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ORIGINAL ARTICLE

Failure to Control Hyperglycemia in NonCritically Ill Diabetes Patients Despite Standard Glycemic Management in a Hospital Setting

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Abstract

Background:

Successful control of hyperglycemia has been shown to improve outcomes for diabetes patients in a clinical setting. We assessed the quality of physician-based glycemic management in two general wards, considering the most recent recommendations for glycemic control for noncritically ill patients (<140 mg/dl for premeal glucose).

Methods:

Quality of glycemic management of 50 patients in two wards (endocrinology, cardiology) was assessed retrospectively by analyzing blood glucose (BG) levels, the glycemic management effort, and the online questionnaire.

Results:

Glycemic control was clearly above the recommended target (mean BG levels: endocrinology: 175 ± 62 mg/dl; cardiology: 186 ± 68 mg/dl). When comparing the first half with the second half of the hospital stay, we found no difference in glycemic control (endocrinology: 168 ± 32 vs 164 ± 42 mg/dl, $P = .67$; cardiology: 174 ± 36 mg/dl vs 170 ± 42 mg/dl, $P = .51$) and in insulin dose (endocrinology: 15 ± 14 IU vs 15 ± 13 IU per day, $P = .87$; cardiology: 27 ± 17 IU vs 27 ± 18 IU per day, $P = .92$), despite frequent BG measurements (endocrinology: 2.7 per day; cardiology: 3.2 per day). A lack of clearly defined BG targets was indicated in the questionnaire.

Conclusion:

The recommended BG target range was not achieved in both wards. Analysis of routine glycemic management demonstrated considerable glycemic management effort, but also a lack of translation into adequate insulin therapy. Implementation of corrective measures, such as structured treatment protocols, is essential.

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Abbreviations: (BG) blood glucose, (IU) international units, (SD) standard deviation

Keywords: diabetes mellitus, glycemic control, glycemic quality, hospital, quality assessment, work effort

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Introduction

Approximately 22% of all patients being admitted to a hospital in the United States and up to 26% admitted in England, have been previously diagnosed with diabetes, making glycemic management an important part of routine care in most hospital wards.[1–5] Hospitalized patients have been reported to experience hyperglycemic events with blood glucose (BG) levels exceeding 200 mg/dl. Even in patients who are not admitted for elevated BG levels, diabetes complications and suboptimal glycemic management can lead to a prolonged hospital stay.[6] This has led to a growing interest in improving the quality of glycemic management in hospitals.[1,6]

Glycemic management in a hospital setting is aimed to avoid both hypo- and hyperglycemic episodes and keep BG levels within a certain range. The association between hyperglycemia and an increased risk for morbidity and mortality has been described for a range of diseases in critically and noncritically ill patients[4,7–10] but large multicenter trials have yielded different results regarding the benefits of tight glycemic control in critical care settings.[11–13] In general wards, most recent recommendations set the premeal BG target for noncritically ill patients who are treated with insulin to <140 mg/dl and random BG levels to <180 mg/dl.[14,15]

Target ranges provide a first guideline in improving glycemic control in a hospital setting; but to identify the need for improvement, a review of the current glycemic management process and outcomes has to be performed individually for each ward.

The aim of this study was to determine in retrospect the quality of clinical glycemic management in two internal medicine wards. Data from patients who had received diabetes treatment were analyzed in the context of the most recent recommendations regarding BG levels. To further characterize the glycemic management during the course of patients' hospital stays, parameters of glycemic management effort, such as change of insulin dose, frequency of insulin injections, and BG measurements were compared for the first and second half of the stay. In addition, nurses in both wards were asked to complete a questionnaire regarding the current procedures of glycemic control.

