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Inpatient Management Of Diabetes Mellitus Among Noncritically Ill Patients At The University Hospital Of Puerto Rico:

Inpatient diabetes management

Myriam Zaydee Allende-Vigo, MD MBA FACP FACE[*], **Rafael A. González-Rosario, MD**[*], **Loida González, MD**[*], **Viviana Sánchez, MD**[*], **Mónica A. Vega, MD**[*], **Milliette Alvarado, MD**[*], and **Raul O. Ramón, MS**[†]

[*]Endocrine Section, Department of Medicine, University of Puerto Rico Medical Sciences Campus

[†]Puerto Rico Clinical and Translational Research Consortium, University of Puerto Rico Medical Sciences Campus, San Juan, Puerto Rico

Abstract

OBJECTIVE—To describe the state of glycemic control in non-critically ill diabetic patients admitted to the PR University Hospital, and the adherence to current standard of care guidelines for the treatment of diabetes.

METHODS—This was a retrospective study of patients admitted to a General Medicine ward with Diabetes Mellitus as a secondary diagnosis. Clinical data was analyzed for the first 5 days and the last 24 hours of admission.

RESULTS—One hundred and forty-seven (147) non-critically ill diabetic patients were evaluated. The rate of hyperglycemia and hypoglycemia was 56.7% and 2.8%, respectively. Nearly 60% of patients were hyperglycemic during the first 24 hrs of admission and 54.2% during the last 24 hrs. Mean last glucose value before discharge was 189.6 ± 73 mg/dL. Most patients were treated with subcutaneous insulin with basal insulin alone used as the most common regimen. The proportion of patients classified as uncontrolled receiving basal-bolus therapy increased from 54.3% on day 1 to 60.0% on day 5, with still 40.0% receiving only basal insulin. Most of the uncontrolled patients had their insulin dose increased (70.1%), however, a substantial portion had no change (23.7%) or even had a decrease (6.2%) in their insulin dose.

CONCLUSIONS—Even though there are areas of improvement in the management of hospitalized diabetic patients, it is still suboptimal, probably due to clinical inertia. A comprehensive educational diabetes management program, along with standardized insulin orders should be implemented to improve the care of these patients.

Keywords

Diabetes; In hospital hyperglycemia; Inpatient management of Diabetes Mellitus

Please address all correspondence and reprint requests to author. Myriam Zaydee Allende-Vigo, PO Box 365067, San Juan, Puerto Rico 00936-5067, Tel. (787) 294-3622, Fax. (787) 765-9183, myriam.allende@upr.edu.

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The authors of this study have no conflicts of interest to disclose.

Introduction

The prevalence of Diabetes Mellitus (DM) is increasing considerably worldwide and in the United States (US), where adults with diabetes has more than tripled in the last 30 years, from 5.5 million to 24.5 million (2). Puerto Rico has the highest prevalence of self-reported DM in US (12.8% vs. 8.7% on 2010). DM is reported as the third cause of death in the island (3-4). DM is a common comorbidity in the hospitalized patient and represents a significant burden on the hospital system. In 2008, nearly one in five hospitalizations were related to patients with DM (7). Approximately 25% of the admissions to the University Hospital have DM as a secondary diagnosis (8).

In-hospital hyperglycemia is a common finding and is considered an important, independent marker of in-hospital poor clinical outcome and mortality in both patients with or without a history of DM (9). Hyperglycemia at the time of admission predicts in-hospital and one-year mortality in patients with diabetes and acute myocardial infarction, and patients in the medical intensive care units (MICU) (10-12). Elevated mean glucose values have also been associated with adverse outcomes such as increased mortality lengh of stay (LOS), rate of complications, and surgery specific risk in non-critically ill patients and patients after non-cardiac surgery. (13-15).

