating effective interventions. Data were collected over one year.

Result:
We found a number of discrepancies with BG timing, meal tray delivery, and insulin administration. Staff obtained BGs >30 min prior to meal 49% of the time, ranging from 166 min before meal to 98 min after meal. Meal timing was inconsistent; delivery to floor varied by 15–30 min each day, followed by tray audits taking ≥15 min on average. The entire process from BG monitoring to insulin administration was completed in <30 min for 39% of patients, 30–60 min for 39% of patients, and >60 min for 22% of patients. We designed and instituted interventions, including standardization of processes and meal delivery times. This decreased the average time from BG monitoring to bedside meal delivery from 44 to 37 min, and patients receiving insulin within 30 min of BG monitoring increased to 65%.

Conclusion:
This quality improvement project improved glycemic control processes in our hospital. In August 2010, we plan for nursing staff to assume all duties from BG monitoring to bedside meal delivery for insulin-receiving patients. We will then repeat the time-in-motion study.

Use of Technology in Implementing Insulin-Driven Protocols

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Objective:
Nursing staff have been reluctant to treat hyperglycemia because of perceived increased risk of hypoglycemia using insulin. It was hoped that a positive experience with insulin-driven protocols would lessen concerns about hypoglycemic events. Documentation of all finger-stick results was inconsistent. Sometimes data were lost because capture relied on nursing memory to record results. Diabetes educators also had to rely on nursing memory to initiate consults. Our goal was to link our finger-stick results with the electronic medical record to achieve tight glycemic control—defined as blood glucose of 60–150 mg/dl—in acute care patients.

Method:
An interface was created between the electronic medical record and glucose meter database, allowing for immediate download of all glucose values and standard documentation of results. Additionally, when abnormal values appeared, computer-generated consults to diabetes educators allowed the educators to monitor the use of protocols more closely.

Results:
The interface allowed all results to be readily available, which encouraged increased compliance with protocols. Tight glycemic control is, in part, measured by our hypoglycemic rate of 1–2%, as determined by all finger sticks.

Conclusion:
Interface of the electronic medical record and glucose meter database have proven to be effective in increasing staff compliance in using the protocols and in eliminating memory-based practice regarding documentation and consultation from diabetes educators.

Identification of Hyperglycemia in Hospitalized Patients

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Objective:
Our objective was to improve the identification of hyperglycemia in hospitalized patients. If patients are routinely identified, then they will receive patient-focused treatment, education, and referral. Additionally, accurate patient population data will drive future glycemic management program planning and resource allocation.

Method:
Physicians were interviewed and commented that they would note the elevated glucose and then document and treat. However, they felt that the elevated glucose could easily be missed by others due to a host of mitigating factors. The coding specialists indicated training and baseline knowledge of hyperglycemia and diabetes can vary, creating disparity in coder analysis and physician query.

Result:
Data from one hospital were extracted for patients with point-of-care glucose or laboratory blood glucose >200 mg/dl random or fasting blood glucose (laboratory) >126 mg/dl using the Enterprise Data Warehouse. Results revealed 31% of patient records were not coded with ICD-9 codes 790.xx (hyperglycemia), 250.xx (diabetes), or 249.xx (secondary diabetes). A chart audit showed a trend toward recognition of abnormal blood glucose and follow-up testing and treatment. However, specific documentation listing hyperglycemia or diabetes was not found. It was unclear if patients were notified and if patient education, referral, and follow-up were initiated.

Conclusion:
A prioritization matrix determined the need for diagnostic guidelines for hyperglycemia and diabetes. The guidelines for diagnosis will serve as part of the integrated glycemic management program tool kit at Scripps Health. Next steps include implementation of the guidelines for diagnosis of hyperglycemia/diabetes mellitus and continued data analysis with feedback to stakeholders regarding use of the guidelines and rates of identification.