Methods

The Ethical Committee of the Medical University of Graz approved this study. Data from 50 noncritically ill patients who were consecutively admitted to the general medical endocrinology and cardiology wards of the Medical University of Graz were included in this study. Patients were assigned to the wards according to their medical diagnosis. Because both wards are general wards at the Department of Internal Medicine, no critically ill patients or patients with scheduled surgery were admitted; however, invasive procedures occurred at both wards as part of standard medical care. All patient data were retrospectively included in this study if any form of glycemic management for BG control was required during hospital stay. Data were included only if patients were not transferred to a different ward during the study period. The two wards had a similar structure and used physician-based standard care regarding glycemic control, but neither ward had standardized diabetes therapy protocols in place. Blood glucose levels were measured by the standardized point-of-care testing (POCT) device Roche ACCU-CHEK® Inform System (Roche Diagnostics, Switzerland) with additional quality control feedback from the hospital laboratory system. All data regarding glycemic management were extracted from patient records and entered into the electronic data management software (OpenClinica®, OpenClinica, LLC, Waltham, MA). Nurses in both wards were asked to fill out an online questionnaire about current glycemic management.

Data Analysis

Patient data were analyzed retrospectively in terms of mean BG values and the percentage of BG levels in the following ranges: <70 mg/dl (hypoglycemic events), 70–140 mg/dl, 70–180 mg/dl, >180 mg/dl, >300 mg/dl (hyperglycemic events). All data were analyzed per population (data per ward), per patient day (data per calendar day for each patient) and per patient stay (data per patient) using the standardized and validated glucometrics method for analyzing in-hospital

BG data.[16] In order to analyze changes in glycemic control and glycemic management effort (e.g., mean number of BG measurements, mean number of insulin injections, and mean insulin dose administered per patient) during the hospital stay, we compared the first half of each patient's hospital stay to the second half with respect to glycemic management effort, but no comparison was attempted between the two wards.

Data are presented as mean ± standard deviation (SD) if not stated otherwise. Since most of the data did not follow a normal distribution, we used Wilcoxon signed rank tests for statistical analyses. P <.05 was considered to be significant. All statistical analyses were performed by using the software R 2.13.1.[17]

Results

Records of 50 consecutively admitted patients were analyzed over a 4-month period. Demographic, admission, insulin therapy, and discharge data for all patients are given in **Table 1**.

Table 1.
Demographic, Admission, Insulin Therapy and Discharge Data for 50 Diabetes Patients

Ward	Endocrinology (n = 25)	Cardiology (n = 25)
Age (years)	70 ± 15	72 ± 9
BMI (kg/m^2)	28.5 ± 5.4	28.2 ± 6.5
Sex (f)	14	14
Diabetes type: 2/1	22/3	25/0
HbA1c (%)	8.1 ± 1.8	7.5 ± 0.8
Outpatient diabetes therapy (%) at admission		
Insulin	64	80
Insulin + other anti-diabetic drugs	36	16
Diet	0	4
Diabetes therapy (% of patients) during hospital stay		
Any insulin therapy	100	96
Bolus insulin	64	60
Premixed insulin	52	60
Basal insulin	16	24
Premixed & bolus insulin	12	32
Basal & bolus insulin	12	16
Sulfonylureas	16	4
Metformin	28	16
Admission diagnosis (n)		
Cardiovascular	10	22
Endocrine	8	0
Infectious	4	2
Pulmonary	1	1
Gastrointestinal	1	0
Nephrological	1	0
Hospital stay (days)	10 ± 5	11 ± 8
Discharge to (n)		
Home	23	19
Nursing home	2	0
Transfer to other hospital	0	6

Glycemic Control

The mean BG values for patients in both wards were clearly above the recommended target of 140 mg/dl for premeal measurements and remained above the target until the end of the hospital stay (**Figure 1**).

