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Associations Between Home Insulin Dose Adjustments and Glycemic Outcomes at Hospital Admission

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Abstract

AIMS—To describe patterns of home insulin dose adjustments for non-surgical, non-critically ill patients at admission and to describe associations between these adjustments and inpatient glycemic control.

METHODS—Hospital records of non-critically ill patients treated with basal insulin prior to admission were identified. After exclusion of records in which a confounding factor influencing insulin dosing was present, 258 patient-admissions over a 3-year time period were included. Multivariate logistic regression was used to analyze the association between adjustments to home insulin total daily dose (TDD) and inpatient glycemic control within the first 48 hours, adjusting for relevant confounders.

RESULTS—On hospital days 1 (HD1) and 2 (HD2), the home insulin TDD was reduced by 43.5% and 23.9%, respectively. Reductions in the home TDD ranging from 10% to 50% were not associated with normoglycemia or hyperglycemia, whereas increases ranging from 10% to 50% were associated with increased 2–5 fold increased odds of hyperglycemia. For patients with home insulin TDD 0.4 units/kg/day, a weight-based dose of 0.4–0.6 units/kg/day was associated with significantly higher odds of normoglycemia on HD2 (OR 3.99; 95% CI 1.42–11.21) compared to lower doses.

CONCLUSIONS—Compared to less aggressive increases, home insulin dose increases ranging from 10% to 50% were associated with greater odds of hyperglycemia without increased odds of hypoglycemia during early hospitalization. Weight-based insulin dosing may be a preferred strategy for glycemic control among patients whose home TDD is 0.4 units/kg/day.

Keywords

Insulin; dose; adjustment; hypoglycemia; hyperglycemia; glycemic; glucose; hospitalization; basal

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1. INTRODUCTION

Nearly one in four hospitalized patients in the United States has diabetes mellitus.[1] For the majority, diabetes is not the primary reason for admission. Nonetheless, adequate glycemic control during hospitalization is recommended for all patients, since hyperglycemia has been associated with increased length of stay, infection risk, and mortality.[2–5] During hospitalization, non-insulin agents are generally discontinued given potential contraindications to their use.[1] For most inpatients, a “basal-bolus” insulin regimen is the recommended method of insulin delivery. Initial insulin total daily dose (TDD) can be estimated from body weight, and distributed into basal, nutritional, and correctional components.[1] However, for patients already on home insulin, guidelines are lacking regarding how to adjust home insulin doses upon initial hospitalization. The Endocrine Society recommends reduction of basal and prandial insulin doses “on admission in patients with poor nutrition intake, impaired kidney function, or with admission blood glucose (BG) levels less than 100 mg/dL.”[1] Similarly, the American Association of Clinical Endocrinologists/American Diabetes Association (AAACE/ADA) consensus statement on inpatient glucose management recommends modification of the insulin regimen for BG levels less than 100 mg/dL.[6]

Despite this general guidance, specific recommendations on how to adjust insulin doses at admission are lacking. In addition to other factors, inpatient providers must rely on the quality of outpatient glycemic control as assessed by most recent A1C as well as the initial BG readings during early hospitalization to make subjective changes to the home insulin regimen. One scenario that is particularly challenging is when weight-based insulin estimates differ significantly from the home TDD. In our experience, inpatient providers often compare weight-based and home insulin regimens to determine an initial insulin regimen, relying on outpatient-based strategies [7] to adjust the hospital insulin TDD (10%–20% or 20%–40% when modest or significant changes are desired, respectively).

The primary aims of this study were to 1) describe insulin dose adjustments made upon initial hospitalization for non-surgical, non-ICU patients and 2) determine whether different degrees of insulin dose adjustments (10%–50%) and weight-based dosing (0.4–0.6 units/kg/day) commonly used in clinical practice are associated with glycemic outcomes during early hospitalization. We hypothesized that excessive insulin dose reductions are made on admission at the expense of glycemic control.

