Abstracts

Evaluation of a First-Generation Automated Blood Glucose Monitor in the Clinic

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Objective:
Edwards Lifesciences and Dexcom Inc. are collaborating to develop an intravenous blood glucose monitor, the GlucoClear System, for improved glycemic control in critically ill patients. The studies evaluated the performance and accuracy of the first-generation *GlucoClear* in the clinical setting.

Method:
GlucoClear contains a glucose oxidase sensor, monitor, indwelling peripheral intravenous (IV) catheter, patient cable, reference solution IV bag, and tubing set. GlucoClear measures blood glucose every 7.5 min and provides data over 72 h. GlucoClear values were blinded, and no treatment was based on its data. Reference blood samples were measured on a YSI 2300 Stat Plus.

A study with 2818 points from 50 otherwise healthy volunteers with diabetes was conducted at the three clinical research center (CRC) settings (study A). A multicenter clinical study was conducted with 100 hospitalized, elective surgery, nonemergent surgery, and medical/surgical intensive care unit (ICU) patients using the first-generation GlucoClear (study B). Preliminary analysis was completed from one center site—the University of Maryland, Baltimore (UMB). A total of 411 points in 27 subjects were compared with YSI using regression analysis and comparative methods defined in International Organization for Standardization (ISO) 15197.

Results:
Study A had 95.0% of GlucoClear values compared with YSI within ISO 15197 across the full range (40 to 400 mg/dl). Study B at UMB had 95.6% of GlucoClear values meeting ISO 15197. The study also identified areas of improvement for ease of use for inclusion into the second-generation GlucoClear.

Conclusion:
The first-generation GlucoClear was demonstrated to have comparable accuracy and performance in critically ill patients in the ICU setting as in healthy volunteer subjects in the CRC. The second-generation GlucoClear is awaiting clinical studies in both healthy volunteers and in critically ill patients.

In-Patient Closed-Loop Blood Glucose Control

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Objective:
We qualify an integrated in-patient control system that would automatically regulate blood glucose (BG) using dual intravenous insulin and dextrose.

Method:
Stress hyperglycemia and diabetes are induced in pigs by streptozotocin (STZ). The dramatic reductions in stress hyperglycemia and insulin requirement that were gradually observed post-STZ provided a robustness test for the control system. Upon regulating initial hyperglycemia, the system was challenged with a carbohydrate load. Seven BG-based experiments, 4–6 h long, were conducted under anesthesia with enteral feeding (1 g carbohydrate/kg) in four pigs (32–65 kg), and 16 interstitial-fluid-glucose-based experiments, 7–29 h long, were conducted in three ambulatory pigs (36–52 kg) with regular feeding (4 g carbohydrate/kg).

Results:
Between ~10–60 U of insulin were required to regulate BG from an initial stress hyperglycemic state of ~500 mg/dl, with a consistent pattern of profoundly more insulin being required in experiments closer to STZ treatment. Upon initial regulation, sensitivity to insulin evidently increased, requiring 1–3 U to regulate BG post-enteral feeding (1 g/kg), with BG kept between 70 and 150 mg/dl, mimicking regulation by a healthy pig. Similar results were observed in multiday experiments in ambulatory pigs, with 15–30 U of insulin required postprandially under more aggressive (4 g carbohydrate/kg) oral feeding.

Conclusion:
The control system demonstrated its efficacy under insulin-resistant and insulin-sensitive conditions to regulate BG starting from severe hyperglycemia and to tightly maintain BG within or near range post-enteral (anesthesia) or oral (ambulatory) feeding, with no hypoglycemia. The experiments validated the reliability and adequacy of the Symbiq dual-infusion system and Navigator continuous glucose monitor for in-patient use and provided validation for our upcoming inpatient clinical study.

Performance of Nova StatStrip Glucose Meter in Newborns

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Objective:
The primary objectives of this study are to assess the performance of the Nova StatStrip hospital whole blood glucose meter relative to the blood gas analyzer ABL835 (Radiometer) currently in use at the Isala Clinics in the Netherlands, for glucose values <2.6 mmol/liter, on newborn blood specimens.

Approximately 2 out of 1000 newborn babies develop hypoglycemia after birth. If hypoglycemia (clinical symptoms such as jitteriness, apnea, hypothermia) in the newborn at risk (i.e., babies born to mothers with diabetes, small for gestational age, or premature infants) is not treated in a timely manner, then the low glucose levels in the blood may have adverse effects on brain function development. A treatment decision depends on the accuracy and precision of glucose testing at a glucose concentration of 2.0 mmol/liter.

Method:
For method comparison, Passing–Bablok regression analysis was applied.

Results:
With the StatStrip, $y = x - 0.2$, $r = 0.82$, and $n = 238$ for glucose values <2.6 mmol/liter.

Conclusion:
Further research is warranted to investigate the deviating results. These results were obtained despite that both methods are excellent in isotope dilution gas chromatography mass spectrometry aligned over the entire reference range for blood glucose. At a glucose concentration of 2.0 mmol/liter determined with Nova StatStrip, 130 babies will receive glucose, and with ABL835, 90 babies will receive glucose. Currently, we are not sure which result is correct. At least StatStrip is on the safe side. Is ABL835 a good reference for glucose values <2.6 mmol/liter? Isotope dilution gas chromatography mass spectrometry aligning of point-of-care glucose meters must be performed for the hypoglycemic range to investigate newborn blood specimens.

Assessment of the Quality of Glycemic Control and Patterns of Insulin Use in Hospitalized Patients: The MAGIE Study

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Objective:
We describe the quality of the glycemic control and patterns of insulin use in patients hospitalized in noncritical care units in an academic center.

Method:
This retrospective study was realized in patients for whom subcutaneous insulin was prescribed and who were hospitalized for at least 5 days in a noncritical care unit of Hôtel-Dieu du Centre Hospitalier de l'Université de Montréal between January and June 2009. Days 2 to 5 were analyzed. A random sample (n = 300) of medical charts was evaluated. Good glycemic control was defined as mean blood glucose between 4 and 10 mmol/liter. Hyperglycemic and hypoglycemic episodes were evaluated to measure safety. The different insulin regimens were noted.

Results:
A total of 150 patients (mean age 68 years; mean hemoglobin A1c 7.6% ± 1.7 %) were included. Of these patients, 59% were male and 78% had known type 2 diabetes. A good glycemic control was found in 60% of patient days, but only 32% of patients had a mean blood glucose in the target range. At least one episode of hyperglycemia (>1.5 mmol/liter), mild to moderate hypoglycemia (2.5–3.9 mmol/liter) or severe hypoglycemia (<2.5 mmol/liter) was seen in 51%, 21%, and 4% of patients, respectively. The most frequently used treatments were sliding scale with oral agent(s) (29% of patient-days) followed by a combination of basal and prandial insulin (25% of patient days). Sliding scale alone was prescribed in 17% of patient days but never by an endocrinologist. A basal insulin was part of the regimen in 43% of patient days.

Conclusion:
The quality of glycemic control was found to be less than optimal in patients hospitalized in non-critical care units. Interventions to improve the glycemic control and patterns of use of insulin will be implemented.

Clinical Relevance of Assessing Glucose Meter Total Analytical Error

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Objective:
Concern is growing regarding the reliability of glucose meters. The Clinical Laboratory Standards Institute and the International Organization for Standardization (ISO) are refining their analytical expectations (i.e., precision and accuracy) for assessing glucose meter performance. Total analytical error has been previously determined to be equal to |% bias (i.e., inaccuracy)| + 1.645 X % imprecision. The objectives of this study are (1) to determine how total analytical error relates to ISO 15197:2003 performance expectations and (2) to determine the extent to which total analytical error might influence clinical decisions.