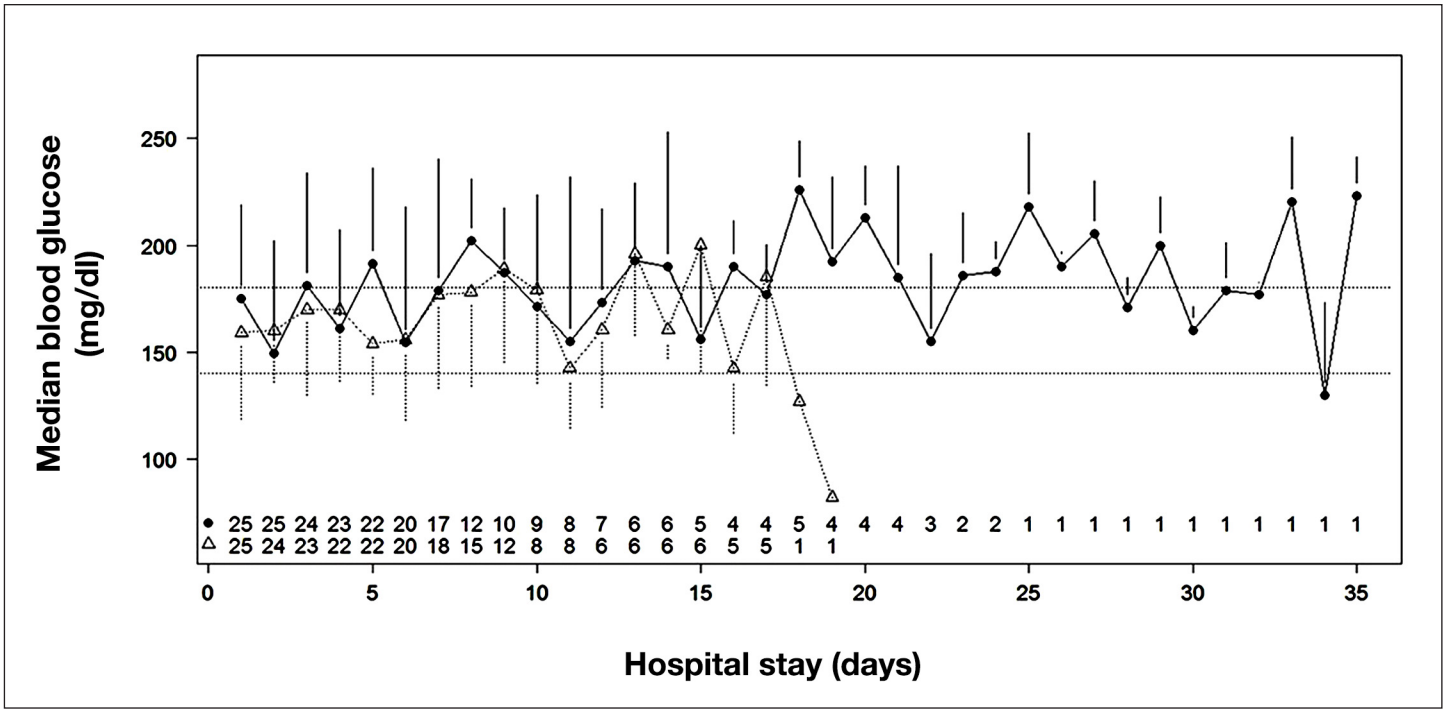

Figure 1. Median BG per day in endocrinology (Δ) and cardiology (•). Error bars are differences between upper quartiles and medians (upper bars), and differences between medians and lower quartiles (lower bars), respectively. Horizontal lines indicate BG limits 140 mg/dl and 180 mg/dl. Numbers at the bottom indicate number of patients.

When comparing several different glucometrics analyses (**Table 2**), 20–32% of BG values were found to be within the target range of 70–140 mg/dl, and 49–64% within the range of 70–180 mg/dl. For both wards, relatively few BG values were in the hypoglycemic range (<70 mg/dl), whereas a significant proportion of values were above the limits of 180 and 300 mg/dl.

There was no significant difference in the mean BG levels of patients in either of the wards when comparing the first half to the second half of the hospital stay (endocrinology: 168 ± 32 vs 164 ± 42 mg/dl, $P = .67$; cardiology: 174 ± 36 mg/dl vs 170 ± 42, $P = .51$).