2. MATERIALS AND METHODS

2.1. Study Population and Setting

This was a retrospective cohort study conducted at Johns Hopkins Hospital, a 1,059-bed tertiary care center in Baltimore, Maryland, between July 1, 2012 and June 30, 2015. The electronic medical record (EMR), Eclipsys Sunrise Clinical Manager, was queried to identify patients receiving basal insulin prior to admission and hospitalized on general medicine, non-critical care units (N=2,025). Basal insulin was defined as any of the following: Lantus (Glargine), NPH (Humulin N, Novolin N), Levemir (Detemir), and mixed

insulins (Humulin 70/30, Novolin 70/30, Novolog Mix 70/30, Humalog Mix 75/25, Humalog Mix 50/50, and Humulin 50/50).

To minimize confounding factors that can alter insulin requirements during hospitalization, we excluded hospital records of: patients receiving nil per os (NPO) or clear liquid diets, total parenteral nutrition, continuous tube feeds, dextrose-containing IV fluids, or glucocorticoids; patients with diagnoses of cystic fibrosis, acute kidney injury, DKA or HHS; patients treated with insulin pumps or infusions; patients with incomplete or undocumented home medications; and patients with hospital stay <48 hours. This time restriction was selected because home diabetic medications might influence glycemic outcomes in the first 24 hours of admission and because the glycemic effects of insulin given late in the first 24 hours of admission might not be seen until the second hospital day. After these exclusions, 258 patient-admissions representing 232 unique patients were included.

2.2. Data Sources and Covariates

Demographic and anthropometric data, diagnosis codes (*International Classification of Diseases, 9th classification* [ICD-9]), admission diagnoses, diet orders, and laboratory data (point-of-care/serum blood glucose [BG], glycated haemoglobin [HbA1c]) were obtained from the EMR. Infection was classified as present or absent by manual review of ICD-9 codes. Hospital day 1 (HD1) was defined as the first 24 hours after admission, and Hospital day 2 (HD2) as 24–48 hours after admission. Diet orders were classified as carbohydrate-controlled (< 60 grams of carbohydrates) or non-carbohydrate controlled (>60 grams). Mortality risk index and complexity scores (minor [1], moderate [2], major [3], extreme [4]) were collected from the Johns Hopkins Datamart financial database. These scores are derived from All Patient Refined Diagnosis Related Groups (APR-DRGs) system, which consider age, principle diagnoses, and interactions of secondary diagnoses. The former describes the likelihood of dying, while the latter describes the extent of physiologic decompensation or organ system dysfunction.[8]

Home medications were collected from manual review of the History and Physical (H&P) and Medication List. Non-insulin agents included metformin, sulfonylureas, meglitinides, thiazolidinediones (TZD), dipeptidyl peptidase 4 (DPP-4) inhibitors, glucagon-like peptide 1 (GLP-1) agonists, alpha glucosidase inhibitors (AGI), pramlintide, sodium-glucose cotransporter 2 (SGLT-2) inhibitors, and combination medications. Administered inpatient medications were collected from review of the Medication Administration Record (MAR). On our institution's formulary, glargine and NPH are the available basal insulins, aspart the nutritional and correctional insulin, and NPH/Regular 70/30 the pre-mixed insulin.

2.3. Insulin Doses

Pre-admission insulin regimens were defined as follows: *basal-only* is long-acting insulin (glargine, detemir, or NPH) without any rapid-acting insulin; *basal-bolus* is long-acting insulin plus a prescribed dose of rapid-acting insulin before each meal, with or without correctional ("sliding-scale") insulin; *basal-correctional* is long-acting insulin plus sliding-scale insulin without nutritional insulin; *nutritional only* is nutritional insulin alone; *correctional only* is sliding-scale insulin alone. The total daily dose (TDD) is the sum of all