Method:
The influence of hematocrit and specimen volume were tested alone and in combination at three glucose concentrations and compared with a plasma hexokinase method. Precision was determined by consecutive analysis (n = 5 whole blood specimens) at three glucose concentrations and three hematocrit levels. Multivariate regression analysis was used to estimate the bias associated with hematocrit and specimen volume, alone and in combination. Total analytical error was estimated as outlined.

Results:
A hematocrit bias was detected that was dependent upon glucose concentration and specimen volume. Meter imprecision was also affected by hematocrit level and glucose concentration. Estimates of total analytical error ranged from 10% to 50% under the conditions tested. Total error of 50% at a 2.5 mmol/liter (45 mg/dl) glucose concentration translates into a potential reported glucose ranging from 1.25 mmol/liter (22.5 mg/dl) to 3.75 mmol/liter (67.5 mg/dl). The ISO 15197:2003 performance expectations were met under all conditions evaluated.

Conclusion:
ISO 15197:2003 performance expectations can be associated with total analytical error of up to 50%. Theoretically, this amount of total error could have profound influence on clinical decision making.

Impacting Quality of Care through Joint Commission Certification for Diabetes Care

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Objective:
We aim to (1) describe how the process of certification impacts quality of care, (2) identify the conceptual framework of Joint Commission national and international certification, (3) list three requirements for achieving diabetes care certification, and (4) identify three benefits of diabetes care certification.

Summary:
How is quality of care influenced by the process of Joint Commission national or international certification for diabetes care? The presentation includes a description of the certification program and process. A description of how the requirements for achieving certification impacts quality of care. The wrap-up is a review of the benefits of pursuing and achieving Joint Commission certification for diabetes care. When considering quality of care for patients with diabetes, implementing the core requirements to achieve certification provides the roadmap to decrease variability in care and improve outcomes for this patient population. The core requirements consist of structuring the care program to meet the Joint Commission international standards, utilizing clinical practice guidelines/ recommendations to guide the care being provided and engaging in performance improvement process by defining, tracking, analyzing data, and creating a performance improvement plan from a minimum of four performance measures.

Management and Monitoring of Hyperglycemia during Admission for Acute Coronary Syndrome Is Less Intensive after the Action to Control Cardiovascular Risk in Diabetes Study

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Objective:
Intensive management of hyperglycemia during acute coronary syndrome (ACS) has been demonstrated to reduce mortality. The Action to Control Cardiovascular Risk in Diabetes (ACCORD) study has raised some doubts in this practice. A hospital audit carried had demonstrated that the commencement of a variable insulin glucose (VIG) infusion protocol was excellent in established diabetes patients but needed improvement in patients not previously known to have diabetes (NkD). A follow on audit was carried to reassess the attitudes of staff to glycemic management in these patients post-ACCORD.

Method:
A retrospective analysis of the Myocardial Infarction National Audit Project database of patients admitted with ACS and hyperglycemia in a U.K. hospital between October 2008 and September 2009 was carried out. Evidence of glycemic monitoring and use of VIG were assessed. Patients with severe heart failure and severe renal failure (glomerular filtration rate <30) were excluded from the audit.

Results:
Thirty-four patients (71% male; mean age 70 years) were identified. Twenty-eight patients (82%) were NkD. Eight (24%) patients were found to have blood glucose (BG) levels >11 mmol/liter, with 7 established on VIG. Only 1 NkD patient had VIG despite 3 having BG >11 mmol/liter (30%). Twenty-six patients(76% of total) had BG between 7 and 10.9 mmol/liter on admission, but only 1 had premeal and/or postmeal BG monitored during admission, and this patient eventually required VIG for BG >11 mmol/liter.

Conclusion:
The use of the VIG protocol in NkD, post-ACCORD, remains unsatisfactory. Crucially also, the routine monitoring of patients with admission BG levels between 7 and 10.9 mmol/liter was not carried out to identify subsequent significant hyperglycemia. This is could impact negatively, resulting in adverse outcomes in this group. Staff attitudes on monitoring and aggressive management of hyperglycemia appear to have relaxed since the ACCORD study.

Glycemic Variability and Glucose Monitoring in Critical Care

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Objective:
Minimizing glycemic variability (GV) during glucose control in critical care patients is acknowledged as an important goal because of deleterious impact of excessive GV on the outcome. The aim of the study was to assess the impact of the characteristics of glucose monitoring on the reliability of the GV measurement.

Method:
We used the Eirus system (Dipylon Medical, Solna, Sweden) based on microdialysis for continuous glucose monitoring (CGM) in a mechanically ventilated patient necessitating continuous intravenous insulin. The CGM system consists of a dedicated single-lumen central venous catheter, a disposable sensor on a reusable sensor holder outside the patient, and a monitor producing a new measurement each minute. During the monitoring period (approximately 18 h), three calibrations were performed using arterial blood samples and a blood gas analyzer (Radiometer SAS, Neuilly-Plaisance, France). The attending nurses performed six blood glucose measurements with a point-of-care glucometer according to our glucose control protocol. Glycemic variability was assessed by the variability index defined as the mean of the absolute value of the first derivative of the glucose "signal" during CGM and as the mean of the absolute value of the variation rate between two consecutive measurements during discontinuous glucose monitoring. In order to simulate semicontinuous and discrete glucose monitoring, we extracted CGM values, respectively, every 15 and 30 min and 1, 2, 3, and 4 h for calculating the corresponding variability index.

Results:
The study results will be presented.

Conclusion:
Low sample rate CGM or discrete glucose monitoring may underestimate GV.

Continuous Central Venous Glucose Monitoring in Critical Care: A Pilot Study

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Objective:
The aim of the study is to assess the feasibility in critical care of a new continuous glucose monitoring system (CGMS) based on the microdialysis technique and to calculate parameters describing glucose control in critical care according to the current glucose metrics consisting of three domains: central tendency, glycemic variability, and minimal glucose level.

Method:
We used the Eirus system (Dipylon Medical, Solna, Sweden) in a mechanically ventilated patient necessitating continuous intravenous insulin. The CGMS consists of a dedicated single-lumen central venous catheter, a disposable sensor on a reusable sensor holder outside the patient, and a monitor producing a new measurement each minute. During the monitoring period (approximately 18 h), the attending nurses performed three calibrations using arterial blood samples and a blood gas analyzer (Radiometer SAS, Neuilly-Plaisance, France) and six blood glucose measurements with a point-of-care (POC) glucometer according to our glucose control protocol.

Results:
The mean glucose level was 7.94 ± 1.94 mmol/liter, and the mean of the absolute value of the difference between the CGMS glucose level and the upper limit of our range (6.1 mmol/liter) was 2.44 mmol/liter. The variability index defined as the mean of the absolute value of the first derivative of the glucose "signal" was 0.0244 mmol/liter^{-1}/min^{-1}. The minimal values given by CGMS and POC monitoring were, respectively, 3.98 and 5.90 mmol/liter.

Conclusion:
The CGMS seems to be promising for calculating parameters assessing the quality of glucose control in the intensive care unit with respect to the current glucose metrics.