Most patients in the endocrinology ward ($n = 21$) had BG ≥140 mg/dl in the first half of stay (**Table 3**). Standard glycemic management did not result in a lowered BG level to the recommended target range for 16 of these 21 patients. Similarly,

Table 2.
Glucometrics Analyses of Blood Glucose Data Analyzed per Population, per Patient Day, and per Patient Stay following Goldberg and Coauthors.[16]

Glucometrics analyses	Per popluation		Per patient day		Per patient stay	
Sample size	Endocrinology $n = 646$	Cardiology $n = 832$	Endocrinology $n = 240$	Cardiology $n = 264$	Endocrinology $n = 25$	Cardiology $n = 25$
Mean BG measurements	n/a	n/a	2.7	3.2	25.8	33.3
Mean BG ± SD (mg/dl)	175 ± 62	186 ± 68	168 ± 54	180 ± 48	172 ± 31	175 ± 34
% BGs in 70–140 mg/dl range	31.7	27.3	24.2	20.5	20.0	20.0
% BGs in 70–180 mg/dl range	56.7	50.6	59.6	48.5	64.0	56.0
% hypoglycemic events (<70 mg/dl)	0.9	0.6	2.9	0.8	0.0	0.0
% hyperglycemic events (>180 mg/dl)	42.4	48.8	37.5	50.8	36.0	44.0
% hyperglycemic events (>300 mg/dl)	4.2	4.9	1.3	1.1	0.0	0.0

Table 3.
2 × 2 Table Showing the Number of Patients with Mean BG Values Above and Within the 140 mg/dl Target during the First Half and the Second Half of Their Hospital Stay

Endocrinology (n = 25)	2nd period <140 mg/dl	2nd period ≥140 mg/dl	∑
1st period <140 mg/dl	3	1	4
1st period ≥140 mg/dl	5	16	21
∑	8	17	25
Cardiology (n = 25)	2nd period <140 mg/dl	2nd period ≥140 mg/dl	∑
1st period <140 mg/dl	3	1	4
1st period ≥140 mg/dl	4	17	21
∑	7	18	25

in the cardiology ward, 17 out of 21 had BG levels of ≥140 mg/dl in the first half of stay that remained ≥140 mg/dl in the second half of stay. Furthermore, glycemic control (<140 mg/dl within first half) deteriorated in one patient in each ward.

Glycemic Management Effort

All but one patient received insulin therapy during the hospital stay (**Table 1**). In both wards, the use of bolus and premixed insulin formulation was predominant, whereas a combination therapy of basal or premixed insulin together with flexible prandial insulin was used less often. Insulin dosage in both wards did not differ between the first half and second half [endocrinology: 15 ± 14 international units (IU) vs 15 ± 13 IU insulin per day, P =.87; cardiology: 27 ± 17 IU vs 27 ± 18 IU insulin per day, P =.92]. In addition, there was no difference in the mean number of insulin injections per day neither in the endocrinology ward (1.4 ± 1.0 vs 1.3 ± 0.8, P = .42) nor in the cardiology ward (1.5 ± 0.7 vs 1.4 ± 0.8, P =.46) but we observed a tendency for less BG measurements in the second half (endocrinology: 2.9 ± 0.8 vs 2.5 ± 0.7, P =.06; cardiology: 3.0 ± 0.8 vs 2.7 ± 0.8, P = .11).

In 16 patients (endocrinology: 7, cardiology: 9) with hyperglycemic levels (mean BG/day ≥180 mg/dl) no insulin dosing was performed in 6.7% of days with hyperglycemia (BG ≥180 mg/dl) despite an average of 3.0 ± 0.7 BG measurements per day. Both, the mean daily insulin dose (first half 25.1 ± 18.5 IU vs second half 26.6 ± 18.1 IU, P =.69) and the mean number of insulin injections per day (1.5 ± 0.6 vs 1.7 ± 0.7, P =.53) did not significantly increase in these patients.

Questionnaire

More than 80% of the nurses stated that glycemia and insulin therapy are regularly evaluated (**Figure 2**). Procedures regarding glycemic management in case of "nothing per mouth" orders were familiar to 57%. Although two-thirds indicated that corrective insulin doses for higher glucose levels are prescribed, less than 50% could specify the target range for these corrective measures. Moreover, both the stated target ranges and the type of target glucose showed high variability (**Figure 2**).