insulin administered (for hospital) or prescribed (for home), and is expressed in absolute units and weight-based doses (units/kg/day). The percentage change in insulin dose was calculated by subtracting the home TDD from the hospital TDD (on day 1 or 2), dividing by the home dose, and multiplying by 100. Using logistic regression analysis, we evaluated glycemic outcomes as binary variables (Section 2.4) and percentage change of the home insulin TDD (on HD2) as a binary variable using arbitrary 10% cut-off points. When evaluating negative percentage change (i.e. insulin dose reductions), we compared outcomes among patients who had a reduction greater than the cut-off point to those with an insulin dose reduction less than or equal to that cut-off (e.g. $<-10\%$ vs. -10%). When evaluating positive percentage change (i.e. insulin dose increases), we compared outcomes among patients who had an increase greater than the cut-off to those with increases less than or equal to the cutoff (e.g. $>10\%$ vs. 10%).

Since body weight is another method of estimating insulin requirements, we calculated predicted weight-based insulin requirements for patients according to our hospital protocols (which rely mainly on BMI) as follows: 0.4 units/kg/day for BMI of 18.5–24.9 kg/m²; 0.5 units/kg/day for BMI 25.0–30.0 kg/m², and 0.6 units/kg/day for BMI >30 kg/m². [9] We compared home insulin TDD with predicted weight-based insulin requirements to gauge how discordance between the two results might influence insulin dose titration at admission. To understand how quality of outpatient glycemic control might influence insulin dose adjustments, we stratified the results of home TDD vs. weight-based predicted TDD according to pre-admission HbA1C status ($<7\%$, 7.0–8.9%, and $\geq 9\%$). We also compared predicted insulin requirements among patients without standing home nutritional insulin (basal only or basal-correctional regimen) to those receiving some form of nutritional insulin (basal-bolus or pre-mixed insulin). Using logistic regression, we compared glycemic outcomes among patients based on whether they received an insulin TDD on HD2 within a typical hospital dosing range of 0.4 to 0.6 units/kg vs. <0.4 units/kg.

2.4. Glycemic Outcomes

Normoglycemia was defined as patient day-weighted mean BG (PDWMBG) of 71–179 mg/dL. Hyperglycemia was defined as PDWMBG ≥ 180 mg/dL. Hypoglycemia was defined as any BG ≤ 70 mg/dL. Since glycemic outcomes on HD1 may be influenced by pre-admission medications, glycemic outcomes on HD2 are reported.

2.5. Statistical Analysis

Descriptive statistics were used to characterize the study population. Normality of data was assessed using the Shapiro-Wilk test. For non-normally distributed data, median and interquartile ranges are provided. To compare differences in non-parametric data across time intervals, the Wilcoxon signed-rank test was used for matched data, and the Wilcoxon rank sum test was used for non-paired data. For logistic regression analyses where percentage change was the independent variable, glycemic outcomes were adjusted for HbA1C ($\geq 9\%$ vs. $<9\%$) and home insulin TDD (≥ 0.4 vs. <0.4 units/kg/day). For logistic regression analyses where weight-based insulin dosing was the independent variable, glycemic outcomes were adjusted only for HbA1C ($\geq 9\%$ vs. $<9\%$). A two-sided p-value of <0.05 was

used as the cutoff for statistical significance. All statistical analyses were performed with *Stata Statistical Software: Release 13.1*. College Station, Tx: Stata Corp, LP.

3. RESULTS

3.1. Patient characteristics

Table 1 summarizes baseline characteristics of this cohort. The majority were obese (median BMI 30.8 kg/m²), female (64.3%), and African American (74.0%). The mean age was ~60 years. The majority were patients with type 2 diabetes (~97%) admitted to teaching services (77.1%). In addition to home basal insulin, many of these patients were on at least one non-insulin agent, the most common of which were metformin (27.6%) and a sulfonylurea (7.4%). Most had an HbA1C value available within 3 months of admission (93.1%), although as a group they exhibited poor diabetes control (median HbA1c 8.7% [11 mmol/l]). Approximately one-third of these admissions involved infection (35.3%), with moderate complexity (2.0) and mortality (2.4) risk scores. The majority (83.3%) were receiving carbohydrate-controlled diets.