Information Technology Solutions for ThinkGlucose, a Nationwide Project to Improve Diabetes Inpatient Care in the United Kingdom

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Objective:
ThinkGlucose is a nationwide project aiming to improve inpatient diabetes care in the United Kingdom. Inpatient diabetes referrals are currently made using paper request forms, faxed referrals, or telephone contact with the diabetes team. We evaluated clinical care outcomes of a locally developed electronic diabetes assessment and referral system integrating iSoft Clinical Manager, NHSmail, and an electronic Bed Management System (eBMS).

Method:
We designed an electronic version of the national ThinkGlucose traffic light diabetes assessment and referral order form that could be undertaken virtually using any computer terminal in the hospital. All referrals are now being sent to, and arrive instantaneously at, a central NHSmail box, where an administrator collates and creates a virtual ward list daily that enables the diabetes inpatient specialist care (DISC) team to review referred patients. In addition, once a diabetes patient has been identified and coded, a ThinkGlucose symbol is displayed on an eBMS screen to facilitate ward review. The inpatient activity is recorded in Lorenzo iSoft Patient Manager, a relational database management system for patient care.

Results:
There has been an incremental rise of quarterly (Q1, Q2, and Q3 electronic referrals, (Q2 vs. Q1 increased by 87.3% and Q3 vs. Q2 by 27.9%). Most patients reviewed within 24 h by the DISC team using this newly implemented system also increased in each quarter (Q2 vs. Q1 by 121% and Q3 vs. Q2 by 16.9%).

Conclusion:
This system provides 24 h, 7-day unrestricted access to the DISC team, abolishing traditional method of referrals. It maintains a central record of the patients for audit purposes, including details of the referral pathway followed in each case. The referral-to-review time has shortened, and the patients receive care appropriate to their needs.

Strict Glycemic Control in Patients with Intracranial Hemorrhage: A Preliminary Report

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Objective:
Intracranial (subarachnoid or intraparenchymal) hemorrhage can result in death or disabilities associated with considerable loss of productivity. Patients with hyperglycemia have been reported to have worse outcomes than normoglycemic patients in this patient population. We tested the hypothesis that tight glucose control in the intensive care unit (ICU) improves neurological outcome in patients with nontraumatic subarachnoid hemorrhage and nontraumatic intraparenchymal hemorrhage.

Method:
With institutional review board approval and informed consent, patients with an admission Glasgow Coma Scale (GCS) of between 6 and 14 were randomly assigned to tight (80–110 mg/dl, n = 24) or conventional (150–170 mg/dl, n = 20) glucose control within 24 h of ICU admission. The primary outcome measure was the degree of morbidity as measured by Karnovsky outcome scale 3 months later. Mortality was the secondary end point.

Results:
The average blood glucose concentration while the patients received insulin drip was 99 ± 9 mg/dl (mean ± standard deviation) in the intensive therapy group and 138 ± 20 mg/dl in the conventional therapy group. Karnovsky scale scores were not different in the two groups (53 ± 55 vs. 60 ± 25; p = .49); however, in a subgroup analysis on patients with an admission GCS of 13 or 14, there was a trend toward a better outcome in the intensive therapy group (50 ± 28 vs. 78 ± 18 for conventional; p = .07). Overall mortality rates at 3 months were similar in the two groups (five patients in each group).

Conclusion:
Intensive insulin therapy in patients with acute subarachnoid or intracerebral hemorrhage did not reduce morbidity as measured by the Karnovsky scale compared with conventional treatment. There may be a benefit of strict glycemic control on outcome in patients with relatively minor neurologic injuries. Mortality does not seem to be affected by intensive insulin therapy.

A Continuous Glucose Monitoring System by Interstitial Fluid Transdermal Extraction Based on Microfluidics

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Objective:
We present a new microfluidic system for transdermal interstitial fluid (ISF) extraction, collection, and volumetric measurement toward the application of noninvasive, continuous, and real-time glucose monitoring. The development of this device overcomes the fluid handling hurdles faced in the realization of a low-cost and portable ISF-based glucose monitoring system.

Method:
This device consists of a venturi tube for vacuum generation, chambers for the introduction of ISF and normal saline solution, pneumatic valves for fluid management, and a volume sensor for normal saline input volume control and ISF volume measurement. Under the management of pneumatic valves, demonstration of the defined volume normal saline injection, ISF extraction, collection, and volumetric measurement functions of the system are presented using the stable vacuum generated by the integrated venturi structure. The device is designed, fabricated, and integrated by microfluidic chip.

Results:
A vacuum pressure of less than 91 kPa has been achieved when a 220 kPa external pressure was applied to the venturi tube realized in this system. Under the management of pneumatic valves and the using the 95 kPa vacuum force generated from the venturi tube, this system has been shown to successfully manipulate fluid transport in the system. A novel integrated volume sensor has been demonstrated that stably (coefficient of variation is 0.0041, $n = 20$) controls the 9.70 μl normal saline injection and is capable of consistently measuring the volume of extracted ISF. This repeatability is shown by the high correlation coefficient ($R^2 = 0.9992$) between the tested volume and the volume measured by a microsyringe in a simulated ISF extraction test.

Conclusion:
This work demonstrates a microfluidic system for ISF extraction, collection, and volumetric measurement toward the application of glucose monitoring.

Hemoglobin A1c as a Prognostic Factor for 1-Year Mortality Following Hospitalization in the Internal Ward

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Objective:
We evaluate the association between admission levels of hemoglobin A1c (HbA1c) and clinical outcomes in the general internal medicine wards.

Method:
We performed a single-center, prospective follow-up study. The HbA1c level of all patients admitted to two general internal medicine wards were measured during the first 24 h of admission. All cause mortality at 1 year was measured.

Results:
A total of 1024 patients were enrolled: 590 (57.6%) patients with known diabetes mellitus (DM group), 120 (11.7%) with hyperglycemia (glucose >140 mg/dl) on admission (H group), and 314 (30.7%) patients without diabetes or hyperglycemia (NDM group). The mean of HbA1c was 5.48 ± 0.51 for the NDM group, 5.77 ± 0.79 for the H group, and 7.96 ± 2.11 for the DM group ($p < .001$). A total of 97 (13%) died during the follow-up period: 70 (11.9%) in the DM group, 12 (10.0%) in the H group, and 15 (4.8%) in the NDM group ($p = .002$). Patients in the NDM group had lower mortality risk than patients from the DM or H group (log-rank $p = .01$). In the H group, HbA1c levels above 6.5% were associated with increased mortality risk (relative risk 3.68, 95% confidence interval 1.50–9.02), and in the DM group, the mortality rate had a J-shaped distribution, i.e., the lowest and highest HbA1c levels were associated with elevated mortality rates.

Conclusion:
We find that HbA1c has an impact on patient mortality. We suggest dividing this group of patients into three groups: diabetes, hyperglycemic, and normal glucose patients. The normal glucose patients are a low-risk group. The group of hyperglycemics is at greater risk with increased HbA1c, and diabetes patients are at greater risk with low and high HbA1c. We suggest HbA1c measured to help define their risk.

Diabetes Connected Health Evaluation

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Objective:
We aim to determine patient and provider engagement on a Web-based diabetes self-management portal and its association with clinical outcomes.

Method:
Patient engagement was determined by number of blood glucose readings and uploads, and provider engagement was determined by number of logins to the Web portal. Clinical outcomes were determined by change in hemoglobin A1c (HbA1c) over one year in the program.