Discussion

In this study, we retrospectively assessed the effects of physician-based standard glycemic management in two general hospital wards and analyzed glycemic management effort in relation to standard glycemic care parameters. In both wards, approximately two-thirds of patients' BG values remained >140 mg/dl, indicating failure to control hyperglycemia according to recent recommendations for glycemic control in noncritically ill diabetes patients.[14,15]

Very few hypoglycemic events <70 mg/dl occurred, whereas a substantial proportion of hyperglycemic events >300 mg/dl was documented. These results are similar to other retrospective studies of glycemic control, which reported that

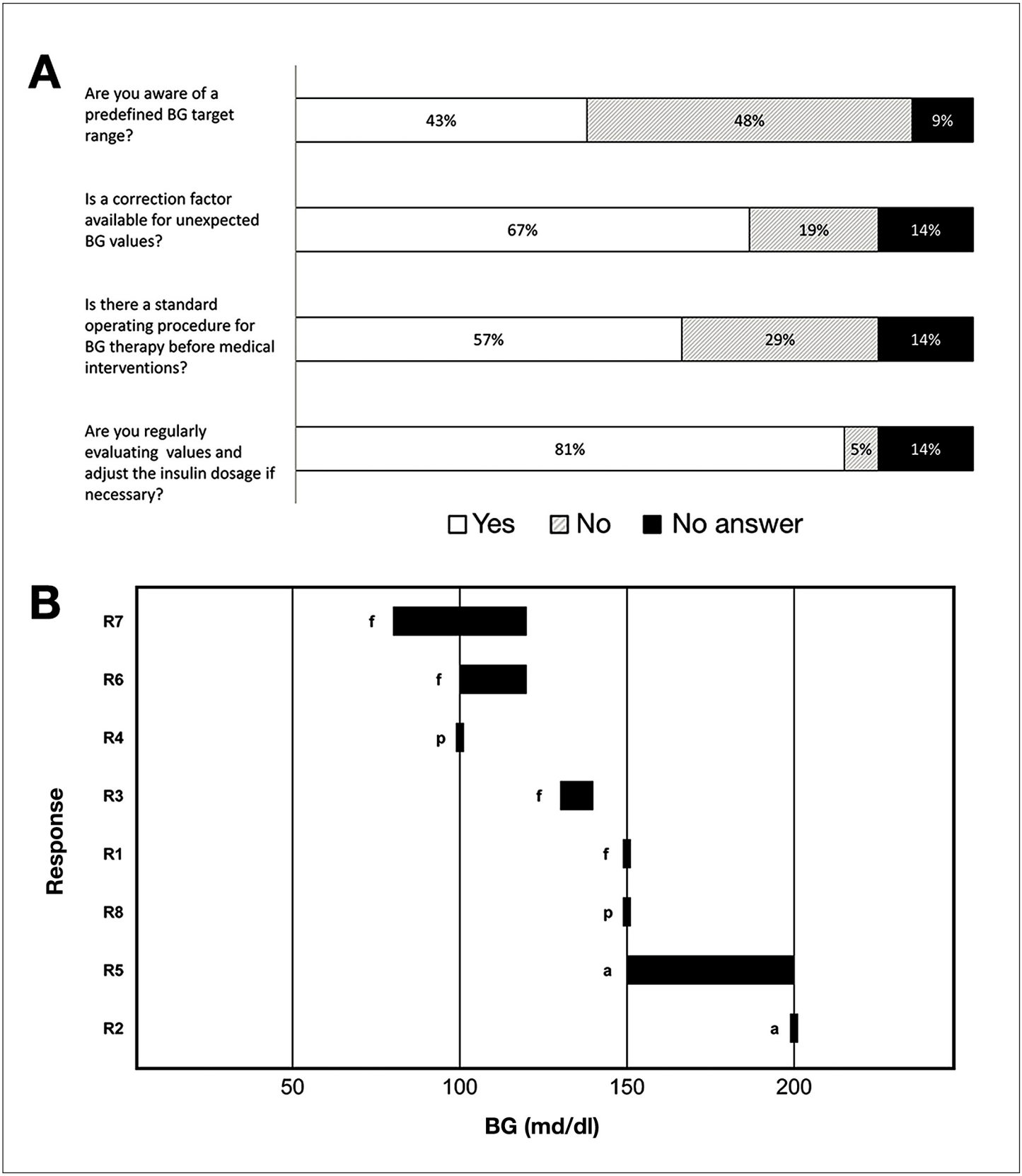

Figure 2. (A) Results of an online anonymous questionnaire about current glycemic management filled in by 21 nurses in both wards. **(B)** BG ranges stated by eight nurses in the online questionnaire defining the type of target glucose level either as fasting (f), average (a) or premeal (*p*).

hyperglycemia was common in a clinical setting whereas hypoglycemic events were rare. Retrospective and prospective studies shared the same difficulties even when a higher BG level of 180 mg/dl had been set as the target.[18–20]

We also assessed whether persistent hyperglycemia might have been caused by insufficient glycemic management effort or heavy workload.[18,21] Neither ward reported a significant change from the first half to the second half in the number of BG measurements per day, the number of insulin injections per day, or in insulin dose adjustments. Basal–bolus insulin therapy, which recent guidelines consider as a key intervention, was not routinely used and although insulin dosing was adjusted individually, it did not result in a significant overall improvement of glycemic control.

While many studies reported similar levels of hyperglycemia in a clinical setting independent of the glycemic management protocols, it is difficult to find a common explanation. The failure to adhere to BG target levels and avoid hyperglycemia is most likely caused by a number of factors such as lack of training, clinical personnel's fear of hypoglycemic events, reluctance to use insulin, preference to administer oral medication, individuality of patients, unfamiliarity with inpatient diabetes management strategies, clinical inertia, and hesitance to institution-wide changes.[21,22] Often, physicians are aware of diabetes at admission, but this diagnosis is often overlooked during hospitalization.[18] Skepticism regarding the benefit of tighter glycemic control also contributes to this problem.[23]