3.2. Insulin requirements

Table 2 summarizes insulin management and glycemic outcomes during early hospitalization. For home regimens, there was an even distribution of basal-only (44.2%) and basal-bolus (43.4%). In contrast, hospital regimens on HD1 and HD2, respectively, were primarily basal-correctional (43.0% and 50.0%). From HD1 to HD2, the proportion of patients on basal-bolus and basal-correctional regimens increased (14.7% to 26.4% and 43.3% to 50.0%, respectively), with fewer patients remaining on basal-only (8.5% to 2.7%). Among patients on home nutritional insulin, only 41.2% had this continued on HD1, increasing to 56.1% by HD2. A small minority of patients were on premixed insulin at home (5.0%), with very few continuing this regimen during hospitalization. Interestingly, although all patients included in our study were on home basal insulin, 10% did not receive *any* insulin on HD1. Additionally, although studies have shown the ineffectiveness of sliding-scale insulin monotherapy in achieving glycemic control[10], 17.8% and 14.0% of patients in our cohort were placed on sliding-scale only regimens on HD1 and HD2, respectively.

Hospital insulin doses were much lower than home insulin doses, but increased during the first two days of hospitalization. The average home insulin TDD was 32 units, compared to 17 units on HD1 and 26 units on HD2, representing a 44% and 24% reduction, respectively. On HD1, a majority of patients had a TDD 20% lower (67.1%) or 10% lower (70.0%) than their home TDD. By HD2, these proportions decreased to 54.7% and 61.6% respectively, indicating gradual increases in insulin doses. Fewer patients had a hospital TDD within 20% (24.0%) or 10% (15.5%) of the home TDD on HD1, with negligible change by HD2. Very few patients received a hospital TDD at least 10% greater (14.3%) or at least 20% greater (8.9%) than their home TDD; however, these proportions increased by HD2 (25.2% and 19.8%, respectively).

Despite being poorly controlled as a group (median A1C 8.7%), the patients in this cohort were on conservative pre-admission insulin doses (median TDD 0.4 units/kg/day; Table 2).

Additionally, their actual insulin doses (expressed by weight) on admission were even lower, or approximately half of the home TDD (0.2 units/kg/day on HD1). By HD2, insulin TDD increased to 0.3 units/kg/day, likely due to the high prevalence of hyperglycemia (53.9%) on the preceding day. A majority (60%) of the insulin TDD in the hospital was comprised of basal insulin.

Pre-admission A1C was positively associated with home insulin TDD. For patients with HbA1C of <7%, 7.0–8.9%, and >9%, the median (IQR) home insulin TDD was 0.20 (0.15–0.32), 0.44 (0.25–0.64), and 0.45 (0.25–0.72) units/kg/day. Figure 1 shows a comparison of weight-based recommendations for insulin dosing relative to actual home insulin TDD, stratified by pre-admission A1C. Among well-controlled patients (A1C <7%), the median (IQR) home insulin TDD was 0.30 (0.26–0.38), 0.16 (0.15–0.22), and 0.20 (0.14–0.28) for those predicted to require 0.4, 0.5, and 0.6 units/kg/day, respectively. Thus, home insulin doses among well-controlled patients were considerably lower than predicted by weight. Among patients with moderately poor glycemic control (A1C 7.0–8.9%), the median (IQR) home insulin TDD was 0.32 (0.16–0.54), 0.44 (0.32–0.59), and 0.52 (0.27–0.75) for those predicted to require 0.4, 0.5, and 0.6 units/kg/day, respectively. Although home insulin doses were more closely aligned with weight-based estimates in this group, they were still consistently less than predicted by body weight. Finally, among those with very poor glycemic control (A1C ≥9.0%), median (IQR) home insulin TDD was 0.40 (0.22–0.54), 0.39 (0.23–0.57), and 0.56 (0.26–0.85) for those predicted to require 0.4, 0.5, and 0.6 units/kg/day, respectively. For this group, the home and weight-based estimates were more closely aligned for those with normal weight (0.4 unit/kg/day) and those with obesity (0.6 units/kg/day); however, the home dosing was lower than predicted for those in the overweight category (0.5 units/kg/day). Taken together, these data show that a) insulin requirements are generally lower for patients with well-controlled diabetes and gradually increase as outpatient glycemic control deteriorates and b) weight-based insulin doses are more likely to align with home insulin TDD for patients with poorer pre-admission glycemic control.