Development of Glucometrix Reporting through an Enterprise Data Warehouse

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Objective:
Our aim was to create an integrated data set for patients hospitalized with abnormal blood glucose and analyze for glucose control, treatment, and cost correlation. Electronic information will be extracted from transactional systems, including the electronic medical record across four hospitals on five campuses within Scripps Health. Reports will be built using Cognos in the Enterprise Data Warehouse (EDW) and available via a Web interface for efficient access to reports.

Method:
A system-wide EDW steering committee provided approval and support for the project, and a master plan for glucose data reporting was created. Reports based on the Yale Glucometrics methodology (http://metrics.med.yale.edu/main/) were built using the following criteria: blood glucose samples are point of care; patients are 18 years and older; a well-managed day is all samples between 70 and 180 mg/dl; an out-of-control day is at least one sample not between 70 and 180mg/dl; and a monitored day is one or more blood glucose samples taken.

Result:
Several reports were created, including Glucometrix, Hospital Ward Glycemic Control, and Service Line Glycemic Control. All reports allow the user to select a date range, site, and ward. Additionally, the information can be filtered by diagnostic code or group as well as physician provider. On select reports, the user can drill through from aggregated data to patient-level data and see detail on glucose excursions.

Conclusion:
Next steps include integration of medication data for analysis of glucose control and medication management. Targets for improvement can be set based on a hospital site's current glycemic control. The EDW continues to build functionality and will ultimately support a glycemia or diabetes registry for the entire Scripps Health system.

Incidence of Intraoperative Hypoglycemia in Diabetes Patients

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Objective:
Intensive insulin therapy (IIT) in the intensive care unit (ICU) has been questioned because of possible increased incidence of hypoglycemia and mortality. Intraoperative use of IIT has mostly followed ICU recommendation. We examined our intraoperative glycemic management practices and the incidence of hypoglycemia during surgery.

Methods:
After institutional review board approval, we queried the intraoperative records of diabetes patients from our anesthesia information management system between 2005 and 2010 to determine their preoperative insulin status, blood glucose (BG) values, insulin boluses and infusions given, and dextrose (D50) doses. Charts from patients receiving D50 were examined manually to exclude hyperkalemia as the indication.

Results:
Of 80,379 cases, 10,966 (13.6%) involved diabetes patients, 39.2% of whom were taking insulin preoperatively, and 60.8% were taking only oral hypoglycemic agents. A total of 3890 diabetes patients (35.5%) received intraoperative insulin, and D50 was given to 61 (0.56%) patients for hypoglycemia. Hypoglycemia (BG = 60 mg/dl) occurred in 106 (2.7%) and severe hypoglycemia (BG <40 mg/dl) occurred in 16 (0.41%). During 1053 cases where insulin was infused, compliance with the department protocol to check BG at least 60 min during insulin infusions was followed during 90.4% of the total infusion time. There was decreased intraoperative insulin use over time in insulin-dependent patients, but not in insulin-independent patients, and a decrease in the maximum intraoperative BG value.

Conclusion:
Despite a relatively nonintensive approach to intraoperative glycemic control and high compliance with the department protocol, clinically relevant hypoglycemia requiring D50 treatment still occurred. Because recognition of clinical signs of hypoglycemia is difficult in anesthetized patients, frequent monitoring of BG is required when intravenous insulin is administered intraoperatively. Use of reliable continuous glucose monitoring sensors could be helpful in this setting.

The Usability of Inpatient Insulin Ordering in Various Computerized Provider Order Entry Systems

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Objective:
A number of fundamental usability principles guide human–computer interaction design. Attention to these principles by the medical community is increasingly important as more physicians begin to use computerized provider order entry (CPOE) systems. We seek to highlight these principles as they apply to analysis of CPOE systems and inpatient insulin ordering. Insulin ordering was chosen because it is a high-risk medication given to many of the more than four million hospitalized patients per year with diabetes mellitus.

Method:
We analyzed inpatient insulin "sliding scale" ordering in three CPOE systems: General Electric's Centricity Enterprise, the Veterans Administration's VistA CPRS, and Epic's EpicCare. We performed a usability analysis using aspects of the heuristic method, cognitive walkthrough method, and think-aloud method.