There is controversial evidence that tight glycemic control, with a blood glucose target of 81 to 105 mg/dL, in the Intensive care unit (ICU) setting is beneficial in reducing mortality, acute renal failure requiring hemodialysis, sepsis, organ dysfunction, need for blood transfusions, LOS, and ventilatory support (16-19). A blood glucose target of 180 mg/dL or less has been suggested as beneficial (19). Most of the studies addressing the effects of tight glycemic control have focused on patients in the ICU. Heterogeneous data on non-critically ill patients is mostly derived from observational studies. The RABBIT 2 Surgery study showed a lower frequency of the composite outcome of perioperative complications including wound infection, pneumonia, bacteremia, respiratory failure, and acute renal failure, in patients treated with basal–bolus therapy, in which a better glycemic control was achieved as compared to sliding scale insulin (SSI) (21). A recent meta-analysis by Murad MH *et al*. concluded there was a potential benefit of glycemic control in the range of 100–180 mg/dl in patients hospitalized in noncritical settings (22) derived from a reduction in the risk of infection.

The American Association of Clinical Endocrinologists (AACE), the American Diabetes Association (ADA), and The Endocrine Society (TES) have developed standards for in-hospital blood glucose targets as an important part of a comprehensive glycemic management plan. Recommendations include a premeal glucose level less than 140 mg/dL, postprandial or random levels less than 180 mg/dL in non-critically ill patients; measuring the blood glucose concentration and HbA_1c levels at hospital admission; and frequent revision of scheduled insulin therapy based on patient response, among others (23-24). Scheduled subcutaneous administration of insulin, with basal, nutritional, and correction components, is the preferred method for achieving and maintaining glucose control. Studies have demonstrated superior glycemic control and clinical outcomes with the use of basal-

bolus therapy as compared to the use of SSI alone (21, 25). The use of sliding scale insulin alone is strongly discouraged. (25).

Despite recommendations, there is increasing evidence suggesting suboptimal management of DM in the non-critically ill hospitalized patient (26-30). Knowledge about the inpatient management of DM among general medicine ward patients in Puerto Rico is limited. The aim of this study was to describe the glycemic control of non-critically ill diabetic patients admitted to our institution, and the current practices being applied for the care of this population including therapeutic strategies being implemented by residents and their modification in response to elevated or low glucose values. Adherence by internal medicine residents to recommendations presented by AACE, ADA and TES, for the treatment of in-hospital DM was also evaluated.

Methods

Setting and participants

This was a retrospective observational study conducted at the Puerto Rico University Hospital. This is a 236-bed, tertiary-care academic teaching hospital associated to the University of Puerto Rico, School of Medicine. Patients between the ages 18 to 80 years old, admitted to one of five General Internal Medicine (GIM) teams, from September 1st, 2010 to August 31st, 2011, with an *International Classification of Disease, 9th Revision, Clinical Modification* (ICD-9-CM) diagnosis code for diabetes (ICD-9-CM code 250.xx) as a secondary diagnosis, were identified. Only those patients with a hospital length of stay (LOS) of at least 5 but no more than 15 days were included in this study. Exclusion criteria included: patients admitted for diabetic ketoacidosis, hyperosmolar hyperglycemic state or gestational diabetes; patients requiring steroid therapy during admission, and patients transferred to a medical, surgical, or neurosurgical ICU; or with criteria for ICU setting (mechanical ventilation, septic shock requiring vasopressor therapy). The presence of inclusion or exclusion criteria was confirmed by medical record review.

Measurements

Record review was performed and clinical data was abstracted for the first five days of admission and for the last 24 hours before discharge. Records were revised by the investigators. In order to maintain patient's confidentiality, a code was assigned to each patient. Included in the review were admission orders, resident's admission, progress, and discharge notes, the hospital's electronic record for laboratory data (Meditech), nursing notes, recorded glucose values on vital sign sheets, and list of medications. Data retrieved included patient age, gender, weight, height, medical insurance, type of DM, medications before admission, medical comorbidities, history of diabetic complications, family history of DM, and primary admission diagnosis.

The study primary outcome was to evaluate the prevalence of hyperglycemia (glucose ≥ 180 mg/dL) and hypoglycemia (glucose < 70 mg/dL) among these noncritically ill patients. All bedside fingertip blood glucose measurements were recorded from each chart and the respective rates were calculated. Bedside fingertip blood glucose values were used instead of

blood values due to higher availability, high correlation with serum laboratory tests, and the fact that most clinical practitioners use daily beside glucose values as their guide for DM management. The glucometer Precision PCx–Medisense was used, and calibrated by nurse staff on a daily basis. These values were used to calculate the mean glucose value per patient for the first 24 hours, for the first five days of admission, and for the last 24 hours before discharge. Secondary outcome included the process of care, which was evaluated by recording number of bedside glucose measurements per day, orders for HgA1c and nutritional evaluation on admission, and the mention of DM on admission, discharge, and daily progress notes.