Figure 2 compares predicted and actual insulin requirements among patients receiving home nutritional insulin to those without. For patients not receiving home nutritional insulin (basal-only or basal-correctional regimens), actual insulin requirements were considerably lower than predicted by weight. For those predicted to require 0.4, 0.5, and 0.6 units/kg/day, median (IQR) home insulin requirements were 0.23 (0.14, 0.15), 0.22 (0.15, 0.42), and 0.24 (0.13, 0.40) units/kg/day, respectively. On the other hand, for patients receiving some form of home nutritional insulin (basal-bolus or pre-mixed insulin regimens), actual insulin requirements were higher than those predicted by weight. For those predicted to require 0.4, 0.5, and 0.6 units/kg/day, median (IQR) home insulin requirements were 0.53 (0.44, 0.69), 0.52 (0.34, 0.72), and 0.63 (0.44, 0.90), respectively.

3.3. Glycemic Outcomes

Consistent with our hospital policies, patients had an average of 3–4 BG checks daily. Glycemic outcomes are summarized in Table 2. As a group, these patients were poorly controlled, with a median (IQR) BG of 186 (147, 237) mg/dl and 183 (147, 229) mg/dl on

HD1 and HD2, respectively. Fifty four (54%) of patients were hyperglycemic and 46% were normoglycemic on HD1; 7% of patients had at least one hypoglycemic episode on HD1. By HD2, the proportion of normoglycemic patients increased slightly (48.5%), while the proportion of hyperglycemic (51.6%) and hypoglycemic (5.4%) patients decreased slightly (although these changes were not statistically significant).

Figure 3 summarizes the association between percentage insulin dose change and glycemic outcomes. Given the overall low rate of hypoglycemia in this cohort (5.4% on HD2), we did not find statistically significant associations between insulin dose change and increased rates of hypoglycemia. On the other hand, we found that patients who had any insulin dose increase (ranging from 10% to 50%) were less likely to be normoglycemic (ORs ranging from 0.17 to 0.39) and more likely to be hyperglycemic (ORs ranging from 2.48 to 5.87) on HD2 compared to those with lower dose increases; although there was a trend towards higher rates of normoglycemia with insulin dose reductions, the results were not statistically significant. There also appeared to be a trend towards higher rates of hyperglycemia with more significant insulin dose increases. For example, the odds ratio for hyperglycemia was 1.34 (95% CI 1.34–4.95) and 5.87 (95% CI 2–17.24) when comparing groups with increases above 10% and above 50%, respectively, to those with increases at or below these cut-offs.

Since home insulin doses were much lower than predicted by body weight, we also explored the association between weight-based insulin dosing and glycemic outcomes. We did not find any association between glycemic outcomes when comparing patients who received an insulin TDD within 0.4 – 0.6 units/kg compared to those receiving doses below the lower limit of these dosing ranges; however, when restricting the analysis to patients with home insulin TDD requirements of ≥ 0.4 units/kg/day (adjusted for pre-admission HbA1C), we found that those who received a dose of 0.4–0.6 units/kg/day had a significantly higher odds of normoglycemia (OR 3.59; 95% CI, 1.32–9.75) and lower odds of hyperglycemia (OR 0.28; 95% CI 0.10–0.76), without any significant increase in hypoglycemia (OR 6.55; 95% CI 0.70–61.41). We did not find any association with glycemic outcomes when restricting to patients on TDD < 0.4 units/kg/day.