Result:
Commonly encountered usability principles included constraints, obviousness, natural mapping, self-evidence, and affordance. The three systems varied in their adherence to these principles, and each system had varying strengths and weaknesses. For example, the principle of "affordance" was used very effectively by Centricity Enterprise and EpicCare, but less so by VistA CPRS. "Obviousness" was used more effectively in VistA CPRS and Centricity Enterprise than in EpicCare. All three systems used "constraints" to their advantage in varying situations.

Conclusion:
Usability principles are important when designing a CPOE system yet, to this point, have been observed to varying degrees. We discovered that competing interests can hinder CPOE designers from strictly adhering to usability principles. Optimal system design in the future will require input from both medical and information technology professionals.

Computerized Insulin Infusion Improves Safety and Saves Time on a Kaiser Permanente Northwest Medical Surgical Ward and Cardiovascular Intensive Care Unit

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Background and Objective:
A review of hospital data from January 2007 to July 2010 indicated 64% of hospitalized patients at Kaiser Sunnyside Medical Center required management of hyperglycemia, 58% of whom had a diagnosis of diabetes and another 6% of whom required glycemic management. Insulin is the preferred drug to treat hospitalized patients with hyperglycemia; however, subcutaneous insulin requires intervals of 24 h to safely adjust to normalize glucose. This can take up to three to four days to normalize blood glucose, whereas intravenous insulin can be adjusted hourly and takes 4 to 6 h to achieve euglycemia. Despite the benefits of intravenous insulin, hourly measurements of blood glucose and insulin adjustments are time-consuming and require a calculation or interpretation of blood sugar using a column based master. Our objective was to develop a tool for calculating insulin infusion rate that could be integrated into the electronic medical record that would save time, improve safety, and trend blood sugar and insulin administration. In addition, the computerized version should allow for collection of data to be used to refine the instrument.

Methods:
Fifteen charts in which the current column-based paper protocol was used revealed a 40% calculation error rate of the 162 data points; 64 insulin calculations deviated from the protocol. Time-in-motion observations were timed on experienced nurses performing the task of figuring out the insulin rate using the column-based protocol. The average time spent doing the calculation was 2 min, not including taking the capillary blood sugar and adjusting the insulin pump. This amounts to 24 min in a 12 h shift.

A Web-based calculator (AutoCal) was developed by the Kaiser iLab at the Garfield Center that automatically performed the insulin drip calculation, reflected alerts if rate of change was more than a 100 mg/dl decrease, tracked intravenous solution, gave recommendations if blood sugar dropped below 70 mg/dl, and graphically displayed blood sugars and insulin rates in real time. The tool was tested on 20 case studies for accuracy of coding. The two wards selected for field study were

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the cardiovascular intensive care unit and 3S, a medical–surgical unit. One percent of post-cardiac patients return from surgery on an insulin drip managed in surgery by anesthesia to a target of 80–110 mg/dl. The average nurse-to-patient ratio is one nurse to one patient with numerous drips and tasks to complete in the initial period after surgery, including insulin infusion. The medical/surgical floor chosen was a medical/telemetry, renal, diabetes specialty unit. Most of the patients on insulin drips were known diabetes, renal, or preoperative podiatry patients. The nurse-to-patient ratio is four to five patients to one registered nurse. Nurses were given a 30 min demonstration of the tool and then tested on the operation. The average amount of test cases to gain proficiency was two. After the tool was operationalized on the floor for four months (September 2009–December 2009), nurses were asked to complete an evaluation of the tool. Every case using the AutoCal was audited for accuracy with positive results.

Result:
The AutoCal performed with 100% accuracy on every calculation, reducing the error rate by 40%. The time-in-motion observation using the AutoCal was less than 30 s, which reduced the calculation time by 18 min in a 12 h shift. Ninety-four percent of the nurses who completed the survey (n = 32) found the AutoCal saved them time, 90% felt confident with the results, and 94% recommended making the tool a permanent part of the electronic medical record as a permanent application.