All orders related to glucose management were recorded. Insulin therapy was classified as "basal only" (only a long-acting formulation), "bolus only" (only a short-acting formulation) or "basal/ bolus" (long-acting plus a short-acting formulation). The amount of insulin administered each day, the use oral hypoglycemic agents, and the use of SSI alone at any time during admission were also recorded. We compared the total insulin units administered during the first 24 hours of admission with the ones administered during the last 24 hours to assess change in insulin dose. For the purpose of analysis, patients were classified based on their mean bedside glucose value during the first five days of admission as controlled (mean blood glucose ≤ 180 md/dL), or uncontrolled if hyperglycemic. Variables evaluated at the moment of discharged included: hospital LOS, admission outcome, endocrinology consult request, and follow up plan after discharge.

The University of Puerto Rico, Medical Sciences Campus Institutional Review Board approved this study. Patient informed consent was not deemed necessary for this study, as there was no direct interaction with patients to collect this non-sensitive data (record review). All necessary steps were taken to minimize any breach in patient confidentiality.

Statistical analysis

Baseline demographics and clinical characteristics were analyzed using frequencies, rates, and means with standard deviations as appropriate. Bedside glucose mean value was calculated by totaling the bedside blood glucose values for every patient for the first 24 hours, first 5 days, and for the last 24 hours of admission and dividing the total by the number of measurements performed on that period of time. We determined the proportion of patients with mean glucose value less or equal to 180 mg/dl (controlled group) and higher than 180 mg/dl (uncontrolled group). Mean blood glucose values of all patients per day were also calculated to assess the daily trend during the course of hospitalization. Insulin-ordering practices were categorized as basal-only and basal-bolus. We excluded bolus-only category due to inadequate sample size (n = 1). Student t test and analysis of variance were used to analyze continuous data between the groups. Differences between proportions were compared using the Chi-square (X^2) test. Results were considered significant at $p<0.05$. Statistical analyses were performed using Statistical Package for the Social Sciences version 17.0 (SPSS, Chicago, Illinois).

Results

From September 1st, 2010 to August 31st, 2011, 2151 patients were admitted to GIM teams. Of these, 598 had DM as a secondary diagnosis, which represented 27.8% of the admissions. After inclusion and exclusion criteria applied, 147 patients were included in the analysis. (Fig. 1) Baseline characteristics of the study subjects are shown in Table 1. The average age of patients was 58 ± 12 yrs. Sixty percent of the patients were men and 90% had type 2 DM. The mean HgbA1C and bedside glucose level on admission were 8.19% and 226.5 ± 97.7 mg/dL, respectively. The mean LOS was 7.58 days. The most common comorbidities were high blood pressure (75.5%), cardiovascular disease (26.5%) and dyslipidemia (19.7%).

Although residents ordered HbA1C on admission in seventy three point five percent (73.5%) of patients, it was reported in only o 59.2% of patients. The median of bedside glucose measurements was 1 during the first five days and 2 on the last 24 hours. The rate of hyperglycemia was high on the first five days of admission, with 691 out of 1218 bedside glucose readings greater than 180 mg/dL (56.7%). The rate of hypoglycemia was low, with only 34 out of 1218 bedside glucose readings lower than 70 mg/dL (2.8%). Although there was a statistically significant difference in the daily mean glucose level during hospitalization (p=0.000), the mean value in the last 24 hours of admission was 196.51 mg/dL, a value above the recommended goal of 180 mg/dL.(Fig.2)

During the first 5 days of admission, more than 50% of the patients had their mean percent of glucose readings above 180 mg/dL. Nearly 60% of patients were hyperglycemic during the first 24 hrs of admission, 53.2% had persistent hyperglycemia on day 5, and 54.2% were hyperglycemic during the last 24 hrs (Fig 3).