4. DISCUSSION

Our study has shown that insulin dose reductions ranging from 10% to 50% were not associated with either normoglycemia or hyperglycemia, whereas any insulin dose increase in this range was associated with a lower likelihood of normoglycemia and higher likelihood of hyperglycemia. In addition, hyperglycemia had a greater magnitude of association with larger insulin dose increases, suggesting that the up-titration of insulin was influenced by either pre-admission glycemic control or early BG results during hospitalization. Although our analyses adjusted for pre-admission A1C, we believe that the association between increases in home TDD and inpatient hyperglycemia may be explained by the following: a) inpatients with better pre-admission glycemic control tend to require less total daily insulin as outpatients, which could lead providers to administer less than weight-predicted doses for these patients given concern about hypoglycemia risk b) a large proportion of inpatients have inadequately controlled diabetes as outpatients and therefore require greater insulin doses in the hospital and c) discontinuation of oral glucose-lowering medications may

reduce insulin sensitivity or endogenous insulin production, resulting in rebound hyperglycemia. Although dose increases of 10%–50% did not appear to be effective, they could nonetheless be considered safe insofar as they were not associated with increased hypoglycemia risk.

To explore the hypothesis that hyperglycemia among those with increases in home TDD was due to inadequate outpatient glycemic control, we compared weight-based predicted insulin doses with actual home doses, stratified by HbA1C. Our study confirmed that patients with moderately poor glycemic control (HbA1C 7.0% – 8.9%) received consistently less insulin than predicted by body weight during admission (Figure 1). Although this difference in predicted vs. actual insulin dosing was less pronounced in very poorly control patients (A1C 9.0%), it may explain in part the fact that increases in home TDD to as much as 50% were not sufficient to control BG during early hospitalization. Weight-predicted insulin doses were also more likely to align with home insulin TDD among patients receiving some form of nutritional insulin at home, but were significantly higher for patients on basal insulin alone. Although we did not find that weight-based dosing was associated with higher rates of hypoglycemia among patients on home insulin TDD <0.4 units/kg/day, strict adherence to a weight-based dosing protocol would expose these patients to a substantially higher amount of insulin in the hospital, where nutritional intake of carbohydrates may be lower than at home.

Weight-based insulin dosing of 0.4–0.6 units/kg/day is widely recommended for the majority of insulin-treated inpatients. Surprisingly, we found that glycemic outcomes overall were no different in patients who received this dose compared to doses <0.4 units/kg/day. We believe that this lack of association can be explained by the heterogeneity of our study population with respect to the home insulin regimen, which included patients on basal insulin only as well as those receiving nutritional insulin. Given the progressive decline in beta cell function over time, patients receiving home nutritional insulin likely have less insulin secretory function than those on basal insulin alone. Indeed, when we restricted our analysis to those patients whose home TDD was 0.4 units/kg/day, administration of weight-based insulin dosing of 0.4–0.6 units/kg/day was associated with significantly greater odds of normoglycemia and lower odds of hyperglycemia, without increased risk of hypoglycemia. At our institution, we recommend initiation of a basal-bolus insulin regimen for patients with 2 or more BG values >180 mg/dl, type 1 diabetes, or type 2 diabetes already treated with insulin or uncontrolled (A1C 7.5%) on non-insulin medications. In light of the results of this study, further studies are needed to determine whether it is appropriate to recommend a basal-bolus insulin regimen universally for all insulin-treated patients admitted to the hospital. Our data would suggest that this recommendation is appropriate for patients whose home insulin TDD is 0.4 units/kg/day; however, it is not clear whether this recommendation can be effectively applied to patients on a lower home TDD.