Results:
A total of 166 patients were enrolled in Diabetes Connect (DC). Of these, 98 (~62%) engaged (at least one upload/month) within 2 months; 43% were never active. Engaged patients consistently uploaded 10–20 blood glucose readings/upload, 2–3 times/month. Less than half remained active after 7 months. The 67 patients with available clinical outcomes were, on average, 60 years old (standard deviation, 11.9), were 64% male, and had started insulin within the past 3 years. Patients engaged in DC had average HbA1c change of 1.5 gm%, while inactive patients had a HbA1c change of 0.4 gm% ($p < .03$). Patients with better outcomes (HbA1c change of greater than 0.8 gm%) typically took less than 10 days to engage, while patients with worse outcomes (increase in HbA1c) took an average of 65 days to upload. Patients with more engaged providers had a better HbA1c change (1.39 vs. 0.87 for practices with average provider logins of 74 vs. 30).

Conclusion:
Outcomes in a collaborative Web-based diabetes self-management tool are impacted positively by their consistent engagement in the program. Patients who engage early and remain active for longer have better clinical outcomes than unengaged patients. Patients who had positive outcomes uploaded consistently over time. Also, patients with engaged providers are more engaged in the program, leading to better clinical outcomes.

Detection in the Emergency Department of Patients at Risk of Variable Blood Glucose during Admission

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Objective:
We seek early identification of patients at risk of hypoglycemia and hyperglycemia during admission to medical wards.

Method:
We performed a retrospective cohort study to investigate the relationship between blood sugars outside the range of 4–11 mmol/liter (normoglycemia) in patients with diabetes hospitalized in the general medical wards and hospital length of stay, mortality, and 28-day readmission rate. Data were obtained from point-of-care glucose meters and hospital administrative databases. We conducted univariate and multivariate analyses after adjustment for comorbidity.

Results:
Among the 300 patients included in this analysis, 106 had normal glucose readings their entire stay in hospital, and 194 had variable glucose readings with at least one hypoglycemic or one hyperglycemic episode: 23 experienced only hypoglycemic events, 59 experienced both hypoglycemia and hyper-glycemia, and 112 experienced only hyperglycemic events in addition to normoglycemia while in hospital. There were 389 hypoglycemic events with an average blood glucose of 3.2 mmol/liter, and 2153 hyperglycemic events with an average blood glucose of 14.7 mmol/liter.

Among 232 patients with glucose readings in the first 24 h, having a hypoglycemic event in the first 24 h was not significantly associated with having variable glucose the rest of stay in hospital [odds ratio = 1.68; 95% confidence interval (CI), 0.74–3.83; $p = 0.2$]. A hyperglycemic episode in the first 24 h significantly increased the odds of having a variable glucose stay by 7.64% (95% CI, 4.08–14.30; $p < .001$), and having both a hyperglycemic and hypoglycemic episode in the first 24 h increased the odds of having a variable glucose stay by 12.25% (95% CI, 1.53–97.94; $p = .02$).

Conclusion:
Monitoring of blood glucose levels early in admission may allow early identification of patients at risk of variable glucose admissions, allowing them to be targeted for closer intervention.

Glucose Variability as a Predictor of Poor Clinical Outcomes among Hospital Inpatients with Diabetes Mellitus

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Objective:
Hyperglycemia in the hospital has been associated with poor clinical outcomes, encouraging tighter glucose control, but benefits may be offset by risk of hypoglycemia. This study aimed to assess whether blood glucose within the range of 4.0–11.0 mmol/liter (normoglycemia) in diabetes patients hospitalized in the general medicine wards is associated with better outcomes.

Method:
We performed a retrospective cohort study of patients at Sunnybrook Health Sciences Centre between November 1, 2009, and April 30, 2010, with type 1 or type 2 diabetes as a comorbidity.

Results:
A total of 300 patients had point-of-care glucose readings: 106 (35.3%) achieved normoglycemia during their entire stay, while 112 (37.3%) had hyperglycemic episodes, 23 (7.7%) had hypoglycemic episodes, and 59 (19.7%) experienced both. Hyperglycemia in the first 24 h significantly increased the odds of having a variable glucose stay by 7.64% [95% confidence interval (CI), 4.08–14.30; p < .001], and having both hyperglycemia and hypoglycemia in the first 24 h increased the odds of having a variable glucose stay by 12.25% (95% CI, 1.53–97.94; p = .02) In multivariate analysis, the average length of stay increased by 1.1 days for every day with a hypoglycemic or hyperglycemic episode (p < .001) and by 1.2 days for patients experiencing both. On average, patients with >9 days with either a hyperglycemic or hypoglycemic episode were in the hospital 11.62 days longer than their expected length of stay, compared with 4.24 days longer for those with normal glucose.

Conclusion:
Patients with normal blood glucose levels in the first 24 h in the hospital may need less frequent blood glucose testing. Variable glucose control is associated with increased length of hospital stay.

Reducing Hypoglycemia by Closing the Diabetes Care Gap

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Objective:
In our already overburdened health care system, the impact of diabetes and its sequelae has reached a tipping point in our hospitals, with 26% of hospitalized patients meeting the criteria for the diagnosis of diabetes. A formalized quality improvement effort has proven to be effective in implementing the needed system-wide change. In order to achieve the best glycemic control possible in a given clinical situation and minimize hypoglycemia in the wards of Sunnybrook Health Sciences Centre (a large academic teaching hospital in Toronto), we have redesigned processes and information to implement effective regimens and protocols to optimize care by increasing the percentage of patients receiving evidence-based, rational insulin regimens; improving the understanding of diabetes care of health care providers; improving the collection of data about glycemic control of inpatients; providing optimal nutritional and dietary support for inpatients with diabetes; and promoting effective evidence-based prevention and treatment of hypoglycemia.

Method:
Interventions included the introduction of standardized insulin order sets; use of algorithms, policies, and protocols; use of hypoglycemia policy and insulin treatment algorithms; and use of comprehensive education programs, patient education video on television, material on wards, and staff education sessions. Outcomes were measured by repeated "snapshot' audits and pre-analysis/postanalysis of glucometrics. Progress was constantly reviewed and process failure points identified and adjusted.

Results:
Hospital-wide rates of hypoglycemia fell from 3.4% of glucose values to 2.9%.

Conclusion:
Sunnybrook's experience in designing, implementing, and evaluating our system-wide approach in achieving efficiencies will be outlined as well as the measures to avoid pitfalls that can derail improvement efforts.

Theoretical Impact of Detecting Whole Blood Glucose Molality and Reporting Plasma Glucose Molarity in Various Patient Populations

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Objective:
Glucose meters and blood gas analyzers report plasma glucose molarity (mmol/liter or mg/dl) by multiplying a volume displacement correction factor with detected whole blood glucose molality. The volume displacement correction factor is derived from hematocrit, plasma water, and red blood cell water fractions. Commercial direct reading glucose biosensors use a constant volume displacement factor that assumes all patient samples have mean values for hematocrit, red cell water, and plasma water. The objective of this study was to determine the distribution of errors in reported glucose molarity derived from the false assumption that all patient samples have mean values for hematocrit, red cell water, and plasma water.

Method:
The distributions of hematocrit, red blood cell water, and plasma water and the volume displacement conversion factor were previously determined for ambulatory, hospitalized, and adult intensive care patients. Differences were determined between theoretical whole blood glucose molality and plasma glucose molarity calculated using the population-specific volume displacement conversion factors.