Regarding admission orders for DM management, 86.4% of the patients were started on insulin as the only treatment, 2.0% of the subjects were treated with oral hypoglycemic agents alone, and only 0.68% of the patients the combination of oral agents and insulin was used. In eleventh percent (11%) of the patients no treatment for DM was ordered on admission. The use of SSI as single treatment was evidenced in 14.3% of patients. The most common insulin regimen used by residents on admission was “Basal Only” (60.0%), followed by “Basal-Bolus” (39.2%), and “Bolus Only” (0.8%). After analyzing the mean bedside glucose value during the first five days of admission, 52 patients (35.4%) were classified as controlled whereas 95 (64.6%) were classified as uncontrolled. No significant differences were found on important variables such as gender, age, medical insurance, type of DM, LOS, BMI, among both groups. Among insulin users classified as controlled upon admission, 70.3% were started on basal insulin alone, whereas 29.7% were started on a basal-bolus insulin regimen (Table 2). The use of basal-bolus insulin was higher among those patients classified as uncontrolled, as 54.3% were started on this regimen, whereas 45.7% were started on basal insulin alone. The proportion of patients classified as uncontrolled who were receiving basal-bolus therapy increased to 60.0% on day 5. However, there were still 40.0% of patients in this group who were receiving only basal insulin even when their mean blood glucose was greater than 180 mg/dL. Changes in insulin doses were recorded, with 47% of patients having their insulin dose increased during the first five days of admission. The same proportion of patients had no change in insulin dose,

whereas only 6% had their insulin dose decreased during that period. Most of the uncontrolled patients had their insulin dose increased (70.1%), however, a substantial portion had no change (23.7%) or even had a decrease (6.2%) in their insulin dose. (Fig. 4) Endocrinology consult was requested for only 2.1% of patients in the uncontrolled group.

Discussion

The large amount of data indicating a strong association between hyperglycemia and adverse outcomes in the hospitalized patient has resulted in an increased interest in the study of the inpatient management of DM. We retrospectively evaluated 147 non-critically ill diabetic patients admitted to the Puerto Rico University Hospital. Our findings indicate that the management of this population is suboptimal, as the majority of patients presented uncontrolled DM. Despite clear recommendations by consensus guidelines to keep blood glucose levels lower than 180 mg/dL in this type of patient, we found a high rate of hyperglycemia, with 57% of bedside blood glucose readings above this value. This elevated rate of hyperglycemia has been previously documented in Puerto Rico. On a recent study of patients admitted to a general ward of a community hospital in Puerto Rico, 59.1% of patients were classified as uncontrolled during the first 72 hours of admission (30). Our populations differ in demographic aspects such as mean age and gender proportion, and on the definition of uncontrolled status, which in that study was defined as having 50.0% or more of the recorded glucose values above 180 mg/dl. Both studies showed a greater degree of hyperglycemia compared to studies performed in the US mainland. In a study performed at Mayo Clinic, Arizona, Cook CB et al. evaluated the care of 2916 hospitalized, non-critically ill, diabetic patients on a tertiary-care academic teaching hospital. They found that throughout admission, from 20 to 25% of patients were hyperglycemic, and defined as bedside glucose > 200 mg/dL (28). Our mean HbA1C of 8.18% on admission was higher than the reported on previous studies on US, which have ranged from 6.9% to 7.0%. The higher proportion of uncontrolled patients in our study could be due to the fact that we only evaluated patients admitted to GIM, whereas must previous studies included patients from all services, including surgery and Ob-Gyn. Patients admitted to GIM ward tend to be sicker and have a greater comorbidity index than patients admitted to these other services. Moreover, being a tertiary-care, referral center, the severity of illness of our patients is usually higher than community hospitals.

We found that most patients were started on subcutaneous insulin upon admission, with only 2% being started on oral hypoglycemic agents. This is consistent with other studies and supports the fact that insulin has become the main therapy in the diabetic, hospitalized patient (26, 28-29). The use of SSI alone was evidenced in 14.3% of our population, a value lower than those reported in previous similar studies where it has been as high as almost two third of patients (26). Torres and colleagues found SSI to be the most common initial modality of treatment for diabetic patients, used in 39.2% of the subjects, and it was the treatment modality most commonly associated to uncontrolled glucose (30). Similarly, Schnipper and colleagues reported the use of SSI in 83% of the diabetic patients evaluated, while it was used alone in 19% of this group (29). The less frequent use of SSI in our study likely reflects increased awareness about the deleterious effects of this regimen when used alone and the emphasis of current guidelines in the inappropriateness of this approach

among internal medicine residents. Recently, the RABBIT 2 study clearly demonstrated the superior glycemic control and improved clinical outcomes with the use of basal/bolus regimes as compared to SSI alone (21, 25).