Conclusion:
Intravenous insulin infusion is an appropriate therapy for managing hyperglycemia in medical surgical wards as well as in the intensive care unit. The time burden and patient safety issues related to insulin infusion were mitigated with the use of an automated insulin infusion calculator. The automated calculator also provides an evaluation database by design to provide feedback on protocol compliance and glucose control, which can be used to improve the protocol.

Continuous Glucose Monitoring in Prolonged Cardiopulmonary Bypass

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Objective:
Standard care for infants on extracorporeal life support (ECLS) relies on intermittent measurement of blood glucose (BG); however, this can lead to significant changes in BG that go unrecognized for several hours. The present study was designed to assess performance and clinical applicability of the Medtronic subcutaneous glucose sensor technology modified for use as a blood-contacting sensor within the ECLS circuit.

Methods:
Twelve children, aged 3 years or less, requiring ECLS support, were studied. Three sensors were inserted into hubs placed inline in the ECLS circuit. Sensor current (I_{SIG}) was transmitted to a laptop computer and retrospectively calibrated on a 6 h interval (one-point calibration). Calibrated sensor glucose (SG) was compared with reference BG values at points other than calibration times.

Result:
Blood glucose during the study was 107.6 ± 36.4mg/dl (mean ± standard deviation), ranging from 58 to 366 mg/dl. Mean absolute relative difference between SG and BG was 11.4%. Regression of paired BG and SG values indicated a slope (0.86 ± 0.030) and intercept (8.8 ± 3.4 mg/dl) different from one and zero ($p < .05$). Values were well correlated (0.74; $p < .001$). The system was not associated with any adverse events. Placement and removal of sensors into the hubs was easily and quickly accomplished.

Conclusion:
We conclude that the subcutaneous technology can be modified for use in an ECLS circuit with reasonably accurate values achieved using a 6 h calibration interval. Further studies will be needed to assess the benefit of continuous monitoring in this population.

Very Low Rates of Hypoglycemia in a Tertiary Center Intensive Care Unit with Intravenous Insulin Protocol

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Objective:
Safe and effective glycemic target in the intensive care unit (ICU) continues to be actively pursued. Large clinical trials have examined the safety and efficacy of insulin infusion protocols in medical and surgical ICUs. We report experiences of a single-center standardized nurse-driven insulin infusion protocol in three ICUs in an observational quality-improvement study.

Method:
We analyzed the hourly glucose levels of ICU insulin infusion protocol (protocol A) with the glycemic target of 80–130 mg/dl in one medical and two surgical ICUs in February 2009. In the wake of the NICE SUGAR study results, the protocol was amended (protocol B) to achieve target glucose of 110–150 mg/dl. The performance of protocol B was assessed in the previously mentioned ICUs in May 2010 and compared to those of protocol A.

Results:
With protocol A, medical [*n* = 44; type 2 diabetes (T2DM) = 17 (39%); type 1 diabetes (T1DM) = 1(2%)] and combined surgical ICUs [*n* = 164; T2DM = 35 (21%); T1DM = 3 (2%)] taken together, the median glucose was 119 mg/dl; the rate of severe hypoglycemia (<40 mg/dl) was 1.4% (3/208); and the rate of moderate hypoglycemia (40–60 mg/dl) was 7.7% (16/208), which was significantly less than published literature. With protocol B, medical [*n* = 44; T2DM = 23 (52%); T1DM = 1 (2%)] and combined surgical ICUs [*n* = 167; T2DM = 34 (20%); T1DM = 2 (1%)] taken together, the median glucose was 132 mg/dl; the rate of severe hypoglycemia was 0 (0/211); and the rate of moderate hypoglycemia was 0.5% (1/211). A single episode of moderate hypoglycemia was noted in a patient with T1DM with multiple comorbidities (hypothyroidism, stroke, pneumonia) in the medical ICU.

Conclusions:
The amended ICU insulin infusion protocol abrogates severe hypoglycemia without compromising glycemic control.