Results:
The 95% confidence intervals for percentage error in glucose molarity in patient groups are as follows: ambulatory (+8.6% to +14.6%), hospitalized (+5.8% to +14.2%), and adult intensive care (+4.9% to +11.3%). The cumulative frequency distribution of the percentage differences at the 0th, 25th, 50th, 75th, and 100th percentile were 2.8%, 10.8%, 11.7% 12.7%, and 19.2% (ambulatory patients); 3.9%, 8.4%, 10.1% 11.5%, and 17.5% (hospitalized patients); and 5.0%, 7.2%, 7.6%, 8.7%, and 13.7% (intensive care unit patients), respectively.

Conclusion:
Plasma glucose molarity showed consistently a positive error due to the false assumption used to convert glucose molality into glucose molarity. The extent of the positive error depended on the patient population examined (2.8–19.2% ambulatory; 3.9–17.5% hospitalized; 5–13.7% intensive care unit).

Certified Nurses Improve Diabetes Care in Non-Intensive Care Unit Hospitalized Patients: A Pilot Study

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Objective:
This pilot study was performed to investigate whether glycemic control could be improved in hospitalized patients with insulin-dependent diabetes mellitus on the vascular surgery unit of Vrije Universiteit University Medical Center by implementing a protocol in which nurses have independent authority to treat abnormal glucose values. The second objective was to evaluate whether the protocol has been implemented satisfactorily.

Method:
After extensive education and examination by diabetes specialized nurses (DSNs), certificate nurses received authorization to apply a protocol, which includes glucose measurements and treatment of hypoglycemia or hyperglycemia (glucose <4 or >11 mmol/liter, respectively) twice a day, under guidance of the DSN. Glucose values and hypoglycemic and hyperglycemic events that occurred during the day were tallied and analyzed. Secondly, a survey was conducted among nurses with regard to satisfaction and degree to which protocol has been applied.

Results:
In comparison with the baseline study group (n = 432 glucose measurements), the comparable protocol group (n = 496) showed a significant decrease in mean glucose levels and glucose values >8 mmol/liter (61% vs. 39%; p = .04), with no increase in hypoglycemic events (5.8% vs. 4.6%). Interventions were more frequently applied during hyperglycemia (22% vs. 61%). The survey among nurses showed that protocol has been applied by 83% of the nurses, and 77% experienced it as being time efficient.

Conclusion:
This study showed that a protocol applied by certified nurses in a non-intensive care unit hospitalized setting can safely improve glycemic control in patients with insulin-dependent diabetes mellitus on a vascular surgery unit. Among the majority of nurses, this protocol was found useful, effective, and time efficient. Due to these results, it may be considered to implement this protocol on a hospital-wide base.

Adherence to Antidiabetic Drug Therapy and Self-Management Practices among Type 2 Diabetes Patients in Ethiopia

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Objective:
We describe the pattern of antidiabetic drug prescribing and ascertain the level of glycemic control and adherence with prescribed antidiabetic medications and diabetes self-management practices among patients with type 2 diabetes mellitus (T2DM) in Jimma University Hospital, Ethiopia.

Method:
The study consisted of two phases. A cross-sectional review of 200 randomly selected case notes of T2DM patients who attended the endocrinology clinic over 3 months and cross-sectional interviews, with a pretested adherence and self-management monitoring tool (ASMMT), of 200 consecutive patients who presented their drug prescriptions at the satellite pharmacy unit over a 4-week period at a 500-bed teaching hospital located in Jimma, Southwestern Ethiopia.

Results:
Oral hypoglycemic agents (OHAs) were prescribed for 86% (171) of cohorts, while insulin and OHAs were prescribed in 14% (29). Approximately 70.8% (121) of patients on OHAs were on combination therapy. The most frequently prescribed OHA combination was glibenclamide and metformin (95.8%). Glibenclamide was prescribed as twice-daily regimen in 69% of cohorts. The most frequently documented side effect was hypoglycemia (60.3%). Only 44% (88) of cohorts had adequate glycemic control; of these, 93% (82) were adjudged adherent with prescribed antidiabetic drugs. Interviews with the structured ASMMT revealed that 59% of patients were nonadherent with the previous antidiabetic drugs due to lack of finance (51.7%), side effects (34.5%), and perceived inefficacy of prescribed antidiabetic drugs, leading to self-medication with local herbs (13.8%). Only 20% of nonadherent patients claimed disclosure to physicians during consultation. The identified factors for nondisclosure were lack of privacy during consultation (58%) and short consultation time (42%). The knowledge and practice of critical components of diabetes self-management behaviors were generally low among the cohort studied. However, it was significantly higher among patients judged adherent with their prescribed antidiabetic medications ($p > .05$).

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Conclusion:

The majority of T2DM patients in an ambulatory tertiary care setting in Ethiopia are managed with OHA combinations, mainly glibenclamide and metformin. While the current prescribing strategy achieved glycemic control in approximately one-third of patients, the majority are still not meeting the recommended blood glucose targets due to poor adherence with prescribed drug regimen and poor knowledge and practice of successful self-management.

Continuous Subcutaneous Insulin Infusion: Lazio Region (Italy) Status of the Art

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Objective:
Continuous subcutaneous insulin infusion (CSII) is an increasingly used treatment and has been shown to improve metabolic control. This method involves an additional economic charge for the National Health Service compared with the traditional multiple daily injections, and to get the desired goals, it requires specific patient and diabetes care team characteristics. The aim of this study was to take a census survey of diabetes care centers using insulin pump therapy in the Lazio region (Italy) and to detect the indicators of process and structure.

Method:
A regional working group identified all the centers using CSII in the Lazio region by either an information letter and by referring to the lists of pharmaceutical companies producing pumps. Subsequently, all the identified centers received a questionnaire.

Results:
The survey identified 24 diabetes care centers for a total of over 1200 pumps actively operating. In 80% of the centers, more than one physician is "trained" in the use of the method, and in 50% of the centers, between 2 and 5 h/week are scheduled for "training" of naïve patients and for the periodical "retraining." In half of the centers, a dedicated team is available. Eighty-five percent of the centers use a trial period of 1 to 2 months before the pump is directly purchased by National Health Service. Few centers (35%) discontinue CSII if metabolic goals are not achieved. The use of glucose sensors is extremely uneven.

Conclusion:
Insulin pumps in the Lazio region represent a valuable therapeutic tool with a well-established care pathway. The optimization of this path will allow improved resource allocation in response to the expected increase in the use pumps and sensors.

Postoperative Glycemic Variability in Patients with and without Diabetes

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Objective:
Glycemic variability increases oxidative stress and may trigger the inflammation and coagulation cascades. Variability may be associated with increased morbidity and mortality in intensive care unit (ICU) patients. We analyzed glycemic variability after major surgery in patients with diabetes (DM) and patients with no diabetes (NDM) using an automated intravenous blood glucose monitor (IVBG).

Method:
After institutional review board approval, 25 patients undergoing abdominal surgery with an anticipated ICU stay of at least 24 h were enrolled in a prospective, blinded, observational study. An investigational intravenous blood glucose monitoring system (Edwards Lifesciences, Irvine, CA) was used for continuous BG monitoring. The IVBG sensor was inserted into the lumen of a peripheral venous catheter and attached to a bedside monitor prior to surgery. The BG concentration was automatically measured every 7 to 8 min for a maximum of 72 h by the IVBG monitor in a blinded fashion. The IVBG measurements were compared with reference BG analyzer measurements (YSI 2300 STAT). Glycemic variability was calculated using standard deviation (SD). Data were analyzed using the two-tailed *t*-test.