Based on the totality of these data, this study did not support our hypothesis that excessive insulin dose reductions at admission are associated with increased rates of hyperglycemia; however, our findings suggest that insulin dose increases by 10%–50% may be insufficient to achieve satisfactory glycemic control in the hospital, even after adjusting for HbA1C and

home insulin TDD. It is possible that the lack of association with normoglycemia observed with insulin dose reductions may have been due to a statistical limitation of our sample size. Further studies using larger cohorts may be able to demonstrate the ideal percentage change of the home insulin dose based on pre-admission glycemic control and home insulin TDD. Although we were unable to identify an optimal percentage change of the home TDD, we did show that a weight-based dose of 0.4 to 0.6 units/kg/day is effective for patients with home TDD 0.4 units/kg/day, since it was the only dosing method associated with greater odds of normoglycemia.

There were several strengths of this study. Most importantly, we sought to decrease confounders by excluding patients with conditions or factors that would be expected to require changes in home TDD. However, there are some potential confounders that we could not account for (e.g. actual percentage of carbohydrates consumed; severity of infection), and there may yet be unmeasured confounders. Additionally, the common practice of discontinuing noninsulin agents on admission may actually increase hospital insulin requirements, and our study was not designed to evaluate this effect. Finally, since our patients were on modest insulin doses overall, further studies may be needed to evaluate glycemic outcomes in patients on significantly higher home TDD than predicted weight-based insulin dosing.

In conclusion, we found that reductions in insulin doses of 10%–50% were not associated with either normoglycemia or hyperglycemia during early hospitalization, whereas increases to the same degree were associated with hyperglycemia in hospitalized patients on medical wards. For insulin-treated patients on at least 0.4 units/kg/day at home, a weight-based dosing regimen may be a more effective strategy to achieving glycemic control in the hospital compared to adjustment of the home TDD by differing degrees. Further studies are needed to determine how to weigh relative factors (HbA1C, initial glycemic control, weight-based insulin recommendations, home doses, active infection, etc) to better estimate hospital insulin requirements. Randomized controlled trials comparing weight-based vs. adjusted home dosing protocols would provide important information about the optimal approach to insulin dosing at admission.

Acknowledgments

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Highlights

- Home insulin doses are commonly reduced at admission.
- Insulin dose increases of 10% to 50% are associated with inpatient hyperglycemia, but not hypoglycemia.
- Weight-based insulin dosing may be preferred strategy for patients on home insulin doses of 0.4 units/kg/day or more.

Figure 1.

Box plot of Home Insulin TDD vs. Weight-Based Insulin TDD according to pre-admission HbA1C. Black circles represent outliers. The following BMI cut-offs were to select weight-based hospital TDD: 0.4 units/kg/day for BMI of 18.5–24.9 kg/m²; 0.5 units/kg/day for BMI of 25.0 – 30.0 kg/m², and 0.6 units/kg/day for BMI >30 kg/m². TDD= total daily dose.

Figure 2.

Box plot of Home Insulin TDD vs. Weight-Based Insulin TDD according to home insulin regimen type. White boxes are patients without home nutritional insulin (i.e. basal only or basal-correctional) and grey boxes are patients with nutritional insulin (i.e. basal-bolus or premixed insulin). Black circles represent outliers. TDD= total daily dose.

Figure 3.

Odds Ratios of Glycemic Outcomes on Hospital Day 2, adjusted for HbA1C (9% vs. <9%) and home insulin TDD (0.4 units/kg/day vs. <0.4 units/kg/day). For negative percentage changes, odds ratio compares percentage change less than value vs. greater than or equal to value; for positive percentage change, odds ratio compares percentage change greater than value vs. less than or equal to value. Odds for hypoglycemia, normoglycemia, and hyperglycemia are summarized by circles, squares, and triangles, respectively. CI= confidence interval.