Efficacy of Glucagon-Like Peptide-1 as an Adjunct to Insulin for Tight Glycemic Control in the Surgical Intensive Care Unit

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Objective:
Intensive insulin therapy (IIT) has been shown to reduce morbidity and mortality in critically ill surgical intensive care unit (SICU) patients. A significant drawback for implementation of IIT is the risk of hypoglycemia. Addition of agents that stimulate endogenous insulin secretion, such as glucagon-like peptide-1 (7-36) amide (GLP-1) may provide a safer and possibly more efficacious therapy to normalize blood glucose in intensive care unit patients.

Methods:
We studied the administration of GLP-1 as an adjunct to IIT for tight glycemic control in critically ill SICU patients. In a prospective, randomized, double-blind, placebo-controlled trial, SICU patients who required IIT to normalize blood glucose for at least 72 h were enrolled. In addition to IIT, these patients received intravenous (IV) saline or GLP-1 (5 mcg/kg/min). The IV insulin dosing and glucose measurements were determined according to standard protocol. After 72 h, glucose levels and the amount of IV insulin used were recorded.

Results:
This is an ongoing double-blind controlled trial. Thus far, we have enrolled 19 patients, and there have been no adverse events. In 50% of the patients, a substantial decrease in the amount of insulin required to maintain target euglycemia has been noted following administration of the study drug. In these patients, glucose levels were much more stable and the incidence of hypoglycemia was reduced.

Conclusion:
It could be suggested that the administration of GLP-1 in achieving tight glycemic control may be more effective with an added margin of safety than insulin alone. Administration of GLP-1 in hyperglycemic critically ill SICU patients may allow safer, less variable control of blood glucose values.

"Precision Profile": A New Approach to Assess Precision of Continuous Glucose Monitoring Sensors and Self-Monitoring of Blood Glucose Meters

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Objective:
The aim was to develop improved methods to evaluate precision and accuracy of glucose meters and sensors based on duplicate measurements.

Method:
The "Precision Profile" characterizes the standard deviation (SD) and coefficient of variation (%CV) as continuous functions of glucose level, adapting methods previously developed to characterize the precision of immunoassay systems. We obtained duplicate measurements (using two sensors or two meters) over a wide range of glucose from hypoglycemic to hyperglycemic values and simultaneous measurements using reference laboratory methods. We computed the SD for all pairs of measurements, plotted SD versus mean glucose, computed the %CV = 100 SD/mean, and displayed SD and %CV versus glucose level after smoothing the curves.

Result:
This method provides a simple and robust method to characterize glucose sensors and meters. The SD increases in a nonlinear fashion with glucose level; %CV showed a minimum near 100 mg/dl, remained fairly constant between 60 and 80 mg/dl, and gradually increases above or below this range. The method has been applied successfully to continuous glucose monitoring (CGM) and self-monitoring of blood glucose (SMBG), comparison of CGM versus SMBG, and CGM versus reference laboratory methods (YSI). The SD, %CV, mean absolute deviation, and mean absolute relative deviation vary systematically as smooth continuous nonlinear functions of glucose level.

Conclusion:
The new method is simple and readily implemented. It characterizes the precision of glucose measurement by CGM sensors and SMBG meters using a method that is readily understandable and usable. The precision profile can facilitate the comparison of the precision and accuracy of sensors and meters.

Using Problem-Based Learning to Teach Acute Care Nurse Practitioners to Initiate and Intensify Insulin Therapy

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Objective:
Diabetes management may be more prone to clinical inertia, or the failure to advance therapy despite an identified need, than other chronic conditions. The primary aim of this study is to implement and evaluate a problem-based learning (PBL) educational intervention to teach acute care nurse practitioners how to effectively initiate and intensify insulin therapy in patients with hyperglycemia in the hospital setting.

Method:
The convenience sample will consist of all acute care nurse practitioners at NewYork-Presbyterian Hospital/Weill Cornell Medical Center who initiate and intensify insulin therapy. A total of four months will be allotted for the recruitment, intervention, and data collection. The intervention will consist of a pretest followed by a 30 min problem-based learning educational intervention and an immediate post-test during month 2. A second post-test will be administered two months later, during month 4. Weill Cornell Medical College institutional review board approval was received on June 22, 2010.