Results:
Eight patients with type 2 diabetes and 17 patients without diabetes were studied. There was no difference in sex, age, American Society of Anesthesiologists physical status, duration of surgery, and length of ICU stay between the groups. Patients underwent aortic valve replacement surgery (2), pancreas resection or Whipple procedure (19), liver resection (1), and esophageal resection (3). The DM patients had a significantly higher mean BG than NDM patients (164.7 ± 16.2 vs. 131.6 ± 14.6 mg/dl, respectively, $p < .001$), preoperative hemoglobin A1c (7.5% ± 1.1% vs. 5.8% ± 0.4%, $p = .006$), and body mass index (39.5 ± 5.1 vs. 29.0 ± 9.0 kg/m^2, $p = .013$). Glycemic variability was significantly increased in DM patients compared with NDM patients. Average glucose SD for each patient's IVBG measurements was 38.0 ± 15.2 vs. 24.3 ± 9.4 mg/dl, respectively, $p = .042$. The IVBG monitor and

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YSI measurements compared closely (6.5 % mean absolute relative difference and 100% of paired data in Clarke error grid zones A and B).

Conclusion:
The DM patients had a significantly higher mean BG and glycemic variability. A prospective study is needed to evaluate if minimizing hyperglycemia, hypoglycemia, and glycemic variability with an automated glucose monitor and insulin can influence clinical outcome after major surgery.

Software-Guided Insulin Dosing Decreases Glycemic Variability in Critically Ill Patients

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Objective:
Severe hyperglycemia, hypoglycemia, and glycemic variability are linked to increased mortality in intensive care unit patients. Intensive insulin guided by paper protocol is commonly used to treat hyperglycemia but, in so doing, raises the risk of hypoglycemia. We tested the hypothesis that software-driven, as compared with paper-protocol-driven, intensive insulin would be more effective and safer.

Method:
In a before/after design, we studied 197 critically ill surgical patients admitted for 6-month periods, during which intensive insulin was used to achieve a target blood glucose of 95–135 mg/dl (5.3–7.5 mmol/liter), in 2008 (paper protocol guided) versus 2009 [software driven, i.e., GlucoStabilizer (Indianapolis, IN)]. The primary endpoint was to decrease glycemic variability over the first 7 days of intensive insulin.

Results:
The study results will be presented.

Conclusion:
Software-guided dosing was comparatively superior to paper-protocol-guided dosing of intensive insulin in critically ill patients. Glycemic control was tighter, hypoglycemia was less, and glycemic variability was decreased and smoothed the glycemic curve.

Assessment of In-Hospital Glycemic Management in Non-Critically Ill Patients

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Objective:
In hospitalized patients, there is substantial observational evidence linking hyperglycemia to poor outcomes. Based on few available interventional data for non-critically ill patients, the premeal blood glucose (BG) target should be <140 mg/dl (7.78 mmol/liter), with random BG <180 mg/dl (10 mmol/liter), provided that these targets can be safely achieved. The aim of the study was to assess the glycemic management process for hospitalized patients who were admitted primarily not because of elevated glycemia.

Method:
Data of 50 patients (age 71.5 ± 12.3 years, body mass index 28.3 ± 6.1 kg/m^2, 22 men/28 women, 3 with type 1 diabetes, 47 with type 2 diabetes, hemoglobin A1c 7.8% ± 1.5%) treated with insulin of two general wards (endocrinology, cardiology) were retrospectively analyzed regarding characteristics of the glucose management process: number of BG measurements, mean BG, BG measurement in the range of 70–140 and 70–180 mg/dl, number of hypoglycemic (<60 mg/dl) and hyperglycemic (>300 mg/dl) events. The data were analyzed per population, patient stay, and patient day. In addition, glucose and insulin were analyzed for the admission and discharge period.

Results:
Mean BG per patient day was 178 ± 38 mg/dl, with 23% of the values between 70 and 140 mg/dl, 55% between 70 and 180 mg/dl, 0.8% <60 mg/dl, and 10% >300 mg/dl. Mean BG and insulin dosing in the admission and discharge period were 167 ± 41 versus 175 ± 45 mg/dl (p = .32, paired t-test) and 21 ± 21 versus 25 ± 21 U (p = .12, Wilcoxon test), respectively.

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Conclusion:
Although the recommended target range was not met in many cases, the data indicate that insulin treatment was not adjusted accordingly during the hospitalization period. The reasons are manifold (unawareness of target range, fear of hypoglycemia, lack of treatment protocol). These issues have to be addressed systematically to improve glycemic control in hospitalized patients.

Funding:
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Strategies for Glucose Management in the Community Hospital

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Objective:
The objective of this project was to develop a glycemic management system that could improve care of persons with preexisting diabetes when they are admitted to our 400-bed California community hospital for treatment of acute illnesses. Diabetes is best managed as a chronic illness, and acutely ill patients with diabetes are subjected to physiological stressors that require careful glycemic management.

Method:
The Northridge Hospital Medical Center (NHMC) interdisciplinary diabetes committee designed and implemented evidence-based practices, including a teaching campaign for nurses and patients on timing insulin injections with meals, introducing carbohydrate counting with carbohydrate-to-insulin ratios, initiating preprinted basal–bolus order forms for all insulin orders, identifying patients with diabetes on the census board and meal trays, introducing insulin pump policy on all units, including patient input on insulin dosing and carbohydrate counting in insulin injection policy, amending pharmacy policy on the use of secretagogues and correction insulin as redundant, eliminating premixed insulin from the formulary, eliminating hour of sleep coverage if not specifically endorsed by prescriber, and adding to standardized orders a midsleep blood glucose check without coverage for the most vulnerable.

Results:
Currently, house-wide hypoglycemia (<70 mg/dl) is less than 3%, with less than 1% in the intensive care unit, and hyperglycemia (>250 mg/dl) is 30%. Laboratory limitations prevented collection of preintervention data, but anecdotal reports suggest improvement.

Conclusion:
The NHMC has achieved effective glycemic management of acutely ill patients with preexisting diabetes that is supported by a hospital-wide plan that overcame barriers of resistance to practice changes, physician unfamiliarity with basal/bolus dosing, fears of hypoglycemia, nurses' limited knowledge, and patients' physiological instability.

Inpatient Diabetes Management Education for Third-Year Medical Students at a United Kingdom Teaching Hospital

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Objective:
We develop a teaching program that will improve third-year medical students' knowledge and understanding of the complexities of inpatient diabetes management and engage them in the specialty of diabetes. The National Inpatient Audit has demonstrated a high number of inpatients with diabetes (15%) and a high incidence of medication and prescription errors (37.1% and 20%, respectively).

Method:
All medical students at Brighton and Sussex Medical School choose to attend two student-selected components (SSCs) over 8 weeks during their third year. A selection of SSCs are available, each in one of the three categories set out by the General Medical Council in Tomorrow's Doctors: the doctor as a scientist, the doctor as a practitioner, and the doctor as a professional. In 2009, we designed an inpatient diabetes management SSC incorporating a variety of teaching methods and directed group work, reviewing diabetes physiology, medications, prescribing, and management, delivered by the inpatient diabetes nurse specialists.

Results:
In the 2 years that the inpatient diabetes management SSC has been running, it has been adapted to reflect the feedback from the students and the members of the multidisciplinary diabetes team delivering the sessions. Overall, the student evaluation has been positive; the most useful aspects reported are the sessions on insulin regimens (including variable rate insulin infusions) and undertaking an audit of drug cards related to diabetes medications and number of patients with diabetes in the hospital.