The extensive use of basal insulin alone differs from most previous studies in hospitalized diabetic patients where the use of basal insulin has been limited (28-29). A significant number of uncontrolled patients (40.0%), were receiving basal insulin only on the fifth day. All current consensus guidelines have concluded that an optimal management of inpatient DM should include basal, prandial, and correction insulin coverage (23-24). Although most of the uncontrolled patients had their insulin dose optimized, substantial portions had no change (23.7%) or even a decrease (6.2%) in their insulin dose during the first five days of admission. This lack of treatment modification has been documented previously both in our population and in US. In the previously mentioned study by Torres and colleagues, 42.2% of the uncontrolled patients received no treatment modification in the first 72 hours of admission (30). Likewise, Cook and colleagues found that a substantial number of patients with uncontrolled DM did not have insulin therapy optimized during their hospital admission and, as much as 31%, actually had a decrease in the insulin dose (28). In their study, Schnipper and colleagues found that only 35% of the patients who had an episode of hyper- or hypoglycemia had a change in dose of any insulin during the first five days of admission (29).

Our findings suggest areas of improvement in the management of hospitalized patients with DM, such as the preferential use of subcutaneous insulin, less use of SSI or oral hypoglycemic, and an increase in the use of a basal/bolus regimen. Still, the care of our patients is suboptimal, probably due to the phenomena of clinical inertia and lack of appropriate intensification of therapy. Fear of hypoglycemia is frequently mentioned as one of the most common causes of clinical inertia, however, a resident survey performed by Cheekati and colleagues found that the most common barrier to successful management of inpatient hyperglycemia was understanding what insulin type or regimen works best, followed by fluctuating insulin demands related to stress and, in the third place, the risk of hypoglycemia (34). The lack of treatment modification in our uncontrolled patients, even with a low rate of hypoglycemia, supports this concept. It appears that the main reason for residents to avoid making changes in insulin treatment is lack of knowledge about its correct use. (34). Surveys among residents have consistently found insufficient knowledge regarding inpatient glycemic management. Rubin and colleagues evaluated the diabetes knowledge of residents using a survey based on current standards of care and found significant knowledge deficits regarding glycemic management (35).

There are no protocols or standard orders for insulin administration at the University Hospital. The implementation of a diabetes order set designed by a multidisciplinary team has been proved to improve DM care in part by increasing orders for scheduled basal/bolus insulin therapy and decreasing the use of SSI alone (36-37). A new order set encouraging the use of scheduled subcutaneous basal, nutritional and correction insulin is currently being implemented in our institution, along with education for residents and nurse staff about its use and proper glycemic targets.

Our study is the first one to look at current practices and management strategies of patients with diabetes at the University Hospital. There were a substantial number of non-critically ill patients admitted with hyperglycemia and good documentation of management and outcomes. Due to the retrospective nature of this study, important limitations should be mentioned. First, the main source of data was patient's charts review, which is highly dependent on appropriate documentation by physicians and nurse staff. Data could be inaccurate or incomplete, and important data unavailable. Also bias and confounders are difficult to control. Data provides only indirect evidence about trends in the glycemic control and management techniques of diabetic patients in our institution. As we only evaluated the orders for modification of DM therapy recorded on the patient's chart, we were unable to evaluate the rationale for changes in therapy or for inaction when confronting sustained hypo or hyperglycemia. In addition, authors were most of the time unable to identify if values represented the premeal or post-meal state making the temporal relationship between glucose level and insulin administration difficult to assess. Another possible limitation of our study is the relatively small sample size.

Conclusions

Assessing the quality of inpatient DM management and recognizing barriers in this process are the first steps to improve care in an institution. This study provides a snapshot about the current state of glycemic sate in our hospital, and an interesting insight into the therapeutic strategies being applied by our internal medicine residents. This gives us a useful background to determine where to direct our efforts. Although important areas of improvement in management were identified, care of our diabetes patients is still suboptimal. New strategies should be developed to overcome clinical inertia, achieve adequate glycemic targets and avoid adverse outcomes related to sustained hyperglycemia or hypoglycemia. Efforts should include a comprehensive educational diabetes management program for residents and all staff involved in the care of the diabetic patient. In addition, standardized insulin order sets should be implemented to improve insulin-ordering practices.