Blood glucose target ranges of <140 mg/dl recommended in recent guidelines may not be appropriate for some patient groups such as terminally ill, geriatric, or pediatric patients, and glycemic target ranges should be modified accordingly.[15,24] Given that the mean age of our study population was 70 years, the recommended target range may not have been applicable to some patients and to some extent may have contributed to the overall elevated glycemia. The wide spectrum of admission diagnosis as well as intensified medical treatment might have influenced individual BG measurements but are unlikely to have affected the average BG values from each ward. However, in the absence of documented individual BG goals, it is difficult to adjust individual target ranges. As indicated by the results of the questionnaires, there is a lack of well-defined target ranges and standardized procedures, which results in highly variable individual glycemic management.

Although we were unable to identify a single underlying reason for the lack of improvement from the first half to the second half of patients' stays, our findings provide a starting point on how to assess and improve glycemic management in hospitalized noncritically ill patients. Awareness must be increased in physicians and nurses about the importance of individual goal setting and documentation. Educational training should lead to adequate insulin adjustments in response to previous BG values and individual targets so as to improve glycemic management.[15,22,25,26]

Electronic decision support systems could also help to achieve a structured treatment protocol. New supportive technologies can make glycemic management processes more effective by reducing prescription errors, thereby increasing effective insulin use, and minimizing the length of patients' stays. Possible electronic implementation approaches are validated alerts and guidelines on the prescription of antidiabetic medication, especially insulin.[1,19,27–29]

In summary, our results show insufficient control of hyperglycemia in noncritically ill hospitalized patients with diabetes despite considerable glycemic management efforts. While the data indicate substantial glycemic management effort in the care of diabetes patients, it did not result in appropriate glycemic control according to recent guidelines. Baseline data must be analyzed to provide a starting point for the evaluation of new interventions in order to improve glycemic management in hospitalized noncritically ill diabetes patients.

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Disclosures:

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