Results:
Descriptive Statistics will be used to characterize mean scores of the various constructs associated with demographics as well as test scores. Comparative statistics such as *t* tests for repeated measures and analysis of variance will be used to examine the relationship between preinterventions and postinterventions. Recruitment is underway, and preliminary data will be available for the October 2010 meeting.

Conclusions:
Clinical practice recommendations are available but are frequently not adopted. Rogers' Diffusion of Innovations theoretical framework was used as a guide to design an educational intervention using problem-based learning to help acute care nurse practitioners incorporate clinical practice recommendations into their treatment of diabetes patients. This intervention will prepare the acute care nurse practitioner to effectively initiate and intensify insulin therapy.

Antidiabetic and Hypolipidemic Effects of *Ficus bengalensis* in Streptozotocin-Induced Diabetic Models

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Objective:
Ficus bengalensis Linn. (Moraceae) root is used in traditional Indian medicine for the treatment of diabetes. The present study deals with further scientific exploration of the antidiabetic potential of *F. bengalensis* aerial roots in severely diabetic animals in addition to its effect on diabetes-induced disturbed lipid profile.

Method:
The antidiabetic activity of aqueous extract of *F. bengalensis* aerial root was evaluated by using normal and streptozotocin (STZ)-induced diabetic rats. The acute effect of aqueous extract was evaluated by administering 300 mg/kg to normal and STZ-induced severely diabetic animals (fasting blood glucose [FBG] >250 mg/dl) that were treated once a day for 30 days. Blood glucose levels, body weights, and different biochemical parameters were also carried out.

Result:
Severely diabetic (FBG >250 mg/dl) animals were treated once a day for 30 days with the most effective dose of 300 mg/kg, identified in a previous study of subdiabetic and mildly diabetic rats, and found to have reduced FBG by 44.4%; the same dose brought about a fall in total cholesterol, triglyceride, low-density lipoprotein, and very low-density lipoprotein levels of 31.8%, 22.7%, 42.7%, and 23%, respectively, and an increase of 28.5% in high-density lipoprotein levels. Levels of serum enzymes were also observed in treated rats as compared to diabetic control.

Conclusion:
These results suggest that aqueous extract of aerial roots of *F. bengalensis* possess significant antidiabetic and hypolipidemic effects.

Comparison of 3 ml versus 10 ml Insulin Vial Sizes on Hospital Pharmacy Budget

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Objective:
The objective was to examine the budgetary impact of a hospital converting floor stock (FS) and individual patient supply (IPS) of rapid-acting insulin analog (RAIA) from 10 to 3 ml vials, respectively.

Method:
A budget impact model was built using data from the literature, opinions of two hospital directors of pharmacy, and RAIA usage/wastage data from a community hospital in Indianapolis, Indiana. Partially utilized or expired vials were used to estimate RAIA wastage. Wastage of 10 ml FS RAIA (%) was calculated over a 2-week period by dividing the volume disposed by the total volume stocked on hospital floors. Individual patient supply wastage (%) was approximated by subtracting the average RAIA use per patient stay, registered over a 3-month period, from the vial volume. For model validation purposes, RAIA purchases were recorded for 3-month periods before and after the hospital transitioned from 10 ml FS to 3 ml FS.

Result:
The RAIA 10 ml FS wastage was approximately 25% over the 2-week period. The 3 ml vial FS wastage was assumed to be 10% due to smaller vial volume. The model projected 17% reduction in RAIA procurement costs and 58% reduction in RAIA wastage when a hospital converted from 10 ml FS to 3 ml FS vials. When transitioning from 10 ml IPS to 3 ml IPS vials, the model projected 70% reduction in RAIA procurement costs and 75% reduction in RAIA wastage. A comparison of 3-month pretransition to posttransition FS data from the hospital showed a reduction in RAIA procurement costs by 30%.