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Abbreviations

AACE	American Association of Clinical Endocrinologists
ADA	American Diabetes Association
BMI	Body Mass Index
DM	Diabetes Mellitus
TES	The Endocrine Society
GIM	General Internal Medicine
ICU	Intensive Care Unit
LOS	Length of stay
SSI	Sliding Scale Insulin
US	United States

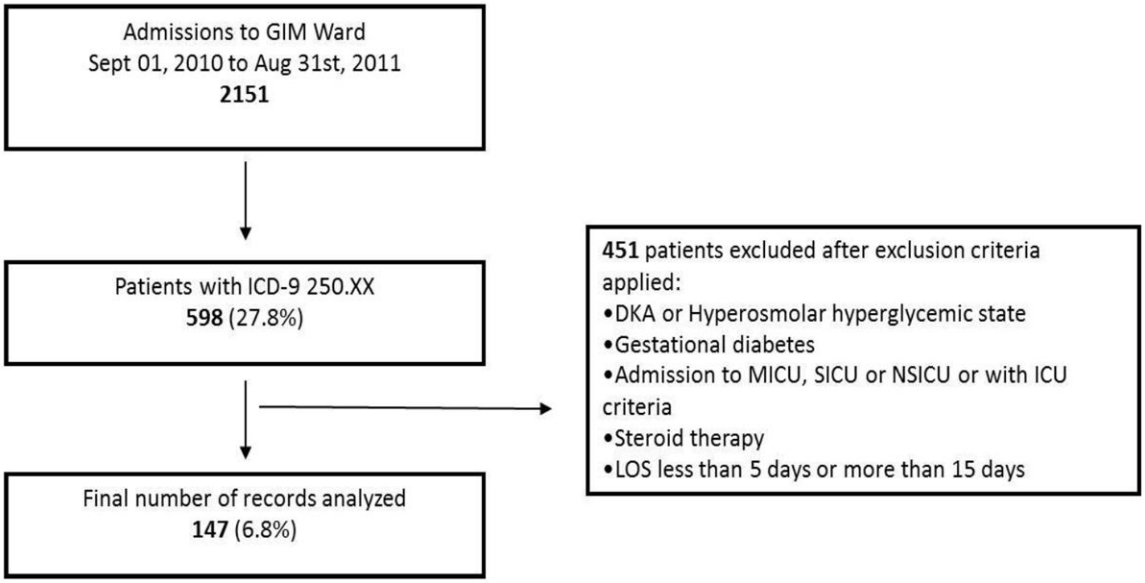


Fig. 1.
Patient Study flow

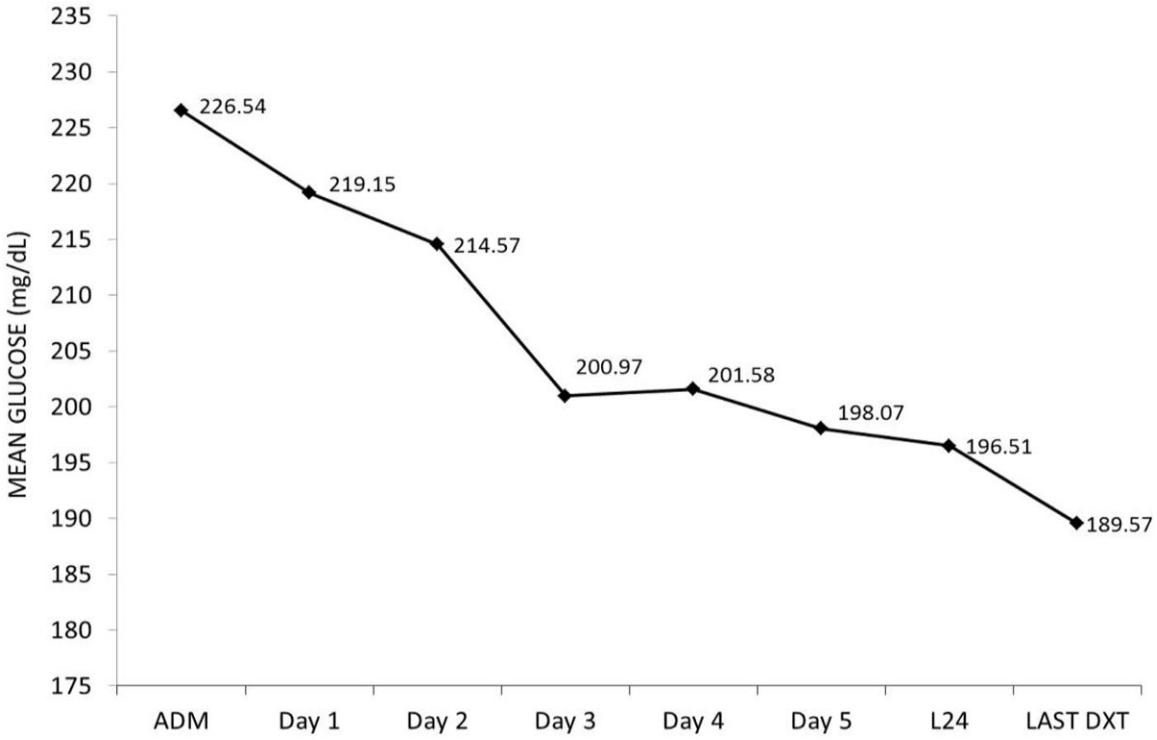


Figure 2.
Mean glucose levels through the admission

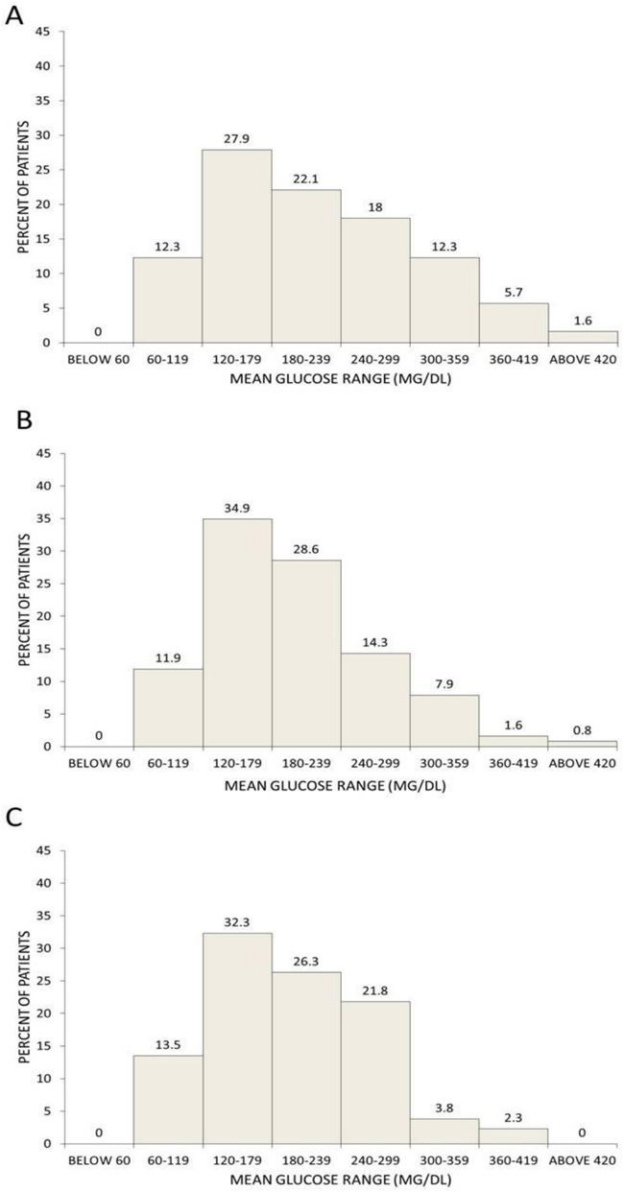
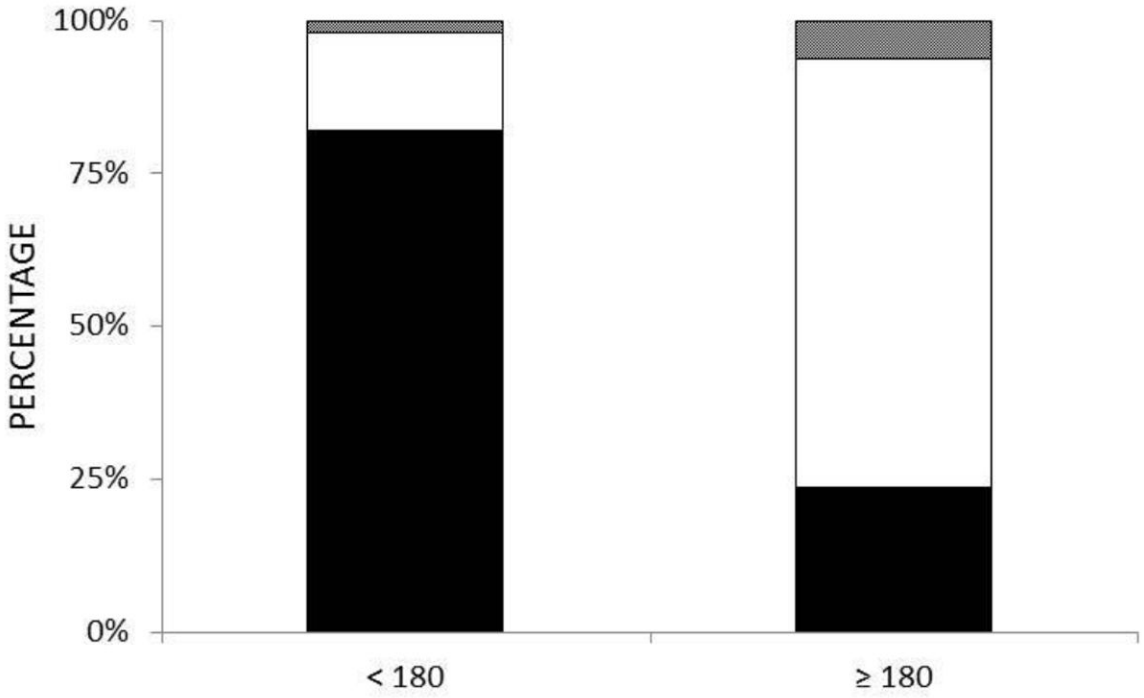