Conclusion:
Appropriate management of diabetes in the hospital setting is essential to ensure better outcomes for patients. The development of this SSC has encouraged the medical students to consider diabetes from admission to discharge, regardless of the patient's reason for admission.

Accuracy of the GlucoCheck Excellent Blood Glucose Monitoring Device Compared with Standard Analyzer YSI 2300 STAT Plus and Compared with the Reference Meter OneTouch UltraEasy

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Objective:
The requirements for blood glucose measurement systems for self-monitoring in diabetes mellitus are defined in the German Institute for Standardization (DIN) edition of European (EN) International Organization for Standardization (ISO) 15197. Ninety-five percent of all blood glucose measurements may not exceed ±15 mg/dl for blood glucose concentrations <75 mg/dl and must be within ±20% in glucose concentrations ≥75 mg/dl compared with reference. Within this study, this requirement was tested for GlucoCheck Excellent from Diabetiker-Bedarf db.

Methods:
In this study, two GlucoCheck Excellent devices were compared with YSI 2300 STAT Plus as standard analyzer and compared with OneTouch UltraEasy by LifeScan as a reference meter. The average mean of the blood sugar measurements of the two GlucoCheck Excellent devices were used for system accuracy, glucose concentration deviation, error grid analysis, and regression.

Results:
The combined system accuracy of both GlucoCheck Excellent devices was 98%. Blood glucose concentrations below 75 mg/dl were ±5 mg/dl within limits in 78.57%, ±10 mg/dl in 85.71%, and ±15 mg/dl in 92.86% for all measurements of both devices. Blood glucose concentrations above 75 mg/dl were ±10% within limits in 83.72%, ±15% in 98.84%, and ±20% in 98.84% for all measurements of both devices. The combined system accuracy for OneTouch UltraEasy as a reference meter was 99%.

Conclusion:
The GlucoCheck Excellent blood glucose measuring device as well as the reference meter OneTouch UltraEasy fulfill the requirements for system accuracy according to EN (DIN) ISO 15197. The use of the GlucoCheck Excellent for type 1 and type 2 diabetes as well as for gestational diabetes is safe.

Accuracy of the Abbott FreeStyle Navigator in Intensive Care Unit Patients

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Objective:
Studies of intensive insulin therapy have used intermittent blood glucose (BG) measurements and were confounded by frequent hypoglycemia. Achieving tight glycemic control without hypoglycemia will require continuous glucose monitoring (CGM). We tested the accuracy of the Abbott FreeStyle Navigator in the intensive care unit (ICU) setting.

Method:
Navigator sensors were worn by 61 patients (Neuro-ICU $n = 27$, medical ICU $n = 16$, cardiac ICU $n = 12$, surgical ICU $n = 6$) for up to 72 h. Reference BG values on arterial blood obtained for usual care were used to calibrate CGM voltage traces to predict BG with 1 min resolution. Calibrations schemes included the stock algorithm (calibrations at 1, 2, 10, and 24 h) and algorithms that retained the 1 and 2 h calibrations and calibrations at 24, 12, 8, 6, 4, or 2 h intervals. For accuracy calculations, reference BGs were paired with the nearest CGM values; BG values used for calibrations were paired with the preceding CGM values.

Results:
The standard algorithm gave mean absolute relative deviation (MARD) values higher in the ICU population (14.2%) than we found in otherwise healthy subjects with type 1 diabetes during closed-loop BG control (13.0%, unpublished data). However, calibrating at 6 h intervals yielded a MARD of 12.7%. There were no significant differences in between patients with and without peripheral edema or pressor dependence, nor between ICUs.

Conclusion:
The FreeStyle Navigator can achieve accuracy in ICU patients comparable to that in healthy subjects with type 1 diabetes using a calibration frequency that is practical for the ICU environment.

Using Information Technology to Optimize Inpatient Insulin Therapy

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Objective:
The primary aim of this study is to implement and evaluate a computer-based provider order entry (CPOE) system to facilitate safe and effective initiation of insulin therapy and reduce clinical inertia with inpatients with hyperglycemia.

Method:
Five comprehensive yet easy-to-use subcutaneous insulin order sets were launched November 1, 2010, to meet the initial insulin requirements of most adult inpatients with hyperglycemia. Clinicians received minimal training via a handout with screen shots of the components of the order set and how to place orders. Evaluation of the safety and efficacy included reviewing point-of-care blood glucose (BG) records comparing 6 months of data soon after launching the order set (January–June 2011) to the same time period in 2010. Descriptive statistics such as a *t*-test were used to compare mean rates of hypoglycemia and hyperglycemia on adult noncritical care inpatient units in a 1000-bed academic medical center.

Results:
The number of patients in the target glycemic range (BG 70–200 mg/dl) increased from 20,538 (67.2%) in January–March, 2010, to 22,095 (70.6%, $p < .0001$) in January–March, 2011. At the same time, BG >200 mg/dl decreased from 9576 (31.35%) to 8655 (27.6%, $p < .0001$) and hypoglycemia rates declined from 947 (3.1%) to 479 (1.5%, $p < .0001$).

Conclusion:
Preliminary findings suggest that CPOE is an effective strategy to lower rates of hyperglycemia without a subsequent rise in hypoglycemia on noncritical care floors. A widely adopted insulin order set can facilitate safe initiation of insulin therapy and reduce clinical inertia. Future research should focus on refining existing and creating new order sets to accommodate more inpatient populations.

Hospital Protocol Improves Glucose Control in a Rural Community Hospital

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Objective:
We aim to examine the efficacy and safety of a new inpatient insulin protocol implemented in a small rural community hospital.

Method:
A retrospective chart review for inpatients who had documented hyperglycemia during admission between February 2010 and June 2011. Charts were obtained using a medical-record-generated patient list. Patients in the medical, surgical, and intensive care units were included, while outpatient surgery, obstetrics, and newborn admissions were excluded.

Results:
A total of 269 charts were reviewed. Of these charts, 248 met study criteria. The new protocol significantly shortened the time to euglycemia (23.58 vs. 11.81 h, $p = .039$). The length of stay was also significantly shortened for all patients (3.55 vs. 2.16 days, $p = .023$) and for those who received insulin (3.59 vs. 2.17 days, $p = .028$). The new insulin protocol had higher rates of both mild and severe hypoglycemia, but this difference was not statistically significant. After the implementation of the new protocol, physicians more often reported a diagnosis of diabetes upon discharge, although this was not statistically significant.

Conclusion:
Implementation of a new inpatient insulin protocol provided a significant improvement in time to euglycemia and length of stay, but with a nonsignificant trend of increased hypoglycemia. This study was limited by a small number of participants and will be ongoing.

Moderate Tight versus Liberal Perioperative Diabetes Management in Low- to Moderate-Risk Surgery

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Objective:
Intensified perioperative blood glucose (BG) management in diabetes patients undergoing high-risk surgery can improve postoperative outcome. Here we tested the hypothesis that a moderate tight perioperative diabetes mellitus protocol (PDMP) has beneficial effects on the incidence of post-operative wound infection and length of hospital stay.

Method:
Medical records of 238 patients with diabetes mellitus (DM) admitted for elective surgery before and after implementation of a PDMP were evaluated. In PDMP patients, insulin was started when BG levels exceeded 10 mmol/liter. Outcome parameters were the perioperative BG results, length of hospital stay, and the incidence of wound infections.