Conclusion:
Based on our model, transitioning from 10 to 3 ml vials was projected to result in reductions of RAIA procurement costs and RAIA wastage.

Improved Glycemic Control in Adult Medical–Surgical Patients

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Objectives:
Crouse Hospital convened a multidisciplinary team to develop and implement an insulin protocol for all medical–surgical patients. The goals included reducing average blood glucose, decreasing hypoglycemia, controlling insulin medication errors, and increasing the number of hemoglobin A1c (HbA1c) measurements ordered on admission.

Methods:
Insulin and hypoglycemia protocols were implemented. Provider and nursing education focused on basal/bolus dosing, timing of finger sticks, consistent carbohydrate diets, and the quality impact of glycemic control. All providers were required to use the protocol for all insulin orders. Nutritional services changed meal tickets to include grams of carbohydrates per serving. Delivery of meals included color-coded trays and announcement of arrival times, which supported capillary sampling and timing of bolus insulin administration. Pharmacy limited the availability of mixed insulins, supported conversion from multidose insulin vials to basal insulin pens, and chose one basal insulin and one rapid-acting insulin for bolus/correction. Multidisciplinary rounds prioritized patient needs.

Results:
All finger-stick glucose readings from January 5, 2007, to March 29, 2010, were evaluated: 106,578 preprotocol and 202,879 postprotocol. The mean glucose of all patients decreased from 164.7 to 156.9 mg/dl ($p < .0001$). Glucose levels above 181 mg/dl decreased from 48.59% to 40.56%, glucose levels between 71 mg/dl and 180 mg/dl increased from 64.59% to 69.96%, glucose levels below 70 mg/dl decreased from 3.70% to 3.02%, and glucose levels below 40 mg/dl decreased from 0.87% to 0.47% (all $p < .0001$). Rates of obtaining HbA1c measurements increased 2.66-fold. There was no significant change in insulin medication errors.

Conclusions:
Medical–surgical insulin protocols can safely decrease average glucose levels, hypoglycemia, and severe hypoglycemia.

Method for Evaluation of Point-of-Care Bedside Glucose Monitors for Use in a Specialty and Transplant Hospital

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Objective:
The patient population in our hospital present with clinical signs and symptoms that require improved accuracy and precision and no interferences in point-of-care testing glucose measurement. Our current device did not always agree with the central laboratory glucose result and raised concern among the clinical staff. We learned from the literature that most devices were affected by patient variables, and it was important for us to determine which devices were least affected by transplant patient clinical variables. Consequently, we evaluated four different glucose meters and their connectivity solutions for use within Methodist Specialty and Transplant Hospital. Selection of a bedside blood glucose monitor with connectivity and seamless data integration was defined as a major process improvement objective for our medical center.

Materials and Methods:
Three data-managed glucose meters were evaluated by the point-of-care team. The meters included StatStrip (Nova Biomedical Corporation, Waltham, MA), Accu-Chek Inform (Roche Diagnostics, Indianapolis, IN), and Precision Xceed Pro (Abbott Diagnostics, Abbott Park, IL). Each glucose monitor was independently compared to the Vista hexokinase method central laboratory method (Siemens Diagnostics, Tarrytown, NY) and our current meter in an interinstrument correlation (whole blood versus plasma). A laboratory analytical correlation was performed in the laboratory before we evaluated the devices for use in the intensive care unit (ICU) by the point-of-care coordinator and nursing staff. The laboratory analytical protocols were designed so that we could study common interfering substances and hematocrit levels consistent with patient variables observed in this hospital. Precision, linearity, and correlation of each glucose monitor was tested, and standard statistical methods were applied. The ICU nurses provided feedback on the usability of each device.

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Data:
The extensive data from each of these separate experiments will be presented in tabular and graphic form to show the performance of each device versus the central laboratory analyzer. These data include mean, standard deviation, coefficient of correlation, and correlation coefficient (R^2). A summary of the decision matrix for connectivity selection, as well as nursing feedback on usability, will also be presented.