Fig. 3.

Distribution of mean bedside glucose values for: the first 24 hours of admission (A); the fifth day of admission (B); and the last 24 hours before discharge (C)



	< 180	≥ 180
Decrease	2.0%	6.2%
Increase	16.0%	70.1%
No change	82.0%	23.7%

Figure 4.

Changes in insulin doses in the controlled (mean glucose < 180mg/dL) and uncontrolled (mean glucose ≥;180mg/dL) groups

Table 1

Baseline Characteristics

Age	58 ± 12 years
Gender	Male 89/147 (60.5%) Female 58 /147 (39.5%)
Type of DM	Type 1 8/147 (5.4%) Type 2 132/147 (89.8%) Not documented 7/147 (4.8%)
HgbA1c	8.18 ± 2.25%
BMI	28.9 ± 7.6 kg/m^2
Mean bedside glucose value on admission	226.5 ± 97.7 mg/dL
LOS	7. 58 ± 2.59 days

Table 2

Daily insulin regimen in the controlled (mean glucose <180mg/dL) and uncontrolled (mean glucose ≥180mg/dL) groups

	N	Glucose (mg/dl)	Mean glucose (mg/dl)	Basal	Basal-Bolus	p
Day 1	37	< 180	149.24	26(70.3)	11(29.7)	0.013**
	70	≥ 180	249.87	32(45.7)	38(54.3)	
Day 2	36	< 180	143.70	22(61.1)	14(38.9)	0.281**
	41	≥ 180	246.70	41(53.2)	36(46.8)	
Day3	46	< 180	136.23	31(67.4)	15(32.6)	0.007**
	77	≥ 180	230.84	33(42.9)	44(57.1)	
Day 4	44	< 180	140.05	32(72.7)	12(27.3)	0.000**
	80	≥ 180	232.45	30(37.5)	50(62.5)	
Day 5	49	< 180	133.95	30(61.2)	19(38.8)	0.020**
	65	≥ 180	226.80	26(40.0)	39(60.0)	
DH Day	56	< 180		29(51.8)	27(48.2)	0.096**
	70	≥ 180		27(38.6)	43(61.4)	