TABLE 1**Baseline Characteristics of Patient Admissions.**

Patient admissions, n	258
Unique patients, n	232
Mean age (SD)	59.8 (14.6)
Sex (M/F)	35.7/64.3
Race	
Black or African-American (%)	74.0
White (%)	20.9
Other (%)	5.0
Diabetes Type	
Type 1 (%)	3.1
Type 2 (%)	96.9
Teaching vs. Non-teaching service (%)	77.1/22.9
Weight ^a , kg	89.9 (69.9, 110.9)
BMI ^a , kg/m ²	30.8 (25.4, 39.2)
Home Regimen (in addition to insulin)	
Metformin (%)	26.7
Sulfonylurea (%)	7.4
TZD (%)	0.4
DPP-4 (%)	2.3
GLP-1 agonist (%)	0.0
HbA1c available within 3 months of admission (%)	93.1
HbA1c value ^a , % ; mmol/L	8.7 (7.2, 10.6); 11 (9, 14)
Infection (%)	35.3
Diet	
Carb-controlled (%)	83.3
Non carb-controlled (%)	16.7
Mortality Risk Index	2.0 (0.7)
Complexity Score	2.4 (0.6)

^a Median (IQR) shown due to non-normal distribution of data.

TABLE 2
Insulin Management on Transition from Home to Hospital and Glycemic Outcomes, N=258 Admissions.

	Home	Day 1	Day 2	P-value (Home vs. Day 1)	P-value (Home vs. Day 2)
Insulin Regimen Administered (% of admissions)					
Basal only	44.2	8.5	2.7	<0.001	<0.001
Basal-bolus	43.4	14.7	26.4	<0.001	<0.001
Basal-plus	7.4	43.0	50.0	<0.001	<0.001
Nutritional only [†]	0.0	5.0	1.6	–	–
Pre-mixed	5.0	1.2	2.3	0.002	0.008
Correctional only	0.0	17.8	14.0	–	–
No insulin administered	0.0	10.0	3.1	–	–
Continuation of Home Insulin Component(s) (% of admissions)					
Basal continued	–	165/245 (67.3)	198/245 (80.8)	–	–
Nutritional continued	–	47/114 (41.2)	64/114 (56.1)	–	–
Pre-mixed continued	–	3/13 (23.0)	6/13 (46.2)	–	–
Insulin TDD^a, units	32 (17, 69)	17 (7, 32)	26 (12, 44)	<0.001	<0.001
% change in insulin TDD from home to hospital					
Insulin TDD ^a , units/kg/day	0.4 (0.2, 0.7)	–43.5 (–75.7, 0.0)	–23.9 (–55.0, 11.1)	<0.001	<0.001
Basal insulin TDD, units/kg/day	0.3 (0.2, 0.5)	0.2 (0.1, 0.3)	0.2 (0.1, 0.3)	<0.001	<0.001
Nutritional insulin TDD, units/kg/day	0.0 (0.0, 0.2)	0.0 (0.0, 0.0)	0.0 (0.0, 0.1)	<0.001	<0.001
Correctional insulin TDD, units/kg/day	–	0.0 (0.0, 0.1)	0.1 (0.0, 0.1)	–	–
Mean (SD) count of BG readings	–	3.6 (1.3)	3.8 (1.2)	–	–
Blood glucose^a, mg/dl	–	186 (147, 237)	183 (147, 229)	–	–
Glycemic Outcomes (% of admissions)					
Hypoglycemia [any BG < 70 mg/dl]	–	7.0	5.4	–	–
Normoglycemia [DWMBG 71–179 mg/dl]	–	45.7	48.5	–	–
Hyperglycemia [DWMBG > 180 mg/dl]	–	53.9	51.6	–	–

^aMedian (IQR) shown due to non-normal distribution of data.

[†]Nutritional insulin alone or nutritional + correctional insulin administered.

[‡]Only among patients treated with a basal. DWMBG= day weighted-mean blood glucose (BG)