Conclusion:
The correlation studies revealed that all devices demonstrated acceptable performance except the Abbott Precision Xceed Pro and Accu-Chek Inform (slope and intercept). The Accu-Chek Inform strips and the Abbott Precision Xceed Pro strips did not achieve the specified precision criteria in the low control. The between-run precision data demonstrated acceptable performance for each device. Linearity of each device was confirmed. StatStrip demonstrated minimal effect due to hematocrit and ascorbic acid in the interference studies.

Analysis of Intensive Care Unit Patients to Determine a High-Risk Category for Hyperglycemia

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Objective:
The aim was to identify a subset of critical care patients who represent the greatest risk of hyperglycemia.

Method:
Glucose levels, obtained through glucometers and phlebotomized samples, were collected on all patients admitted to the intensive care unit over a 2-month period in 2007. Standard demographic data were collected, and an additional four clinical variables were considered by the team to be indicative of high-risk status: body mass index, a positive patient history of diabetes, corticosteroid use, and ongoing nutritional support (parenteral and enteral). Data were analyzed through the use of the following tools: Pareto charts, histograms, scatter diagrams, and Minitab statistical software.

Result:
Of 105 patients, 65.7% had normal glucose levels and 34.3% had at least one episode of hyperglycemia (over 140 mg/dl); these patients accounted for 1284 glucose tests out of a total of 1510 drawn during the observation period (85.0%). Of the patients with normal glucose levels, 63.8% had no high-risk factors compared to only 5.6% of the hyperglycemic group. Additionally, 26.1% of the normal group had only one risk factor compared to the 44.4% of the hyperglycemic group. Overall, 23.8% of the total population had two or more high-risk factors but accounted for 73.4% of all the glucose tests and averaged 61.6 glucose tests per patient.

Conclusion:
Clearly, in this study, a relatively small percentage of the patients accounted for the majority of all the glucose tests and all the episodes of hyperglycemia, consistent with the Pareto Principle. The information obtained in this study presents opportunities to create more focused strategies in glucose control and management in critical care.

Association of Hyperglycemia, Glucocorticoids, and Insulin Use with Morbidity and Mortality in the Pediatric Intensive Care Unit

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Objective:
Studies of pediatric intensive care unit (PICU) patients have shown a significantly increased morbidity and mortality risk associated with hyperglycemia. We retrospectively evaluated the degree of hyperglycemia as well as its correlation with glucocorticoid and insulin use and then assessed its association with hospital length of stay (LOS) and mortality.

Method:
Electronic medical records at Kosair Children's Hospital in Louisville, KY, were reviewed retrospectively for all PICU admissions from January 1 to December 31, 2008. Patients with known diabetes mellitus were excluded. The prevalence of hyperglycemia was defined by having two peak glucose values greater than cutoff thresholds of 140, 180, and 200 mg/dl, and occurrences of hyperglycemia were correlated with the use of glucocorticoids and insulin.

Result:
In 12 months, 1285 eligible admissions generated 21,254 blood glucose values (median 123 mg/dl, range 10–1430 mg/dl). There was a high prevalence of hyperglycemia at cutoffs of 140 mg/dl (36.8% of admissions), 180 mg/dl (24.9%), and 200 mg/dl (20.9%). Glucocorticoids were used in 25.5% of patients with a peak glucose <140 mg/dl but were significantly more common with higher peak values. 56.5% of those above the 200 mg/dl cutoff were treated with glucocorticoids. However, only 16.7% in that group were also treated with insulin. Patients at the 200 mg/dl cutoff had the highest mean PICU (7.3 days) and total hospital LOS (12.9 days). Mortality was also associated with increasing peak glucose values, reaching 10% among patients greater than the 200 mg/dl cutoff.

Conclusion:
Hyperglycemia was prevalent in the PICU and was associated with increased morbidity, as characterized by increased LOS and increased mortality. Glucocorticoid use was prevalent among patients exhibiting hyperglycemia. Insulin use was uncommon.