Results:
Except for a higher body mass index in the PDMP group (30 ± 6 vs. 28 ± 6 kg/m^2; p = .02), there were no differences with the control group. Despite an increased frequency of insulin administration (69% for PDMP vs. 22% for control) and a higher mean insulin dose (10.9 ± 14.2 U for PDMP vs. 3.3 ± 7.9 U for control), we observed no differences in perioperative BG levels between groups. The PDMP was associated with a reduced hospital stay (8 ± 1 vs. 5 ± 5 days; p = .035) and lower incidence of postoperative wound infections (15% vs. 7%; p = .03).

Conclusion:
Structural perioperative DM management in patients undergoing low- to moderate-risk surgery is associated with beneficial effects on postoperative wound infections and could be a cost-effective tool to reduce hospital stay. Interestingly, the mean perioperative BG results did not differ between groups, suggesting that the beneficial effects might be related to different mechanisms.

Diabetes Patients' Perceptions of Illness and Treatment: The Case of Somale Regional State, Ethiopia

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Background:
Nonadherence to medication and lifestyle regimes in diabetes is associated with increased hospitalizations and mortality, yet many patients fail to adhere to treatment recommendations. Recently, illness perceptions have been associated with adherence to diet and exercise recommendations, blood glucose monitoring, clinic attendance, and blood glucose levels. Specific treatment perceptions are more predictive of adherence to specific behaviors than combined treatment perception scales. The objective of this study is to investigate diabetes patients' perceptions of illness and treatments and explore relationships to adherence and blood glucose control in Somale Regional State, Eastern Ethiopia.

Methodology:
This cross-sectional study was completed at the diabetes clinic in Karamara Hospital in Somale Regional State, Eastern Ethiopia. A total of 54 type 1 diabetes and 205 type 2 diabetes patients completed questionnaires assessing illness perceptions, treatment beliefs, and adherence to medications, diet, and exercise. Blood glucose control was assessed from blood tests.

Results:
Patients rated medication more important than diet and exercise and reported lower adherence to medications. Oral hypoglycemic agents were perceived as more helpful for diabetes, while antihypertensives and weight loss were perceived more helpful for preventing heart problems. Perceptions were associated with adherence to insulin, cholesterol and antihypertensive medications, exercise, and diet. Blood glucose control in type 1 diabetes patients was associated with insulin adherence and perceived personal control and, in type 2 diabetes patients, was associated with being prescribed insulin or antihypertensives and perceived personal control.

Conclusions:
Findings suggest that adherence may be improved by altering patients' illness and treatment perceptions. Interventions to change illness perceptions have been shown to improve outcomes in heart attack patients and their spouses. The first intervention trial to investigate the effects of changing illness perceptions in poorly controlled diabetes patients is underway.

Glucose Control Algorithms in the Intensive Care Unit: *In Silico* Comparison Using Validated Virtual Population

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Objective:
We compare algorithms for glycemic control in the intensive care unit (ICU) using *in silico* testing and a validated virtual population.

Method:
Three well-known algorithms for ICU insulin delivery—Glucommander (GL), NICE-SUGAR (NS), and enhanced model-predictive controller (eMPC)—were compared in 48 h long simulated experiments. We used a virtual population of 56 critically ill subjects created from routine data collected at four European surgical and medical ICUs during the European Commission-funded CLINICIP project. Validity of the virtual population was assessed by evaluating its ability to reproduce results of two clinical studies. The three algorithms suggested the insulin infusion rate and also sampling frequency. Target glucose range 4.4 to 6.1 mM was assumed.

Results:
Glucommander demonstrated the highest percentage of time spent in target glucose range [67% (55–77%) vs. 65% (46–81%) vs. 62% (48–73%); GL vs. NS vs. eMPC] and the lowest hyperglycemic index [0.18 (0.09–0.41) vs. 0.24 (0.07–0.53) vs. 0.24 (0.08–0.47) mM; GL vs. NS vs. eMPC] while advising the highest insulin infusion rate [3.8 (2.5–5.3) vs. 3.1 (2.2–5.0) vs. 3.3 (2.3–5.2) U/h; GL vs. NS vs. eMPC]. NICE-SUGAR achieved the lowest glucose concentration (6.0 ± 0.7 vs. 5.7 ± 0.6 vs. 6.0 ± 0.5 mmol/liter; GL vs. NS vs. eMPC), employing the most frequent sampling [81 (73–87) vs. 70 (58–80) vs. 121 (99–143) min; GL vs. NS vs. eMPC]. One episode of severe hypoglycemia (<2.2 mM) was observed in eMPC, two in GL, and five in NS algorithms.

Conclusion:
Computer simulations may provide alternative resource-efficient means to test and optimize algorithms for glycemic control in the critically ill. Differences in the performance of commonly used algorithms appear to exist.

Evaluation of Diabetes Education in Patients with Type 2 Diabetes in Mongolia

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Objective:
We evaluate the diabetes education conducted among outpatients with type 2 diabetes.

Method:
The study involved 109 patients with type 2 diabetes under the control of endocrinologists at State Central Clinical Hospital. Knowledge about diabetes was evaluated with the four-package questionnaire with 16 questions before and after the education, and clinical measurements, including body mass index, waist circumference, blood pressure, hemoglobin A1c, blood cholesterol, and triglyceride, were tested before the education and 1 and 6 months after. The statistical data were analyzed by SPSS12.00 software.

Results:
Following the inclusion criteria and obtaining an informed consent per individual, 109 participants with age ranges from 26–54 were involved in the study. Seven participants were excluded from the study. Of the study participants, 77% were from urban and 23% were from rural areas, 51% were male, and 49% were female. The average duration of illness was 3.8 ± 1.6 years. A total of 5 days of training was conducted per individual and group. The participants' knowledge about disease was significantly correlated with fasting blood glucose, waist circumference, and body mass index ($r = 0.18$, $p < .005$) before and one and six months after the training. Hemoglobin A1c level was improved significantly ($p < .02$) after 6 months of the training.

Conclusion:
Individual and group diabetes education is important for patients with type 2 diabetes.

Type 2 Diabetes Risk Assessment

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Objective:
We assess type 2 diabetes risk by Finnish Diabetes Risk Score (FINDRISC) questionnaire.

Method:
In this cross-sectional survey using the FINDRISC questionnaire of the Finnish Diabetes Association, we randomly selected the participants from among two organizations' employees evaluated at the annual health checkup at the National Central Clinical Hospital.

Results:
A total of 93 subjects were aged between 29 and 56 years (65% male, 35% female). Data on the FINDRISC were available from each participant. The FINDRISC was very high in 2.1%, high in 10.7%, moderate in 12.9%, slightly elevated in 19.3%, and low in 54.8%, respectively. Among the subjects with very high and high risk scores, 5 individuals were diagnosed with impaired glucose tolerance (IGT) after a 2 h plasma glucose level of 140–200 mg/dl from oral glucose tolerance test or capillary blood glucose test; 1 individual was diagnosed with type 2 diabetes, and 6 were healthy. The sex and waist circumference correlation was weak ($r = 0.25$, $p < .01$). Fasting glucose was correlated to the body mass index ($r = .13$, $p < .005$).

Conclusion:
The result indicated that the FINDRISC was very high in 2.1%, high in 10.7%, moderate in 12.9%, slightly elevated in 19.3%, and low in 54.8%, respectively. Among the subjects with very high and high risk scores, five individuals were diagnosed with IGT, one individual was diagnosed type 2 diabetes, and six were healthy. Ninety percent of people with very high and high risk score had family history and no daily physical activity of at least 30 min at work and/or during leisure time (including normal daily activity).